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Attorney for Protestants Save the California Delta Alliance, et al.

BEFORE THE CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

IN RE CALIFORNIA WATERFIX CALIFORNIA DEPARTMENT OF WATER RESOURCES AND U.S. BUREAU OF RECLAMATION PETITION FOR CHANGES IN WATER RIGHTS, POINTS OF DIVERSION/RE-DIVERSION	**CORRECTED DECLARATION OF MICHAEL A. BRODSKY IN SUPPORT OF PROTESTANT SAVE THE CALIFORNIA DELTA ALLIANCE'S RENEWED MOTION TO AMEND PROTEST**

I, Michael A. Brodsky, do declare as follows:

1) I am an attorney duly licensed to practice and admitted before all the courts of the State of California, the United States District Court for the Northern District of California, the United States Court of Appeals for the Ninth Circuit, and the United States Supreme Court.

2) I am counsel of record for Petitioners Save the California Delta Alliance et al., in the above-captioned matter.

3) I make this declaration of my own personal knowledge, and if called as a witness could, and would, competently testify to the matters asserted herein.

4) Attached hereto as Exhibit A is a true and correct copy of Chapter 3 of the Biological Assessment for the California WaterFix, prepared by the United States Department of the Interior, Bureau of Reclamation and State of California, Department of Water Resources. On July 18, 2016, I visited the California Department of Water Resource's California WaterFix official website and obtained the Biological Assessment at http://cms.capitoltechsolutions.com/ClientData/CaliforniaWaterFix/uploads/i4bpd_CWF_BA_TOC.pdf.

5) Attached hereto as Exhibit B is a true and correct copy of DWR's March 11, 2016, Written Response to March 4 Requirement to Address Information Requests from California Water Research and Sacramento Valley Water Users. On July 18, 2016, I visited the State Water Resources Control Board's California WaterFix Website and obtained Exhibit B at http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/water_right_petition.shtml.

6) Attached hereto as Exhibit C is a true and correct copy of Simenstad, et al., Independent Review Panel Report for the 2016 California WaterFix Aquatic Science Peer Review. On July 18, 2016, I visited the California WaterFix Aquatic Science Peer Review Website and obtained Exhibit C at http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/BDCP/ca_waterfix_aq_sci_review_report_final.pdf.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.
Executed this 18th day of July, 2016, at Capitola, California

By: ______________________________
Michael A. Brodsky
Attorney for Protestants
Save the California Delta Alliance et al

EXHIBIT A

Biological Assessment for the California WaterFix

United States Department of the Interior, Bureau of Reclamation, Federal Lead Agency

Contact: Michelle Banonis (916) 978-5198

State of California, Department of Water Resources, Applicant

Contact: Cassandra Enos-Nobriga (916) 651-0178

January 2016

Biological Assessment for the California WaterFix

PREPARED FOR:

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January 2016

ICF International. 2016. *Biological Assessment for the California WaterFix*. January. (ICF 00237.15.) Sacramento, CA. Prepared for United States Department of the Interior, Bureau of Reclamation, Sacramento, CA.

3 Description of the Proposed Action

3.1 Introduction

The CVP/SWP comprises two major inter-basin water storage and delivery systems that divert and re-divert water from the southern portion of the Delta. The CVP/SWP includes major reservoirs upstream of the Delta, and transports water via natural watercourses and canal systems to areas south and west of the Delta. The CVP also includes facilities and operations on the Stanislaus and San Joaquin Rivers. The major facilities on these rivers are New Melones and Friant Dams, respectively.

The California State Water Resources Control Board (SWRCB) permits the CVP and SWP to store water during wet periods, divert unstored water, and re-divert water that has been stored in upstream reservoirs. The CVP/SWP operates pursuant to water right permits and licenses issued by the SWRCB to appropriate water by diverting to storage or by directly diverting to use and re-diverting releases from storage later in the year. As conditions of their water right permits and licenses, the SWRCB requires the CVP/SWP to meet specific water quality, quantity, and operational criteria within the Delta. Reclamation and the California Department of Water Resources (DWR) closely coordinate the CVP/SWP operations, respectively, to meet these conditions.

The proposed action (PA) includes new water conveyance facility construction, new conveyance facility operation in coordination with operation of existing CVP/SWP Delta facilities, maintenance of the existing facilities and newly constructed facilities, implementation and maintenance of conservation measures, and required monitoring and adaptive management activities. Each of these components of the PA is described in detail below. The chapter ends with a discussion of activities that may be interrelated or interdependent with the PA.

Table 3.1-1 identifies the proposed new facilities, identifies the existing requirements that apply to CVP/SWP facilities in the Delta region, and notes which requirements are (or are not) incorporated in the PA. As such, Table 3.1-1 clarifies which facilities and activities addressed under the 2008 FWS and 2009 NMFS Biological Opinions will be replaced and superseded by the PA once the new facilities are operational, provided, however, that requirements listed in Table 3.1-1 may be adjusted to the extent allowed by law based on new data and/or scientific analyses, including data from the coordinated monitoring and research to be conducted under the Coordinated Science and Adaptive Management Program and real time operations, such that operations will still adequately protect listed species from jeopardy while maximizing water supplies.

Table 3.1-1. CVP/SWP Facilities and Actions Included and Not Included in the Proposed Action

Topic	Action	Description	Source	Comments
Facilities and Activities Included in the PA				
New Facilities	Conveyance facilities construction	Construction, operations, and maintenance of the proposed north Delta intakes and associated conveyance facilities.	This document	
New Facilities	Head of Old River Gate construction	Construction, operations, and maintenance of the proposed head of Old River operable gate.	This document	
Real-time Operations	Real-time Decision-making	Apply real-time decision-making to assist fishery management; 2081 application specifies structure: SWG, DOSS, WOMT.	Reclamation (2008) USFWS (2008) DWR (2009), NMFS (2009)	Changes needed to incorporate operations of new facilities and corresponding changes in management structure.
Real-time Operations	NMFS IV.3	Reduce likelihood of entrainment or salvage at the export facilities	NMFS (2009)	PA operational criteria supplement this RPA.
Real-time Operations	USFWS RPA General	Smelt Working Group and Water and Operations Management Team	USFWS (2008)	WOMT coordinates with and provides recommendations to the RTO Team for the Delta operations.
Real-Time Operations	NMFS 11.2.1.1	Technical Team	NMFS (2009)	The technical groups are incorporated into the PA unchanged. WOMT coordinates with and provides recommendations to the RTO Team for the Delta operations. All other technical groups (SRTTG, SWG, DOSS etc.) are incorporated into the PA with revised responsibilities to address the operations of the new facilities.
Real-time Operations	NMFS IV.5	Formation of Delta Operations for Salmon and Sturgeon Technical Working Group	NMFS (2009)	These technical groups are incorporated in the PA unchanged.
Barriers	Temporary Barriers	Operation of the temporary barriers project in the south Delta	Reclamation (2008)	Temporary barriers are included with regard to hydrodynamic effects, with year-to-year placement and removal subject to separate authorizations. HORB replaced by operable HOR gate.

Topic	Action	Description	Source	Comments
Barriers	Do not implement Permanent Barriers	South Delta Improvement Program—Phase I (Permanent Operable Gates)	USFWS (2008), NMFS (2009)	SDIP is not being implemented. The HOR gate is included in the PA.
Barriers	DO in Stockton Deep-Water Ship Channel	Operate HORB to improve DO in the Stockton Deep-Water Ship Channel	Reclamation (2008)	Existing aeration facility in the Stockton Deep-Water Ship Channel is not included in the PA.
Flow	CDFW Condition 5	Flow criteria, also including real-time operational considerations	CDFG (2009)	PA operational criteria supersede this condition.
Flow	Jones Pumping Plant	Permitted diversion capacity of 4,600 cfs	Reclamation (2008) USFWS (2008) NMFS (2009)	To be operated per flow criteria.
Flow	Banks Pumping Plant	Diversion rate normally restricted to 6,680 cfs, with exceptions	Reclamation (2008) USFWS (2008) DWR (2009) NMFS (2009)	To be operated per flow criteria.
Flow	NMFS IV.2.1	San Joaquin River inflow to export ratio (and 61-day pulse flows)	NMFS (2009)	Modeling criteria of PA uses this as mechanism to meet spring outflow criteria in April and May. PA operational criteria for south Delta operations supersede this RPA action; PA operational criteria include this I:E ratio for April and May only. See Table 3.3-1.
Flow	NMFS IV.2.3	OMR flow management	NMFS (2009)	PA operational criteria incorporate and replace this RPA action. See Table 3.3-1.
Flow	USFWS 1	Adult migration and entrainment; first flush: limit exports so average daily OMF flow is no more negative than -2,000 cfs for 14 days, with a 5-day running average no more negative than -2,500 cfs	USFWS (2008)	PA operational criteria incorporate and replace this RPA action. See Table 3.3-1.
Flow	USFWS 2	Adult migration and entrainment	USFWS (2008)	PA operational criteria incorporate and replace this RPA action.
Flow	USFWS 3	Entrainment protection of larval smelt	USFWS (2008)	PA operational criteria incorporate and replace this RPA action.

Topic	Action	Description	Source	Comments
Flow	USFWS 4	Estuarine habitat during fall (provide Delta outflow to maintain average X2 for September, October, and November)	USFWS (2008)	
North Bay Aqueduct	North Bay Aqueduct Monitoring	Conduct monitoring at NBA	Reclamation (2008)	Monitoring would continue.
North Bay Aqueduct	North Bay Aqueduct Operations	Operate NBA	USFWS (2008) CDFG (2009)	No change from 2008/2009 operational constraints.
Delta Cross Channel	Delta Cross Channel Operations	Operate Delta Cross Channel	Reclamation (2008) NMFS (2009)	NMFS IV.1.2 operational criteria is assumed in the modeling with no change. NMFS IV.1.1 is addressed by real-time operations. As described in Section 3.4.8, *Monitoring and Research Program*, the monitoring associated with current operations would continue.
Interior Delta Entry	Engineering solutions to reduce interior Delta entry	Reduce interior Delta entry	Reclamation (2008) NMFS (2009)	NMFS IV.1.3 is addressed in PA by Georgiana Slough non-physical barrier and HOR gate.
Tracy and Skinner Facilities	CDFW Condition 6.2	Skinner facility operations	CDFG (2009)	No change from 2009 operational constraints.
Tracy and Skinner Facilities	CDFW Condition 6.3	Skinner facility salvage operations	CDFG (2009)	No change from 2009 operational constraints.
Suisun Marsh Facilities	Suisun Marsh Salinity Control Gates	Operate Suisun Marsh salinity control gates, as described	Reclamation (2008) DWR (2009)	No change from 2009 operational constraints.
Suisun Marsh Facilities	Roaring River Distribution System	Operations	Reclamation (2008) NMFS (2009) DWR (2009)	No change from 2009 operational constraints.
Suisun Marsh Facilities	Morrow Island Distribution System	Operations	Reclamation (2008) NMFS (2009) DWR (2009)	No change from 2009 operational constraints.
Suisun Marsh Facilities	Goodyear Slough Outfall	Operations	Reclamation (2008) NMFS (2009) DWR (2009)	No change from 2009 operational constraints.
Studies	NMFS 11.2.1.2	Research and adaptive management	NMFS (2009)	California WaterFix proposes new program.

Topic	Action	Description	Source	Comments
Studies	NMFS 11.2.1.3	Monitoring programs and reporting regarding effects of CVP/SWP operations	NMFS (2009)	This work is performed by IEP with take authorization via scientific collection permits. This would continue and include any additional monitoring and reporting as required by CWF.
Studies	CDFW Condition 8	Monitoring and reporting	CDFG (2009)	No change from 2009 activities.
Other Facilities	CCWD Facilities	Operation and maintenance of CCWD facilities owned by Reclamation: the Rock Slough Intake and Contra Costa Canal	Reclamation (2008)	Rock Slough diversion is included in modeling/baseline.
Other Facilities	Clifton Court Forebay Aquatic Weed Control Program	Application of herbicide to control aquatic weeds and algal blooms in CFF	Reclamation (2008) DWR (2009)	
Facilities and Activities Not Included in the PA				
Existing Requirements	D-1641	Implement D-1641, as described	SWRCB D-1641	Incorporated into the environmental baseline. PA may include discretionary operations as allowed under the existing regulatory criteria and proposed operations criteria.
Existing Requirements	COA	Implement existing COA	P.L. 99-546	Incorporated into the environmental baseline. PA may include discretionary operations as allowed under the existing regulatory criteria and proposed operations criteria.
Existing Requirements	CVPIA	Implement CVPIA, as authorized	P.L. 102-575	Incorporated into the environmental baseline. PA may include discretionary operations as allowed under the existing regulatory criteria and proposed operations criteria.
Existing Requirements	SWRCB WRO 90-05	Implement WRO 90-05	SWRCB WRO 90-05	Incorporated into the environmental baseline.
Flow	VAMP	Vernalis Adaptive Management Plan (VAMP)	D-1641 Reclamation (2008)	VAMP has expired, per agreement.
North Bay Aqueduct	CDFW Condition 6.4	NBA, RRDS, and Sherman Island diversions and fish screens	CDFG (2009)	Will be complete prior to start of PA.

Topic	Action	Description	Source	Comments
Tracy and Skinner Facilities	NMFS IV.4.1	Tracy fish collection facility improvements to reduce pre-screen loss and improve screening efficiency	NMFS (2009)	Will be completed before north Delta diversion operations begin; subject to a separate take authorization.
Tracy and Skinner Facilities	NMFS IV.4.2	Skinner fish collection facility improvements to reduce pre-screen loss and improve screening efficiency	NMFS (2009)	Will be completed before north Delta diversion operations begin; subject to a separate take authorization.
Tracy and Skinner Facilities	NMFS IV.4.3	Tracy fish collection facility and the Skinner fish collection facility actions to improve salvage monitoring, reporting, and release survival rates	NMFS (2009)	Will be completed before north Delta diversion operations begin; subject to a separate take authorization.
Studies	NMFS IV.2.2	Six-year acoustic tag experiment	NMFS (2009)	Completed.
Habitat Restoration	NMFS I.5	Funding for CVPIA Anadromous Fish Screen Program	NMFS (2009)	
Habitat Restoration	NMFS I.6.1	Restoration of floodplain rearing habitat	NMFS (2009)	Occurs in Yolo Bypass; subject to separate take authorization.
Habitat Restoration	NMFS I.6.2	Near-term actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass	NMFS (2009)	Actions already under way and will have separate take authorization.
Habitat Restoration	NMFS I.6.3	Lower Putah Creek enhancements	NMFS (2009)	Actions already under way and will have separate take authorization.
Habitat Restoration	NMFS I.6.4	Lisbon Weir improvements	NMFS (2009)	Actions already under way and will have separate take authorization.
Habitat Restoration	NMFS I.7	Reduce migratory delays and loss of salmon, steelhead, and sturgeon at Fremont Weir and other structures in the Yolo Bypass	NMFS (2009)	Occurs in Yolo Bypass; subject to separate take authorization.
Habitat Restoration	USFWS 6	Habitat restoration (create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh)	USFWS (2008)	Action is being implemented and is expected to be completed before north Delta diversion operations begin.

Topic	Action	Description	Source	Comments
Habitat Restoration	CDFW Condition 7	LFS habitat restoration	CDFG (2009)	Action is being implemented and may be included in the USFWS 6 requirement above. Action is expected to be completed before north Delta diversion operations begin.
Studies	CDFW Condition 6.1	MIDS study of entrainment effects	CDFG (2009)	Study is underway and will complete prior to initiation of PA.
Other Facilities	CCWD Alternative Intake	Construction of alternative intake at Rock Slough	Reclamation (2008)	Operates under existing BiOps, incorporated into the environmental baseline.

BiOp = biological opinion
CAMT = Collaborative Adaptive Management Team
CCWD = Contra Costa Water District
CDFW = California Department of Fish and Wildlife
CESA = California Endangered Species Act
cfs = cubic feet per second
COA = Coordinated Operations Agreement
CVPIA = Central Valley Project Improvement Act
DO = Dissolved oxygen
ESA = Endangered Species Act of 1972, as amended
HOR = head of Old River
HORB = head of Old River barrier
ITP = Incidental take permit
LFS = Longfin smelt
MIDS = Morrow Island Distribution System
NBA = North Bay Aqueduct
OMR = Old and Middle Rivers
RPA = Reasonable and Prudent Alternative
RRDS = Roaring River Distribution System
RTO = Real-Time Operations
SWG = Smelt Working Group
SWRCB = State Water Resources Control Board
WOMT = Water and Operations Management Team

The purpose of this BA is to evaluate the effects of the proposed action on federally listed species. The PA will allow for the construction and operation of facilities and/or improvements for the movement of water entering the Delta from the Sacramento Valley watershed to the existing CVP/SWP pumping plants located in the southern Delta. The PA will also allow for the operation of the existing and proposed new CVP/SWP Delta facilities to occur in a manner that minimizes or avoids adverse effects on listed species, and allows for the protection and enhancement of aquatic, riparian, and associated natural communities and ecosystems. The PA will maintain the ability of the CVP/SWP to deliver up to full contract amounts, when hydrologic conditions result in the availability of sufficient water, consistent with the requirements of state and Federal law and the terms and conditions of water delivery contracts held by SWP contractors and certain members of San Luis Delta Mendota Water Authority, and other existing applicable agreements.

3.1.1 Central Valley Project

The CVP is the largest Federal Reclamation project and was originally authorized by the Rivers and Harbors Act of 1935. The CVP was reauthorized by the Rivers and Harbors Act of 1937 for the purposes of "improving navigation, regulating the flow of the San Joaquin River and the Sacramento River, controlling floods, providing for storage and for the delivery of the stored waters thereof, for construction under the provisions of the Federal Reclamation Laws of such distribution systems as the Secretary of the Interior (Secretary) deems necessary in connection with lands for which said stored waters are to be delivered, for the reclamation of arid and semiarid lands and lands of Indian reservations, and other beneficial uses, and for the generation and sale of electric energy as a means of financially aiding and assisting such undertakings and in order to permit the full utilization of the works constructed." This Act provided that the dams and reservoirs of the CVP "shall be used, first, for river regulation, improvement of navigation and flood control; second, for irrigation and domestic uses; and, third, for power." The CVP was reauthorized in 1992 through the Central Valley Project Improvement Act (CVPIA). The CVPIA modified that authorization under Rivers and Harbors Act of 1937 adding mitigation, protection, and restoration of fish and wildlife as a project purpose. Further, the CVPIA specified that the dams and reservoirs of the CVP should now be used "first, for river regulation, improvement of navigation, and flood control; second, for irrigation and domestic uses and fish and wildlife mitigation, protection and restoration purposes; and, third, for power and fish and wildlife enhancement."

CVPIA (Public Law 102-575, Title 34) includes authorization for actions to benefit fish and wildlife intended to implement the purposes of that Title. Specifically, Section 3406(b)(1) is implemented through the Anadromous Fish Restoration Program (AFRP). The AFRP objectives, as they relate to operations, are further explained below. CVPIA Section 3406(b)(1) provides for modification of the CVP Operations to meet the fishery restoration goals of the CVPIA, so long as the operations are not in conflict with the fulfillment of the Secretary's contractual obligations to provide CVP water for other authorized purposes. The U.S. Department of the Interior's (Interior) decision on Implementation of Section 3406(b)(2) of the CVPIA, dated May 9, 2003, provides for the dedication and management of 800,000 acre-feet (af) of CVP-water yield annually by implementing upstream and Delta actions. Interior manages and accounts for (b)(2) water pursuant to its May 9, 2003, decision and the Ninth Circuit's decision in *Bay Institute of San Francisco v. United States*, 66 Fed. Appx. 734 (9th Cir. 2003), as amended, 87 Fed. Appx. 637 (2004). Additionally, Interior is authorized to acquire water to supplement (b)(2) water, pursuant to Section 3406(b)(3).

A portion of the water conserved in upstream reservoirs on the Sacramento and San Joaquin Rivers and their tributaries is pumped at the Tracy Pumping Plant (Tracy PP) in the Delta and delivered to the south of the Delta, the CVP service area.

Under the PA, the Jones PP will continue to fulfill its role, in conjunction with the Banks PP. Both pumping plants will also use water diverted from the Sacramento River at three new intakes located in the north Delta and conveyed to the south Delta export facilities via new tunneled and connecting conveyance, as described in Section 3.2, *Conveyance Facility Construction*. Flow criteria affecting CVP/SWP water withdrawals under the PA are described in Section 3.3, *Operations and Maintenance of New and Existing Facilities*, as are operational criteria for other CVP/SWP facilities and activities in the Delta, as well as facilities maintenance.

3.1.2 State Water Project

DWR was established in 1956 as the successor to the Department of Public Works for authority over water resources and dams within California. DWR also succeeded to the Department of Finance's powers with respect to state application for the appropriation of water (Stats. 1956, First Ex. Sess., Ch. 52; see also Wat. Code Sec. 123) and has permits for appropriation from the SWRCB for use by the SWP. DWR's authority to construct state water facilities or projects is derived from the Central Valley Project Act (CVPA) (Wat. Code Sec. 11100 et seq.), the Burns-Porter Act (California Water Resources Development Bond Act) (Wat. Code Sec. 12930-12944), the State Contract Act (Pub. Contract Code Sec. 10100 et seq.), the Davis-Dolwig Act (Wat. Code Sec. 11900-11925), and special acts of the State Legislature. Although the Federal government built certain facilities described in the CVPA, the Act authorizes DWR to build facilities described in the Act and to issue bonds. See *Warne v. Harkness*, 60 Cal. 2d 579 (1963). The CVPA describes specific facilities that have been built by DWR, including the Feather River Project and California Aqueduct (Wat. Code Sec. 11260), Silverwood Lake (Wat. Code Sec. 11261), and the North Bay Aqueduct (Wat. Code Sec. 11270). The Act allows DWR to administratively add other units (Wat. Code Sec. 11290) and develop power facilities (Wat. Code Sec. 11295).

The Burns-Porter Act, approved by the California voters in November 1960 (Wat. Code Sec. 12930-12944), authorized issuance of bonds for construction of the SWP. The principal facilities of the SWP are Oroville Reservoir and related facilities, and San Luis Dam and related facilities, Delta facilities, the California Aqueduct including its terminal reservoirs, and the North and South Bay Aqueducts. The Burns-Porter Act incorporates the provisions of the CVPA. DWR is required to plan for recreational and fish and wildlife uses of water in connection with state-constructed water projects and can acquire land for such uses (Wat. Code Sec. 233, 345, 346, 12582). The Davis-Dolwig Act (Wat. Code Sec. 11900-11925) establishes the policy that preservation of fish and wildlife is part of state costs to be paid by water supply contractors, and recreation and enhancement of fish and wildlife are to be provided by appropriations from the General Fund.

DWR holds contracts with 29 public agencies in northern, central, and southern California for water supplies from the SWP. Water stored in the Oroville facilities, along with water available in the Delta (consistent with applicable regulations) is captured in the Delta and conveyed through several facilities to SWP contractors.

The SWP is operated to provide flood control and water for agricultural, municipal, industrial, recreational, and environmental purposes. A large portion of the water conserved in Oroville Reservoir is released to serve three Feather River area contractors, two contractors served from the North Bay Aqueduct, and pumped at the Harvey O. Banks Pumping Plant (Banks PP) in the Delta serving the remaining 24 contractors in the SWP service areas south of the Delta. In addition to pumping water released from Oroville Reservoir, the Banks PP pumps water from other sources entering the Delta.

Under the PA, the Banks PP will continue to fulfill this role, but will also use water diverted from the Sacramento River at three new intakes located in the north Delta and conveyed to the Banks PP via new tunneled and connecting conveyance, as described in Section 3.2, *Conveyance Facility Construction*. Flow criteria affecting CVP/SWP water withdrawals under the PA are described in Section 3.3, *Operations and Maintenance of New and Existing Facilities*, as are operational criteria for other CVP/SWP facilities and activities in the Delta, and facilities maintenance.

3.1.3 Coordinated Operations Agreement

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

Under the COA, Reclamation and DWR agree to operate the CVP/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 CVP and the SWP 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% of the responsibility to withdraw from storage is borne by the CVP and 25% by the SWP. The COA also provides that during balanced conditions when unstored water is available for export, 55% of the sum of stored water and the unstored water for export is allocated to the CVP, and 45% is allocated to the SWP. Although the principles were intended to cover a broad range of conditions, changes implanted in subsequent the 2000 Trinity ROD, recent biological opinions (Chapter 2, *Consultation History*), a Revised D-1641 (Section 3.1.4.2, *Decision 1641 and Revised D1641*), and changes to the CVPIA were not specifically addressed by the COA. However, these variances have been addressed by Reclamation and DWR through mutual, informal agreements.

3.1.4 Delta Operations Regulatory Setting

3.1.4.1 1995 Water Quality Control Plan

The SWRCB adopted the 1995 Bay-Delta Water Quality Control Plan (WQCP) on May 22, 1995, which became the basis of SWRCB Decision-1641. The SWRCB continues to hold workshops and receive information regarding processes on specific areas of the 1995 WQCP. The SWRCB amended the WQCP in 2006 (as discussed below), but, to date, the SWRCB has made no significant changes to the 1995 WQCP framework.

3.1.4.2 Decision 1641 and Revised D1641

The SWRCB has issued numerous orders and decisions regarding water quality and water right requirements for the Bay-Delta Estuary which imposes multiple operations responsibilities on

CVP/SWP in the Delta to meet the flow objectives in the Water Quality Control Plan (WQCP) for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary ("1995 Bay-Delta Plan"). With D-1641 (issued December 29, 1999) and its subsequent revision (Revised D1641, dated March 15, 2000), the SWRCB implements the objectives set forth in the 1995 Bay-Delta WQCP, resulting in flow and water quality requirements for CVP/SWP operations to assure protection of beneficial uses in the Delta. The SWRCB also conditionally allows for changes to points of diversion, e.g., for the PA, with Revised D-1641.

The various flow objectives and export restraints are designed to protect fisheries. These objectives include specific outflow requirements throughout the year, specific export restraints in the spring, and export limits based on a percentage of estuary inflow throughout the year. The water quality objectives are designed to protect agricultural, municipal and industrial (M&I), and fishery uses, and they vary throughout the year and according to the wetness of the year (five water-year types: W, AN, BN, D, CD) classification scheme (e.g., the five water-year types using Sacramento Valley 40-30-30 Water Year Index). These flow and water quality objectives remain in effect and are subject to revision per petition process or every 3-5 year revision process set by the SWRCQB.

On December 29, 1999, SWRCB adopted and then revised (on March 15, 2000) D-1641, amending certain terms and conditions of the water rights of the CVP/SWP under D1485. D-1641 substituted certain objectives adopted in the 1995 Bay-Delta Plan for water quality objectives that had to be met under the water rights of the CVP/SWP. The requirements in D-1641 address the standards for fish and wildlife protection, M&I water quality, agricultural water quality, and Suisun Marsh salinity. SWRCB D-1641 also authorizes the CVP/SWP to jointly use each other's points of diversion in the southern Delta, with conditional limitations and required response coordination plans. SWRCB D-1641 modified the Vernalis salinity standard under SWRCB Decision 1422 to the corresponding Vernalis salinity objective in the 1995 Bay-Delta Plan.

3.1.4.3 2006 Revised WQCP

The SWRCB undertook a proceeding under its water quality authority to amend the WQCP for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan) adopted in 1978 and amended in 1991 and in 1995. Prior to commencing this proceeding, the SWRCB conducted a series of workshops in 2004 and 2005 to receive information on specific topics addressed in the Bay-Delta Plan.

The SWRCB adopted a revised Bay-Delta Plan on December 13, 2006. There were no changes to the Beneficial Uses from the 1995 plan to the 2006 plan, nor were any new water quality objectives adopted in the 2006 plan. A number of changes were made simply for readability. Consistency changes were also made to assure that sections of the 2006 plan reflected the current physical condition or current regulation. The SWRCB continues to hold workshops and receive information regarding Pelagic Organism Decline (POD), Climate Change, and San Joaquin salinity and flows, and will coordinate updates of the Bay-Delta Plan with on-going development of the comprehensive Salinity Management Plan.

3.1.4.4 Current Water Quality Control Plan Revision Process

The State Water Board is in the process of developing and implementing updates to the Bay-Delta Water Quality Control Plan (WQCP) that protect beneficial uses in the Bay-Delta watershed. This update is broken into four phases, some of which are proceeding concurrently. Phase 1 of this work, currently in progress, involves updating San Joaquin River flow and southern Delta water quality requirements for inclusion in the Bay-Delta WQCP. Phase 2 will involve comprehensive changes to the Bay-Delta WQCP to protect beneficial uses not addressed in Phase 1, focusing on Sacramento River driven standards. Phase 3 will involve implementation of Phases 1 and 2 through changes to water rights and other measures; this phase requires a hearing to determine the appropriate allocation of responsibility between water rights holders within the scope of the Phase 1 and Phase 2 plans. Phase 4 will involve developing and implementing flow objectives for priority Delta tributaries upstream of the Delta.

3.1.5 Real-Time Operations Upstream of the Delta

The goals for real-time decision making to assist fishery management are to minimize adverse effects for listed species while meeting permit requirements and contractual obligations for water deliveries. Real-time data assessment promotes flexible operational decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. High uncertainty exists regarding real time conditions that can change management decisions to balance operations to meet beneficial uses in 2030.

The PA does not propose changing any of the existing real-time processes currently in place. However, as described in Section 3.3.3, *Real-Time Operational Decision-Making Process*, an additional real-time operations process would be implemented under the PA. The PA assumes that continuing upstream real-time operations processes, or other processes achieving the same objectives, would be in place during implementation of the PA.

Sources of uncertainty that are considered and responded to during real-time operations include the following.

- Hydrologic conditions
- Tidal variability
- Listed species (presence, distribution, habitat, and other factors including ocean conditions)
- Ecological conditions

3.1.5.1 Ongoing Processes to support Real-Time Decision Making

Real-time changes to CVP and SWP operations that help avoid and minimize adverse effects on listed species must also consider public health, safety, and water supply reliability. While Reclamation and DWR maintain their respective authorities to operate the CVP and SWP, various operating criteria are influenced by a number of real-time factors. To facilitate real-time operational decisions and fishery agency determinations, Reclamation, DWR, and the fishery agencies (consisting of USFWS, NMFS, and the California Department of Fish and Wildlife [CDFW]) have developed and refined a set of processes to collect data, disseminate information, develop recommendations, make decisions, and provide transparency. This process consists of three types of groups that meet on a recurring basis (Table 3.1-2):

- The management team comprised of management staff from Reclamation, DWR, and the fishery agencies. SWRCB also participates in management team meetings.
- Information teams are teams that disseminate and coordinate information among agencies and stakeholders.
- Fisheries and operations technical teams are comprised of technical staff from state and Federal agencies.

These teams review the most up-to-date data and information on fish status and Delta conditions, and develop recommendations that can be used to modify operations or criteria to improve the protection of listed species.

The process to identify actions to protect listed species varies to some degree among species and geographic area, but abides by the following general outline. A fisheries or operations technical team compiles and assesses current information regarding species or hydrologic conditions, such as stages of reproductive development, geographic distribution, relative abundance, and physical habitat conditions. That team then provides a recommendation to the agency with statutory obligation to enforce protection of the species in question, within guidelines established within the respective biological opinion or incidental take authorization. The agency's staff and management review the recommendation and use it as a basis for developing, in cooperation with Reclamation and DWR, an operational response that minimizes adverse effects on listed species. In rare cases, certain actions may require input from the SWRCB to assess consistency with D-1641 or other water rights permit terms. In the event it is not possible or appropriate to implement the proposed operational response, given the available resources or hydrologic conditions, the Project Agencies consult with the fishery agency(ies) to address the limiting issue. The outcomes of protective actions that are implemented are monitored and documented, and this information informs future actions by the real-time decision-making teams.

Table 3.1-2. Ongoing Real-Time Decision Making Groups

Team Name	Abbreviation	Composition
Water Operations Management Team	WOMT	Reclamation, DWR, USFWS, NMFS, and CDFW. SWRCB participates
Sacramento River Temperature Task Group	SRTTG	Multiagency group
Smelt Working Group	SWG	USFWS, CDFW, DWR, USEPA, and Reclamation
Delta Condition Team	DCT	Scientists and engineers from the state and federal agencies, water contractors, and environmental groups
Delta Operations Salmonid and Sturgeon	DOSS	Reclamation, DWR, CDFW, USFWS, SWRCB, USGS, USEPA, and NMFS
American River Group	ARG	Reclamation, USFWS, NMFS, CDFW, and the Water Forum
Delta Cross Channel Project Work Team	DCC Project Work Team	Multiagency group
Stanislaus Operations Group	SOG	To be further developed as part of the New Melones revised plan of operations

3.1.5.1.1 Salmon Decision Process

The Salmon Decision Process is used by the fishery agencies and Project operators to facilitate the often complex coordination issues surrounding Delta Cross Channel (DCC) gate operations and the purposes of fishery protection closures, Delta water quality, and/or export reductions. Inputs such as fish life stage and size development, current hydrologic events, fish indicators (such as the Knight's Landing Catch Index and Sacramento Catch Index), and salvage at the export facilities, as well as current and projected Delta water quality conditions, are used to determine potential DCC closures and/or export reductions. The Salmon Decision Process includes "Indicators of Sensitive Periods for Salmon," such as hydrologic changes, detection of spring-run salmon or spring-run salmon surrogates at monitoring sites or the salvage facilities, and turbidity increases at monitoring sites, which trigger the Salmon Decision Process. The coordination process has worked well during the recent fall and winter DCC operations and is expected to be used in the present or modified form in the future.

3.1.5.2 Groups Involved in Real-Time Decision Making and Information Sharing

3.1.5.2.1 Management Team

The Water Operations Management Team (WOMT) is composed of representatives from Reclamation, DWR, USFWS, NMFS, and CDFW. SWRCB participates in discussions. This management-level team was established to facilitate timely decision-support and decision making at the appropriate level. The WOMT first met in 1999, and continues to meet to make management decisions. Although the goal of WOMT is to achieve consensus on decisions, the participating agencies retain their authorized roles and responsibilities.

3.1.5.2.2 Operations and Fisheries Technical Teams

Several fisheries-specific teams have been established to provide guidance and recommendations on current operations (flow and temperature regimes), as well as resource management issues. These teams include the Sacramento River Temperature Task Group, the Smelt Working Group, the Delta Conditions Team, the Delta Operations Salmonid and Sturgeon Workgroup, American River Group, and Delta Cross Channel Project Work Team. Each of these teams is described below.

3.1.5.2.2.1 The Sacramento River Temperature Task Group

The Sacramento River Temperature Task Group (SRTTG) is a multiagency group formed pursuant to SWRCB Water Rights Orders 90-5 and 91-1, to assist with improving and stabilizing the Chinook salmon population in the Sacramento River. Annually, Reclamation develops temperature operation plans for the Shasta and Trinity divisions of the CVP. These plans consider impacts on winter-run and other races of Chinook salmon and associated Project operations. The SRTTG meets initially in the spring to discuss biological, hydrologic, and operational information, objectives, and alternative operations plans for temperature control. Once the SRTTG has recommended an operations plan for temperature control, Reclamation then submits a report to SWRCB, generally on or before June 1 each year.

After implementation of the operations plan, the SRTTG may perform additional studies. It holds meetings as needed, typically monthly through the summer and into fall, to develop plan revisions based on updated biological data, reservoir temperature profiles, and operations data. Updated plans may be needed for summer operations to protect winter-run, or in fall for the fall-run spawning season. If there are any changes in the plan, Reclamation submits a supplemental report to SWRCB.

3.1.5.2.2.2 Smelt Working Group

The Smelt Working Group (SWG) consists of representatives from USFWS, CDFW, DWR, USEPA, and Reclamation. USFWS chairs the group, and a member is assigned by each agency. The SWG evaluates biological and technical issues regarding Delta Smelt and develops recommendations for consideration by USFWS. Since longfin smelt became a state candidate species in 2008, the SWG has also developed recommendations for CDFW to minimize adverse effects on longfin smelt.

The SWG compile and interpret the latest real-time information regarding state- and federally listed smelt, such as stages of development, distribution, and salvage. After evaluating available information, if the SWG members agree that a protective action is warranted, the SWG submits its recommendations in writing to USFWS and CDFW.

The SWG may meet at any time at the request of USFWS, but generally meets weekly during the months of January through June, when smelt salvage at the CVP and SWP export facilities has occurred historically.

3.1.5.2.2.3 Delta Condition Team

The existing SWG and WOMT advise USFWS on smelt conservation needs and water operations. In addition, a Delta Condition Team (DCT), consisting of scientists and engineers from the state and federal agencies, water contractors, and environmental groups, meet weekly to review the real time operations and Delta conditions, including data from new turbidity monitoring stations and new analytical tools such as the Delta Smelt behavior model. The members of the DCT provide their individual information to the SWG and the Delta Operations Salmonid and Sturgeon (DOSS) workgroup. SWG meet later on the day the DCT meets to assess risks to Delta Smelt based upon Delta conditions and the other factors set forth above. The SWG and individual members of the DCT may provide, in accordance with a process provided by the WOMT, their information to the WOMT for its consideration in developing a recommendation to the Project Agencies for actions to protect Delta Smelt and other listed fish. The WOMT supplies information for Project Agencies to consider, including impacts on other species and on water supply.

3.1.5.2.2.4 Delta Operations Salmonid and Sturgeon Workgroup

The DOSS workgroup is a technical team with relevant expertise from Reclamation, DWR, CDFW, USFWS, SWRCB, U.S. Geological Survey (USGS), USEPA, and NMFS that provides advice to WOMT and to NMFS on issues related to fisheries and water resources in the Delta and recommendations on measures to reduce adverse effects of Delta operations of the CVP and SWP to salmonids and green sturgeon. The purpose of DOSS is to provide recommendations for real-time management of operations to WOMT and NMFS; annually review CVP and SWP operations in the Delta and the collected data from the different ongoing monitoring programs; and coordinate with the SWG to maximize benefits to all listed species.

3.1.5.2.2.5 American River Group

In 1996, Reclamation established a working group for the Lower American River, known as the American River Group (ARG). Although open to the public, the ARG meetings generally include representatives from several agencies and organizations with ongoing concerns and interests regarding management of the Lower American River. The formal members of the group are Reclamation, USFWS, NMFS, CDFW, and the Water Forum.

The ARG convenes monthly or more frequently if needed, with the purpose of providing fishery updates and reports for Reclamation to help manage operations at Folsom Dam and Reservoir for the protection of fishery resources in the Lower American River, and with consideration of its other intended purposes (e.g., water and power supply).

3.1.5.2.2.6 Delta Cross Channel Project Work Team

The DCC Project Work Team is a multiagency group. Its purpose is to determine and evaluate the effects of DCC gate operations on Delta hydrodynamics, water quality, and fish migration.

3.2 Conveyance Facility Construction

Conveyance facility construction includes the following component parts, with each discussed in a subsection to this chapter as follows:

- Geotechnical exploration, Section 3.2.1.
- North delta diversions construction, Section 3.2.2.
- Tunneled conveyance, which will connect the intakes to the forebays, Section 3.2.3.
- Intermediate Forebay (IF), Section 3.2.4.
- Clifton Court Forebay, an existing structure that will be reconfigured in accordance with the new dual-conveyance system design, Section 3.2.5.

- Connections to the Banks and Jones Pumping Plants, which are existing CVP/SWP export facilities, Section 3.2.6.
- Power supply and grid connections, Section 3.2.7.
- Head of Old River (HOR) gate, Section 3.2.8.
- Temporary access and work areas, Section 3.2.9.

A detailed description of the construction activities associated with each of these component parts is provided below. Figure 3.2-1 provides a map overview of these facilities, and Figure 3.2-2 provides a schematic diagram showing how these facilities will work with existing water-export facilities to create a modified water-export infrastructure facility for the Delta. Further design detail is provided in these following appendices: Appendices 3.A, *Map Book for the Proposed Action*; 3.B, *Conceptual Engineering Report, Volume 1*; 3.C, *Conceptual Engineering Report, Volume 2*; and 3.D, *Assumed Construction Schedule for the Proposed Action*. Many of the construction techniques that will be employed during construction phase, such as cofferdams, sheet pile walls, slurry and diaphragm walls, are detailed in Appendix 3.B, *Appendix B Conceptual Level Construction Sequencing of DHCCP Intakes* (despite the title, Appendix 3.B addresses engineering techniques common to intake, shaft, and forebay construction).

Components of conveyance facility construction share common construction-related activities; for example, some of the component parts require dewatering. Table 3.2-1 identifies 11 most common construction-related activities, each of which is described in greater detail in Section 3.2.10, *Common Construction-Related Activities*. In addition, all construction-related activities described in the PA will be performed in accordance with the standard avoidance and minimization measures, as detailed in Appendix 3.F, entitled *General Avoidance and Minimization Measures (AMMs)*. Specific avoidance and minimization measures (Table 3.2-2) are referred to in the following descriptions as applicable, except that *AMM-1, Worker Awareness Training*, is a general AMM and is applicable to all personnel and all aspects of conveyance facility construction, and therefore will not be repeated in this description. Except where stipulated by an applicable general or specific AMM, proposed work may occur at any time of the day or night. Proposed construction-related work entails the use of equipment that may produce in-air sound at levels in excess of the local acoustic background; see the effects analysis (Chapter 6) for detailed analysis of the effects of exposure to in-air sound associated with various activities on listed species.

In Appendix 3.A, *Map Book for the Proposed Action*, a detailed set of aerial photographs showing the proposed facilities and areas of both temporary and permanent impact are presented. Temporary impacts are defined to include impacts associated with new facility construction, but not ongoing or future facility operations. Because all temporary impacts (other than those associated with geotechnical exploration) have the potential to persist for greater than one year and are therefore considered permanent impacts for purposes of analyzing effects on listed species. Note that the map book does not show facilities having unknown locations. Such unknown locations fall into three types: geotechnical exploration sites, safe haven work areas, and barge landings. Section 3.2.1, *Geotechnical Exploration,* below, describes geotechnical exploration sites; Section 3.2.3, *Tunneled Conveyance,* describes safe haven work areas; and

Section 3.2.10.9, *Barge Operations,* describes barge landings. See Chapter 5, *Effects Analysis for Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, and Chapter 6, *Effects Analysis for Delta Smelt and Terrestrial Species*, for a discussion of how effects of these activities on listed species were analyzed.

In Appendix 3.B, *Conceptual Engineering Report, Volume 1,* we provide detailed descriptions and related information pertaining to conveyance facility construction. Sections of Appendix 3.B are referenced in the following subsections where appropriate. Similarly, Appendix 3.C, *Conceptual Engineering Report, Volume 2,* provides detailed drawings of conveyance facilities.

In Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*, detail is provided regarding conveyance facility construction-related scheduling, and forms the basis for statements regarding scheduling in this chapter.

Pile driving assumptions are detailed in Appendix 3.E*, Pile Driving Assumptions for the Proposed Action*.

Table 3.2-1. Components of Conveyance Construction and the Common Construction Activities Used in Each

Common Construction Activity	Conveyance System Component							
	Geotechnical Exploration	Delta Intakes	Tunnels	Intermediate Forebay	Clifton Court Forebay	Connections to Banks and Jones	Power Supply and Grid Connections	Head of Old River Gate
Clearing[a]	At upland sites	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Site work[b]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ground improvement[c]	No	Yes	Shafts	Yes	Yes	Yes	Yes	No
Borrow fill[d]	No	Yes	Yes	Yes	Yes	Yes	No	No
Fill to flood height[e]	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Dispose spoils[f]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dewatering[g]	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Dredging and Riprap Placement[h]	No	Yes	Yes	No	Yes	Yes	No	Yes
Barge operations[i]	No	Yes	Yes	Yes	Yes	Yes	No	Yes
Landscaping[j]	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pile Driving[k]	Yes	Yes	No	No	Yes	Yes	No	Yes

[a] Includes grubbing, clearing, and grading. Assumed to affect entire construction footprint; any areas not actually cleared are nonetheless subject to sufficiently invasive activity that their value as habitat for listed species is reduced to near zero.
[b] Includes all initial site work: Construct access, establish stockpiles and storage areas, construction electric, fencing, stormwater treatment per a SWPPP (Stormwater Pollution Prevention Plan). Occurs only on cleared sites.
[c] Includes drilling, injection of materials, installation of dewatering wells, etc. Occurs only on cleared sites.
[d] Includes excavation, dewatering (separate activity), and transport of borrow material. Occurs only on cleared sites.
[e] Includes placement of engineered fill to design flood height. Occurs only on cleared sites that previously or concurrently experience ground treatment and dewatering. Fill work meets U.S. Army Corps of Engineers (USACE) levee specifications where relevant.
[f] Includes placement of excavated, dredged, sedimentation basin, or reusable tunnel material (RTM) material on cleared sites where site work has been done.
[g] Includes dewatering via groundwater wells or by direct removal of water from excavation, as well as dewatering of excavated material; water may be contaminated by contact with wet cement or other chemicals (e.g., binders for RTM); includes dewatering of completed construction, e.g. of shafts during tunneling.
[h] Includes any work that occurs in fish-bearing waters, except that barge operations and pile driving are separately described.
[i] Includes barge landing construction; barge operations in river (e.g., to place sheetpiles); tug operations; barge landing removal.
[j] Includes placement of topsoil, installation of plant material, and irrigation and other activities as necessary until performance criteria are met. Occurs only on cleared sites.
[k] Includes work that involves vibratory and/or impact driving of piles in fish-bearing waters.

Table 3.2-2. Summary of the Avoidance and Minimization Measures Detailed in Appendix 3.F

Number	Title	Summary
AMM1	Worker Awareness Training	Includes procedures and training requirements to educate construction personnel on the types of sensitive resources in the work area, the applicable environmental rules and regulations, and the measures required to avoid and minimize effects on these resources.
AMM2	Construction Best Management Practices (BMPs) and Monitoring	Standard practices and measures that will be implemented prior, during, and after construction to avoid or minimize effects of construction activities on sensitive resources (e.g., species, habitat), and monitoring protocols for verifying the protection provided by the implemented measures.
AMM3	Stormwater Pollution Prevention Plan	Includes measures that will be implemented to minimize pollutants in stormwater discharges during and after construction related to the PA, and that will be incorporated into a stormwater pollution prevention plan to prevent water quality degradation related to pollutant delivery from action area runoff to receiving waters.
AMM4	Erosion and Sediment Control Plan	Includes measures that will be implemented for ground-disturbing activities to control short-term and long-term erosion and sedimentation effects and to restore soils and vegetation in areas affected by construction activities, and that will be incorporated into plans developed and implemented as part of the National Pollutant Discharge Elimination System (NPDES) permitting process for the PA.
AMM5	Spill Prevention, Containment, and Countermeasure Plan	Includes measures to prevent and respond to spills of hazardous material that could affect navigable waters, including actions used to prevent spills, as well as specifying actions that will be taken should any spills occur, and emergency notification procedures.
AMM6	Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material	Includes measures for handling, storage, beneficial reuse, and disposal of excavation or dredge spoils and reusable tunnel material, including procedures for the chemical characterization of this material or the decant water to comply with permit requirements, and reducing potential effects on aquatic habitat, as well as specific measures to avoid and minimize effects on species in the areas where RTM will be used or disposed.
AMM7	Barge Operations Plan	Includes measures to avoid or minimize effects on aquatic species and habitat related to barge operations, by establishing specific protocols for the operation of all PA-related vessels at the construction and/or barge landing sites. Also includes monitoring protocols to verify compliance with the plan and procedures for contingency plans.
AMM8	Fish Rescue and Salvage Plan	Includes measures that detail procedures for fish rescue and salvage to avoid and minimize the number of Chinook salmon, steelhead, green sturgeon, and other listed species of fish stranded during construction activities, especially during the placement and removal of cofferdams at the intake construction sites.
AMM9	Underwater Sound Control and Abatement Plan	Includes measures to minimize the effects of underwater construction noise on fish, particularly from impact pile–driving activities. Potential effects of pile driving will be minimized by restricting work to the least sensitive period of the year and by controlling or abating underwater noise generated during pile driving.
AMM10	Methylmercury Management	Design and construct wetland mitigation sites to minimize ecological risks of methylmercury production.
AMM11	Design Standards and Building Codes	Ensure that the standards, guidelines, and codes, which establish minimum design criteria and construction requirements for project facilities, will be followed. Follow any other standards, guidelines, and code requirements that are promulgated during the detailed design and construction phases and during operation of the conveyance facilities.

Number	Title	Summary
AMM12	Transmission Line Design and Alignment Guidelines	Design the alignment of proposed transmission lines to minimize impacts on sensitive terrestrial and aquatic habitats when siting poles and towers. Restore disturbed areas to preconstruction conditions. In agricultural areas, implement additional BMPs. Site transmission lines to avoid greater sandhill crane roost sites or, for temporary roost sites, by relocating roost sites prior to construction if needed. Site transmission lines to minimize bird strike risk.
AMM13	Noise Abatement	Develop and implement a plan to avoid or reduce the potential in-air noise impacts related to construction, maintenance, and operations.
AMM14	Hazardous Material Management	Develop and implement site-specific plans that will provide detailed information on the types of hazardous materials used or stored at all sites associated with the water conveyance facilities and required emergency-response procedures in case of a spill. Before construction activities begin, establish a specific protocol for the proper handling and disposal of hazardous materials.
AMM15	Construction Site Security	Provide all security personnel with environmental training similar to that of onsite construction workers, so that they understand the environmental conditions and issues associated with the various areas for which they are responsible at a given time.
AMM16	Fugitive Dust Control	Implement basic and enhanced control measures at all construction and staging areas to reduce construction-related fugitive dust and ensure the Action commitments are appropriately implemented before and during construction, and that proper documentation procedures are followed.
AMM17	Notification of Activities in Waterways	Before in-water construction or maintenance activities begin, notify appropriate agency representatives when these activities could affect water quality or aquatic species.

During the process of developing the PA, a great deal of refinement has occurred, enabling substantial reductions in potential impacts. These refinements are summarized in Table 3.2-3.

Table 3.2-3. California WaterFix Design Refinements

PA Refinement	Administrative Draft EIR/EIS (December 2012)	2013 Design Refinements	2014 Design Refinements
Water facility footprint	3,654 acres	1,851 acres	1,810 acres
Intermediate forebay size (water surface)	750 acres	40 acres	28 acres
Private property impacts	5,965 acres	5,557 acres	4,288 acres
Public lands used	240 acres	657 acres	733 acres
Number of intakes	5	3	3
Number of tunnel reaches	6	5	5
Number of launch and retrieval shaft locations	7	5	5
Agricultural impacts	6,105 acres	6,033 acres	4,890 acres

3.2.1 Geotechnical Exploration

3.2.1.1 Overview of Geotechnical Exploration

Geotechnical exploration will be used to obtain data to support the development of an appropriate geologic model, characterize ground conditions, and reduce the geologic risks associated with the construction of proposed facilities.

California Department of Water Resources (DWR) will perform a series of geotechnical investigations along the selected water conveyance alignment, at locations proposed for facilities, and at material borrow areas. The proposed exploration is designed as a two-part program (Phases 2a and 2b) to collect geotechnical data. The two-part program will allow refinement of the second part of the program to respond to findings from the first part. The Draft Geotechnical Exploration Plan (Phase 2) provides additional details for both phases regarding the rationale, methodology, locations, and criteria for obtaining subsurface soil information and laboratory test data (Appendix 3.G, *Geotechnical Exploration Plan—Phase 2*).

Sampling will occur at locations along the water conveyance alignment and at proposed facility sites. The exploration will include field and laboratory testing of soil samples. The field tests will consist of auger and mud-rotary drilling with soil sampling using a standard penetration test (SPT) barrel (split spoon sampler) and Shelby tubes; cone penetrometer testing (CPT); geophysical testing; pressure meter testing; installation of piezometers and groundwater extraction wells; dissolved gas sampling; aquifer testing; and excavation of test pits. All of these techniques, except test pit excavation and CPT, entail drilling. The field exploration program will evaluate soil characteristics and collect samples for laboratory testing. Laboratory tests will include soil index properties, strength, compressibility, permeability, and specialty testing to support tunnel boring machine (TBM) selection and performance specification.

3.2.1.2 Methods for Land-Based Exploration

The land-based portion of the proposed Phase 2a and 2b exploration will occur at approximately 1,500 to 1,550 geotechnical exploration locations. The exploration locations will be selected on the basis of location (as shown in Appendix 3.G, *Geotechnical Exploration Plan—Phase 2, Attachment A*) and on accessibility for truck or track-mounted drill rigs. At approximately 60 of the exploration locations, test pits will be excavated, with test pit dimensions 4 feet wide, 12 feet long, and 12 feet deep. Test pits are used to evaluate bearing capacity, physical properties of the sediments, location of the groundwater table, and other typical geologic and geotechnical parameters.

Temporary pumping wells and piezometers will be installed at intake, forebay, pump shaft, and tunnel shaft exploration locations to investigate soil permeability and to allow sampling of dissolved gases in the groundwater. Small test pits will be excavated at some locations to obtain near-surface soil samples for laboratory analysis.

At each geotechnical exploration location, DWR will implement BMPs that include measures for air quality, noise, greenhouse gases, and water quality. Direct impacts to buildings, utilities, and known irrigation and drainage ditches will be avoided during geotechnical exploration activities.

Each geotechnical exploration location will be active for a period from a few hours to 12 work days, depending on exploration type and target depth. After each site is explored, drilled excavations will be backfilled with cement-bentonite grout in accordance with California regulations and industry standards (Water Well Standards, DWR 74-81 and 74-90). Test pits will be backfilled with the excavated material on the same day as they are excavated, with the stockpiled topsoil placed at the surface and the area restored as closely as possible to its original condition. Total duration of most of the activities at each site is not expected to exceed 15 days, except that at sites where piezometers are installed, technicians may periodically revisit the sites to collect data. Duration of aquifer tests proposed for select sites is not expected to exceed 10 days.

3.2.1.3 Methods for Overwater Exploration

The overwater portion of the proposed Phase 2a and 2b exploration will occur at approximately 90 to 100 exploration locations. At these locations, geotechnical borings and CPTs will be drilled in the Delta waterways. The exploration locations will be selected on the basis of location (as shown in Appendix 3.G, *Geotechnical Exploration Plan—Phase 2, Attachment A*), with precise site selection based upon practicability considerations such as avoidance of navigation markers and underwater cables. Approximately 30 of these locations will be in the Sacramento River to obtain geotechnical data for the proposed intake structures. Another 25 to 35 of these locations will be at the major water undercrossings along the tunnel alignment. An additional 30 to 35 of these locations will be at the proposed barge unloading facilities and Clifton Court Forebay (CCF) modifications. The borings and CPTs are planned to explore depths of between 100 and 200 feet below the mud line (i.e., river bottom).

DWR will conduct overwater drilling only during the period from August 1 to October 31 (i.e., the in-water work window) between the hours of sunrise and sunset. Duration of drilling at each location will vary depending on the number and depth of the holes, drill rate, and weather conditions, but activities are not expected to exceed 60 days at any one location. Overwater borings for the intake structures and river crossings for tunnels will be carried out by a drill ship and barge-mounted drill rigs.

3.2.1.4 Extent of Phase 2a Land-based and Overwater Work

Phase 2a exploration will focus on collecting data to support preliminary engineering through soil borings and CPTs at approximately 600 locations. Land-based explorations will be conducted for the intake perimeter berms, State Route (SR) 160, sedimentation basins, pumping plants, forebay embankments, tunnel construction and vent shafts, and other appurtenant facilities (subsequent subsections herein describe these facilities in detail). Overwater explorations will support the design of intake structures and the major water crossings along the conveyance alignment.

Phase 2a exploration for tunnel construction will entail land-based drilling approximately every 1,000 feet along the tunnel alignment. One-third of the sites will receive only soil borings, half will receive only CPTs, and one-sixth will receive both soil borings and CPTs. All of the land-based boreholes along the tunnel alignments will be fitted with piezometers. Overwater drilling is planned in Potato Slough (three sites), San Joaquin River (three sites), Connection Slough (two sites), and CCF (35 sites).

In addition, six soil borings and four CPTs will occur at each tunnel shaft or CCF pumping plant shaft site. Once drilling is completed at each shaft site, two of the boreholes will be converted into groundwater extraction wells and the other four boreholes will be converted into piezometers. Boreholes and CPTs are also proposed for the intake and pumping plant sites and SR 160. Approximately six boreholes at each of the proposed intakes will be converted into piezometers.

3.2.1.5 Extent of Phase 2b Land-based and Overwater Work

Phase 2b exploration will support final design, permitting requirements, and planning for procurement and construction-related activities. Phase 2b explorations will include soil borings, CPTs, and test pits at approximately 950 locations.

Phase 2b exploration for tunnel construction will entail land-based drilling for soil borings near the Phase 2a CPT locations such that a borehole (soil boring or CPT) will have been located at approximately 500-foot intervals along the entire tunnel alignment, a spacing that generally conforms to typical design efforts for tunnels like those proposed.

Similarly, Phase 2b boring will occur at the construction and ventilation shaft sites, and will also occur at the safe haven intervention sites (these types of facilities are described in Section 3.2.3 *Tunneled Conveyance*). Overwater boreholes and CPTs are planned in the Sacramento River, Snodgrass Slough, South Fork Mokelumne River, San Joaquin River, Potato Slough, Middle River, Connection Slough, Old River, North Victoria Canal, and CCF. Phase 2a and Phase 2b geotechnical exploration are summarized in Table 3.2-4.

Table 3.2-4. Planned Geotechnical Exploration

Siting	Location	Maximum Number of Exploration Sites	
		Phase 2a	Phase 2b
On land	All locations	600	950
Over-water	Sacramento River	0	30
Over-water	Snodgrass Slough	0	3
Over-water	South Fork Mokelumne River	0	3
Over-water	San Joaquin River	3	12
Over-water	Potato Slough	3	18
Over-water	Middle River	0	2
Over-water	Connection Slough	2	7
Over-water	Old River	0	6
Over-water	West Canal	0	8
Over-water	CCF	35	5

3.2.1.6 Schedule

Phase 2a and Phase 2b land-based explorations will require approximately 24 months, using six land-based drill rigs operating concurrently for six days per week. Land-based explorations will typically occur from April through November, and when performed in suitable habitat will conform to timing constraints for terrestrial species as specified in Section 3.4, *Conservation Measures*. Phase 2a and Phase 2b overwater explorations will require approximately 14 months, using two drill rigs operating concurrently for six days per week. Work will be performed within designated in-water work windows (June 1 to October 31). This schedule will be expedited if possible, depending on the availability of site access, drilling contractors and equipment, permit conditions, and weather. Most of the proposed geotechnical explorations will be performed during the first three years of implementation. See Appendix 3.D, *Assumed Construction Schedule for the Proposed Action,* for a detailed conveyance facility construction schedule.

3.2.2 North Delta Diversions

The siting process featured evaluations of a wide variety of locations for north Delta diversion intakes and various configurations. Possible intake locations and configurations were considered and analyzed in terms of the availability of quantity and quality of water for the diversion, the ability to divert at each intake location, potential impacts on other nearby diverters and dischargers, fish exposure-risk to intakes, presence of fish migration corridors, potential water quality considerations, and reasonable costs estimates involved in construction and operation, among other considerations. This preliminary analysis provided information sufficient to focus on potential intake locations, which at that time assumed a diversion facility consisting of five (5) intakes with a total capacity of 15,000 cubic feet per second (cfs). Potential siting of intake locations ranged in distance as far upstream on the Sacramento River to north of the American River confluence in Sacramento County, to as far downstream as south of Steamboat Slough in Solano County. Detailed analysis of these potential intake configurations were conducted in 2010. These analyses showed that actual intake locations are primarily influenced by exposure risk for fish, and to a lesser extent, migration pathways (California Department of Water Resources et al. 2013 [Appendix 3.A]). After extensive analysis and consultation with stakeholders, in July 2012 the project proponents proposed to evaluate the construction and use of three intakes (Intakes 2, 3, and 5) located between Courtland and Clarksburg for a total maximum pumping capacity of 9,000 cfs. This configuration and capacity was chosen because the water facilities would meet projected water supply needs. The use of three intakes was found to be sufficient to meet forecast diversion volume needs and would have lower environmental impacts compared to construction of five intakes. The intakes are designed as on-bank screens. Design and operational criteria supporting this concept included design constraints developed in collaboration with the fish and wildlife agencies (Fish Facilities Technical Team 2008, 2011), as well as minimum performance standards for bypass flows, sufficient to minimize the risk of covered fishes becoming entrained or impinged on the screens.

The intake design process also reflects a long duration of collaborative discussions between the project proponents and the fish and wildlife agencies. In 2008, the Fish Facilities Technical Team's (FFTT) preliminary draft, *Conceptual Proposal for Screening Water Diversion Facilities along the Sacramento River*, reviewed and evaluated various approaches to the screening of diversion facilities, using screen design principles offered by the National Marine Fisheries

Service (NMFS), California Department of Fish and Wildlife (CDFW), and U.S. Fish and Wildlife Service (USFWS) (Fish Facilities Technical Team 2008). These principles included using designs that would comply with the following criteria:

- Be biologically protective.
- Provide a positive, physical barrier between fish and water intakes.
- Avoid the need to collect, concentrate, and handle fish passing the intake.
- Avoid bypasses that would concentrate fish numbers, increasing the risk of predation.
- Avoid off-channel systems, in order to avoid handling fish.
- Select locations that have desirable hydraulic characteristics (e.g., uniform sweeping velocities, reduced turbulence).
- Use the best available existing technology in use in the Sacramento Valley.
- Use smaller multiple intakes (as opposed to a single large intake) to enhance fish protection with operational flexibility under varying flow conditions.
- Minimize the length of intake(s) to reduce the duration of exposure to the screen surface for fish.
- Select locations on the Sacramento River as far north as practicable to reduce the exposure of delta smelt, longfin smelt, and other estuarine species.
- Avoid areas where predators may congregate or where potential prey would have increased vulnerability to predation.
- Avoid areas of existing riparian habitat.

3.2.2.1 Intake Design

The PA will include construction of three intakes (Intake 2, Intake 3, and Intake 5) on the east bank of the Sacramento River between Clarksburg and Courtland, in Sacramento County, California. Intake locations and plans are shown in Figure 3-1; in Appendix 3.A, *Map Book for the Proposed Action*, Sheets 1 and 2; and Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheets 10 to 32, 44, and 45. The materials in Appendix 3.C include a rendering of a completed intake, as well as both overview and detail drawings for each intake site. The intakes are described in Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 6.1, *Description and Site Plans*; see particularly Tables 6-1 and 6-2, which describe intake design criteria relevant to analysis of effects, such as approach and sweeping velocities and fish screen specifications, and Section 6.1.1.1, *Intake Structures*, which describes fish screen design. Other intake components are behind the fish screens and have no potential to affect listed species. Information relevant to intakes construction details is provided in Appendix 3.B, *Conceptual*

Engineering Report, Volume 1, Section 6.2, *Construction Methodology*. General intake dimensions are shown in Table 3.2-5.

Table 3.2-5. Intake Dimensions

Intake	Location (river mile)	Overall Length of Fish Screen Structure along Sacramento River Bank (feet)	Area of Intake Construction Site (acres)	Area of In-water Work (acres)
Intake 2	41.1	1,667	190	14.9
Intake 3	39.4	1,373	152	11.0
Intake 5	36.8	1,667	144	10.6
Total	**--**	**4,707**	**486**	**36.5**

Source: Appendix 3.C

Each intake can divert a maximum of 3,000 cfs of river water. Each intake consists of an intake structure fitted with on-bank fish screens; gravity collector box conduits extending through the levee to convey flow to the sedimentation system; a sedimentation system consisting of sedimentation basins to capture sand-sized sediment and drying lagoons for sediment drying and consolidation; a sedimentation afterbay providing the transition from the sedimentation basins to a shaft that will discharge into a tunnel leading to an IF; and an access road, parking area, electrical service, and fencing (as shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheets 11, 12, and 13).

3.2.2.2 Fish Screen Design

The intakes include fish screens designed to minimize the risk that fish or larvae will be entrained into the intakes or injured by impingement on the fish screens. The foremost design attribute achieving this purpose is to meet criteria established by the fish agencies limiting water velocities through the screen (called the approach velocity) to values substantially less than swimming speeds achievable by the fish species of concern and limiting water velocities parallel to the surface of the screen (called the sweeping velocity) to values that will allow fish to travel past the screen with minimal additional effort or risk of impingement (Fish Facilities Technical Team 2011). However, many other aspects of facility design also help determine its effects upon fish, thus the process of design has been and will continue to be subject to extensive collaborative discussions with the fish agencies. A variety of preconstruction studies are proposed to aid in refinement of the fish screen design; see Section 3.4.8, *Monitoring and Research Program*, for a listing and description of these studies.

Each screened intake will consist of a reinforced concrete structure subdivided into six individual bays that can be isolated and managed separately. Water will be diverted from the Sacramento River by gravity into the screened intake bays and routed from each bay through multiple parallel conveyance box conduits to the sedimentation basins. Flow meters and flow control sluice gates will be located on each box conduit to assure limitations on approach velocities and that flow balancing between the three intake facilities is achieved. All of the intakes will be sized at the design water surface elevation (WSE) to provide approach velocities at the fish screen of less than or equal to 0.20 feet per second (ft/s) at an intake flow rate of 3,000 cfs. The design

WSE for each site has been established as the 99% exceedance (Sacramento River stage) elevation, and the maximum design WSE was established as the 200-year flood elevation plus an 18-inch allowance for sea level rise, which is a conservative estimate in the context of available forecasts (Mineart et al. 2009).

The fish screen will include screen panels and solid panels that form a barrier to prevent fish from being drawn into the intake and the traveling screen cleaning system. Fish screen design has not yet been finalized, and final design is subject to review and approval by the fish and wildlife agencies (i.e., USFWS, NMFS, and CDFW). Design specifications for the fish screens meet Delta Smelt criteria, which require an approach velocity less than or equal to 0.2 ft/s. When coupled with equal or greater sweeping velocities, Delta Smelt impingement and screen contact are thereby minimized (Swanson et al. 2005; White et al. 2010), and thus this standard has been adopted as a performance standard for the North Delta Diversions (Fish Facilities Technical Team 2011). The Delta Smelt approach velocity criterion is also protective of salmonids, because it is well below the 0.33 ft/s approach velocity standard for Chinook salmon fry[1]. Fish screens will be provided with monitoring systems capable of verifying approach and sweeping velocity standard compliance in real time.

As currently designed, the fish screens will be a vertical flat plate profile bar type made from stainless steel with a maximum opening of 0.069 inches and porosity of 43%. Proposed fish screens dimensions are shown in Table 3.2-6. Each of the configurations shown in the table provides hydraulic performance adequate to divert up to 3,000 cfs within a design range of river flows. Each configuration achieves this with a given total area of active fish screen, but the size of the intakes is variable due to differences in screen height, and the length of the intakes incorporates unscreened refugium areas (further discussed below).

Table 3.2-6. Fish Screen Dimensions

Intake	Screen Height	Screen Width	Number of Screens	Total Length of Screens
Intake 2	12.6 feet	15 feet	90	1,350 feet
Intake 3	17.0 feet	15 feet	74	1,110 feet
Intake 5	12.6 feet	15 feet	90	1,350 feet

Source: Appendix 3.C

See Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheets 16, 17, 19, 22, and 23 for illustration of the following elements of the fish screen system. Screen panels will be installed in the lower portion of the intake structure face, above a 2-foot wall against which sediment could accumulate between maintenance intervals (described in Section 3.3.6.1.2, *Sediment Removal*). Solid panels will be stacked above the screen panels in guides extending above the deck of the structure. The screen panels will be arranged in groups, with each screen bay group providing sufficient screen area for 500 cfs of diversion. There will be six separate screen bay groups per

[1] The specific performance standard is: "Diversions should be designed to operate at an approach velocity of 0.33 fps to minimize screen length, however, to minimize impacts to delta smelt, the diversions should be operated to an approach velocity of 0.2 fps at night if delta smelt are suspected to be present, based on a real-time monitoring program. The diversions may be operated to an approach velocity of 0.33 fps at all other times" (Fish Facilities Technical Team 2011).

intake facility, all of which will be hydraulically independent. A log boom will protect the screens and screen cleaning systems from impact by large floating debris. Each screen bay group will have a traveling screen cleaning system. The screen cleaners will be supported by a monorail and driven by an electric motor and cable system with a cycle time of no more than 5 minutes. Flow control baffles will be located behind each screen panel and will be installed in guides to accommodate complete removal of the baffle assembly for maintenance. These flow control baffles will be designed to evenly distribute the approach velocity to each screen such that it meets the guidelines developed by the FFTT (Fish Facilities Technical Team 2011). The flow control baffle guides will also serve as guides for installing bulkhead gates (after removal of the flow control baffles) for maintenance of each screen bay group. The bulkhead gates will be designed to permit dewatering of a screen bay group under normal river conditions.

Because of the length of the screens and extended fish exposure to their influence (screens and cleaners), incorporation of fish refugia areas will be evaluated as part of next engineering design phase of the intakes, as recommended by the FFTT (Fish Facilities Technical Team 2011). Current conceptual design for the refugia would provide areas within the columns between the fish screen bay groups that would provide fish resting areas and protected cover from predators. The current design calls for a 22-foot-wide refugium between each of the six screen bay groups at each intake. Design concepts for fish refugia and studies to evaluate their effectiveness are still in development, and final refugia design is subject to review and approval by the fish agencies (i.e., USFWS, NMFS, and CDFW). Two recent examples of fish refugia design and installation include the Red Bluff Diversion fish screen and that of Reclamation District 2035, on the Sacramento River just north of Sacramento (Svoboda 2013). The Red Bluff Diversion fish screen design used a physical model study to assess hydraulic parameters such as velocity and turbulence in relation to behavior of juvenile Chinook salmon, white sturgeon, and rainbow trout. The refugia consist of flat recessed panels protected by vertical bars. Bar spacing at the entrance to each refugium was selected based on fish size, to allow entry of protected species while excluding predators. A final design was chosen to reduce velocity in the refuge while minimizing turbulence; under this design, a total of four fish refugia were constructed along 1,100 feet of screen. At the Reclamation District 2035 fish screen, an initial design included a single refuge pocket midway along the intake, which was subsequently modified to include 2-ft-long refugia between each screen panel along the intake. This fish screen also included juvenile fish habitat elements into the upstream and downstream sheet pile training walls and the sloped soil areas above the training walls, with grating materials attached to the sheet pile walls to prevent predatory fish from holding in the corrugated areas by the walls and to provide another form of refuge for small fish (Svoboda 2013). These two examples serve to illustrate the site-specific design considerations that are necessary for construction of large intakes. The effectiveness of refugia requires study (Svoboda 2013).

All fish screen bay groups will be separated by piers with appropriate guides to allow for easy installation and removal of screen and solid panels as well as the flow control baffle system and bulkheads; these features will be removable by gantry crane (Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheet 17). Piers will support the operating deck set with a freeboard of 18 inches above the 200-year flood level with sea level rise. The levee in the immediate area will be raised to provide a freeboard of 3 feet above the 200-year flood level with sea level rise. Sheet pile training walls will have a radius of 200 feet and will be upstream and downstream of the intake structures providing improved river hydraulics and vehicular access to the operating deck as well as transitioning the intake structure to the levee (Appendix 3.C, Sheets 33 and 34 show the extent of levee modifications).

3.2.2.3 Construction Overview and Schedule

The timeline for water conveyance facility construction is presented in Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*. The schedule is complex, with work simultaneously occurring at all major facilities for a period of years, and tunnel boring likewise occurring simultaneously at multiple sites for a period of years. During construction, the sequence of activities and duration of each schedule element will depend on the contractor's available means and methods, definition and variation of the design, departure from expected conditions, and perhaps other variable factors. The proposed schedule for intake construction is shown in Table 3.2-7.

Each intake has its own construction timeline with Intakes 2, 3, and 5 taking 3.8, 5.3, and 3.5 years respectively. Early phase tasks to facilitate construction will include mobilization, site work, and establishing concrete batch plants, pug mills, and cement storage areas. During mobilization the contractors will bring materials and equipment to construction sites, set up work areas, locate offices, staging and laydown areas, and secure temporary electrical power. Staging, storage, and construction zone prep areas for each intake site will be approximately 5 to 10 acres.

Site work consists of clearing and grubbing (discussed in Section 3.2.10.1, *Clearing*), constructing site work pads, and defining and building construction access roads (discussed in Section 3.2.9, *Temporary Access and Work Areas*) and barge access (discussed in Section 3.2.10.9, *Barge Operations*). Before site work commences, the contractor will implement erosion and sediment controls in accordance with the SWPPP (See Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM3 Stormwater Pollution Prevention Plan*, for a detailed description). Site clearing and grubbing and site access to stockpile locations have not yet been developed, but will be subject to erosion and dust control measures as specified in the SWPPP and other permit authorizations.

Although DWR plans to use existing roads to the greatest extent possible, some new roads and bridges will be constructed to expedite construction activities and to minimize impact to existing commuters and the environment. Access roads and environmental controls will be maintained consistent with BMPs and other requirements of the SWPPP and permit documents.

Substantial amounts of engineered fill will be placed landward of the levee, amounting to approximately 2 million cubic yards at each intake site. This fill material will be used primarily in levee work, pad construction for the fills, and other placements needed to ensure that the permanent facilities are at an elevation above the design flood (i.e., a 200-year flood with additional allowance for sea level rise). The required engineered fill material will preferably be sourced onsite from locations within the permanent impact footprint, for instance from excavations to construct the sedimentation basins. Material sourced from offsite will be obtained as described in Section 3.2.10.4, *Borrow Fill*.

Table 3.2-7. Overview Schedule for Construction Activities at the North Delta Diversions

Activity	Start[a]	End[a]	Duration (months)
Overall			
Routine supply delivery for duration of construction	1/3/2022	5/11/2028	77
Install and operate intakes worksite temporary facilities	2/28/2022	4/12/2028	75
Erect and operate Intakes Concrete Batch Plant	5/9/2022	9/7/2027	65
Intake 3			
Initial site work	8/3/2022	1/29/2023	6
In–water work – Construct temporary crib wall in river	9/15/2022	1/14/2023	4
Sediment basin work – construct diaphragm wall, excavate basin, ground improvement, pile installation, concrete work, finish work	2/2/2023	9/9/2025	32
In–water work – Install cofferdam	8/7/2023	11/28/2023	4
In–water work – Excavate inside cofferdam, drill piers, place tremie concrete, dewater, place cross bracings, cast structural concrete, place fish screens & cleaning system	10/5/2023	2/6/2026	29
Levee work – Excavate inside cofferdam, place tremie concrete, pipe to sediment basin, complete piping and gates	5/9/2025	4/26/2026	12
Pipe Intake 3 to Sediment Basin	5/9/2025	11/16/2025	6
Final Site Work	2/23/2026	8/26/2026	6
Reach 2 Tunnel Complete	4/22/2027	4/21/2027	0
Concrete and finish Junction Structure	4/22/2027	12/28/2027	8
Intake 5			
Initial site work	2/22/2023	8/6/2023	6
In–water work – Construct temporary crib wall in river	8/7/2023	12/3/2023	4
Sediment basin work – construct diaphragm wall, excavate basin, ground improvement, pile installation, concrete work, finish work	12/6/2023	7/25/2027	44
In–water work – Install cofferdam	8/5/2024	1/20/2025	6
In–water work – Excavate inside cofferdam, drill piers, place tremie concrete, dewater, place cross bracings, cast structural concrete, place fish screens & cleaning system	10/3/2024	9/1/2027	35
Levee work – Excavate inside cofferdam, place tremie concrete, pipe to sediment basin, complete piping and gates	7/21/2026	7/4/2027	12
Final site work	**8/14/2027**	**2/12/2028**	**6**
Intake 2			
In–water work – Construct temporary crib wall in river	8/7/2023	12/3/2023	4
Initial site work	8/7/2023	2/16/2024	6
Sediment basin work – construct diaphragm wall, excavate basin, ground improvement, pile installation, concrete work, finish work	2/21/2024	11/7/2027	45
In–water work – Install cofferdam	8/5/2024	1/25/2025	6
In–water work – Excavate inside cofferdam, drill piers, place tremie concrete, dewater, place cross bracings, cast structural concrete, place fish screens & cleaning system	10/3/2024	9/5/2027	36
Levee work – Excavate inside cofferdam, place tremie concrete, pipe to sediment basin, complete piping and gates	7/2/2026	9/18/2027	15
Final site work	**9/14/2027**	**5/1/2028**	**8**

[a] Dates given in this table assume a Record of Decision date of 1/1/2016 and a construction end date of 7/11/2029.

3.2.2.4 Levee Work

Levee modifications will be needed to facilitate intake construction and to provide continued flood management. The levee modifications are described in Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 15, *Levees*, and in Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawings 6, 10 to 17, 19, 44, and 45. Additional information on cofferdam construction (one element of the levee work) appears in Appendix 3.B, Section 6.2.1, *General Constructability Considerations*. The Sacramento River levees are Federal Flood Control Project levees under the jurisdiction of USACE and Central Valley Flood Protection Board, and specific requirements are applicable to penetrations of these levees. Authorizations for this work have not yet been issued. All construction on these levees will be performed in accordance with conditions and requirements set forth in the USACE permit authorizing the work.

Principal levee modifications necessary for conveyance construction are here summarized. See the referenced text in Appendices 3.B and 3.C, *Conceptual Engineering Report, Volumes 1 and 2,* for detailed descriptions of the work; Appendix 3.B, Section 15.2, *Sequence of Construction at the Levee,* includes a table detailing the sequence of construction activities in levee work.

New facilities interfacing with the levee at each intake site will include the following elements.

3.2.2.4.1 Levee Widening

Levees near the intakes will be widened on the land-side to increase the crest width, facilitate intake construction, provide a pad for sediment handling, and accommodate the Highway 160 realignment. The widened levee sections will allow for construction of the intake cofferdams, associated diaphragm walls, and levee cutoff walls within the existing levee prism while preserving a robust levee section to remain in place during construction.

3.2.2.4.2 On-Bank Intake Structure, Cofferdam, and Cutoff Walls

The intake structure and a portion of the box conduits will be constructed inside a dual sheet pile cofferdam installed within the levee prism on the river-side (Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawings 15, 16, 17 and 19; construction techniques are described in Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Sections 6.2.1, *General Constructability Considerations*; 15.1, *Configuration of Facilities in the Levee;* and 15.2, *Sequence of Construction at the Levee.* See Section 3.2.2.5, *Pile Installation for Intake Construction*, for detail on the pile placement required for cofferdam construction). The intake structure foundation will use a combination of ground improvement (as described in Section 3.2.10.3, *Ground Improvement*) and steel-cased driven piles or drilled piers. The cofferdams will project from 10 to 35 feet into the river, relative to the final location of the intake screens, dewatering up to 5 acres of channel at each intake site.

The back wall of the cofferdam along the levee crest will be a deep slurry diaphragm cutoff wall designed for dual duty as a structural component of the cofferdam and to minimize seepage through and under the levee at the facility site. The diaphragm wall will extend along the levee crest upstream and downstream of the cofferdam and the fill pad for the sedimentation on the land-side, which will allow for a future tie-in with levee seepage cutoffs that are not part of the PA. The other three sides of the cofferdam, including a center divider wall, will be sheet pile walls. The cofferdam will include a 5-foot-thick tremie concrete seal in the bottom to aid dewatering and constructability within the enclosed work area.

Once each cofferdam is completed and the tremie seal has been poured and has cured, the enclosed area will be dewatered as described in Section 3.2.10.7, *Dewatering*, and, excavated to the level of design subgrade using clam shell or long-reach backhoe before ground improvements (jet grouting and deep soil mixing) and installation of foundation piles as described below in Section 3.2.2.5, *Pile Installation for Intake Construction*.

In conjunction with the diaphragm wall, a slurry cutoff wall (soil, bentonite, and cement slurry) will be constructed around the perimeter of the construction area for the land-side facilities. This slurry wall will be tied into the diaphragm wall at the levee by short sections of diaphragm wall perpendicular to the levee. The slurry cutoff wall will overlap for approximately 150 feet along the diaphragm wall at the points of tie-in. The slurry wall is intended to help prevent river water from seeping through or under the levee during periods when deep excavations and associated dewatering are required on the land-side. By using the slurry wall in conjunction with the diaphragm wall, the open cut excavation portion of the work on the landside will be completely surrounded by cutoff walls. These walls will minimize induced seepage from the river through the levee, both at the site and immediately adjacent to the site, and serve as long-term seepage control behind the levee.

At the upstream and downstream ends of the intake structure, a sheet pile training wall will transition from the concrete intake structure into the river-side of the levee. Riprap will be placed on the levee-side slope upstream and downstream of the structure to prevent erosion from anomalies in the river created by the structure. Riprap will also be placed along the face of the structure at the river bottom to resist scour.

The cofferdam structure and the berm surrounding the entire intake construction site will provide temporary flood protection during construction; see Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Section 15.3.1, *Temporary Flood Protection Features*, for a detailed explanation of how this will be accomplished.

After intake construction is complete the cofferdammed area will be flooded and underwater divers using torches or plasma cutters will trim the sheet piles at the finished grade/top of structural slab. A portion of the cofferdam will remain in place to facilitate dewatering as necessary for maintenance and repairs, as shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawing 16.

3.2.2.4.3 Box Conduits

Large gravity collector box conduits (12 conduits at each intake) will lead from the intake structure through the levee prism to the landside facilities. The box conduits will be constructed by open-cut methods after the intake portion of the cofferdam is backfilled. Backfill above the box conduits and reconstruction of the disturbed portion of the levee prism will be accomplished using low-permeability levee material in accordance with USACE specifications.

3.2.2.5 Pile Installation for Intake Construction

Structural properties of the sediment at the construction site are a principal consideration in determining the effort required for pile installation. See Appendix 3.B, Section 6.2.2, *Intake Structure and Sediment Facilities Geotechnical*, for a description of geotechnical findings at each intake site. Generally, sediments at the intake sites consist of a surficial layer of soft to medium stiff, fine-grained soils to a depth of approximately 20 to 30 feet below ground surface; underlain by stratified stiff clay, clayey silt, and dense silty sand to the depth of the soil borings.

See Section 3.2.10.11, *Pile Driving*, for a general description of how pile driving will be performed. Table 3.2-8 summarizes proposed pile driving at the intake sites, including the type, size, and number of piles required, as well as the number of piles driven per day, the number of impact strikes per pile, and whether piles will be driven in-water or on land (source: Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*). Table 3.2-8 specifies 42-inch steel piles for the intake foundations; however, depending on the findings of the geotechnical exploration, it may be feasible to replace some or all of those steel piles with cast-in-drilled-hole (CIDH) foundation piles. The CIDH piles are installed by drilling a shaft, installing rebar, and filling the shaft with concrete; no pile driving is necessary with CIDH methods. Use of concrete filled steel piles will involve vibratory or impact-driving hollow steel piles, and then filling them with concrete. Table 3.2-8 assumes that all piles will be driven using impact pile driving, but vibratory pile driving will be the preferred technique, with impact driving used to finalize pile placement. In-water pile driving will be subject to abatement, hydroacoustic monitoring, and compliance with timing limitations as described in Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM9 Underwater Sound Control and Abatement Plan*.

Table 3.2-8. Pile Driving for Intake Construction

Feature	On-land or In-water	Pile Type/ Sizes	Total Piles	Number of Pile Drivers in Concurrent Use	Piles/ Day	Strikes/ Pile	Strikes/ Day
Intake Cofferdam	In-water	Sheet pile	2,500	4	60	700	42,000
Intake Structure Foundation – Intake 2	In-water	42-inch diameter steel	1,120	4	60	1,500	90,000
Intake Structure Foundation – Intake 3	In-water	42-inch diameter steel	850	4	60	1,500	90,000
Intake Structure Foundation – Intake 5	In-water	42-inch diameter steel	1,120	4	60	1,500	90,000
SR-160 Bridge (Realignment) at Intake	On-land	42-inch diameter steel	150	2	30	1,200	36,000
Control Structure at Intake	On-land	42-inch diameter steel	650	4	60	1,200	72,000
Pumping Plant and Concrete Sedimentation Basins at Intake	On-land	42-inch diameter steel	1,650	4	60	1,200	72,000

Sheet piles will be installed in two phases starting with a vibratory hammer and then switching to impact hammer if refusal is encountered before target depths. Therefore, the number of strikes resulting from this two-phased installation method could be substantially lower than the number

(700 strikes per pile) provided in Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*. Similarly, pile strike estimates in Appendix 3.E assume that hollow steel piles will be driven solely by impact driving, but it may be feasible to place all or part of each pile using vibratory driving, thereby reducing the number of impact strikes required.

Sheet pile placement for cofferdam installation will be performed by a barge-mounted crane equipped with vibratory and impact pile-driving rigs. Foundation pile placement within the cofferdammed area may be done before or after the cofferdammed area is dewatered. If it is done after the cofferdammed area is dewatered and the site is dry, a crane equipped with pile driving rig will be used within the cofferdam. If done before the cofferdam is dewatered, pile driving will be performed by a barge-mounted crane positioned outside of the cofferdam or a crane mounted on a deck on top of the cofferdam.

At the conclusion of construction, the intake facilities will be landscaped, fenced, and provided with security lighting as described in Section 3.2.10.10, *Landscaping and Associated Activities*.

3.2.3 Tunneled Conveyance

Although conceptual proposals for north Delta diversions of water for the CVP/SWP have been discussed since at least the early 1960s[2], the earlier proposals all relied upon canal designs that would have resulted in extensive and unacceptable adverse impacts on both the human and natural environment in the Delta.

In 2009, however, the project proponents selected a pipeline and tunnel-based system as the preferred basis of design for conveyance of water from the North Delta Diversions to the CVP/SWP export facilities. The initial tunneled conveyance design, analyzed in the draft EIR/EIS for the PA (U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Water Resources 2013), had pump stations sited at each of the intakes, and somewhat smaller tunnels, north of the IF, compared to the PA.

Subsequent value engineering studies revealed that if the tunnels were made larger, then a gravity-feed system would work, allowing elimination of the pump stations at the intakes and their replacement with a consolidated pump station at the CCF. This design change reduced overall electricity consumption associated with operations of the PA, with a concomitant reduction in greenhouse gas generation (for electric power production). It also eliminated the need for new, permanent high-voltage electrical transmission lines serving the new intakes, and thereby eliminated the potential bird strike and other adverse effects associated with those transmission lines (although temporary transmission lines are still needed, to power TBMs and provide other construction electricity).

[2] See Draft EIR/EIS Appendix 3.A, (California Department of Water Resources et al. 2013), for a detailed description of the historical development of the tunneled conveyance concept.

3.2.3.1 Design

The conveyance tunnels will extend from the proposed intake facilities (Section 3.2.2, *North Delta Diversions*) to the North Clifton Court Forebay (NCCF). The tunneled conveyance includes the North Tunnels, which consist of three reaches that connect the intakes to the IF; and two parallel Main Tunnels, connecting the IF to the NCCF. Final surface conveyance connecting the NCCF to the existing export facilities is described in Section 3.2.6, *Connections to the Banks and Jones Pumping Plants*. The water conveyance tunnels will be operated with a gravity feed system, delivering to a pumping station located at the NCCF.

Each tunnel segment will be excavated by a TBM. This technique largely limits surface impacts on those associated with initial geotechnical investigations on the TBM route (Section 3.2.1, *Geotechnical Exploration*), surface facilities located at the TBM launch and reception shafts (this section), the disposition of material excavated by the TBMs (Section 3.2.10.6, *Dispose Spoils*), the provision of electric power to the TBM (Section 3.2.7, *Power Supply and Grid Connections*), and points where the TBM cutterhead may need to be accessed for repair or maintenance (Section 3.2.3.3.5, *Intermediate Tunnel Access*). Water quality impact potential is associated with dewatering procedures and construction stormwater disposition at the TBM launch and reception surface facilities, and would be addressed via relevant minimization measures described in Section 3.2.10.7, *Dewatering*, and relevant AMMs (Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM3 Stormwater Pollution Prevention Plan, AMM4 Erosion and Sediment Control Plan*, and *AMM5 Spill Prevention, Containment, and Countermeasure Plan*).

The TBM launch facilities will be relatively large and active construction sites because they are continuously active during a TBM tunnel drive, when they will provide the only surface access to the tunnel. Thus they will require stockpiles of materials used by the TBM, will provide access to the TBM for its operation and maintenance, and will receive all materials excavated by the TBM. Conversely, TBM reception facilities will be used to recover the TBM at the end of its drive, and thus have a smaller footprint and a more limited operating scope. Table 3.2-9 summarizes all of the proposed tunnel drives, identifying launch and reception shafts, tunnel lengths, and tunnel diameters. Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Figure 11-1, shows this information on a map. Note that Bouldin Island and the IF will be the primary tunneling sites; the IF will be the launch point for 25.1 miles of two 40-foot tunnels and 4.8 miles of a 28-foot tunnel, while Bouldin Island will be the launch point for four, 40-foot tunnels with a total length of 25.4 miles. Bacon Island will be the launch point for two, 40-foot tunnels with a total length of 16.6 miles, while Intake 2 will be a relatively small site, acting as launch point for one 28-foot tunnel that will be 2.0 miles long.

For a detailed explanation of the tunneling work, see Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Sections 3.1, *Proposed Alignment and Key Components*, 3.2, *Reach Descriptions*, and 11.0, *Tunnels*; Sections 11.2.5, *Tunnel Excavation Methods*, and 11.2.6, *Tunnel Support*, in particular, detail the process of tunneling. Briefly[3], tunneling will be

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[3] An excellent video summarizing how a TBM tunnels through soft sediment is available at https://www.youtube.com/watch?v=qx_EjMlLgqY. Neither the contractor nor the project depicted in the video has

performed by a TBM, which is a very large and heavy electrically-powered machine that will be launched from the bottom of a launch shaft, and will tunnel continuously underground to a reception shaft. The cutterhead of the TBM will be hydrostatically isolated from the remainder of the machine, so that the inside of the tunnel will be dry and at atmospheric pressure. As the TBM proceeds, precast concrete tunnel lining sections will be assembled within the TBM to produce a rigid, water-tight tunnel lining. Typically very little dewatering will be needed to keep the interior of the tunnel dry. A small-gauge electrically-powered railway or conveyor will carry excavated material from the TBM back to the launch shaft, where a conveyor will carry the material to the surface for disposal (Section 3.2.10.6, *Dispose Spoils*). The railway will also be used to carry workers, tunnel lining segments, and other materials from the launch shaft to the TBM.

A map book showing all of the tunnel drives is presented in Appendix 3.A, *Map Book for the Proposed Action*. Design drawings showing tunnel routing, design of the shaft structures, and layout of the surface facilities at launch and reception sites appear in Appendix 3.C, *Conceptual Engineering Report, Volume 2*; see Drawings 44 to 54, showing the tunnel routing and all associated areas of surface activity. A detailed project schedule, showing periods of tunneling and associated activities, is given in Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*. Each TBM launch or retrieval shaft will require barge access for equipment and materials; see Section 3.2.10.9, *Barge Operations,* for further information. Avoidance and minimization measures (AMMs) to be implemented during construction work at all surface facilities supporting the tunneling work appear in Appendix 3.F, *General Avoidance and Minimization Measures*, and are referenced below as appropriate.

Table 3.2-9. Tunnel Drive Summary

Reach	Launch Shaft	Reception Shaft	Inside Diameter (ft)	Length (miles)
1	Intake 2	Intake 3 junction structure	28	1.99
2	IF inlet	Intake 3 junction structure	40	6.74
3	IF inlet	Intake 5	28	4.77
4 (west tunnel)	IF	Staten Island	40	9.17
4 (east tunnel)	IF	Staten Island	40	9.17
5 (west tunnel)	Bouldin Island	Staten Island	40	3.83
5 (east tunnel)	Bouldin Island	Staten Island	40	3.83
6 (west tunnel)	Bouldin Island	Bacon Island	40	8.86
6 (east tunnel)	Bouldin Island	Bacon Island	40	8.86
7 (west tunnel)	NCCF	Bacon Island	40	8.29
7 (east tunnel)	NCCF	Bacon Island	40	8.29

any relationship to the proposed action, but the type of machine used and the procedures depicted are very similar to those that would occur under the proposed action.

3.2.3.2 Schedule

Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*, provides scheduling information for tunneling activities. The TBM launch shafts will be most active, producing RTM on a nearly continuous basis, for the following time periods:

- CCF: May 2020 to February 2025
- Bouldin Island: October 2020 to May 2025
- IF: May 2021 to October 2026
- Intake 2: October 2021 to July 2025

Overall, the peak period of activity will be from October 2020 to April 2025. Considering time required to prepare each site, as well as time required to stabilize and restore RTM storage areas, each site will remain active throughout essentially the whole period of construction (2018 to 2030). Since the CCF, IF, and Intake 2 are essential components of the conveyance system, these sites will remain permanently active. The Bouldin Island site, however, will close following attainment of revegetation and restoration objectives for the associated RTM storage areas, although a small permanent tunnel access shaft will remain.

3.2.3.3 Construction

Launch shaft sites (IF, Bouldin, NCCF, and Intake 2) are shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 56, 50, 76, and 11, respectively. Reception shaft sites (Intake 3, Intake 5, Staten Island, and Bacon Island) are similar in design. Appendix 3.C, Drawings 69 to 73 show typical work area and finished construction plans for paired tunnel shafts.

3.2.3.3.1 Shaft Site Facilities

Facilities at launch shaft sites will include a concrete batch plant and construction work areas including offices, parking, shop, short-term segment storage, fan line storage, crane, dry houses, settling ponds, daily spoils piles, temporary RTM storage, electrical power supplies, air, water treatment, and other requirements. There will also be space for slurry ponds at sites where slurry wall construction is required. Work areas for RTM handling and permanent spoils disposal will also be necessary, as discussed in Section 3.2.10.6, *Dispose Spoils*. Facilities at reception shafts will be similar but more limited, as there will be no need for a concrete batch plant or for RTM storage.

3.2.3.3.2 Shaft Site Preparation

Shaft site preparation is detailed in Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 11.2.1, *Advance Works Contracts*. During shaft site preparation, vehicular access will be established and electrical service will be provided via temporary transmission line (see Section 3.2.7, *Power Supply and Grid Connections*). The shafts will be located on pads elevated to above the 200-year flood elevation; fill will be placed to construct these pads and to preload the ground to facilitate settling. The site will be fenced for security and made ready for full construction mobilization. Due to the pervasive nature of these activities, all surface disturbance associated with construction at each shaft site will occur very early during the period of activity at each site; the entire site footprint will be disturbed and will remain so for the duration of construction activity.

3.2.3.3.2.1 Access Routes

Access routes for each shaft site are shown in Appendix 3.A, *Map Book for the Proposed Action*, and in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 44 to 54. These sources also depict the footprint for new permanent access roads, which will be a feature of every shaft site. SR 160 provides access to the intakes and their associated shafts, but for all other shafts (including atmospheric safe haven access shafts, discussed in Section 3.2.3.3.5, *Intermediate Tunnel Access*), access roads will be constructed. Those roads will be permanent features except at atmospheric safe haven access shafts, where they will be temporary.

3.2.3.3.2.2 Fill Pads

Permanent conveyance facilities (intakes, permanent shaft sites, IF, and CCF facilities) must be sited at elevations that are at minimal risk of flooding; see Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 3.5, *Flood Protection Considerations*, for a detailed discussion of this issue. This means that the facilities will require fill pads with a top surface elevation of approximately 25 feet to 35 feet, depending upon location (Appendix 3.B, Table 3-4). These sites are currently near or below sea level, so substantial fill volumes will be needed, the placement of which will cause consolidation settlement of underlying delta soils at the construction sites. The shafts at the IF are an exception; these will initially be constructed at near existing site grades, and final site grades will be established in conjunction with final IF inlet and outlet facilities. The permanent elevated pad perimeters are assumed to extend to 75 feet from the outside of the shafts to facilitate heavy equipment access for maintenance and inspection. As the existing ground elevations are significantly lower than the final planned elevations, the pad fills will slope down to the adjacent existing site grades at an inclination of between 3 horizontal to 1 vertical (3H to 1V) to 5H to 1V.

Due to the soft ground conditions expected at the construction sites, it will also be necessary to improve existing sites to support heavy construction equipment, switchyards, transformers, concrete and grout plants, cranes and hoists, TBMs, and water treatment plants. See Section 3.2.10.3, *Ground Improvement*, for discussion of how this will be achieved.

Preliminary estimates suggest 8 to 10 feet of consolidation settlement can be expected from the placement of shaft pad area fills. Pre-loading of the existing pad and placement of vertical wick drains, spaced at 5 feet on center to a depth of 60 feet, will be used to achieve soil consolidation through vertical relief of excess pore water pressure in the compressible soils. It is expected that all but approximately 12 inches of the total settlement will occur within 1 year following pad placement. Thus pad construction will significantly precede other work at the shaft site; at the IF, for instance, earthwork will begin 2.5 years prior to ground improvement, and will then be followed by a 9-month period of ground improvement, before the site will be ready for mobilization (Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*).

Construction of the pad fills will require substantial amounts of material, which will be sourced from borrow sites; see Section 3.2.10.4, *Borrow Fill,* for further discussion.

3.2.3.3.3 Shaft Construction

During mobilization, construction manpower, stockpiles of materials, and needed equipment will be stationed at the construction site.

Shaft construction procedures are described in Appendix B, *Conceptual Engineering Report, Volume 1*, Section 11.2.3, *Shaft Construction*, and here summarized. Shafts are circular in plan with a 100-foot diameter for 28 foot tunnels and a 113-foot diameter for 40-foot tunnels. These minimum sizes are constrained by the equipment needs to launch and retrieve the TBM from the bottom of the shaft.

Final design of shafts is not complete, but the basic objective is to use concrete construction methods to create a watertight shaft sufficiently strong to resist hydrostatic pressure within the delta sediments. This will be done by constructing a concrete cylinder prior to removing the sediment from the structure. Potential construction methods include overlapping concrete caisson walls, panel walls, jet-grout column walls, secant piles walls, slurry walls, precast sunken caissons, and potentially other technologies. In the areas where TBMs enter and exit, a special break-in/break-out section will be constructed as an integral part of the shaft.

Shaft bottoms will be stabilized to resist uplift associated with external hydrostatic pressures, during both excavation and operation. It may be necessary to pretreat ground at the shaft area from the surface to the bottom of the shaft to control blowouts during excavation of the shaft. Concrete working slabs capable of withstanding uplift will be required at all shaft locations to provide a stable bottom and a suitable working environment. To place the bottom slab, the shaft will be excavated to approximately 30 to 50 feet below the invert level of the tunnel, and a concrete base will be placed underwater using tremie techniques. It is expected that this will be an unreinforced mass concrete plug to withstand ground water pressure, with optional relief wells to relieve uplift pressure during tunnel construction. The launch and reception of the TBMs will require that large openings be created in the shaft walls. To maintain structural stability, it will be necessary to provide additional structural support. This will be provided by a reinforced concrete buttress or frame structure within the shaft.

Dewatering will be required during shaft construction and operation, and will be performed as described in Section 3.2.10.7, *Dewatering*. Dewatering of sediments surrounding the shaft may be needed during construction, depending upon the construction method selected. Dewatering will also be needed during excavation within the shaft, following placement of the tremie seal, and continuously thereafter until completion of construction work within the shaft.

3.2.3.3.4 Tunnel Excavation

The tunnel excavation procedure is described in Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Sections 11.2.5, *Tunnel Excavation Methods*, to 11.2.8, *Logistics*. Tunnel excavation will occur entirely underground and thus will entail no surface impacts, apart from those associated with the TBM launch and reception shafts (discussed above) and the construction access shafts (discussed below). Tunnel dewatering needs will be minor, compared to those associated with shaft construction, and are discussed above. Disposition of material excavated during tunnel construction is addressed in Section 3.2.10.6, *Dispose Spoils.*

3.2.3.3.5 Intermediate Tunnel Access

In the event that maintenance, inspection, or repair of the TBM cutterhead will be needed, contractors will be able to access their equipment either from inside the TBM or from the surface using construction access shafts. Such access points are termed "safe havens" because they constitute points where humans can work on the outside of the TBM in conditions of comparative safety.

Access to the cutterhead from inside the TBM will occur at a "pressurized safe haven intervention." It will be a "pressurized" safe haven because compressed air will be used to create a safe work area; the air pressure will exclude sediment and water from the excavation. Consequently humans in the work area will be subject to risks similar to those experienced by SCUBA divers: they will have a limited time during which they can safely work in the excavation, and must undergo a long and potentially dangerous decompression process when they leave the work area. In order to minimize that risk, surface-based equipment is commonly used to inject grout into the sediments surrounding the work area, minimizing the risk that the excavation will collapse and allowing workers to work in a less highly pressurized environment. Pressurized safe haven interventions will be constructed by injecting grout from the surface to a point in front of the TBM, or by using other ground improvement techniques including ground freezing or installing dewatering wells to depressurize the ground around the TBM. Once the ground has been stabilized by one of these techniques, the TBM will then bore into the treated area. Surface equipment required to construct the safe haven intervention site will include a small drill rig and grout mixing and injection equipment, and facilities to control runoff from dewatering (dewatering, if required, will be performed as described in Section 3.2.10.7, *Dewatering*). Disturbance at the site is expected to be limited to an area of approximately 100 feet by 100 feet. The surface drilling and treatment operation will typically take about 8 weeks to complete. Once complete, all equipment will be removed and the surface features reestablished. To the greatest extent possible, established roadways will be used to access the intervention sites. If access is not readily available, temporary access roads will be established.

Access to the cutterhead from the surface, referred to as an "atmospheric safe haven interventions," will require construction of a shaft. These construction access shafts will not require pad construction to elevate the top of the shaft to above the 200-year flood level. At these sites, a shaft roughly equal to the diameter of the TBM cutterhead will be excavated to tunnel depth. Approximately 3 acres will be required at each of these locations to set up equipment, construct flood protection facilities, excavate/construct the shaft, and set up and maintain the equipment necessary for the TBM maintenance work. It is anticipated that all work associated with developing and maintaining these shafts will occur over approximately 9 to 12 months. At the completion of the TBM maintenance at these sites, the TBM will mine forward, and the shaft location will be backfilled. Dewatering at construction access shafts, if required, will be performed as described in Section 3.2.10.7, *Dewatering*. Drilling muds or other materials required for drilling and grouting will be confined on the work site and such materials will be disposed of offsite at a permitted facility. Disturbed areas will be returned to preconstruction conditions by grading and appropriate revegetation (in most cases, returning the site to use as cropland).

Final determination of the number and siting of shaft locations will depend upon determinations by the tunnel construction contractor(s). Moreover, it is likely that final siting of both pressurized and atmospheric safe haven intervention sites will not occur until after geotechnical explorations are completed, as information from those explorations is needed to determine the appropriate spacing for safe haven intervention sites (TBM cutterhead wear rates depend partly upon the types of material being tunneled). Table 3.2-10 shows the number of safe haven interventions expected to be associated with each tunnel, based upon current understanding of site conditions.

Table 3.2-10. Expected Safe Haven Interventions

Reach	Length (miles)	Number of Safe Haven Interventions	
		Pressurized	Atmospheric
1	1.99	1	1
2	6.74	5	1 to 3
3	4.77	3	1 to 2
4 (twin tunnel)	9.17	7	1 to 4
5 (twin tunnel)	3.83	2	1
6 (twin tunnel)	8.86	7	1 to 4
7 (twin tunnel)	8.29	6	1 to 3

Both pressurized and atmospheric safe haven intervention sites will be located to minimize impacts on sensitive terrestrial and aquatic habitats. Because intervention sites are not determinable at this time, potential effects on species are estimated using a conservative analysis, as detailed in in Appendix 6.B *Terrestrial Effects Analysis Methods*.

3.2.3.4 Landscaping

As at the Delta intakes, the construction phase at both permanent and temporary shaft sites will conclude with landscaping and the installation of safety lighting and security fencing, which will be performed as described in Section 3.2.10.10, *Landscaping and Associated Activities*.

3.2.4 Intermediate Forebay

The IF will receive water from the three North Delta Diversions and discharge it to the twin tunneled conveyance to CCF. When first proposed, the IF was a much larger facility (750 acres) and was located in an environmentally sensitive location, on private land adjacent to the Stone Lakes National Wildlife Refuge. Subsequent hydraulic design of the conveyance system that locates the pumping plants at CCF allows the IF to be located on a DWR-owned parcel of land. The IF footprint is a water surface area of 54 acres at maximum water elevation.

3.2.4.1 Design

Appendix 3.A, *Map Book for the Proposed Action*, Sheet 5, shows the IF, access routes, and related facilities in the area. Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawings 55 to 68, show an artist's concept of the completed forebay, as well as drawings showing the complete forebay and various design details. Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Section 14, *Forebays*, provides detail on the design, construction and operations of the IF; see particularly Sections 14.1. (description and site plan), 14.2. (construction methodology), 14.2.4 (embankment completion), 14.2.6 (spillway), and 14.2.8 (inlet and outlet structures).

Section 5.3.1, *Intermediate Forebay Size Evaluation*, describes the basis for design sizing of the IF. Proposed construction will comply with avoidance and minimization measures identified in Appendix 3.F, *General Avoidance and Minimization Measures*.

The IF, located on Glannvale Tract, will store water between the proposed intake and conveyance facilities and the main tunnel conveyance segment. The IF provides an atmospheric break in the deep tunnel system and buffer volume for the upstream intake sites and the downstream CCFPP. This buffer provides make-up water and storage volume to mitigate transients generated as a result of planned or unplanned adjustments of system pumping rates. The IF also facilitates isolating segments of the tunnel system, while maintaining operational flexibility. Thus each tunnel, into and out of IF, can be hydraulically isolated for maintenance, while maintaining partial system capacity.

The IF will have a capacity of 750 acre feet (af) and an embankment crest elevation of +32.2 feet, which meets Delta Habitat Conservation and Conveyance Program (DHCCP) flood protection standards (i.e., a 200-year flood with provision for sea level rise). Current ground surface elevation at the site averages +0 feet. The WSE varies between a maximum elevation of +25 feet and a minimum elevation of -20 feet. The IF will include an emergency spillway and emergency inundation area to prevent the forebay from overtopping. This spillway will divert water during high flow periods to an approximately 131-acre emergency inundation area adjacent to and surrounding the IF. From the IF, water will be conveyed by a gravity bypass system through an outlet control structure into a dual-bore 40-foot-diameter tunnel that runs south to the CCF. The IF will serve to enhance water supply operational flexibility by using forebay storage capacity to regulate flows from the intakes to the CCF.

3.2.4.2 Schedule

Appendix 3.D, *Assumed Construction Schedule for the Proposed Action*, provides scheduling information for IF construction. The principal dates for construction of the IF are shown in Table 3.2-11.

Table 3.2-11. Summary Construction Schedule for the Intermediate Forebay

Description	Start[a]	End[a]	Duration
Contract management, supervision, administration, temporary facility operations, and delivery of construction supplies	7/1/2024	7/11/2029	61 months
Earthworks	7/1/2024	12/25/2027	42 months
Inlet & outlet ground improvements	12/28/2026	10/12/2028	23 months
Inlet & outlet site work	9/27/2027	4/12/2028	8 months
Operate concrete batch plant; inlet & outlet concrete work	3/27/2028	4/11/2029	13 months
Inlet & outlet gates, mechanical & electrical work	12/25/2028	7/11/2029	7 months

[a] Dates given in this table assume a Record of Decision date of 1/1/2016 and a construction end date of 7/11/2029.

3.2.4.3 Construction

Construction of the IF entails first excavating the embankment areas down to suitable material. A slurry cutoff wall is then emplaced to a depth of -50 feet to eliminate the potential for piping or seepage beneath the embankment. The embankment is then constructed of compacted fill material. Inlet and outlet shafts (which also serve as TBM launch shafts as described in Section 3.2.3, *Tunneled Conveyance*) are then constructed. Then the interior basin is excavated to design depth (-20 feet), and the spillway is constructed. All excavations are expected to require dewatering, and dewatering is expected to be continuous throughout construction of the IF; see Section 3.2.10.7, *Dewatering,* for further discussion of how this will be achieved. Ground improvement (described in Section 3.2.10.3, *Ground Improvement*) may be needed beneath structures, depending upon the outcomes of the geotechnical explorations described in Section 3.2.1, *Geotechnical Exploration*.

The IF and the emergency inundation area will have a combined surface footprint of 648 acres, all of which is permanent impact. Approximately 1 million cubic yards (cy) of excavation and 2.3 million cy of fill material are required for completing the IF embankments. Much of the excavated material is expected to be high in organics and unsuitable for use in embankment construction and requires disposal (see Section 3.2.10.6, *Dispose Spoils*).

Construction of the IF embankments and tunnel shaft pans will require substantial volumes of engineered fill. The required fill material will preferably be sourced onsite from locations within the permanent impact footprint. Material sourced from offsite will be obtained as described in Section 3.2.10.4, *Borrow Fill*.

As at the Delta intakes, the construction phase at the IF will conclude with landscaping and the installation of safety lighting and security fencing, which will be performed as described in Section 3.2.10.10, *Landscaping and Associated Activities*.

3.2.5 Clifton Court Forebay

3.2.5.1 Design

Functionally, the facilities at CCF are proposed to receive water from north Delta and south Delta sources, and to deliver that water into the CVP/SWP. The forebay itself will be needed to accommodate hydraulic surges and transitions related to short-term (typically less than 24 hours) differences in the rate of water delivery to CCF and the rate of export by the CVP/SWP pumps. The CCF will also be the site for a pump station, the operations of which constrain the rate of flow through the tunnels coming from the north Delta and thus, form a primary constraint on the rate of water diversion through the intakes (although that rate is also subject to control at the intakes, and also through operations at the IF; operations of those facilities will be coordinated through an operations center sited at the CCF pump station). For cost reasons and to minimize environmental impacts, the proposed size of the CCF and its appurtenant facilities have been minimized consistent with the overall design goal of the PA to achieve diversion rates at the North Delta Diversions not exceeding 9,000 cfs, and to achieve overall CVP/SWP water export rates consistent with existing authorizations for those facilities, subject to operational and regulatory constraints detailed in Section 3.3, *Operations and Maintenance of the New and Existing Facilities*.

Maps and drawings depicting the CCF and its spatial relationship to other elements of the PA are shown in the Appendices. Appendix 3.A, *Map Book for the Proposed Action*, Sheet 13, shows the CCF, access routes, and related facilities in the area. Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Drawing 2, provides an overview of the CCF facilities in relation to the rest of the conveyance facilities, and Drawing 54 provides a site-scale view of the proposed facilities at CCF. Drawing 74 shows an artist's concept of the completed CCF pumping plant, and Drawings 75 to 78 show details of the proposed pumping plant. Drawing 82 is a detailed overall CCF site plan, and Drawings 85 to 87 provide sectional views of the proposed embankments that contain the CCF. Drawings 90 and 91 provide plan and section views of the proposed spillway from the NCCF into Old River.

Detailed information on design of the proposed facilities at CCF is given in Appendix 3.B, *Conceptual Engineering Report, Volume 1.* Sections 4.4.6, *Clifton Court Forebay Pump Plant (CCFPP) Operations*; 4.4.7, *North Clifton Court Forebay Operations*; and 4.6, *Implications of Modified Pipeline/Tunnel Clifton Court Option on Current SWP and CVP Operations*, describe how the CCF pump plant and the NCCF will be operated to support overall conveyance system functions. Section 7, *CCF Pumping Plant*, describes the design and construction of the CCF pumping plant, while the north and south CCF and their construction methodology are described in Sections 14.1.2, *North Clifton Court Forebay*; 14.1.3, *South Clifton Court Forebay*; 14.2.2, *General Excavation for the NCCF and SCCF*; 14.2.3, *General Excavation for the Existing South Embankment of Clifton Court Forebay*; 14.2.5, *New Clifton Court Forebay Embankment*; 14.2.6, *New Spillway and Stilling Basin*; and 14.2.8, *New Forebay Structures*. Construction will comply with avoidance and minimization measures identified in Appendix 3.F, *General Avoidance and Minimization Measures*.

Construction at the CCF will also include connections to the existing Banks and Jones pumping plants. Design and construction of those connections are described in Section 3.2.6, *Connections to Banks and Jones Pumping Plants*.

The overall schedule for activities at CCF is shown in Table 3.2-12; see drawings in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, for locations of the referenced structures. Four major elements of the proposed construction will occur in the CCF area: tunneling, the CCPP, the CCF, and connections to the Banks and Jones pumping plants:

- Tunneling (Reach 7) will start from the CCPP construction site and will excavate north to Bacon Island, as described in Section 3.2.3, *Tunneled Conveyance*; RTM from the tunnels will be disposed near CCF as described in Section 3.2.10.6, *Dispose Spoils*. Tunneling activity will be continuous from November 2019 through December 2025.

- The CCPP will be constructed at the north end of the CCF and includes the shafts used to launch the TBMs. Construction will start at the CCPP at the beginning of January 2019 and construction at the site remains continuously active through April 2027.

- CCF work will occur throughout the site, and will be continuously active from January 2023 through March 2028. Apart from startup activities (access improvement, mobilization, etc.), embankment and canal work will continue from June 2023 to October 2027, and dredging from January 2023 through February 2027. Work on control structures and spillways will occur from March 2025 through March 2028.

- Connections to the Banks and Jones pumping plants are described in Section 3.2.6, *Connections to Banks and Jones Pumping Plants*.

Table 3.2-12. Overview Schedule for Activities at Clifton Court Forebay

Activity	Start[a]	End[a]	Duration
Tunneling			
Launch TBMs, excavate east and west tunnels to Bacon Island, decommission tunneling equipment.	11/13/2019	12/29/2025	62 months
Work on the CCF Facility			
Grading and soil movement (not continuous; overall duration)	1/1/2023	10/14/2027	46 months
Access construction	1/3/2023	2/24/2024	14 months
Dredging the CCF	1/17/2023	2/21/2027	38 months
Embankment work, gate to embankment, south end of CCF	6/26/2023	9/17/2024	16 months
NCCF outlet canal	10/28/2023	4/22/2025	18 months
SCCF embankment work (southwest corner of CCF)	10/28/2023	1/13/2025	15 months
NCCF embankment work (west side of NCCF)	9/28/2024	12/15/2025	15 months
SCCF embankment work (southeast corner of CCF)	1/21/2025	4/13/2026	15 months
Control Structures # 1 and #2sd	3/22/2025	7/4/2026	16 months
Old River Structure	9/30/2025	1/4/2027	16 months
NCCF embankment work (north side of NCCF)	12/22/2025	3/15/2027	16 months
New spillway	4/6/2026	7/9/2027	17 months
New CCF partition embankment	4/19/2026	10/14/2027	18 months
Control Structures # 3 and #4	10/12/2026	3/3/2028	17 months
Work on the CCPP facility			
Access Construction	1/1/2018	4/7/2018	4 months
Grading and Soil Movement (overall duration)	1/1/2018	3/7/2027	111 months
Cofferdam for pad fill and barge landing	3/18/2018	8/21/2018	6 months
Pad, Initial Earthwork	4/8/2018	11/8/2018	8 months
Substation & Elect. Distribution	6/30/2018	12/25/2018	6 months
Operate Water Treatment Plant	1/4/2019	8/16/20	20 months
Slurry Wall Installation	4/18/2019	7/20/19	4 months
Tunnel shaft work	7/19/2019	6/1/20	12 months
Pump Plant Construction	6/15/2020	4/15/2026	70 months
Bypass Outlet Structures	9/19/2025	3/23/2026	7 months
Bypass Outlet Spillway Structure	11/24/2025	2/24/2026	3 months
Other Facility Buildings	2/21/2026	8/15/2026	6 months
Water Treatment Facility/Tanks	2/22/2026	8/15/2026	6 months
Complete pad fill, place riprap, finish	9/9/2026	4/10/2027	8 months

[a] Dates given in this table assume a Record of Decision date of 1/1/2016 and a construction end date of 7/11/2029.

3.2.5.1.1 Clifton Court Pumping Plant

Each of the two units at CCPP will have a design pumping capacity of 4,500 cfs and will include 4 large pumps (1,125 cfs capacity) and 2 smaller pumps (563 cfs capacity). One large pump at each plant will be a spare. Each pumping plant will be housed within a building and will have an associated electrical building. The pumping plant buildings will be circular structures with a diameter of 182 feet and each will be equipped with a bridge crane that will rotate around the building and allow for access to the main floor for pump removal and installation. The total site for the pumping plants, electrical buildings, substation, spillway, access roads, and construction staging areas is approximately 95 acres. The main floor of the pumping plants and appurtenant permanent facilities will be constructed at a minimum elevation of 25 feet to provide flood protection. The bottom of the pump shafts will be at an elevation of approximately -163 feet, though a concrete base slab, shaft lining, and diaphragm wall will be constructed to deeper levels (to an elevation of -275 feet). A control room within an electrical building at the pumping facility site will be responsible for controlling and monitoring the communication between the intakes, pumping plants, and the Delta Field Division Operations and Maintenance Center, DWR Headquarters, and the Joint Operations Center.

A 230 kV transmission line and associated 230Kv–115kV substation used during construction will be repurposed and used to power the pumping plants at the CCF location during operations. The repurposed substation will provide power to a new substation that will convert power from 115kV to 13.8kV. This substation will then include 13.8 kV feeder lines to a proposed electrical building to distribute the power to the major loads including the main pumps, dewatering pumps, and 13.8kV to 480V transformers.

3.2.5.1.2 Clifton Court Forebay

SWP pumps operate primarily during off-peak electrical usage hours, which minimizes electricity costs and makes optimal use of available generating capacity. Thus the current CCF is sized to accommodate the hydraulic differential generated by the difference between a fairly constant rate of flow into the Forebay, but a highly variable rate of discharge into the export canal. Under the PA, the CCF will be divided into two separate but contiguous forebays: North Clifton Court Forebay (NCCF) and South Clifton Court Forebay (SCCF). The NCCF will be sized to meet the hydraulic needs of balancing water entry from the North Delta Diversions with discharge via the CVP/SWP export pumps. Since NCCF will receive the flow from the Delta Intakes, this will be water that has passed through the Delta Intake fish screens and is therefore expected to contain no fish. The SCCF will continue to meet the needs of SWP export pumps taking in south Delta water; as such it will function as a replacement for the current CCF, and thus must be enlarged south in order to maintain its current size while still accommodating he creation of the NCCF. SCCF will consist of the southern portion of the existing CCF, with expansion to the south into Byron Tract 2.

The CCF will be expanded by approximately 590 acres to the southeast of the existing forebay. The existing CCF will be dredged, and the expansion area excavated, to design depths of -8 feet for the north cell (the NCCF) and -10 feet for the south cell (the SCCF). A new embankment will be constructed around the perimeter of the forebay, as well as an embankment dividing the forebay into the NCCF and the SCCF. The tunnels from the Sacramento River intakes will enter the CCPP at the northeastern end of the NCCF, immediately south of Victoria Island, and flows will typically enter the NCCF via pumping (unpumped gravity flow will be feasible when the Sacramento River is at exceptionally high stages; see Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 7.1.3.2, *Pumping Hydraulics*, for detailed discussion of hydraulic constraints on gravity-driven vs. pumped operations).

3.2.5.2 Construction

3.2.5.2.1 Clifton Court Pumping Plant

3.2.5.2.1.1 Overview

A detailed account of CCPP construction appears in Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Section 7.2*, Construction Methodology*. In general, construction of the CCPP will follow the procedures described for tunnel shaft construction in Sections 3.2.3.3.1, *Shaft Site Facilities*; 3.2.3.3.2, *Shaft Site Preparation*; and 3.2.3.3.3, *Shaft Construction*. The CCPP shafts will be larger in inside diameter (150 feet instead of 113 feet) than most shafts serving 40-foot tunnel bores due to the design needs of the pumping plant. As shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawings 75 and 76, the appurtenant facilities will be more extensive than at most tunnel shaft sites, including a permanent electrical substation, two electrical buildings, and an office/storage building, as well as temporary facilities for storage, staging, construction electrical, and water treatment (for stormwater). All of these facilities will be sited on the CCF embankment, at the design flood elevation (i.e., a 200-year flood with provision for sea level rise) of 25 feet.

3.2.5.2.1.2 Site Access

Vehicular site access during construction will use existing roads: from the east, from Byron Highway via Clifton Court Road and the Italian Slough levee crest road or the NCCF embankment crest road. Access from the south will be from the Byron Highway via NCCF embankment crest road and West Canal levee crest road. Barge access will also be needed, for transport of heavy TBM sections and other very large equipment and materials, and possibly for transport of bulk materials (fill material or excavated material). Barge access will be from the West Canal using a proposed barge unloading facility. See Section 3.2.10.9, *Barge Operations*, for further discussion of the use, design, and construction of barge landings. Proposed barge traffic and landing facilities are also generally described in Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Section 23.3.

3.2.5.2.1.3 Cofferdam and Fill Work

A sheet pile cofferdam will be placed to enclose the entire area of the CCPP fill pad (Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawings 75 and 83). Sheet pile placement for cofferdam installation will be performed by a barge-mounted crane and/or a crane mounted on the existing levee, equipped with vibratory and impact pile-driving rigs. The general approach to pile driving, including minimization measures to be used, is described in Section 3.2.10.11, *Pile Driving*. Assumptions for pile driving are given in Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*, which addresses the type and size of piles required, as well as the number of piles driven per day, the number of impact strikes per pile, and whether piles will be driven in-water or on land (piles driven to construct the cofferdam will all be “in-water”). Pile driving for cofferdams in the CCF is estimated to require placement of 2,500 piles at a rate of up to 60 piles per day, needing in total 450 days of work.

Sheet piles will be driven starting with a vibratory hammer, then switching to an impact hammer if refusal is encountered before target depths. Therefore, the number of impact strikes could be substantially lower than the number (700 strikes per pile) provided in Appendix 3.E, *Pile Driving Assumptions for the Proposed Action*, which assumes exclusive use of an impact pile driving rig. In-water pile driving will be subject to abatement, hydroacoustic monitoring, and compliance with timing limitations as described in Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM9 Underwater Sound Control and Abatement Plan*.

Fill pad construction will then proceed within the dewatered area, as described in Section 3.2.3.3.2.2, *Fill Pads*, including fill placement, compaction, and ground improvement.

3.2.5.2.1.4 Dewatering

Dewatering and water treatment associated with cofferdam installation will be as described in Section 3.2.10.7, *Dewatering*. This procedure includes fish removal as prescribed in Appendix 3.F, *General Avoidance and Minimization Measures, AMM8 Fish Rescue and Salvage Plan*.

Extensive dewatering will be required during construction of the CCPP shafts. Dewatering will be performed as described in Section 3.2.3.3.3, *Shaft Construction*. Other construction activities with the potential to affect listed species are described below, in the discussion of how CCF embankments and related facilities will be constructed.

3.2.5.2.2 Clifton Court Forebay

Due to the duration and complexity of the proposed work at CCF, a phased work schedule is planned. The phases are described in Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 14.2.2.1, *Clifton Court Forebay Phased Construction*, and include the following:

- Phase 1 – SCCF expansion (western part of expansion area shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawings 54 and 82)
- Phase 2 – SCCF expansion (eastern part of expansion area shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawings 54 and 82)
- Phase 3 – Removal of embankment separating the existing CCF from the expansion area
- Phase 4 – Dredging of CCF to design depths
- Phase 5 – Construction of embankment separating NCCF and SCCF
- Phase 6 – NCCF East Side Embankment
- Phase 7 – NCCF West Side Embankment
- Phase 8 – NCCF North Side Embankment.

3.2.5.2.2.1 Embankments

All construction except Phase 4 (dredging of CCF) will consist of embankment construction. In all phases, this will follow the same general approach:

- Clearing and grubbing of existing vegetation where necessary for construction work to proceed. See Section 3.2.10.1, *Clearing*, for further discussion of how clearing will be performed.

- Temporary or permanent relocation or installation of electrical transmission lines as needed.

- Driving sheet piles to enclose the construction area with a cofferdam. Piles will be driven from a barge, or from land where possible. Note that all sheet pile driving within the existing CCF or adjacent to the existing waterways, Old River and Italian Slough, will occur within fish-bearing waters. Only in Phase 2, where a portion of the new SCCF embankment adjoins the existing Jones PP approach canal, will pile driving occur in non-fish-bearing waters. See Section 3.2.10.11, *Pile Driving,* for further discussion of how pile driving will be performed.

- Dewatering area enclosed by cofferdam. See Section 3.2.10.7, *Dewatering,* for further discussion of how dewatering will be performed.

- Dewatering and excavating down to foundation depth. Excavation equipment will include scrapers, excavators, bulldozers, off-road and on-road trucks as deemed appropriate. Material suitable for use in constructing the new embankments will be stockpiled within the construction area limits and reused. Unsuitable material will be disposed as described in Section 3.2.10.6, *Dispose Soils*.

- Possible installation of slurry cutoff wall. The need for such walls will be determined following detailed geotechnical investigations.

- Construction of new embankment using similar equipment as excavation operations, but also including compaction equipment, rollers, motor graders, and water trucks or water pulls to place material in lifts until finish heights are reached. The required embankment material will be borrowed from within the limits of the forebays to the extent feasible, or from borrow sites, as described in Section 3.2.10.4, *Borrow Fill*. A total of 9.3 million cy of fill will be used in the new and modified CCF embankments

- Trimming or removal of sheet piles and placing riprap on water-side of slopes using excavators, loaders and trucks as required.

The phases of work in embankment construction will include the following:

- Phase 1 – Drive sheet piles on southwest side of CCF by outflow channel to facilitate new channel and new embankment work. Clear, grub, and perform exploration of SCCF expansion property to find suitable soils for embankment fills and potential spoil areas. Construct embankment fills as described above.

- Phase 2 – Drive sheet piles on southeast side of forebay by inflow gates to facilitate new embankment work. Construct embankment fills as described above. Modify existing SCCF intake concurrently with embankment construction. Relocate or raise electrical transmission towers within the construction area concurrently with embankment construction.

- Phase 3 – Drive sheet piles between the two sets of sheet piles installed on the south side of CCF during Phases 1 and 2. Excavate existing embankment down to invert elevation. Excavated material suitable for use in constructing the new embankments will be stockpiled within the construction area limits and reused. Unsuitable material will be disposed as described in Section 3.2.10.6, *Dispose Spoils*.

- Phase 5 – Drive sheet piles for partitioning forebay. Following completion of Phases 1 and 2, allow water to be introduced into the new forebay section on the south of CCF until water height of the two locations is even, then remove the sheet piles placed during Phase 3. Construct partition embankment fill as described above. Implement fish rescue and salvage plan as required per Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM8 Fish Rescue and Salvage Plan*. Dewater NCCF, which is now blocked off by partition sheet piles.

- Phase 6 – Drive sheet piles on east side embankment past new spillway location (note that sheet piles will only be installed on the Old River side of the embankment, since NCCF is now dewatered). Embankment construction will be similar to what was described above. Construct spillway (described below) concurrently with embankment construction.

- Phase 7 – Drive sheet piles on west side embankment as needed (note that sheet piles will only be installed on the Italian Slough side of the embankment, since NCCF is now dewatered). Embankment construction is similar to what is described above.

- Phase 8 – Drive sheet piles on north side embankment (note that sheet piles will only be installed on the Old River side of the embankment, since NCCF is now dewatered; and that much of the north side work will have already been completed during pad construction for the CCPP). Embankment construction will be similar to what was described above. Construct spillway (described below) concurrently with embankment construction.

3.2.5.2.2.2 Dredging

Dredging of the CCF will occur during Phase 4 of CCF construction. The area designated for the NCCF will be dredged to provide a bottom elevation of -8.0 ft except locally at the inlet and outlet connections. The portion of SCCF that lies within the extent of the existing CCF will be dredged to an elevation of approximately -10.0 ft, which will be the bottom elevation of SCCF.

Dredging will be performed with a cutter head dredge, a dragline type dredge, or other suitable dredging technique. Silt curtains or other means of limiting turbidity in the existing forebay will be used as required by applicable permits, and other measures to minimize potential effects will be implemented as described in Section 3.2.10.8, *Dredging and Riprap Placement,* and in Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*. Dredged material suitable for use in constructing the new embankments will be stockpiled within the construction area limits and reused. Unsuitable material will be disposed as described in Section 3.2.10.6, *Dispose Spoils.* As described there, up to 7,000,000 cubic yards of dredged material will be produced. It is assumed for the purposes of this analysis that all of that material will be classified as unsuitable and require disposal, but the material will be evaluated and re-used in embankment construction to the extent feasible.

3.2.5.2.2.3 CCF Spillway

An emergency spillway will be constructed in the NCCF east side embankment, south of the CCPP fill pad. The spillway will be sized to carry emergency overflow (9,000 cfs, the maximum inflow from the North Delta Diversions) to the Old River, so a containment area will not be necessary.

The shallow foundation beneath this structure must be improved to prevent strength loss and seismic settlement. The ground improvement (Section 3.2.10.3, *Ground Improvement*) will be to elevation -50.0 feet within the footprint of the structure and beyond the structure by a distance of approximately 25 feet. The work will be performed within the sheet pile installed for embankment filling under construction Phase 6.

3.2.6 Connections to Banks and Jones Pumping Plants

3.2.6.1 Design

Under existing conditions, the C.W. "Bill" Jones Pumping Plant ("Jones PP"; part of the CVP) draws water from the Middle River via an approach canal that originates at the Tracy Fish Collection Facility, near the southeast corner of the CCF. The existing Harvey O. Banks Pumping Plant ("Banks PP"; part of the SWP) draws water from the CCF via an approach canal that originates at the southwest corner of the CCF, at the Skinner Delta Fish Protective Facility. (note, the PA entails no changes to the Tracy or Skinner fish facilities).

The new system configuration allows both the Banks PP and the Jones PP to draw water from existing sources and/or from the NCCF. See Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Sheet 82, for a drawing showing the following:

- The Jones PP will continue to draw water from the Middle River via the existing canal. A new control structure will be installed downstream of the Tracy Fish Collection Facility.
- The Jones PP will also be able to draw water from the NCCF via a new canal on the south side of SCCF that connects with the existing Jones PP approach canal. A new control structure will be installed just upstream of the connection.
- The Banks PP will continue to draw water from the CCF (which will become part of the SCCF) via the Skinner Delta Fish Protective Facility, but a new control structure will be installed between the SCCF and the fish facility.
- The Banks PP will also be able to draw water from the NCCF via the same canal used by the Jones PP. That canal will fork near the southwest corner of SCCF; the east branch will go toward the Jones PP, and the south branch will enter a control structure and then connect with the existing Banks PP approach canal.

The new system configuration will require, in addition to the canals and control structures mentioned above, two new siphons, shown in Appendix 3.C, *Conceptual Engineering Report,* *Volume 2,* Sheets 83 and 84. One siphon will convey NCCF water beneath the SCCF outlet canal. The second siphon will convey NCCF water to the Banks PP underneath the Byron Highway and the adjacent Southern Pacific Railroad line. Siphons are proposed because the water level in the canals is higher than the level of either the railroad or the highway. Each siphon will have a control structure fitted with radial gates at the inlet, to regulate upstream WSE and flow through the siphons. In order to isolate a siphon for repairs and inspections, stop logs will also be provided at the downstream end of the siphon barrel.

Control structures, fitted with radial gates, will also be located at the end of the new approach channels to control the amount of flow delivered to Jones PP and Banks PP.

For further detail on the design and configuration of these connections, see the material in the following appendices:

- Appendix 3.A, *Map Book for the Proposed Action*, Sheet 13, provides a photo-aerial map view of the proposed system configuration changes.
- Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 4, *Conveyance System Operations*, describes the existing and proposed facilities and the hydraulic constraints on their operations.
- Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 10, *Culvert Siphons—Shallow Crossings*, describes the siphons and their construction.
- Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Sections 14.1.2, *North Clifton Court Forebay*; 14.1.3, *South Clifton Court Forebay*; 14.2.7, *New Approach Canals to Banks and Jones Pumping Plants*; and 14.2.9, *Banks and Jones Channel Control Structures* describe design and construction of various elements of the Banks and Jones connections. Further details appear in Sections 24.4.3.4, *Canals (Approach Canals to Jones and Banks Pumping Plants)* and 24.4.3.5, *Culvert Siphons*.
- Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheets 82 to 84, are drawings showing the proposed canals, siphons, and control structures.

3.2.6.2 Construction

3.2.6.2.1 NCCF Canal

The new canal delivering water from the NCCF to the Banks PP and Jones PP will originate at NCCF Siphon 1, which will convey water from the NCCF under the existing CCF outlet. The canal will run due south for 2,700 feet, where it will fork; the south fork will pass through Siphon 2 and then join the existing Banks PP approach canal at a location downstream of the existing Skinner Delta Fish Protective Facility. The east fork will parallel the Byron Highway on its north side for 4,900 feet, where it will join the existing Jones PP approach canal at a location downstream of the existing Tracy Fish Collection Facility (Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Sheet 82).

As with SCCF, the embankment crest elevation for the NCCF canal is +24.5 feet, which includes considerations for flood levels and sea-level rise. The canal invert is -5 feet at Siphon 1, dropping gradually to meet the existing invert depths at the points where it connects to the existing Banks and Jones approach canals. The ground beneath the canal will be subject to ground improvement (Section 3.2.10.3, *Ground Improvement*) to depth -50 feet. The canal will be excavated and its embankments constructed using the same procedure described in Section 3.2.5.2.2.1, *Embankments*. That procedure will entail cofferdam installation to provide a dry work area, in places where construction will be contiguous with waters of the state. The canal adjoins fish-bearing waters, and entails pile driving in or near those waters, for approximately 800 feet along the Banks PP approach canal upstream of the Skinner Delta Fish Protective Facility. Apart from this section, construction pile driving associated with the Banks and Jones connections will not occur in or near fish-bearing waters.

3.2.6.2.2 NCCF Siphon 1 (Beneath SCCF Outlet)

NCCF Siphon 1 will convey water from the NCCF beneath the existing CCF outlet (which will become the SCCF outlet) and into the NCCF canal, leading to the Banks PP and Jones PP approach canals (Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Sheet 82). The siphon will be 1,500 feet long and will consist of 3 concrete box culverts, each 23 feet wide and 23 feet tall, with a total conveyance capacity of 15,000 cfs, matching the combined pumping capacity of the Banks PP plus the Jones PP and providing maximum operational flexibility for drawdown of the forebay. It will be provided with radial gates at the inlet, and it will have provision for stop logs at the outlet, enabling dewatering of each culvert if necessary for maintenance.

The siphon will be supported on a pile foundation, and will be constructed within a cofferdam erected in the CCF outlet channel. Concrete structures will be cast-in-place. The CCF outlet channel is a fish-bearing water, so cofferdam installation is subject to timing, noise abatement, and other constraints as identified in Section 3.2.10.11, *Pile Driving,* and in Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM9 Underwater Sound Control and Abatement Plan*. Foundation pile driving, if required, will occur within a dewatered cofferdam and thus will not be an in-water activity. Dewatering of the cofferdam will occur as described in Section 3.2.10.7, *Dewatering,* and will require compliance with Appendix 3.F, *General Avoidance and Minimization Measures, AMM8 Fish Rescue and Salvage Plan*.

The siphon will be constructed in two phases, each phase lasting approximately one year. In the first phase, a temporary cofferdam will be constructed approximately halfway along the length of the siphon and then the area will be dewatered and excavated to the desired lines and grade. Half of the total length of the culvert siphon will be constructed inside the cofferdam, temporarily plugged, and backfilled to the desired waterway bottom configuration. During the second phase, the cofferdam will be re-installed across the other half of the siphon, the area will be dewatered, and the remainder of the siphon will be constructed and backfilled.

The siphon structure footprint will be as shown in the map book (Appendix 3.A, *Map Book for the Proposed Action*, Sheet 13). The area of impact will be up to 250 feet wide. A 15-acre area will be required for construction staging, also as shown in the map book.

3.2.6.2.3 NCCF Siphon 2 (Beneath Byron Highway)

NCCF Siphon 2, which will pass beneath Byron Highway and the adjacent Southern Pacific Railroad line, will be of the same basic design as NCCF Siphon 1, but will be smaller, consisting of 2, 23-foot-square box culverts with a total flow capacity of 10,300 cfs; the siphon will be 1,000 feet long.

Construction of NCCF Siphon 2 will be as described above for NCCF Siphon 1, except that no cofferdam will be needed, no fish-bearing waters will be affected, construction will occur within one year, and reroutes of the Byron Highway and the SPRR will be needed during construction. These reroutes will occur within the temporary impact areas shown in the map book (Appendix 3.A, *Map Book for the Proposed Action*, Sheet 13). The excavation will require dewatering as described in Section 3.2.10.7, *Dewatering*, and the footprint of the construction work and staging areas will be as shown in the map book (Appendix 3.A, Sheet 13).

3.2.6.2.4 Canal Control Structures

Four canal control structures will be constructed (shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheet 82):

- Middle River/Jones PP canal control structure.
- NCCF/Jones PP canal control structure.
- NCCF/Banks PP canal control structure.
- SCCF/Banks PP canal control structure.

Two of these will be constructed in the existing Banks PP and Jones PP approach canals, and the others will be constructed in the forks of the new NCCF canal that lead to the Banks PP and Jones PP approach canals. Use of these control structures will enable operational decisions about how much water to divert to each PP from each water source (i.e., north or south Delta waters). Control structure designs are shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheets 88 and 89. All control structures will be sited in non-fish-bearing waters and will be located downstream of fish-bearing waters. Structures will be cast-in-place concrete structures with ground improvement (Section 3.2.10.3, *Ground Improvement*) used for foundation work. Footprints for construction will range from 476 by 200 feet (Old River/Jones PP canal structure) to 656 by 422 feet (NCCF/Banks PP canal structure); in each case, the footprint will lie within the area otherwise occupied by the canal itself.

3.2.7 Power Supply and Grid Connections

The PA as originally envisioned entailed new pumping plants at each of the new North Delta Diversions, which would have required long runs of high-voltage (250 kV) electrical transmission lines powerlines to establish grid connections. Those powerlines transmission lines resulted in substantial adverse effects on covered listed species due to construction, maintenance, and bird strike potential of the operational lines. Redesign to eliminate the intake pumping plants has greatly reduced the electrical demand of the operating project. During construction, the PA will rely primarily upon electrical power sourced from the grid via temporary transmission lines to serve the TBMs and other project components. Use of diesel generators or other portable electrical power sources will be minimized due to the adverse air quality impacts of onsite power generation. Once operational, the largest power consumption will be for the pumping plant at CCF, where a grid connection will be available nearby. The intakes and IF will have relatively low operational power demands, which will be met via relatively short and lower-voltage connections to nearby grid sources.

3.2.7.1 Design

Electric power will be required for intakes, pumping plants, operable barriers, boat locks, and gate control structures throughout the proposed conveyance alignment. Temporary power will also be required during construction of water conveyance facilities.

New temporary electrical transmission lines to power construction activities will be built prior to construction of permanent transmission lines to power conveyance facilities. These lines will extend existing power infrastructure (lines and substations) to construction areas, generally providing electrical capacity of 12 kV at work sites. Main shafts for the construction of deep tunnel segments will require the construction of 69 kV temporary electrical transmission lines. Both temporary and permanent electrical transmission lines serving the PA are shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheet 94. Temporary and permanent transmission lines are also shown in the map book, Appendix 3.A, *Map Book for the Proposed Action*, Sheets 1 to 15.

Transmission lines to construct and operate the water conveyance facilities will connect to the existing grid in two different locations. The northern point of interconnection will be located north of Lambert Road and west of Highway 99 (Appendix 3.A, *Map Book for the Proposed Action*, Sheet 4). From here, a new 230 kV transmission line will run west, along Lambert Road, where one segment will run south to the IF on Glannvale Tract, and one segment will run north to connect to a substation where 69 kV lines will connect to the intakes. At the southern end of the conveyance alignment, the point of interconnection will be in one of two possible locations: southeast of Brentwood near Brentwood Boulevard (Appendix 3.A, sheet 15) or adjacent to the Jones Pumping Plant (Appendix 3.A, sheet 13). While only one of these points of interconnection will be used, both are depicted in figures, and the effects of constructing transmission lines leading from both sites are combined and accounted for in the effects analysis. A 230 kV line will extend from one of these locations to a tunnel shaft northwest of CCF, and will then continue north, following tunnel shaft locations, to Bouldin Island. Lower voltage lines (Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheet 94) will be used to power intermediate and reception shaft sites between the main drive shafts. Because the power required during operation of the water conveyance facilities will be much less than that required during construction, and because it will largely be limited to the pumping plants, all of the new electrical transmission lines between the IF and the CCF will be temporary.

An existing 500kV line, which crosses the area proposed for expansion of the CCF, will be relocated to the southern end of the expanded forebay in order to avoid disruption of existing power facilities. No interconnection to this existing line is proposed.

Temporary substations will be constructed at each intake, at the IF, and at each of the launch shaft locations. To serve permanent pumping loads, a permanent substation will be constructed adjacent to the pumping plants at CCF, where electrical power will be transformed from 230 kV to appropriate voltages for the pumps and other facilities at the pumping plant site. For operation of the three intake facilities and IF, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Utility interconnections are planned for completion in time to support most construction activities, but for some activities that need to occur early in the construction sequence (e.g., constructing raised pads at shaft locations and excavating the shafts), onsite generation may be required on an interim basis. As soon as the connection to associated utility grid power is completed, electricity from the interim onsite generators will no longer be used.

3.2.7.2 Construction

Selection of transmission line alignments is subject to Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM12 Transmission Line Design and Alignment*, which identifies mandatory habitat avoidance measures and defines other aspects of transmission line design and routing. Temporary lines will be constructed from existing facilities to each worksite where power will be necessary for construction, following the alignments shown in Appendix 3.A, *Map Book for the Proposed Action*. Construction of new transmission lines will require three phases: site preparation, tower or pole construction, and line stringing. For 12 kV and 69 kV lines, cranes will be used during the line stringing phase. For stringing transmission lines between 230 kV towers, cranes and helicopters will be used.

Construction of 230 kV and 69 kV transmission lines will require a corridor width of 100 feet and, at each tower or pole, a 100- by 50-foot area will be required for construction laydown, trailers, and trucks. Towers or poles will be located at intervals of 450 feet for 69kV lines, and 750 feet for 230kV lines. Construction will also require about 350 feet along the corridor (measured from the base of the tower or pole) at conductor pulling locations, which includes any turns greater than 15 degrees and/or every 2 miles of line. Construction will also require vehicular access to each tower or pole location. Vehicular access routes have not yet been determined, but will use existing routes to the greatest extent practicable, and are likewise subject to the siting constraints of AMM12.

For construction of 12 kV lines (when not sharing a 69 kV line), a corridor width of 25–40 feet will be necessary, with 25 feet in each direction along the corridor at each pole. Construction will also require 200 feet along the corridor (measured from the base of the pole) and a 50-foot-wide area at conductor pulling locations, which will include any turns greater than 15° and/or every 2 miles of line. For a pole-mounted 12 kV/480 volt transformer, the work area will only be that normally used by a utility to service the pole (typically about 20 by 30 feet adjacent to pole). For pad-mounted transformers, the work area will be approximately 20 by 30 feet adjacent to the pad (for construction vehicle access). Construction of 12kV lines will also require vehicular access to each tower or pole location. Vehicular access routes have not yet been determined, but will use existing routes to the greatest extent practicable, and are likewise subject to the siting constraints of AMM12.

3.2.8 Head of Old River Gate

3.2.8.1 Design

An operable gate will be constructed at the head of Old River. One purpose of the HOR gate is to keep outmigrating salmonids in the mainstem of the San Joaquin River and to prevent them from moving into the south Delta via Old River; another purpose is to improve water quality in the San Joaquin River (particularly the Stockton Deep Water Ship Channel) in the fall by keeping more water in the mainstem San Joaquin River. The barrier will be located at the divergence of the head of Old River and the San Joaquin River, as shown in Appendix 3.A. *Map Book for the Proposed Action*, Sheet 16; this location is approximately 300 feet west of the temporary rock barrier that is annually installed and removed under current conditions. Preliminary design of the HOR gate specifies that it will be 210 feet long and 30 feet wide overall, with top elevation of +15 feet (Appendix 3.C, *Conceptual Engineering Report, Volume 2*, Sheets 95 and 96). Design and construction of the structure are further detailed in Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Section 17, *Operable Barrier*.

This structure will include seven bottom-hinged gates, totaling approximately 125 feet in length. Other components associated with this barrier are a fish passage structure, a boat lock, a control building, a boat lock operator's building, and a communications antenna. Appurtenant components include floating and pile-supported warning signs, water level recorders, and navigation lights. The barrier will also have a permanent storage area (180 by 60 feet) for equipment and operator parking. Fencing and gates will control access to the structure. A propane tank will supply emergency power backup.

The boat lock will be 20 feet wide and 70 feet long. The associated fish passage structure will be designed according to guidelines established by NMFS and USFWS, and will be 40 feet long and 10 feet wide, constructed with reinforced concrete. Stop logs will be used to close the fish passage structure when not in use to protect it from damage. When the gate is partially closed, flow will pass through the fish passage structure traversing a series of baffles. The fish passage structure is designed to maintain a 1-foot-maximum head differential across each set of baffles. The historical maximum head differential across the gate is 4 feet; therefore, four sets of baffles will be required. The vertical slot fish passage structure will be entirely self-regulating and will operate without mechanical adjustments to maintain an equal head drop through each set of baffles regardless of varying upstream and downstream water surface elevations.

3.2.8.2 Construction

The operable barrier will be sited within the confines of the existing channel, with no levee relocation. To ensure the stability of the levee, a sheet pile retaining wall will be installed in the levee where the operable barrier connects to it.

Construction will comply with relevant avoidance and minimization measures detailed in Appendix 3.F, *General Avoidance and Minimization Measures*, including:

- *AMM2 Construction Best Management Practices and Monitoring*
- *AMM3 Stormwater Pollution Prevention Plan*

- *AMM4 Erosion and Sediment Control Plan*
- *AMM5 Spill Prevention, Containment, and Countermeasure Plan*
- *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*
- *AMM7 Barge Operations Plan*
- *AMM8 Fish Rescue and Salvage Plan*
- *AMM9 Underwater Sound Control and Abatement Plan*
- *AMM11 Design Standards and Building Codes*
- *AMM14 Hazardous Materials Management*
- *AMM15 Construction Site Security*
- *AMM16 Fugitive Dust Control*
- *AMM17 Notification of Activities in Waterways*

3.2.8.2.1 Dredging

Dredging to prepare the channel for gate construction will occur along 500 feet of channel, from 150 feet upstream to 350 feet downstream from the proposed barrier. A total of up to 1,500 cubic yards of material will be dredged. Dredging would occur at a time between August 1 and November 30, lasting approximately 15 days, and will otherwise occur as described in Section 3.2.10.8, *Dredging and Riprap Placement*, and subject to the constraints described in Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*. Dredging may use either a hydraulic or a sealed clamshell dredge, in either case operated from a barge in the channel.

Dredging is proposed to deviate from the procedure described in AMM6 in one respect. Assuming that on-land disposal of dredged material is determined by the appropriate review authorities to be suitable, the material will be spread on adjacent agricultural fields in a layer approximately 1-foot thick, subject to landowner approval. If required to use an existing dredged material disposal site, the site currently used for dredged material disposal in association with temporary rock barrier placement and removal will be used. This site, at the junction of Old and Middle rivers, is shown in Appendix 3.A, *Map Book for the Proposed Action*, Sheet 16.

3.2.8.2.2 Gate Construction

The HOR gate will be constructed using cofferdam construction, which will create a dewatered construction area for ease of access and egress. Construction will occur in two phases. The first phase will include construction of half of the operable barrier, masonry control building, operator's building, and boat lock. The second phase will include construction of the second half of the operable barrier, the equipment storage area, and the remaining fixtures, including the communications antenna and fish passage structure. The construction period is estimated to be up to 32 months, with a maximum construction crew of 80 people. A temporary work area of up to 15 acres will be sited in the vicinity of the barrier for such uses as storage of materials, fabrication of concrete forms or gate panels, placing of stockpiles, office trailers, shops, and construction equipment maintenance. The operable barrier construction site, including the temporary work area, has for many years been used for seasonal construction and removal of a temporary rock barrier, and all proposed work will occur within the area that is currently seasonally disturbed for temporary rock barrier construction. Site access roads and staging areas used in the past for rock barrier installation and removal will be used for construction, staging, and other construction support facilities for the proposed barrier.

All in-water work, including the construction of cofferdams, sheetpile walls and pile foundations, and placing rock bedding and stone slope protection, will occur during the approved in-water work window established by CDFW, NMFS, and USFWS (currently August 1 to November 30) to minimize effects on fish. All other construction will take place from a barge or from the levee crown and will occur throughout the year.

The construction of the cofferdam and the foundation for the HOR gate will require in-water pile driving, performed as described in Section 3.2.10.11, *Pile Driving*. The installation of the cofferdam will require approximately 550 sheet piles. Approximately 15 piles, a maximum of 50 feet long and to a depth of 13.5 to 15 feet, will be set per day with up to 700 strikes per pile over an estimated 40 day period. Sheet piles will be installed starting with a vibratory hammer, then switching to impact hammer if refusal is encountered before target depths. The installment of the foundation for the operable barrier will require 100 14-inch steel pipe or H-piles to be set with 1 pile driver on site. Approximately 15 piles, a maximum of 50 feet long and to a depth of 13.5 to 15 feet, will be set per day with up to 1,050 strikes per pile over an estimated 7 day period. Foundation pile driving may be done in the dry or in the wet. It is possible that cast-in-drilled-hole concrete foundation piles will be used, in which case pile driving of foundation piles will not be required, but that determination awaits results of geotechnical analysis and further design work; the effects analysis assumes that impact driving will occur.

The first construction phase involves installing a cofferdam in half of the channel and then dewatering the area (see Section 3.2.10.7, *Dewatering*). The cofferdam will remain in the water until the completion of half of the gate. The cofferdam will then be flooded, and removed or cut off at the required invert depth, and another cofferdam installed in the other half of the channel. In the second phase, the gate will be constructed using the same methods, with the cofferdam either removed or cut off. Cofferdam construction will in both phases begin in August and last approximately 35 days. Construction has been designed so that the south Delta temporary barriers at this site can continue to be installed and removed as they are currently until the permanent gates are fully operable, however, the installation and removal of the temporary barriers is not part of the PA.

3.2.9 Temporary Access and Work Areas

Construction work areas for the conveyance facilities will include areas for construction equipment and worker parking, field offices, a warehouse, maintenance shops, equipment and materials laydown and storage, and stockpiled topsoil strippings saved for reuse in landscaping, as discussed in Section 3.2.10.10, *Landscaping and Associated Activities*.

Surface vehicular access will be needed for construction of all water conveyance facilities. Geotechnical exploration sites on water or on agricultural lands can be accessed by suitable vehicles, but all other construction sites will require road access. All-weather roads (asphalt paved) will be needed for year-round construction at all facilities, while dry-weather roads (minimum 12 inch thick gravel or asphalt paved) can be used for construction activities restricted to the dry season. Dust abatement will be addressed in all construction areas as provided by Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM16 Fugitive Dust Control*. Heavy construction equipment, such as diesel-powered dozers, excavators, rollers, dump trucks, fuel trucks, and water trucks will be used during excavation, grading, and construction of access/haul roads. Detour roads will be needed for all intakes and for traffic circulation around the work areas.

Temporary barge unloading facilities will be constructed, used, and decommissioned as detailed in Section 3.2.10.9, *Barge Operations*.

As described in Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 24.3.4 *Concrete Batch Plants, Pug Mills, and Cement Storage*, temporary concrete batch plants will be needed due to the large amount of concrete required for construction and the schedule demands of the PA. A batch plant is proposed for siting at each TBM launch shaft or TBM retrieval shaft location (listed in Table 3.2-9). The area required for these plants will be within the construction footprint for these facilities as shown in Appendix 3.A, *Map Book for the Proposed Action*, but precise facility siting within the construction site has not yet been determined. Other facilities to be co-located with concrete batch plants within the construction site footprint will include fuel stations, pug mills, soil mixing facilities, cement storage, and fine and coarse aggregate storage. Fuel stations will be needed for construction equipment fueling. Pug mills will be needed for generating processed soil materials used at the various sites. Soil mixing facilities will be needed for some of the muck disposal and for ground improvement activities. Cement and required admixtures will be stored at each site to support concrete, slurry walls, ground improvement, soil mixing, and other similar needs. TBM launch sites may also contain facilities for production of precast tunnel segments. If constructed, these will be located adjacent to concrete plants, and will also be within the construction site footprint as shown in Appendix 3.A. It is likely that each precast segment plant would require approximately 10 acres for offices, concrete plant, materials storage, and casting facilities.

All storage and processing areas will be properly contained as required for environmental and regulatory compliance. In addition, work at all sites will be required to comply with terms of all applicable avoidance and minimization measures listed in Appendix 3.F, *General Avoidance and Minimization Measures*.

3.2.10 Common Construction-Related Activities

3.2.10.1 Clearing

Essentially all lands within the temporary and permanent impact footprint are assumed to be cleared; the only exceptions are lands that are underlain by a structure (TBM-excavated tunnels), or that are beneath a structure (electrical transmission line wires, between the towers), or that are underwater (in association with the Delta intakes, the CCF, the Banks and Jones connections, and the HOR gate). Grading will be performed where required by the project design. Clearing and grading will be performed using standard equipment such as bulldozers. Topsoil from cleared areas will be stockpiled and reused at the close of construction (see Section 3.2.10.10, *Landscaping and Associated Activities*).

Clearing will be the principal conveyance construction impact on listed species of wildlife, resulting in habitat removal as well as potential effects on animals. Impacts due to clearing and grading will be treated as permanent when they persist for more than one year, which will be the case for all conveyance construction components except geotechnical exploration (see Section 3.2.1, *Geotechnical Exploration*, for explanation). Clearing work will be subject to relevant avoidance and minimization measures including *AMM2 Construction Best Management Practices and Monitoring, AMM3 Stormwater Pollution Prevention plan, AMM4 Erosion and Sediment Control Plan, AMM5 Spill Prevention, Containment, and Countermeasure Plan, AMM14 Hazardous Material Management, AMM16 Fugitive Dust Control*, and the appropriate species-specific measures applicable to modeled habitat at the construction site (see Appendix 3.F, *General Avoidance and Minimization Measures,* for full detail on these measures).

3.2.10.2 Site Work

Site work will occur within previously cleared areas. It will include construction of site access, establishment of stockpiles and staging and storage areas, site fencing, onsite electric (such as a substation), and erection of temporary construction buildings (primarily offices and storage). Equipment used during site work mainly will include large vehicles and vehicle-mounted equipment such as cranes, which have the potential to create noise and light comparable to other construction equipment. Performance of site work will entail the risk of spills associated with vehicles and with materials transport, and the potential for erosion or stormwater effects associated with cleared areas. These risks will be minimized by implementing all of the same avoidance and minimization measures named above for clearing and grading work.

3.2.10.3 Ground Improvement

Ground improvement will occur within previously cleared areas. Ground improvement serves to improve existing substrates at a site so that they can bear heavy loads and otherwise support the design of the proposed construction. Activities performed in ground improvement will include drilling, and injection of materials. Ground improvement commonly will occur in association with grading (Section 3.2.10.1, *Clearing*) and dewatering (Section 3.2.10.7, *Dewatering*). Equipment used in ground improvement will include large vehicle-mounted drilling and injection equipment with potential to create noise and light comparable to other construction equipment. Performance of ground improvement will entail the risk of spills associated with vehicles and with materials transport. These risks will be minimized by implementing avoidance and minimization measures *AMM2 Construction Best Management Practices and Monitoring, AMM5 Spill Prevention, Containment, and Countermeasure Plan*, and *AMM14 Hazardous Material Management*.

3.2.10.4 Borrow Fill

The total amount of borrow material for engineered fill used in all aspects of the PA will be approximately 21 million cy (as bank cubic yards). This total amount will include approximately 3 million cy for tunnel shaft pads, 6.5 million cy for the CCF embankments, 2 million cy for the IF embankments, 6.7 million cy at the three intake sites (approximately 2 million cy each), and 2.6 million cy at the CCPP site. Source locations for this borrow material will be within the work area footprint shown in Appendix 3.A, *Map Book for the Proposed Action*. Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 21, *Borrow Sites,* describes the criteria for selection of borrow sites and identifies suitable geological materials that could be used as sources of borrow material. Apart from engineering specifications, the criteria for selection of borrow sites will include the following:

- Borrow material should not require post-excavation processing (other than moisture conditioning).
- Borrow material should be exposed at surface and require no, or very limited, overburden removal.
- Borrow areas should be selected to minimize the impact or encroachment on existing surface and subsurface development and environmentally sensitive areas as much as possible.

3.2.10.5 Fill to Flood Height

Permanent levees, embankments, and fills on which structures are sited at the intakes, the IF, the CCPP, and the Banks and Jones connections, will be filled to the design flood height, which is the level of the 0.5% annual exceedance flood (i.e., the 200-year flood), plus an 18-inch allowance for sea level rise. Since current ground elevations at most of the construction sites are at or slightly below sea level, substantial volumes of material will be needed to construct these fills, and the weight of this material will cause substantial compaction and settling in the underlying ground. Compaction and settling issues will be addressed by ground improvement (Section 3.2.10.3, *Ground Improvement*) and dewatering wells (Section 3.2.10.7, *Dewatering*), which are used to reduce hydraulic pressure within the sediments and accelerate the rate of compaction.

Fills to flood height will occur at sites that have previously been cleared. The fill material will be sourced from borrow sites (Section 3.2.10.4, *Borrow Fill*) and transported using conventional earthmoving equipment, or possibly conveyors if the distances involved are short and are entirely within the area cleared for facility construction. Performance of this work will entail the risk of spills associated with vehicles and with materials transport, and the potential for erosion or stormwater effects associated with cleared areas. These risks will be minimized by implementing all of the same avoidance and minimization measures named above for clearing and grading work (Section 3.2.10.1, *Clearing*).

3.2.10.6 Dispose Spoils

Spoils will include materials removed from the construction area and placed for nonstructural purposes. The principal sources of spoils will be materials removed during excavation of tunnels (RTM) and dredging of the CCF. Secondary sources will include structural excavations during facilities construction.

Dredged material composition is not currently determined. Composition, potential contamination, and resulting considerations in disposition of this material are described in *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F, *General Avoidance and Minimization Measures*). Properties and disposition of RTM are detailed below.

RTM is the by-product of tunnel excavation using a TBM. The RTM will be a plasticized mix consisting of soil cuttings, air, water, and may also include soil conditioning agents. Soil conditioning agents such as foams, polymers, and bentonite may be used to make soils more suitable for excavation by a TBM. Soil conditioners are non-toxic and biodegradable. During tunnel construction the daily volume of RTM withdrawn at any one shaft location will vary, with an average volume of approximately 6,000 cubic yards per day. It is expected that the transport of the RTM out of the tunnels and to the RTM storage areas will be nearly continuous during mining or advancement of the TBM. The RTM will be carried on a conveyor belt from the TBM to the base of the launch shaft. The RTM will be withdrawn from the tunnel shaft with a vertical conveyor and placed directly into the RTM work area using another conveyor belt system. From the RTM work area, the RTM will be roughly segregated for transport to RTM storage and water treatment (if required) areas as appropriate. Appendix 3.A, *Map Book for the Proposed Action*, Sheets 1–5 and 7–15 show conveyor belt and RTM storage area locations.

RTM must be dewatered in order to stabilize it for long-term placement in a storage area. Atmospheric drying by tilling and rotating the material, combined with subsurface collection of excess liquids will typically be sufficient to render the material dry and suitable for long-term storage or reuse. Leachate will drain from ponds to a leachate collection system, then be pumped to leachate ponds for possible additional treatment. Disposal of the RTM decant liquids will require permitting in accordance with NPDES and Regional Water Quality Control Board regulations. A retaining dike and underdrain liquid collection system (composed of a berm of compacted soil, gravel and collection piping, as described below), will be built at each RTM storage area. The purpose of this berm and collection system will be to contain any liquid runoff from the drying material. The dewatering process will consist of surface evaporation and draining through a drainage blanket consisting of rock, gravel, or other porous drain material. The drainage system will be designed per applicable permit requirements. Treatment of liquids (primarily water) extracted from the material could be done in several ways, including conditioning, flocculation, settlement/sedimentation, and/or processing at a package treatment plant to ensure compliance with discharge requirements.

Disposition and reuse of all spoils will be subject to *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F, *General Avoidance and Minimization Measures*). That AMM prescribes criteria for the selection of spoils storage areas;

preparation of storage areas; and the procedures for draining, chemical characterization, and treatment of spoils, including how any existing contamination of the spoils will be addressed.

Table 3.2-13 provides a summary of how spoils would be stored, and Table 3.2-14 summarizes the disposition of spoils material. Designated spoils storage areas are shown in the map book, Appendix 3.A, *Map Book for the Proposed Action*. RTM will be the largest source of this material, and disposition of that material will be, on an acreage basis, one of the largest impacts of the PA. Dredged material from the CCF will be the second largest source of spoils.

Table 3.2-13. Spoils and Reusable Tunnel Material Storage: Key Construction Information

- Final locations for storage of spoils, RTM, and dredged material will be selected based on the guidelines presented in *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F, *General Avoidance and Minimization Measures*).
- Conventional earthmoving equipment, such as bulldozers and graders, would be used to place the spoil. Some spoil, with the exception of RTM, may be placed on the landside toes of canal embankments and/or setback levees.
- Spoils may temporarily be placed in borrow pits or temporary spoil laydown areas pending completion of embankment or levee construction. Borrow pits created for this project will be the preferred spoil location.
- RTM that may be have potential for re-use in the PA (such as levee reinforcement, embankment or fill construction) will be stockpiled. The process for testing and reuse of this material is described further in *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F, *General Avoidance and Minimization Measures*).
- A berm of compacted imported soil will be built around the perimeter of the RTM storage area to ensure containment. The berm will conform to USACE guidelines for levee design and construction.
- RTM will be stacked to an average depth of 10 ft; precise stacking depth will vary across disposal sites.
- Maximum capacity of RTM storage ponds will be less than 50 af.
- RTM areas may be subdivided by a grid of interior earthen berms in RTM ponds for dewatering.
- Dewatering will involve evaporation and a drainage blanket of 2 ft-thick pea gravel or similar material placed over an impervious liner.
- Leachate will drain from ponds to a leachate collection system, then be pumped to leachate ponds for possible additional treatment.
- Transfer of RTM solids to disposal areas may be handled by conveyor, wheeled haul equipment, or barges, at the contractor's discretion.
- Where feasible, the invert of RTM ponds will be a minimum of 5 ft above seasonal high groundwater table.
- An impervious liner will be placed on the invert and along interior slopes of berms, to prevent groundwater contamination.
- RTM will not be compacted.
- Spoil placed in disposal areas will be placed in 12-inch lifts, with nominal compaction.
- The maximum height for placement of spoil is expected to be 6 ft above preconstruction grade (10 ft above preconstruction grade for sites adjacent to CCF), and have side slopes of 5H:1V or flatter.
- After final grading of spoil is complete, the area will be restored based on site-specific conditions following project restoration guidelines.

Table 3.2-14. Spoils Disposition, Volumes and Acreages

Disposal Site	Volume (cy)	Disposal Area (acres)
RTM and dredged material disposal site near Intake 2	1,020,000	45.6
RTM disposal sites near IF	9,060,000	404.7
RTM disposal site on Bouldin Island	8,340,000	1,208.8
RTM and dredged material disposal sites near CCF	5,370,000 (RTM) 7,000,000 (dredged)	899.6
TOTAL	**30,790,000**	**2,558.7**

RTM is expected to be reusable, suitable as engineered fill for varied applications, and also suitable for restoration work such as tidal habitat restoration. However, end uses for that material have not yet been identified. It is likely that the material will remain in designated storage areas for a period of years before a suitable end use is identified, and any such use will be subject to environmental evaluation and permitting independent of the PA. Therefore disposition of RTM is assumed to be permanent, and future reuse of this material is not part of the PA.

Materials removed during surface excavation and dredging, or from clearing of the sedimentation basins, may also be reusable. Much of this material is expected to have a high content of fines and/or organic matter and thus may not be suitable for use as engineered fill, but may be suitable for use in habitat restoration projects. As with RTM, no end uses for this material have yet been identified, such use is not part of the PA, and the material will be permanently disposed in the designated RTM and dredged material storage areas. The exception to this statement is topsoil removed during clearing for construction. Topsoil is not classified as spoils; it will be stockpiled and reused for landscaping and restoration, as described in Section 3.2.10.10, *Landscaping and Associated Activities*.

Sacramento River sediment removed from the water column at the intake sedimentation basins will be reused as described above. However, to the maximum extent practicable, the first and preferred disposition of this material will be to reintroduce it to the water column in order to maintain Delta water quality (specifically, turbidity, as a component of Delta Smelt critical habitat; as described in Section 6.1.3.5.3 *Sediment Removal (Water Clarity)*). DWR will collaborate with USFWS and CDFW to develop and implement a sediment reintroduction plan that provides the desired beneficial habitat effects of maintained turbidity while addressing related permitting concerns (the proposed sediment reintroduction is expected to require permits from the Central Valley Regional Water Quality Control Board and USACE). USFWS and NMFS will have approval authority for this plan and for monitoring measures, to be specified in the plan, to assess its effectiveness.

3.2.10.7 Dewatering

Due to the generally high groundwater table in the Delta, the location of much of the construction alignment at below-sea-level elevations, and the extensive construction of below-grade structures, dewatering will be needed for nearly all components of conveyance construction. “Dewatering” as used in this document refers to the removal of water from a work area or from excavated materials, and discharge of the removed water to surface waters in accordance with the terms and conditions of a valid NPDES permit and any other applicable Central Valley Regional Water Quality Control Board requirements.

Dewatering will generally be accomplished by electrically powered pumps, which will either dewater via groundwater wells (thereby drawing down the water table to minimize the amount of water entering a work area) or by direct removal of water from an excavation or other work area (such as a cofferdam or the bottom of a completed tunnel access shaft). Dewatering of excavated materials would be accomplished in a similar manner, by stockpiling the material and allowing the water to infiltrate to an impervious layer such as a liner or the bottom of a storage tank, and then pumping or draining it prior to treatment or discharge. At most conveyance facilities, dewatering will be an ongoing activity throughout most of the period of construction activity.

Dewatering water is subject to contamination. Groundwater at a site may be contaminated due to a preexisting condition, such as elevated salinity; or contaminants may be introduced by construction activity. The most frequent contaminants are expected to be alkalinity caused by water contact with curing concrete or ground improvement materials, or viscous binders used in drilling mud or to treat sediments being excavated by a TBM. There is also the potential for accidental contamination due to spillage of construction materials such as diesel fuel. Dewatering waters will be stored in sedimentation tanks; tested for contaminants and treated in accordance with permit requirements; and discharged to surface waters. Treatment of the removed groundwater has not yet been determined and could include conditioning, flocculation, settlement/sedimentation, and/or processing at a package treatment plant. Velocity dissipation structures, such as rock or grouted riprap, will be used to prevent scour where dewatering discharges enter the river. Location of dewatering discharge points will be determined at time of filing for coverage under the NPDES general permit or before start-up of discharge as appropriate. Additional information will be developed during design and the contractor will be required to comply with permit requirements.

3.2.10.8 Dredging and Riprap Placement

For the purposes of this analysis, dredging and riprap placement are defined to be activities that occur in fish-bearing waters. This definition thus excludes, for instance, dredging that occurs in the sedimentation basins at the intakes, or riprap placement that occurs in a dewatered area.

Dredging is subject to constraints imposed by the Federal permit for the activity, and further would be conducted as specified in Appendix 3.F, *General Avoidance and Minimization Measures, AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material.* AMM6 requires preparation of a sampling and analysis plan; compliance with relevant NPDES and SWRCB requirements; compliance with applicable in-water work windows established by CDFW, NMFS, and USFWS[4]; and other measures intended to minimize risk to listed species.

[4] Proposed in-water work windows vary within the Delta: June 1 to October 31 at the NDDs, June 1 to November 30 at the CCF, and August 1 to November 30 at the HOR Gate.

Riprap placement would also comply with relevant NPDES and SWRCB requirements; and with applicable in-water work windows established by CDFW, NMFS, and USFWS[5].

3.2.10.9 Barge Operations

Contractors will use barges to deliver TBM components to TBM launch sites, and may also use barges to deliver other heavy or bulky equipment or materials to those sites, or to haul such materials from those sites.

This activity will include barge landing construction, barge operations in the river, tug operations, and barge landing removal.

Barge docks will be needed at each TBM launch shaft site, i.e., Intake 2, the IF, Bouldin Island, and the CCF. Locations of these docks are shown in the map books, Appendix 3.A, *Map Book for the Proposed Action*. Locations are approximate; precise siting and dimensions of these docks are to be determined by DWR’s construction contractors. Barge docks are also likely to be needed to serve safe haven access sites, if they will be sited in areas where existing surface roads will not be adequate to transport the equipment needed for shaft construction. Barge docks may also be needed, at contractors’ discretion, at the Intake 3 and Intake 5 construction sites, at the Staten Island TBM retrieval shaft, and at the Banks and Jones Connections construction sites. Further points characterizing the barge docks will include the following items.

- Barges could be used for pile-driving rigs and barge-mounted cranes; suction dredging equipment; transporting RTM; crushed rock and aggregate; pipeline sections, etc.; post-construction underwater debris removal; and other activities.

- Barges will be required to use existing barge docks where possible and maintain a minimum waterway width greater than 100 ft (assuming maximum barge width of 50 ft).

- The cumulative physical extent of all barge dock sites will be approximately 33 acres.

- Each dock site will have an approximately 300 ft by 50 ft, pile-supported dock to provide construction access and construction equipment to portal sites.

- Each dock will be supported by 24-inch steel piles placed approximately every 20 ft under the dock, for a total of up to 4 piles (3 rows of 16 piles each)[6]. In addition, the dock perimeter will be sheetpiled, with backfill; thus the construction procedure involves the sequence sheetpile placement, then fish rescue and site dewatering, then round pile placement, and then backfill.

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[5] Proposed in-water work windows vary within the Delta: June 1 to October 31 at the NDDs, June 1 to November 30 at the CCF, and August 1 to November 30 at the HOR Gate.

[6] Note that this description is inconsistent with that presented in Appendix 3.B. The engineering staff have stated that the approach presented in Appendix 3.B has been superseded by this approach.

- Impact pile driving may take up to an average of 700 strikes per pile, depending on hammer type and subsurface conditions (see Section 3.2.10.11, *Pile Driving,* for further discussion of pile driving).

- Each dock will be in use during the entire construction period at each location, five to six years. All docks will be removed at the end of construction. Sheet and round pile will either be removed, or cut at the mudline.

See Appendix 3.B, *Conceptual Engineering Report*, *Volume 1*, Section 23.3, *Barge Traffic and Landing Facilities*, for further discussion of barge traffic and barge docks.

- All barge operations will be required to comply with the provisions of a barge operations plan, as specified in Appendix 3.F, *General Avoidance and Minimization Measures, AMM7 Barge Operations Plan*. As there stated, the barge operations plan will be subject to review and approval by DWR and the other resource agencies (CDFW, NMFS, and USFWS included), and will address the following.
    - Bottom scour from propeller wash.
    - Bank erosion or loss of submerged or emergent vegetation from propeller wash and/or excessive wake.
    - Sediment and benthic community disturbance from accidental or intentional barge grounding or deployment of barge spuds (extendable shafts for temporarily maintaining barge position) or anchors.
    - Accidental material spillage.
    - Hazardous materials spills (e.g., fuel, oil, hydraulic fluids).

3.2.10.10 Landscaping and Associated Activities

The construction phase at most conveyance facilities will conclude with landscaping. Revegetation of disturbed areas will be determined in accordance with guidance given by DWR's WREM No. 30a, Architectural Motif, State Water Project and through coordination with local agencies through an architectural review process. This guidance from DWR WREM No 30a is set forth as follows.

> If possible, the natural environment will be preserved. If not possible, a re-vegetation plan will be developed. Landscaping plans may be required if deemed appropriate to enhance facility attractiveness, for the control of dust/mud/wind/unauthorized access, for reducing equipment noise/glare, for screening of unsightly areas from visually sensitive areas. Planting will use low water-use plants native to the Delta or the local environment, with an organic/natural landscape theme without formal arrangements. For longevity and minimal visual impact, low maintenance plants and irrigation designs will be chosen. Planting plans will use native trees, shrubs or grasses and steps will be taken to avoid inducing growth of non-native invasive plant species/CA Plant

> Society weedy species[7]. Planting of vegetation will be compatible with density and patterns of existing natural vegetation areas and will be placed in a manner that does not compromise facility safety and access. Planting will be done within the first year following the completion of the project and a plant establishment plan will be implemented.

Landscaping in cleared areas will reuse topsoil stockpiled at the time of site clearing. Site revegetation plans will be developed for restoration of areas disturbed by PA activities.

Other activities occurring at the conclusion of construction will include site cleanup, installation of operational lighting, and installation of security fencing.

Site cleanup will consist of removal of all construction equipment, materials, and debris from the site. Construction debris will be disposed at a regional facility authorized to receive such materials.

Operational lighting will be needed at the intakes, the IF, the consolidated pumping plant at CFF, at the HOR gate, and at the control structures associated with the Banks and Jones connections; operational lighting will also continue to be provided at the existing CVP/SWP facilities. Lighting for the proposed facilities will be designed in accordance with guidance given by DWR's WREM No. 30a, Architectural Motif, State Water Project and through coordination with local agencies through an architectural review process. This guidance is set forth as follows.

> All artificial outdoor lighting is to be limited to safety and security requirements. All lighting is to provide minimum impact on the surrounding environment and is to be shielded to direct the light only towards objects requiring illumination. Lights shall be downcast, cut-off type fixtures with non-glare finishes set at a height that casts low-angle illumination to minimize incidental spillover of light onto adjacent properties, open spaces or backscatter into the nighttime sky. Lights shall provide good color rendering with natural light qualities with the minimum intensity feasible for security, safety and personnel access. All outdoor lighting will be high pressure sodium vapor with individual photocells. Lighting will be designed per the guidelines of the Illuminating Engineering Society (IES). Additionally, all lights shall be consistent with energy conservation and are to be aesthetically pleasing. Lights will have a timed on/off program or will have daylight sensors. Lights will be programmed to be on whether personnel is present or not.

The intakes, the IF, the consolidated pumping plant at CFF, and the HOR gate will be provided with security fencing to prevent unauthorized public access. Security camera systems and intrusion alarm systems will be located at these sites. Admission to the sites and buildings will require credentialed entry through access control gates and secure doors, respectively. At each

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[7] This text refers to plant species identified as invasive by the California Invasive Plant Council. For further information see http://www.cal-ipc.org/.

site, the fence line will be coincident with or within the area of permanent impact shown in Appendix 3.A, *Mapbook for the Proposed Action*.

3.2.10.11 Pile Driving

Sheet pile and tubular steel pile driving will be required for intake construction, barge dock construction, embankment work at CCF, the Banks and Jones connections, and construction of the HOR gate. Both vibratory and impact pile driving are expected to occur at each of these locations, as structural requirements call for impact pile driving to refusal.

In-water pile driving will be subject to abatement, hydroacoustic monitoring, and compliance with timing limitations as described in Appendix 3.F, *General Avoidance and Minimization Measures, AMM9 Underwater Sound Control and Abatement Plan*.

The sheetpile cofferdams proposed at the Delta intakes, the CCF, and at the HOR gate are planned to use vibratory pile driving for approximately 80–90% of the time, depending on the specific site conditions. Piles will be installed using vibratory methods or other non-impact driving methods for the intakes, wherever feasible, to minimize adverse effects on fish and other aquatic organisms. However, the degree to which vibratory driving can be performed effectively is unknown at this time due to as yet undetermined geologic conditions at the construction sites. The remaining pile driving would be conducted using an impact pile driver. Once constructed, if the foundation design for either the Delta intakes or HOR gate requires pile driving, such work would be conducted from within the cofferdam; it is still undetermined if the foundation would use piles or concrete-in-drilled-hole methods, which does not require pile driving. If driven foundation piles are included in the design, DWR will require contractors to isolate pile driving activities within dewatered cofferdams as a means of minimizing noise levels and potential adverse effects on fish.

The barge docks would require pile driving of 24-inch tubular steel piles in the water. DWR will work with contractors to minimize pile driving, particularly impact pile driving, by using floating docks instead of pile-supported docks, wherever feasible considering the load requirements of the landings and the site conditions; floating docks would need fewer piles. If dock piles for barge landings cannot be installed using vibratory methods, the construction contractor will use a bubble curtain or other attenuation device to minimize underwater noise.

Table 3.2-15 shows the timing and duration of pile driving for each facility or structure where pile driving is proposed to occur in open water or on land within 200 feet of open water.

Table 3.2-15. Pile Driving Sites and Durations

Facility or Structure	Average Width of Water Body (feet)	Year of Construction	Duration of Pile Driving (days)
Intake 2 Cofferdam	645	Year 4	42
Intake 2 Foundation	645	Year 5	8
Intake 3 Cofferdam	560	Year 3	42
Intake 3 Foundation	560	Year 4	8
Intake 5 Cofferdam	535	Year 2	42
Intake 5 Foundation	535	Year 3	8
Barge Docks	300–1,350	Year 5	13
CCF Cofferdams	10,500	Year 8	450
CCFN Siphon Inlet	10,500	Year 9	72
CCFN Siphon Outlet	10,500	Year 9	72
HOR gate Cofferdams	700	Year 7	37
HOR gate Foundation	700	Year 7	7

3.3 Operations and Maintenance of New and Existing Facilities

This section of Chapter 3 discusses proposed operations and maintenance of CVP/SWP facilities in the Delta. It includes the following subsections.

- Section 3.3.1, *Implementation*
- Section 3.3.2, *Operational Criteria,* describes the approach to flow management and identify specific operational criteria applying to both existing and proposed CVP/SWP facilities in the Delta.
- Section 3.3.3, *Real-Time Operational (RTO) Decision-Making Process,* describes how those criteria will be implemented in real time using available system status information.
- Section 3.3.4, *Operation of South Delta Facilities,* describes how the south Delta facilities are operated to minimize harm to listed species of fish, and to control invasive aquatic vegetation.
- Section 3.3.5, *Water Transfers,* describes what water transfers are and defines the extent to which they are covered activities under the PA.
- Section 3.3.6, *Maintenance of the Facilities,* describes how the new and existing facilities will be maintained under the PA.

The operational criteria in this section that are in addition to the criteria prescribed by existing biological opinions were developed, based on the best scientific and commercial data available, as part of a proposed habitat conservation plan for the purpose of contributing to the recovery of listed and nonlisted covered species. In addition, those criteria will only take effect once the north Delta export facilities become operational and Reclamation determines, after conferring with FWS and NMFS, that those criteria are required to ensure the coordinated operations of the

CVP and SWP are not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of designated critical habitat for those species. Further, those criteria were developed based on the best available scientific information at the time this document was prepared. This determination will be based on the best scientific and commercial data available at the time the north Delta export facilities become operational, including data collected and analysis conducted through the collaborative science and adaptive management program described in Section 3.4.8.3, *Monitoring Prior to Operations*. If those data and analyses indicate that one or more of the water operations flow criteria in Table 3.3-1 should be eliminated or modified, Reclamation will, if required, reinitiate consultation pursuant to Section 7 of the ESA and/or DWR will, if required, commence a permit amendment process under California law to modify the operating criteria, as appropriate.

3.3.1 Implementation

Implementation of the PA will include operations of both new and existing water conveyance facilities once the new north Delta diversion facilities are completed and become operational, Most existing facilities will continue to be operated consistent with existing regulatory authorizations, including the USFWS (2008) and NMFS (2009)[8] BiOps. However, operational limits included in this PA for south Delta export facilities will replace the south Delta operational limits currently implemented in compliance with the USFWS (2008) and NMFS (2009) BiOps when the proposed north Delta diversion becomes operational. See Table 3.1-1 for a complete summary of facilities and actions included in the proposed action. The PA also includes criteria for spring outflow and new minimum flow criteria at Rio Vista during the months of January through August that will apply when the proposed north Delta diversion becomes operational. The north Delta diversions and the head of Old River gate are 'new' facilities for the SWP and will be operated consistent with the PA criteria presented in this BA for these facilities.

For CVP/SWP activities not covered in this BA, the USFWS (2008) and NMFS (2009) BiOps for CVP/SWP will continue to apply. To summarize the proposed action includes modified or new operational criteria for the following facilities:

- north Delta Intakes
- south Delta export facilities
- Head of Old River (HOR) gate operations

Additionally, the operation of the following facilities is included in the PA once the north Delta diversions are operational, but no changes to their operations are proposed.

- Delta Cross Channel (DCC) gate operations
- Suisun Marsh facilities

[8] Note: Any reference to the NMFS (2009) BO in this Chapter is to include the amendments to that BO, as issued by NMFS on April 7, 2011.

- North Bay Aqueduct (NBA) Intake

The proposed operational criteria are described in the following sections and in Table 3.3-1. The longfin smelt is a species listed under the California Endangered Species Act (CESA). Therefore, it will be necessary for DWR to meet CESA permit issuance criteria for this species. To avoid a reduction in overall abundance for longfin smelt, the PA includes spring outflow criteria, which are intended to be provided by appropriate beneficiaries through the acquisition of water from willing sellers. If sufficient water cannot be acquired for this purpose, the spring outflow criteria will be accomplished through operations of the CVP/SWP to the extent an obligation is imposed on either the SWP or CVP under federal or applicable state law. Best available science, including that developed through a collaborative science program, will be used to analyze and make recommendations on the role of such flow in supporting longfin smelt abundance to CDFW, who will determine whether it is necessary to meet CESA permitting criteria.

Operations under the PA may result in substantial change in Delta flows compared to the expected flows under the existing Delta configuration, and in some instances real-time operations will be applied for water supply, water quality, flood control, and/or fish protection purposes. Two key drivers of CVP/SWP operations, Fall X2 and spring outflow, as well as many of the individual operational components described below, are designed to adapt to developing scientific information as a consequence of the level of uncertainty associated with those criteria. A Collaborative Science and Adaptive Management Program will be used to evaluate and consider changes in the operational criteria based on information gained before and after the new facilities become operational. Described in more detail in Section 3.4.7, *Collaborative Science and Adaptive Management Program* this program will be used to consider and address scientific uncertainty regarding the Delta ecosystem and to inform implementation of the operational criteria in the near term for existing BiOps for the coordinated operations of the CVP/SWP (U.S. Fish and Wildlife Service 2008, National Marine Fisheries Service 2009) and the 2081b permit for the SWP facilities and operations (California Department of Fish and Game 2009), as well as in the future for the new BiOp and 2081(b) for this PA.

3.3.2 Operational Criteria

Table 3.3-1 provides an overview of the proposed new criteria and other key criteria assumed for Delta operations. The proposed operational criteria were developed in coordination with NMFS, USFWS, and DFW to minimize project effects on listed species. A brief description of the modeling assumptions for each criterion is also included. Additional detail regarding modeling assumptions is included in Table 3.3-2. Actual operations will also rely on real-time operations as described in Section 3.3.3, *Real-Time Operational Decision-Making Process*. Criteria presented in Table 3.3-1 for south Delta operations represent the maximum restrictions on exports. A detailed operations plan will be developed by Reclamation and DWR in coordination with DFW, NMFS and USFWS that would allow implementation of the criteria presented in Table 3.3-1.

Table 3.3-1. New and Existing Water Operations Flow Criteria and Relationship to Assumptions in CALSIM Modeling

Parameter	Criteria	Summary of CALSIM Modeling Assumptions[a]
New Criteria Included in the Proposed Action		

North Delta bypass flows[9]	• Bypass Flow Criteria (specifies bypass flow required to remain downstream of the North Delta intakes):
	  ○ October, November: Minimum flow of 7,000 cfs required in river after diverting at the North Delta intakes.
	  ○ December through June: see below
	  ○ July, August, September: Minimum flow of 5,000 cfs required in river after diverting at the North Delta intakes.
	• Initial Pulse Protection:
	  ○ Low-level pumping of up to 6% of total Sacramento River flow at Freeport such that bypass flow never falls below 5,000 cfs. No more than 300 cfs can be diverted at any one intake.
	  ○ Low level pumping maintained through the initial pulse period.
	  ○ Sacramento River pulse is determined based on the criteria specified in Table 3.3-2, and real-time monitoring of juvenile fish movement.
	  ○ If the initial pulse begins and ends before Dec 1, <u>post-pulse criteria for the month of May go into effect</u> after the pulse until Dec 1. On Dec 1, the Level 1 rules defined below apply unless a second pulse occurs. If a second pulse occurs before June 30th, will have the same protective operation as the first pulse.
	• Post-pulse Criteria (specifies bypass flow required to remain downstream of the North Delta intakes):
	  ○ December through June: once the initial pulse protection ends, post-pulse bypass flow operations will not exceed Level 1 pumping unless specific criteria have been met to increase to Level 2 or Level 3. If those criteria are met, operations can proceed as defined in Table 3.3-2. The specific criteria for transitioning between and among pulse protection, Level 1, Level 2, and/or Level 3 operations, will be developed and based on real-time fish monitoring and hydrologic/behavioral cues upstream of and in the Delta as discussed in Section 3.3.3.1, *North Delta Diversion*. During operations,
		• Initial Pulse Protection:
		  ○ Low-level pumping of up to 6% of total Sacramento River flow such that bypass flow never falls below 5,000 cfs. No more than 300 cfs can be diverted at any one intake.
		  ○ If the initial pulse begins and ends before Dec 1, criteria for the appropriate month (Oct–Nov) go into effect after the pulse until Dec 1. On Dec 1, the Level 1 rules defined in Table 3.3-2 apply until a second pulse, as defined in Table 3.3-3 occurs. The second pulse will have the same protective operation as the first pulse.

[9] Sacramento River flow upstream of the intakes to be measured as a 3-day running average flow at Freeport. Bypass flow is the Sacramento River flow measured downstream of the Intake # 5.

Parameter	Criteria	Summary of CALSIM Modeling Assumptions[a]
	adjustments to the default allowable diversion level specified in Table 3.3-2 are expected to be made to improve water supply and/or migratory conditions for fish by making real-time adjustments to the diversion levels at the north Delta intakes. These adjustments are expected to fall within the operational bounds analyzed for the BA and will be managed under real time operations (RTOs).	
South Delta operations	• October, November: No south Delta exports during the D-1641 San Joaquin River 2-week pulse[10], no OMR flow[11] restriction during 2 weeks prior to pulse, and a 3-day average of −5,000 cfs in November after pulse. • December: OMR flows will not be more negative than an average of −5,000 cfs when the Sacramento River at Wilkins Slough pulse (same as north Delta diversion bypass flow pulse defined in Table 3.3-2) triggers[12], and no more negative than an average of −2,000 cfs when the delta smelt USFWS (2008) BiOp action 1 triggers. No OMR flow restriction prior to the Sacramento River pulse or delta smelt action 1 triggers. • January, February[13]: OMR flows will not be more negative than a 3-day average of 0 cfs during wet years, −3,500 cfs during above-normal years, or −4,000 cfs during below-normal to critical years, except −5,000 in January of dry and critical years. • March[14]: OMR flows will not be more negative than a 3-day average of 0 cfs during wet or above- normal years or −3,500 cfs during below-normal and dry year and -3,000 cfs during critical years. • April, May[15]: Allowable OMR flows depend on gaged flow measured at Vernalis, and will be determined by a linear relationship. If Vernalis flow is below 5,000 cfs, OMR flows will not be	• October, November: Assumed no south Delta exports during the D-1641 San Joaquin River 2-week pulse, no OMR restriction during 2 weeks prior to pulse, and −5,000 cfs in November after pulse. • December: −5,000 cfs only when the Sacramento River pulse based on the Wilkins Slough flow (same as the pulse for the north Delta diversion) occurs. If the USFWS (2008) BiOp Action 1 is triggered,−2,000 cfs requirement for 14 days is assumed. Remaining Dec days were assumed to have an allowable OMR of -8000 cfs to compute a composite monthly allowable OMR level. • April, May: OMR requirement for the Vernalis flows between 5000 cfs and 30000 cfs were determined by linear interpolation. For example, when Vernalis flow is between 5,000 cfs and 6,000 cfs, OMR requirement is determined by linearly interpolating between −2,000 cfs and +1,000 cfs. • January–March and June–September: Same as the criteria • New OMR criteria modeled as monthly average values.

[10] San Joaquin River pulse timing as defined by real-time schedule of the pulse releases.
[11] OMR measured through the currently proposed index-method (Hutton 2008) with a 3-day averaging period
[12] Sacramento River pulse determined by flow increases at Wilkins Slough of greater than 45% within 5-day period and exceeding 12,000 cfs at the end of 5-day period, and real-time monitoring of juvenile fish movement.
[13] Water year type based on the Sacramento 40-30-30 index to be based on 50% forecast per current approaches; the first update of the water year type to occur in February. CALSIM II modeling uses previous water year type for October through January, and the current water year type from February onwards.
[14] Water year type as described in the above footnote.
[15] When OMR target is based on Vernalis flow, will be a function of 3-day average measured flow; OMR flow targets are 3-day average values.

Parameter	Criteria	Summary of CALSIM Modeling Assumptions[a]
	more negative than -2000 cfs. If Vernalis is 6,000 cfs, OMR flows will not be less than +1000 cfs. If Vernalis is 10,000 cfs, OMR flows will not be less than +2,000 cfs. If Vernalis is 15,000 cfs, OMR flows will not be less than +3,000 cfs. If Vernalis is at or exceeds 30,000 cfs, OMR flows will not be less than 6,000 cfs. • June: Similar to April and May, allowable flows depend on gaged flow measured at Vernalis (except without interpolation). If Vernalis is less than 3,500 cfs, OMR flows will not be more negative than −3,500 cfs. If Vernalis exceeds 3,500 cfs up to 10,000 cfs, OMR flows will not be less than 0 cfs. If Vernalis exceeds 10,000 cfs up to 15,000 cfs, OMR flows will not be less than +1,000 cfs. If Vernalis exceeds 15,000 cfs, OMR flows will not be less than +2,000 cfs. • July, August, September: No OMR flow constraints. • OMR criteria under 2008 USFWS and 2009 NMFS BiOps or the above, whichever results in more positive, or less negative OMR flows, will be applicable.	
HOR gate operations	• October 1–November 30: RTO management – HOR gate will be closed in order to protect the D-1641 pulse flow designed to attract upstream migrating San Joaquin origin adult Fall-Run Chinook Salmon (Section 3.3.3, *Real-Time Operational Decision-Making Process)*. HOR gate will be closed approximately 50% during the time immediately before and after the SJR pulse and it will be fully closed during the pulse unless new information suggests alternative operations are better for fish. • January: When salmon fry are migrating (determined based on real time monitoring), initial operating criterion will be to close the gate subject to RTO for purposes of water quality, stage, and flood control considerations. • February–June 15th: Initial operating criterion will be to close the gate subject to RTO for purposes of water quality, stage, and flood control considerations (Section 3.3.3, *Real-Time Operational Decision-Making Process)*. Reclamation, DWR, NMFS, USFWS, and DFW will actively explore the implementation of reliable juvenile salmonid tracking technology that may enable shifting to a more flexible real time operating criterion based on the presence/absence of listed fishes. • June 16 to September 30, December: Operable gates will be open.	• Assumed 50% open from January 1 to June 15, and during days in October prior to the D-1641 San Joaquin River pulse. Closed during the pulse. 100% open in the remaining months.

Parameter	Criteria	Summary of CALSIM Modeling Assumptions[a]
Spring Outflow	March, April, May: Initial operations will maintain the March–May average delta outflow that would occur with existing facilities under the operational criteria described in the 2008 USFWS BiOp and 2009 NMFS BiOp (U.S. Fish and Wildlife Service 2008; National Marine Fisheries Service 2009). The 2011 NMFS BiOp action IV.2.1 (San Joaquin River i-e ratio) will be used to constrain Apr–May total Delta exports under the PA to meet March–May Delta outflow targets per current operational practices (National Marine Fisheries Service 2009).[16] March–May average delta outflow targets representative of the modeled outflows under the current BiOps with existing facilities at the time the North Delta Diversion will be operational are tabulated below for 10% exceedance intervals (U.S. Fish and Wildlife Service 2008; National Marine Fisheries Service 2009). Exceedance — Outflow criterion (cfs)* 10% — 44,500 20% — 44,500 30% — 35,000 40% — 27,900 50% — 20,700 60% — 16,800 70% — 13,500 80% — 11,500 90% — 9,100 * Values based on Mar – May average Delta Outflow modeled under No Action Alternative using January 27th, 2015 version of CALSIM II considering the climate change and sea level rise effects projected at Early Long Term (around year 2025), and not including San Joaquin River Restoration Flows. The detailed modeling assumptions for this No Action Alternative are described in Appendix 5.A, *CALSIM Methods and Results*. *For conditions drier than 90% exceedance, outflow targets will be based on the SWRCB's D-1641 requirements, and no additional outflow will be provided.	• 2011 NMFS RPA for San Joaquin River i-e ratio constraint is the primary driver for the Apr-May Delta outflow under the No Action Alternative, this criterion was used to constrain Apr-May total Delta exports under the PA to meet Mar-May Delta outflow targets.

Exceedance	Outflow criterion (cfs)*
10%	44,500
20%	44,500
30%	35,000
40%	27,900
50%	20,700
60%	16,800
70%	13,500
80%	11,500
90%	9,100

[16] For example, if best available science resulting from collaborative scientific research program shows that Longfin Smelt abundance can be maintained in the absence of spring outflow, and DFW concurs, an alternative operation for spring outflow could be to follow flow constraints established under D-1641. Any changes in the PA will be implemented consistent with the Collaborative Science and Adaptive Management Program, including coordination with USFWS and NMFS.

Parameter	Criteria	Summary of CALSIM Modeling Assumptions[a]
Rio Vista minimum flow standard[17]	• January through August: flows will exceed 3,000 cfs • September through December: flows per D-1641	• Same as PA criteria
Key Existing Delta Criteria Included in Modeling[18]		
Fall Outflow	• No change. September, October, November: implement the USFWS 2008 BO Fall X2 requirements in wet (W) and above normal (AN) year types.	• September, October, November: implement the 2008 USFWS BiOp "Action 4: Estuarine Habitat During Fall" (Fall X2) requirements (U.S. Fish and Wildlife Service 2008).
Winter and summer outflow	• No change. Flow constraints established under D-1641 will be followed if not superseded by criteria listed above.	• SWRCB D-1641 Delta outflow and February – June X2 criteria.
Delta Cross Channel Gates	• No change in operational criteria. • Operating criteria as required by NMFS (2009) BiOp Action IV.1 and D-1641	• Delta Cross Channel gates are closed for a certain number of days during October 1 through December 14 based on the Wilkins Slough flow, and the gates may be opened if the D-1641 Rock Slough salinity standard is violated because of the gate closure. Delta Cross Channel gates are assumed to be closed during December 15 through January 31. February 1 through June 15, Delta Cross Channel gates are operated based on D-1641 requirements.
Suisun Marsh Salinity Control Gates	• No change. Gates will continue to be closed up to 20 days per year from October through May.	For the DSM2 modeling, used generalized seasonal and tidal operations for the gates. • Seasonal operation: The radial gates are operational from Oct to Feb if Martinez EC is higher than 20000, and for remaining months they remain open. • Tidal operations when gates are operational: Gates close when: downstream channel flow is < 0.1 (onset of flood tide); Gates open when: upstream to downstream stage difference is greater than 0.3 ft (onset of ebb tide)

[17] Rio Vista minimum monthly average flow in cfs (7-day average flow not be less than 1,000 below monthly minimum), consistent with the SWRCB D-1641
[18] All the CALSIM II modeling assumptions are described in Appendix 5.A, *CALSIM Methods and Results*.

Parameter	Criteria	Summary of CALSIM Modeling Assumptions[a]
Export to inflow ratio	• Operational criteria are the same as defined under D-1641, and applied as a maximum 3-day running average. • The D-1641 export/inflow (E/I) ratio calculation was largely designed to protect fish from south Delta entrainment. For the PA, Reclamation and DWR propose that the NDD be excluded from the E/I ratio calculation. In other words, Sacramento River inflow is defined as flows downstream of the NDD and only south Delta exports are included for the export component of the criteria.	• Combined export rate is defined as the diversion rate of the Banks Pumping Plant and Jones Pumping Plant from the south Delta channels. • Delta inflow is defined as the sum of the Sacramento River flow downstream of the proposed north Delta diversion intakes, Yolo Bypass flow, Mokelumne River flow, Cosumnes River flow, Calaveras River flow, San Joaquin River flow at Vernalis, and other miscellaneous in-Delta flows.

[a] See Table 3.3-2 for Proposed Action CALSIM II Modeling Assumptions

Table 3.3-2. Proposed Action CALSIM II Criteria and Modeling Assumptions

Dual Conveyance Scenario with 9,000 cfs North Delta Diversion (includes Intakes 2, 3 and 5 with a maximum diversion capacity of 3,000 cfs at each intake)
1. North Delta Diversion Bypass Flows These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of hydrologic conditions and fish presence/movement as described in Section 3.3.3.1, *North Delta Diversion*.
<u>Low-Level Pumping (Dec-Jun)</u> Diversions of up to 6% of total Sacramento River flow such that bypass flow never falls below 5,000 cfs. No more than 300 cfs can be diverted at any one intake.
<u>Initial Pulse Protection</u> Low level pumping as described in Table 3.3-1will be maintained through the initial pulse period. For modeling, the initiation of the pulse is defined by the following criteria: (1) Sacramento River flow at Wilkins Slough increasing by more than 45% within a five-day period and (2) flow on the fifth day greater than 12,000 cfs. The pulse (and low-level pumping) continues until either (1) Sacramento River flow at Wilkins Slough returns to pre-pulse flow level (flow on first day of pulse period), or (2) Sacramento River flow at Wilkins Slough decreases for 5 consecutive days, or (3) Sacramento River flow at Wilkins Slough is greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (Sub-Table A). If the initial pulse period begins and ends before Dec 1st in the modeling, then any second pulse that may occur before the end of June will receive the same protection, i.e., low level pumping as described in Table 3.3-1.
<u>Post-Pulse Operations</u> After initial pulse(s), allowable diversion will go to Level I Post-Pulse Operations (see Sub-Table A) until 15 total days of bypass flows above 20,000 cfs occur. Then allowable diversion will go to the Level II Post-Pulse Operations until 30 total days of bypass flows above 20,000 cfs occur. Then allowable diversion will go to the Level III Post-Pulse Operations.
Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows Implement following bypass flow requirements sufficient to minimize any increase in the upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to minimize any increase in upstream transport toward the proposed intakes or into Georgiana Slough. Allowable diversion will be greater of the low-level pumping or the diversion allowed by the following bypass flow rules.

Level I Post-Pulse Operations			Level II Post-Pulse Operations			Level III Post Pulse Operations		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
Dec–Apr								
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May								
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs

Level I Post-Pulse Operations			Level II Post-Pulse Operations			Level III Post Pulse Operations		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs
Jun								
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs

Level I Post-Pulse Operations			Level II Post-Pulse Operations			Level III Post Pulse Operations		
If Sacramento River flow is over...	But not over...	The bypass is...	If Sacramento River flow is over...	But not over...	The bypass is...	If Sacramento River flow is over...	But not over...	The bypass is...

Bypass flow requirements in other months:		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**
Jul–Sep		
0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	No limit	A minimum of 5,000 cfs
Oct–Nov		
0 cfs	7,000 cfs	100% of the amount over 0 cfs
7,000 cfs	No limit	A minimum of 7,000 cfs

2. South Delta Channel Flows

OMR Flows

All of the baseline model logic and input used in the No Action Alternative as a surrogate for the OMR criteria required by the various fish protection triggers (density, calendar, turbidity and flow based triggers) described in the 2008 USFWS and the 2009 NMFS CVP/SWP BiOps were incorporated into the modeling of the PA except for NMFS BO Action IV.2.1 – San Joaquin River i/e ratio. The PA includes the proposed operational criteria, as well. Whenever the BiOps' triggers require OMR be less negative or more positive than those shown below, those OMR requirements will be met. These newly proposed OMR criteria (and associated HOR gate operations) are in response to expected changes under the PA, and only applicable after the proposed north Delta diversion becomes operational. Until the north Delta diversion becomes operational, only the OMR criteria under the current BiOps apply to CVP/SWP operations.

Combined Old and Middle River flows must be no less than values below[a] (cfs)

(Water year type classification based Sacramento River 40-30-30 index)

Month	W	AN	BN	D	C
Jan	0	-3,500	-4,000	-5,000	-5,000
Feb	0	-3,500	-4,000	-4,000	-4,000
Mar	0	0	-3,500	-3,500	-3,000
Apr	varies[b]	varies[b]	varies[b]	varies[b]	varies[b]
May	varies[b]	varies[b]	varies[b]	varies[b]	varies[b]
Jun	varies[b]	varies[b]	varies[b]	varies[b]	varies[b]
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A

Oct	varies[c]	varies[c]	varies[c]	varies[c]	varies[c]
Nov	varies[c]	varies[c]	varies[c]	varies[c]	varies[c]
Dec	-5,000[d]	-5,000[d]	-5,000[d]	-5,000[d]	-5,000[d]

[a] Values are monthly averages for use in modeling. The model compares these minimum allowable OMR values to 2008 USFWS BiOp RPA OMR requirements and uses the less negative flow requirement.

[b] Based on San Joaquin inflow relationship to OMR provided below in Sub-Table B.

[c] Two weeks before the D-1641 pulse (assumed to occur October 16-31 in the modeling), No OMR restrictions (for modeling purposes an OMR requirement of -5,000 cfs was assumed during this 2 week period)
Two weeks during the D-1641 pulse, no south Delta exports
Two weeks after the D-1641 pulse, -5,000 cfs OMR requirement (through November)

[d] OMR restriction of -5,000 cfs for Sacramento River winter-run Chinook salmon when North Delta initial pulse flows are triggered or OMR restriction of -2,000 cfs for delta smelt when triggered. For modeling purposes (to compute a composite Dec allowable OMR), remaining days were assumed to have an allowable OMR of -8000 cfs.

Head of Old River Operable (HOR) Gate Operations/Modeling assumptions (% OPEN)

MONTH	HOR Gate[a]	MONTH	HOR Gate[a]
Oct	50% (except during the pulse)[b]	May	50%
Nov	100% (except during the post-pulse period)[b]	Jun 1–15	50%
Dec	100%	Jun 16–30	100%
Jan	50%[c]	Jul	100%
Feb	50%	Aug	100%
Mar	50%	Sep	100%
April	50%		

[a] Percent of time the HOR gate is open. Agricultural barriers are in and operated consistent with current practices. HOR gate will be open 100% whenever flows are greater than 10,000 cfs at Vernalis.

HOR gate operation is triggered based upon State Water Board D-1641 pulse trigger. For modeling assumptions only, two weeks before the D-1641 pulse, it is assumed that the HOR gate will be open 50%.

[b] During the D-1641 pulse (assumed to occur October 16-31 in the modeling), it is assumed the HOR gate will be closed.
For two weeks following the D-1641 pulse, it was assumed that the HOR gate will be open 50%.
Exact timing of the action will be based on hydrologic conditions.

[c] The HOR gate becomes operational at 50% when salmon fry are migrating (based on real time monitoring). This generally occurs when flood flow releases are being made. For the purposes of modeling, it was assumed that salmon fry are migrating starting on January 1.

In the CALSIM II modeling, the "HOR gate open percentage" specified above is modeled as the percent of time within a month that HOR gate is open. In the DSM2 modeling, HOR gate is assumed to operate such that the above-specified percent of "the flow that would have entered the Old River if the HOR gate were fully open", would enter the Old River.

Sub-Table B. San Joaquin Inflow Relationship to OMR

April and May		June	
If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following (interpolated linearly between values)	If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following (no interpolation)
≤ 5,000 cfs	-2,000 cfs	≤ 3,500 cfs	-3,500 cfs
6,000 cfs	+1,000 cfs	3,501 to 10,000 cfs	0 cfs
10,000 cfs	+2,000 cfs		
15,000 cfs	+3,000 cfs	10,001 to 15,000 cfs	+1,000 cfs
≥30,000 cfs	+6,000 cfs	>15,000 cfs	+2,000 cfs

3. Delta Cross Channel Gate Operations

<u>Assumptions</u>

Per SRWCB D-1641 with additional days closed from Oct 1 – Jan 31 based on NMFS BiOp (Jun 2009) Action IV.1.2 (closed during flushing flows from Oct 1 – Dec 14 unless adverse water quality conditions). This criterion is consistent with the No Action Alternative.

4. Rio Vista Minimum Instream Flows

<u>Assumptions</u>

Sep–Dec: Per D-1641; Jan-Aug: Minimum of 3,000 cfs

5. Delta Outflow

<u>Delta Outflow</u>

SWRCB D-1641 requirements, or outflow per requirements noted below, whichever is greater

Months	Delta Outflow Requirement
Spring (Mar–May):	Additional spring outflow requirement[a]
Fall (Sep–Nov):	Implement USFWS 2008 BO Fall X2 requirement

Notes:

[a] Additional Delta Outflow required during the Mar-May period to maintain Delta outflows that would occur under the No Action Alternative at the time North Delta Diversion would become operational (for modeling purposes this is represented by the No Action Alternative model with projected climate (Q5) and sea level conditions at Early Long-Term). Mar–May average Delta outflow targets for the PA are tabulated below for 10% exceedance intervals based on the modeled No Action Alternative Mar-May Delta outflow. Since 2009 NMFS BO San Joaquin River i-e ratio constraint is the primary driver for the Apr-May Delta outflow under the No Action Alternative, this criterion was used to constrain Apr-May TOTAL Delta exports under the PA to meet Mar-May Delta outflow targets.

Percent Exceedance:	10%	20%	30%	40%	50%	60%	70%	80%	90%
Proposed Mar-May Delta Outflow Target (cfs)*:	44,500	44,500	35,000	27,900	20,700	16,800	13,500	11,500	9,100

* values based on the flow frequency of Mar – May average Delta Outflow modeled under No Action Alternative (January 27th, 2015 Bureau of Reclamation update) under Early Long-Term Q5 climate projections, without San Joaquin River Restoration Flows for this BA (Dated 4/8/2015).

6. Operations for Delta Water Quality and Residence Time
Assumptions Jul–Sep: Prefer south delta intake up to total pumping of 3,000 cfs; No specific intake preference beyond 3,000 cfs. Oct–Jun: Prefer north delta intake; (real-time operational flexibility)
7. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements
Assumptions Existing D-1641 AG and MI standards
8. D-1641 E-I Ratio Computation
Assumptions In computing the E-I Ratio in the CALSIM II model, the North Delta Diversion is not included in the export term, and the Sacramento River inflow is as modeled downstream of the North Delta Intakes.

Flow criteria are applied seasonally (month by month) and according to the following five water-year types. Under the observed hydrologic conditions over the 82-year period (1922–2003), the number of years of each water-year type is listed below. The water-year type classification, unless otherwise noted, is based on the Sacramento Valley 40-30-30 Water Year Index defined under Revised D-1641.

- Wet (W) water-year: the wettest 26 years of the 82-year hydrologic data record, or 32% of years.
- Above-normal (AN) water-year: 12 years of 82, or 15%.
- Below-normal (BN) water-year: 14 years of 82, or 17%.
- Dry (D) water-year: 18 years of 82, or 22%.
- Critical (C) water-year: 12 years of 82, or 15%.

The above noted frequencies are expected to change slightly under projected climate conditions at year 2030. The number of years of each water-year type per D-1641 Sacramento Valley 40-30-30 Water Year Index under the projected climate condition assumed for this BA, over the 82-year period (1922–2003) is provided below. Appendix 5A, Section 5.A.3, *Climate Change and Sea Level Rise* provides more information on the assumed climate change projection at year 2030 for this BA.

- Wet water-year: the wettest 26 years of the 82-year hydrologic data record, or 32% of years.
- Above-normal water-year: 13 years of 82, or 16%.
- Below-normal water-year: 11 years of 82, or 13%.
- Dry water-year: 20 years of 82, or 24%.
- Critical water-year: 12 years of 82, or 15%.

3.3.2.1 Operational Criteria for North Delta CVP/SWP Export Facilities

The proposed operational criteria were developed based on the scientific information available at the time of document preparation and are intended to minimize project effects on listed species while providing water supply reliability. The proposed north Delta diversions will allow the PA to export water, consistent with applicable criteria, during periods of high flow. Thus, north Delta diversions will be greatest in wetter years and lowest in drier years, when south Delta diversions will provide the majority of the CVP/SWP exports. North Delta bypass flow criteria were developed primarily to avoid impacts on listed species, with the considerations enumerated below. Real time operations will also be used to adjust operations to further limit effects on listed species and maximize water supply benefits (Section 3.3.3, *Real-Time Operational Decision-Making Process)*. Additionally, the PA operations include a preference for south Delta facility pumping in July through September to limit any potential water quality degradation in the south

Delta. Delta channel flows and diversions may be modified in response to real-time operational needs such as those related to Old and Middle Rivers (OMR), Delta Cross Channel operations (DCC), or North Delta bypass flows.

In addition to the bypass flow criteria described below and in Table 3.3-1, and Table 3.3-2, constraints incorporated in the design and operation of the north Delta intakes include the following.

- The new north Delta diversion intakes will consist of three separate intake units with a total, combined intake capacity not exceeding 9,000 cfs (maximum of 3,000 cfs per unit); details in Section 3.2.2, *North Delta Diversions*.

- Project conveyance will be provided by a tunnel capacity sized to provide for gravity-assisted flow from an IF to the south Delta pumping facilities when supported by sufficient flow conditions.

- The facility will, during operational testing and as needed thereafter, demonstrate compliance with the then-current NOAA, USFWS, and CDFW fish screening design and operating criteria, which govern such things as approach and sweeping velocities and rates of impingement. In addition, the screens will be operated to achieve the following performance standard: Maintain listed juvenile salmonid survival rates through the reach containing new north Delta diversion intakes (0.25 mile upstream of the upstream-most intake to 0.25 mile downstream of the downstream-most intake) of 95% or more of the existing survival rate in this reach. The reduction in survival of up to 5% below the existing survival rate will be cumulative across all screens and will be measured on an average monthly basis.

- The facility will precede full operations with a phased test period during which DWR, as project applicant, in close collaboration with NMFS and CDFW, will develop detailed plans for appropriate tests and use those tests to evaluate facility performance across a range of pumping rates and flow conditions. This phased testing period will include biological studies and monitoring efforts to enable the measurement of survival rates (both within the screening reach and downstream to Chipps Island), and other relevant biological parameters which may be affected by the operation of the new intakes.

- Operations will be managed at all times to avoid increasing the magnitude, frequency, or duration of flow reversals in the Sacramento River at the Georgiana Slough junction above pre-north Delta diversion intakes operations levels.

- The fish and wildlife agencies (i.e., USFWS, NMFS, and CDFW) retain responsibility for determination of the operational criteria and constraints (i.e., which pumping stations are operated and at what pumping rate) during testing. The fish and wildlife agencies are also responsible for evaluating and determining whether the diversion structures are achieving performance standards for listed species of fish over the course of operations. Consistent with the experimental design, the fish and wildlife agencies will also determine when the testing period should end and full operations consistent with developed operating criteria can commence. In making this determination, fish and wildlife agencies expect and will consider that, depending on hydrology, it may be difficult to test for a full range of conditions prior to commencing full operations. Therefore, tests of the facility to ensure biological performance standards are met are expected to continue intermittently after full operations begin, to enable testing to be completed for different pumping levels during infrequently occurring hydrologic conditions.

- The Collaborative Science and Adaptive Management Program will, among other things, develop and use information focused on minimizing uncertainties related to the design and operation of the fish screens (Section 3.4.7, *Collaborative Science and Adaptive Management Program*).

- Once full operation begins, the real-time operations program (Section 3.3.3, *Real-Time Operational Decision Making Process*) will be used to ensure that adjustments in pumping are made when needed for fish protection or as appropriate for water supply, water quality, flood control, and/or fish protection purposes as described in Section 3.3.3 for each real-time operational component.

- The Collaborative Science and Adaptive Management Program will review the efficacy of the North Delta bypass criteria, to determine what adjustments, if any, are needed to further minimize adverse effects on listed species of fish.

The objectives of the north Delta diversion bypass flow criteria include regulation of flows to (1) maintain fish screen sweeping velocities, (2) minimize potential increase in upstream transport of productivity in the channels downstream of the intakes, (3) support salmonid and pelagic fish movements to regions of suitable habitat, (4) reduce losses to predation downstream of the diversions, and (5) maintain or improve rearing habitat conditions in the north Delta.

To ensure that these objectives are met, diversions must be restricted at certain times of the year that bracket the main juvenile salmon migration period (mostly from December through June). This is achieved by restricting the north Delta diversion to low level pumping (maximum diversion of 6% of Sacramento River flow measured upstream of the intakes up to 900 cfs [300 cfs per intake]) when the juvenile fish begin their outmigration, which generally coincides with seasonal high flows triggered by fall/winter rains followed by a ramping up of allowable diversion rates, while ensuring flows are adequate to be protective of aquatic species during the remainder of the outmigration. Additional but less restrictive requirements apply for the late spring to late fall period.

A flow condition will be categorized as an initial flow pulse based on real-time monitoring of flow at Wilkins Slough and movement of listed juvenile salmonids (as described in Section 3.3.3.1, *North Delta Diversion*). The definition of the initial flow pulse is provided below in Table 3.3-1, which, along with real time monitoring of fish movement, will be used to determine the fish pulse. If the initial pulse begins and ends before December 1, the Level 1 post pulse criteria for May will go into effect after the pulse until December 1. On December 1, the post-pulse rules defined below for December through April, starting with Level 1, apply. If a second pulse, as defined above, occurs, the second pulse will have the same protective operations as the first pulse.

At the end of the pulse phase, post-pulse operations described in Table 3.3-3 will apply, with potential adjustments made based on real-time operations. The conditions that trigger the transition from the pulse protection to post-pulse operations are described in Table 3.3-2, along with bypass operating rules for the post-pulse phase, which provide maximum allowable levels of diversion for a given Sacramento River inflow measured upstream of the intakes. Additionally, as described in Table 3.3-3, there will be biologically based triggers to allow for transitioning between and among the different diversion levels shown in Table 3.3-2 (Section 3.3.3.1, *North Delta Diversion*).

In July through September, the bypass rules are less restrictive, allowing for a greater proportion of the Sacramento River flow to be diverted, as described in Table 3.3-1. In October through November, the bypass amount is increased from 5,000 cfs to 7,000 cfs, allowing a smaller proportion of the Sacramento River flow to be diverted during the fall months.

In addition, north Delta diversion at the three intakes are subjected to approach velocity and sweeping velocity restrictions at the proposed fish screens. Appendices 5A and 5B describes the assumptions used in modeling the sweeping velocity restrictions on the north Delta diversion.

3.3.2.2 Operational Criteria for South Delta CVP/SWP Export Facilities

The objective of the new south Delta flow criteria is to further minimize take at south Delta pumps by reducing the hydrodynamic effects of south Delta operations that may affect fish movement and migration routing during critical periods for listed fish species. The south Delta channel flow criteria are based on the parameters for Old and Middle River (OMR) flows and the San Joaquin River inflow, as summarized below and in Tables 3.3-1 and 3.3-2, and HOR gate operations (summarized in Section 3.3.2.3, *Operational Criteria for the Head of Old River Gate*).

Additionally, the PA operations include a preference for south Delta pumping in July through September to provide limited flushing flows to avoid water quality degradation in the south Delta.

The OMR flow criteria chiefly serve to constrain the magnitude of reverse flows in the Old and Middle Rivers to limit fish entrainment into the south Delta and increase the likelihood that Delta smelt can successfully reproduce in the San Joaquin River. The rational for using OMR flow criteria is based on the USFWS (2008) and NMFS (2009) BiOp RPA Actions, and are described in Table 3.3-1 and Table 3.3-2. These newly proposed additional OMR criteria (and associated HOR gate operations in Section 3.3.2.3, *Operational Criteria for the Head of Old River Gate*) are designed primarily to secure operations that are expected to provide beneficial changes in south Delta flows under the PA, (i.e., they would lessen reverse flows in Old and Middle Rivers); and they are only applicable only after the proposed north Delta diversion becomes operational.

In April, May, and June, minimum allowable OMR flow values would be based upon the San Joaquin River inflow (Table 3.3-1 and Table 3.3-2). In October and November, OMR and south Delta export restrictions are based upon State Water Board D-1641 pulse trigger, as follows.[19]

- Two weeks before the State Water Board D-1641 pulse trigger: no OMR restrictions.
- During State Water Board D-1641 pulse trigger: no south Delta exports.
- Two weeks following State Water Board D-1641 pulse trigger: OMR operated to be no more negative than -5,000 cfs through November.

Additionally, new criteria based on the water year type in December through March will be implemented as described in detail in Table 3.3-1. The new criteria generally constrain the south Delta exports more under the wetter years compared to the requirements under the USFWS (2008) and NMFS (2009) BiOps. The new OMR criteria (and associated HOR gate operations) are primarily to preserve the reduced reverse flow conditions under the PA, and are only applicable after the proposed north Delta diversion becomes operational. Until the north Delta diversion becomes operational only the OMR criteria under the current BiOps apply to CVP/SWP operations.

3.3.2.3 Operational Criteria for the Head of Old River Gate

As described in Section 3.2, *Conveyance Facility Construction,* a new permanent, operable gate at the head of Old River (at the divergence from the San Joaquin River) will be constructed and operated to protect outmigrating San Joaquin River salmonids in the spring and to provide water quality improvements in the San Joaquin River in the fall. The new HOR gate will replace the temporary rock barrier that is typically installed at the same location. (Temporary agricultural barriers on Middle River and Old River near Tracy and Grant Line Canal will continue to be installed consistent with current operations). Operation of the HOR gate could vary from completely open (lying flat on the channel bed) to completely closed (erect in the channel, prohibiting any flow of San Joaquin River water into Old River), with the potential for operations in between that will allow partial flow. The operational criteria are described in Table 3.3-1. The actual operation of the gate will be determined by real-time operations (Section 3.3.3, *Real-Time Operational Decision-Making Process*) based on actual flows and/or fish presence.

- **October 1–November 30:** RTO management and HOR gate will be closed in order to protect the D-1641 San Joaquin River pulse flow designed to attract upstream migrating adults (Section 3.3.3, *Real-Time Operational Decision-Making Process*).
- **January:** When juvenile salmonids are migrating (determined based on real time monitoring), initial operating criterion will be to close the gate subject to RTO for purposes of water quality, stage, and flood control considerations.

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[19] For the purposes of modeling, it was assumed that the D-1641 pulse in San Joaquin River occurs in the last 2 weeks of October.

- **February–June 15:** The gate will be closed, but subject to RTO for purposes of water quality, stage, and flood control considerations (Section 3.3.3, *Real-Time Operational Decision-Making Process*). The agencies will actively explore the implementation of reliable juvenile salmonid tracking technology that may enable shifting to a more flexible real time operating criterion based on the presence/absence of listed fishes.
- **June 16 to September 30, December:** Operable gates will be open.
- HOR gate will remain open if San Joaquin River flow at Vernalis is greater than 10,000 cfs.

3.3.2.4 Operational Criteria for the Delta Cross Channel Gates

The Delta Cross Channel (DCC) is a gated diversion channel in the Sacramento River near Walnut Grove and Snodgrass Slough (Appendix 3.A *Map Book for the Proposed Action*, Sheet 5) that is owned and operated by Reclamation. No changes to DCC operational criteria from the operations described in D-1641 and the USFWS (2008) and NMFS (2009) BiOps are proposed. Flows into the DCC from the Sacramento River are controlled by two 60-foot by 30-foot radial gates. When the gates are open, water flows from the Sacramento River through the cross channel to channels of the lower Mokelumne and San Joaquin Rivers toward the interior Delta. The DCC operation improves water quality in the interior Delta by improving circulation patterns of higher-quality water from the Sacramento River towards Delta diversion facilities.

Reclamation operates the DCC in the open position to (1) improve water quality in the interior Delta, and (2) reduce saltwater intrusion rates in the western Delta. During the late fall, winter, and spring, the gates are often periodically closed to protect out-migrating salmonids from entering the interior Delta. In addition, whenever flows in the Sacramento River at Sacramento reach 20,000 to 25,000 cfs (on a sustained basis), the gates are closed to reduce potential scouring and flooding that might occur in the channels on the downstream side of the gates.

Flow rates through the gates are determined by Sacramento River stage and are not affected by export rates in the south Delta. The DCC also serves as a link between the Mokelumne River and the Sacramento River for small craft. It is used extensively by recreational boaters and anglers whenever it is open. Because alternative routes around the DCC are quite long, Reclamation tries to provide adequate notice of DCC closures so boaters may plan for the longer excursion.

Under the PA, the DCC will continue to be operated as it is now operated under the terms of the NMFS (2009) BiOp. The gates will be closed if fish are present in October and November, with closure decisions at that time reached through the existing real-time operations process described in Section 3.3.3, *Real-Time Operational Decision Making Process*. The CALSIM II modeling assumed DCC operations as required by NMFS (2009) BiOp RPA Action IV.1.2 by using a regression of Sacramento River monthly flow at Wilkins Slough and the number of days in the month when the daily flow would be greater than 7500 cfs. The latter was assumed to be an indicator that salmonids would be migrating to the delta. In the modeling, DCC gates are closed for the same number of days as Wilkins Slough is estimated to exceed 7500 cfs during October 1 through December 14, and the gates may be opened if the D-1641 Rock Slough salinity standard is violated because of the gate closure. DCC gates are assumed to be closed during December 15 through January 31. February 1 through June 15, DCC gates are operated based on D-1641 requirements.

3.3.2.5 Operational Criteria for the Suisun Marsh Facilities

The Suisun Marsh facilities are jointly operated by CVP/SWP and include the Suisun Marsh Salinity Control Gates (SMSCG), Roaring River Distribution System (RRDS), Morrow Island Distribution System (MIDS), and Goodyear Slough Outfall. No changes to the operations of the Suisun Marsh facilities from those described in the USFWS (2008) and NMFS (2009) BiOps are proposed.

3.3.2.5.1 Suisun Marsh Salinity Control Gates

The SMSCG are located on Montezuma Slough about two miles downstream from the confluence of the Sacramento and San Joaquin Rivers, near Collinsville (Appendix 3.A *Map Book for the Proposed Action*, Sheet 17). Operation of the SMSCG began in October 1988 as Phase II of the Plan of Protection for the Suisun Marsh. The objective of SMSCG operation is to decrease the salinity of the water in Montezuma Slough. The facility, spanning the 465-foot width of Montezuma Slough, consists of a boat lock, a series of three radial gates, and removable flashboards. The gates control salinity by restricting the flow of higher salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water from east to west.

When Delta outflow is low to moderate and the gates are not operating, tidal flow past the gate is approximately 5,000 to 6,000 cfs while the net flow is near zero. When operated, flood tide flows are arrested while ebb tide flows remain in the range of 5,000 to 6,000 cfs. The net flow in Montezuma Slough becomes approximately 2,500 to 2,800 cfs. The Corps of Engineers permit for operating the SMSCG requires that it be operated between October and May only when needed to meet Suisun Marsh salinity standards. Historically, the gate has been operated as early as October 1, while in some years (e.g., 1996) the gate was not operated at all. When the channel water salinity decreases sufficiently below the salinity standards or at the end of the control season, the flashboards are removed and the gates raised to allow unrestricted movement through Montezuma Slough. Details of annual gate operations can be found in "Summary of Salinity Conditions in Suisun Marsh During WYs 1984–1992", or the "Suisun Marsh Monitoring Program Data Summary" produced annually by DWR, Division of Environmental Services.

The approximately 2,800 cfs net flow induced by SMSCG operation is effective at moving the salinity downstream in Montezuma Slough. Salinity is reduced by roughly one-hundred percent at Beldons Landing, and lesser amounts further west along Montezuma Slough. At the same time, the salinity field in Suisun Bay moves upstream as net Delta outflow (measured nominally at Chipps Island) is reduced by gate operation. Net outflow through Carquinez Strait is not affected.

The boat lock portion of the gate is held open at all times during SMSCG operation to allow for continuous salmon passage opportunity. With increased understanding of the effectiveness of the gates in lowering salinity in Montezuma Slough, salinity standards have been met with less frequent gate operation, compared to the early years of operations (prior to 2006). For example, despite very low outflow in fall 2007 and fall 2008, gate operation was not required at all in 2007, and was limited to 17 days during winter 2008. Assuming no significant, long-term changes in the drivers mentioned above, this level of operational frequency (10 to 20 days per year) can generally be expected to continue to meet standards in the future except perhaps during the most critical hydrologic conditions and/or other conditions that affect Delta outflow.

3.3.2.5.2 Roaring River Distribution System

The RRDS (Appendix 3.A *Map Book for the Proposed Action*, Sheet 17) was constructed during 1979 and 1980 as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The system was constructed to provide lower salinity water to 5,000 acres of private and 3,000 acres of DFG-managed wetlands on Simmons, Hammond, Van Sickle, Wheeler, and Grizzly islands.

The RRDS includes a 40-acre intake pond that supplies water to Roaring River Slough. Motorized slide gates in Montezuma Slough and flap gates in the pond control flows through the culverts into the pond. A manually operated flap gate and flashboard riser are located at the confluence of Roaring River and Montezuma Slough to allow drainage back into Montezuma Slough for controlling water levels in the distribution system and for flood protection. DWR owns and operates this drain gate to ensure the Roaring River levees are not compromised during extremely high tides.

Water is diverted through a bank of eight 60-inch-diameter culverts equipped with fish screens into the Roaring River intake pond on high tides to raise the water surface elevation in RRDS above the adjacent managed wetlands. Managed wetlands north and south of the RRDS receive water, as needed, through publicly and privately owned turnouts on the system.

The intake to the RRDS is screened to prevent entrainment of fish larger than approximately 25 mm. DWR designed and installed the screens based on CDFW criteria. The screen is a stationary vertical screen constructed of continuous-slot stainless steel wedge wire. All screens have 3/32-inch slot openings. To minimize the risk of delta smelt entrainment, RRDS diversion rates are controlled to maintain an average approach velocity below 0.2 ft/s at the intake fish screen. Initially, the intake culverts were held at about 20% capacity to meet the velocity criterion at high tide. Since 1996, the motorized slide gates have been operated remotely to allow hourly adjustment of gate openings to maximize diversion throughout the tide.

3.3.2.5.3 Morrow Island Distribution System

The MIDS (Appendix 3.A *Map Book for the Proposed Action*, Sheet 17) was constructed in 1979 and 1980 in the south-western Suisun Marsh as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. The contractual requirement for Reclamation and DWR is to provide water to the ownerships so that lands may be managed according to approved local management plans. The system was constructed primarily to channel drainage water from the adjacent managed wetlands for discharge into Suisun Slough and Grizzly Bay. This approach increases circulation and reduces salinity in Goodyear Slough.

The MIDS is used year-round, but most intensively from September through June. When managed wetlands are filling and circulating, water is tidally diverted from Goodyear Slough just south of Pierce Harbor through three 48-inch culverts. Drainage water from Morrow Island is discharged into Grizzly Bay by way of the C-Line Outfall (two 36-inch culverts) and into the mouth of Suisun Slough by way of the M-Line Outfall (three 48- inch culverts), rather than back into Goodyear Slough. This helps prevent increases in salinity due to drainage water discharges into Goodyear Slough. The M-Line ditch is approximately 1.6 miles in length and the C-Line ditch is approximately 0.8 miles in length.

3.3.2.5.4 Goodyear Slough Outfall

The Goodyear Slough Outfall (Appendix 3.A *Map Book for the Proposed Action*, Sheet 17) was constructed in 1979 and 1980 as part of the Initial Facilities in the Plan of Protection for the Suisun Marsh. A channel approximately 69 feet wide was dredged from the south end of Goodyear Slough to Suisun Bay (about 2,800 feet). The excavated material was used for levee construction. The control structure consists of four 48-inch culverts with flap gates on the bay side. On ebb tides, Goodyear Slough receives watershed runoff from Green Valley Creek and, to a lesser extent, Suisun Creek. The system was designed to draw creek flow south into Goodyear Slough, and thereby reduce salinity, by draining water one-way from the lower end of Goodyear Slough into Suisun Bay on the ebb tide. The one-way flap gates at the Outfall close on flood tide keeping saltier bay water from mixing into the slough. The system creates a small net flow in the southerly direction overlaid on a larger, bidirectional tidal flow. The system provides lower salinity water to the wetland managers who flood their ponds with Goodyear Slough water. Another initial facility, the MIDS, diverts from Goodyear Slough and receives lower salinity water. Since the gates are passively operated (in response to water surface elevation differentials) there are no operations schedules or records. The system is open for free fish movement except very near the Outfall when flap gates are closed during flood tides.

3.3.2.6 Operational Criteria for the North Bay Aqueduct Intake

The Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct (NBA) for delivery in Napa and Solano Counties. Maximum pumping capacity is 175 cubic feet per second (cfs) (pipeline capacity). During the past few years, daily pumping rates have ranged between 0 and 140 cfs. The current maximum pumping rate is 140 cfs due to the physical limitations of the existing pumps. Growth of biofilm in a portion of the pipeline also limits the NBA ability to reach its full pumping capacity.

The NBA intake is located approximately 10 miles from the mainstem Sacramento River at the end of Barker Slough (Appendix 3.A *Map Book for the Proposed Action*, Sheet 17). Per salmon screening criteria, each of the ten NBA pump bays is individually screened with a positive barrier fish screen consisting of a series of flat, stainless steel, wedge-wire panels with a slot width of 3/32 inch. This configuration is designed to exclude fish approximately one inch or larger from being entrained. The bays tied to the two smaller units have an approach velocity of about 0.2 feet per second (ft/s). The larger units were designed for a 0.5 ft/s approach velocity, but actual approach velocity is about 0.44 ft/s. The screens are routinely cleaned to prevent excessive head loss, thereby minimizing increased localized approach velocities.

The NBA fish screens are also designed to comply with USFWS criteria for delta smelt protection (Reclamation 2008), which are likewise protective of longfin smelt. A larval delta smelt monitoring program occurs each spring in the sloughs near NBA. This monitoring program is used to trigger NBA export reductions when delta smelt larvae are nearby.

Delta smelt monitoring was required at Barker Slough under the March 6, 1995 OCAP BiOp. Starting in 1995, monitoring was required every other day at three sites from mid- February through mid-July, when delta smelt may be present. As part of the Interagency Ecological Program (IEP), DWR has contracted with DFW to conduct the required monitoring each year since the BO was issued. Details about the survey and data are available on DFG's website (http://www.delta.dfg.ca.gov/data/NBA). Beginning in 2008, the NBA larval sampling was replaced by an expanded 20-mm survey (described at http://www.delta.dfg.ca.gov/data/20mm) that has proven to be fairly effective at tracking delta smelt distribution and reducing entrainment. The expanded survey covers all existing 20-mm stations, in addition to a new suite of stations near the NBA. The expanded survey also has an earlier seasonal start and stop date to focus on the presence of larvae in the Delta. These surveys also collect information on longfin smelt.

3.3.3 Real-Time Operational Decision-Making Process

The real-time operational decision-making process (real-time operations [RTO]) allows short-term adjustments to be made to water operations, within the range of criteria described in Section 3.3.2, *Operational Criteria*, in order to maximize water supply for CVP/SWP, subject to providing the necessary protections for listed species. RTO will be implemented on a timescale practicable for each affected facility and are part of the operating criteria, which will be periodically evaluated and possibly modified through the adaptive management process (Section 3.4.7, *Collaborative Science and Adaptive Management Program*).

As part of the PA, the Action Agencies (DWR and Reclamation) will convene a real time operations coordination team that includes representatives of USFWS, NMFS, CDFW, DWR and Reclamation. DWR and Reclamation also will designate one representative of the SWP contractors and one representative of the CVP contractors as participants on the coordination team in an advisory capacity.

This RTO coordination effort will enable USFWS, NMFS and CDFW to fulfill their responsibilities in the Delta, and the designated participants from the SWP and CVP will assist DWR and Reclamation to fulfill their responsibility to inform the SWP and CVP participants regarding available information and real time decisions.

The Action Agencies and fishery agency representatives will confer with the SWP and CVP contractor representatives regarding ideas, options and additional funding to enhance the information available for decisions on RTO. The SWP and CVP contractor representatives will confer with other SWP and CVP contractors regarding RTO coordination and decisions. This RTO coordination team supplements and will coordinate with existing RTO management teams as described in Appendix 3.J. The existing RTO decision making process as described in Appendix 3.J is expected to continue to gather and analyze information, and make recommendations, regarding adjustments to water operations under the PA.

This coordination effort shall also periodically review how to enhance or strengthen the scientific and technical information used to inform decision-making, and how to communicate with the public and other interested parties. The RTO Team[20] will be responsible for evaluating real-time hydrology, operations, and fish data, and will use that information to make adjustments to the default operations outlined in Tables 3.3-1 and 3.3-2. The RTO representatives may utilize technical teams (e.g., Smelt Working Group, Delta Operations for Salmonids and Sturgeon) and/or a subset of technical teams comprising PWA members and other interested parties (e.g., Delta Conditions Team) to provide and help evaluate the necessary information to assist them in their decision-making. When developing adjustments to operations in real-time, the RTO Team will consider the following.

- Risks to listed species of fish, including real-time hydrology and biological modelling, as available.
- Actions to avoid or minimize adverse effects on listed species of fish.
- Water quality.
- Water supply.
- Allocations in the year of action or in future years.
- End of water year storage.
- San Luis Reservoir low point.
- Delivery schedules for any SWP or CVP contractor.
- Actions that could be implemented throughout the year to recover any water supplies reduced by actions taken by the RTO team.

The operational adjustments made through the RTO processes apply only to the facilities and activities identified in the PA. RTOs are expected to be needed during at least some part of the year at the north and south Delta diversions and the HOR gate. The RTO team, in making operational decisions, will take into account operational constraints, such as coldwater pool management, instream flow, and temperature requirements. The extent to which real time adjustments that may be made to each parameter related to these facilities shall be limited by the criteria and/or ranges set out in Section 3.3.2, *Operational Criteria*. That is, operational adjustments shall be consistent with the criteria, and within any ranges, established in the PA. Subsections 3.3.3.1, *North Delta Diversion*; 3.3.3.2, *South Delta Diversion*; and 3.3.3.3, *Head of Old River Gate*, provide considerations for the real-time operations. Modifications to the parameters subject to real time operational adjustments or to the criteria and/or ranges set out in the operating criteria shall occur only through the collaborative science and adaptive management Program, and the effects of any such modifications shall be analyzed in order for NMFS and USFWS to determine if amendment to the BiOp is necessary prior to implementation. Similarly, any changes to the facilities or activities subject to real time

[20] The RTO Team will develop its operating procedures and any other details of its governance structure.

operational adjustments shall occur only through the adaptive management program, and the effects of any such changes shall be analyzed in order for NMFS and USFWS to determine if amendment to the BiOp is necessary prior to implementation.

The CVP-SWP operators conduct seasonal planning of the CVP-SWP operations taking into account many factors such as the existing regulatory requirements, forecasted hydrology, contractual demands etc. The operators also consider any recommendations resulting from the RTO decision making to minimize adverse effects for listed species while meeting permit requirements and contractual obligations for water deliveries.

Existing RTO decision making process allows for a flexible decision making that can be adjusted to address uncertainties such as the hydrologic conditions, ocean conditions, presence and distribution of the listed species, and other ecological conditions while taking into account public health, safety and water supply reliability. Appendix 3.J outlines the existing RTO decision making process, and describes the management team, the information teams, and fisheries and operations technical teams that are part of the RTO decision making. Table 3.3-1 shows the list of the RTO decision making groups. The RTO teams review the most up-to-date data and information on fish status and habitat conditions, and develop recommendations that fishery agencies' management can use in identifying actions to protect listed species.

Existing RTO decision making process is expected to continue to gather and analyze information, and make recommendations, regarding adjustments to water operations under the PA within the range of flexibility prescribed in the implementation procedures for a specific action in their particular geographic area.

3.3.3.1 North Delta Diversion

Operations for North Delta bypass flows will be managed according to the following criteria:

- **October, November:** Minimum bypass flows of 7,000 cfs required after diverting at the North Delta intakes.

- **December through June:** Post-pulse bypass flow operations will not exceed Level 1 pumping unless specific criteria have been met to increase to Level 2 or Level 3. If those criteria are met, operations can proceed as defined in Table 3.3-1 and Table 3.3-2. The specific criteria for transitioning between and among pulse protection, Level 1, Level 2, and/or Level 3 operations, will be developed and based on real-time fish monitoring and hydrologic/ behavioral cues upstream of and in the Delta. During operations, adjustments are expected to be made to improve water supply and/or migratory conditions for fish by making real-time adjustments to the pumping levels at the north Delta diversions. These adjustments will be managed under RTOs as described below.

- **July, August, September:** Minimum bypass flows of 5,000 cfs required after diverting at the north Delta diversion intakes.

Real-time operations of the north Delta intakes are intended to allow for the project objective of water diversion while also providing the protection needed to migrating and rearing salmonids.

RTOs will be a key component of NDD operations, and will likely govern operations for the majority of the December through June salmonid migration period. Under RTOs, the NDD would be operated within the range of Levels 1-3, depending on risk to fish and with consideration for other factors such as water supply and other Delta conditions, and by implementing pulse protection periods when primary juvenile winter-run Chinook salmon migration is occurring. Post-pulse bypass flow operations will remain at Level 1 pumping while juvenile salmonids are migrating through and rearing in the north Delta, unless it is determined through initial operating studies that an equivalent level of protection can still be provided at Level 2 or 3 pumping. The specific criteria for transitioning between and among pulse protection, Level 1, Level 2, and/or Level 3 operations, will be based on real-time fish monitoring and hydrologic/ behavioral cues upstream of and in the Delta that will be studied as part of the PA's Collaborative Science and Adaptive Management Plan (Section 3.4.7). Based on the outcome of the studies listed in Section 3.4.7, information about appropriate triggers, off-ramps, and other RTO management of NDD operations will be integrated into the operations of the PA. The RTOs will be used to support the successful migration of salmonids past the NDD and through the Delta, in combination with other operational components of the PA[21].

The following operational framework serves as a modified example based on the recommended NDD RTO process (Marcinkevage and Kundargi 2016), and will be further developed and refined by a 5-agency technical team co-chaired by NMFS and CDFW based on a science plan developed through the collaborative science process and finalized through the adaptive management process prior to commencement of actual operations of the north Delta facilities.

3.3.3.1.1 Pulse-Protection

- A fish pulse is defined as catch of X_p winter-run-sized Chinook salmon in a single day at a specified location[22].

- Upon initiation of fish pulse, operations must reduce to low-level pumping.

- Low-level pumping must be maintained for duration of fish pulse. A fish pulse is considered over after X^2 consecutive days with daily winter-run-sized Chinook salmon catch less than X_p at or just downstream of the new intakes[22].

- Operations may increase to Level 1 when the fish pulse is over as described in the above criteria are met.

- A second fish pulse, if detected using the same definition (catch of X_p winter-run-sized Chinook salmon in a single day at a specified location), is given the same low-level

[21] Operations necessary to support Delta rearing of juvenile salmonids will be addressed through the adaptive management program, due to limited information on rearing flow needs at this time.
[22] Triggers will be developed from data provided by monitoring stations.

pumping protection as the first pulse if the first pulse occurred before December [1][23]. Otherwise, operations remain at Level 1 during the second fish pulse.

- A maximum of two fish pulses are protected in a year.
- After protection of pulse(s), post-pulse migration protection criteria are imposed.

3.3.3.1.2 Post-Pulse Migration Protection

- Post-pulse operations must remain at Level 1 until combined catch at all Sacramento stations is below X_a[24] for five consecutive days and bypass flows are greater than 20,000 cfs for 15 non-consecutive days (as stated in Table 3.3-2). If both conditions are met, operations may transition to Level 2.
- Operations at Level 2 can remain at Level 2 as long as there is no subsequent fish migration event detected, in which case operations would revert back to level 1 (see following two bullets). Provided there are no fish migration events detected, operations must remain at Level 2 until bypass flows are greater than 20,000 cfs for 15 (additional) non-consecutive days (as stated in Table 3.3-2). If both conditions are met, operations may transition to Level 3.
- A fish migration event is defined as catch of X_m Chinook salmon of any size or run in a single day at a specific location[25].
- Upon initiation of a migration event, operations must revert back to Level 1 (if not already there) for migration protection.
- Migration protection operations must be maintained at Level 1 until the combined catch at all Sacramento stations is below X_a[24] for X^3 consecutive days. If this criteria is met, operations may return to the pre-migration event level (i.e., Level 2 or Level 3).

3.3.3.2 South Delta Diversions

The south Delta diversions will be managed under RTO throughout the year based on fish protection triggers (e.g., salvage density, calendar, species distribution, entrainment risk, turbidity, and flow based triggers [Table 3.3-3]). Increased restrictions as well as relaxations of the OMR criteria outside of the range defined in Table 3.3-3 may occur through adaptive management as a result of observed physical and biological information. Additionally, RTO will also be managed to distribute pumping activities among the three north Delta and two south Delta intake facilities to maximize both survival of listed fish species in the Delta and water supply.

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[23] Triggers and the exact date in December will be developed from data provided by monitoring stations. Effects analysis based on pulse protection period ending December 1st.
[24] X_a – Specific durations and triggers will be developed from data provided by monitoring stations.
[25] X_m – Specific durations and triggers will be developed from data provided by monitoring stations.

Table 3.3-3. Salvage Density Triggers for Old and Middle River Real-Time Flow Adjustments January 1 to June 15[a] (source: National Marine Fisheries Service 2011).

First Stage Trigger
(1) Daily CVP/SWP older juvenile Chinook salmon[b] loss density (fish per TAF) is greater than incidental take limit divided by 2,000 (2% WRJPE ÷ 2,000), with a minimum value of 2.5 fish per taf, or (2) Daily CVP/SWP older juvenile Chinook salmon loss is greater than 8 fish per TAF multiplied by volume exported (in TAF), or (3) Coleman National Fish Hatchery coded wire tagged late fall-run Chinook salmon or Livingston Stone National Fish Hatchery coded wire tagged winter-run Chinook salmon cumulative loss is greater than 0.5% for each surrogate release group, or (4) Daily loss of wild steelhead (intact adipose fin) is greater than 8 fish per TAF multiplied by volume exported (in TAF).[c] Response: • Reduce exports to achieve an average net OMR flow of -3,500 cfs for a minimum of 5 consecutive days. The 5-day running average OMR flows will be no more than 25% more negative than the targeted flow level at any time during the 5-day running average period (e.g., -4,375 cfs average over 5 days). • Resumption of -5,000 cfs flows is allowed when average daily fish density is less than trigger density for the last 3 days of export reduction.[c] Reductions are required when any one criterion is met.
Second Stage Trigger
(1) Daily CVP/SWP older juvenile Chinook salmon loss density (fish per TAF) is greater than incidental take limit divided by 1,000 (2% of WRJPE ÷ 1,000), with a minimum value of 5 fish per TAF, or (2) Daily CVP/SWP older juvenile Chinook salmon loss is greater than 12 fish per TAF multiplied by volume exported (in TAF), or (3) Daily loss of wild steelhead (intact adipose fin) is greater than 12 fish per TAF multiplied by volume exported (in TAF). Response: • Reduce exports to achieve an average net OMR flow of -2,500 cfs for a minimum 5 consecutive days. Resumption of -5,000 cfs flows is allowed when average daily fish density is less than trigger density for the last 3 days of export reduction. Reductions are required when any one criterion is met.
End of Triggers
• Continue action until June 15 or until average daily water temperature at Mossdale is greater than 72°F (22°C) for 7 consecutive days (1 week), whichever is earlier. Response: • If trigger for end of OMR regulation is met, then the restrictions on OMR are lifted for the remainder of the water year.
[a] Salvage density triggers modify PA operations only within the ranges proposed in Table 3.3-1. Triggers will not be implemented in a manner that reduces water supplies in amounts greater than modeled outcomes. [b] *Older juvenile Chinook salmon* is defined as any Chinook salmon that is above the minimum length for winter-run Chinook salmon, according to the Delta Model length-at-date table used to assign individuals to race. [c] Three consecutive days in which the combined loss numbers are below the action triggers are required before the OMR flow reductions can be relaxed to no more negative than -5,000 cfs. A minimum of 5 consecutive days of export reduction are required for the protection of listed salmonids under the action. Starting on day 3 of the export curtailment, the level of fish loss must be below the action triggers for the remainder of the 5-day export reduction to relax the OMR requirements on day 6. Any exceedance of a more conservative trigger restarts the 5-day OMR action response with the 3 consecutive days of loss monitoring criteria. TAF = thousand acre-feet. WRJPE = the current year's winter-run Chinook salmon juvenile production estimate.

3.3.3.3 Head of Old River Gate

Operations for the HOR gate will be managed under RTOs as follows.

- **October 1–November 30th:** RTO management in order to protect the D-1641 pulse flow designed to attract upstream migrating adults.
- **January:** When salmon fry are migrating (determined based on real time monitoring), initial operating criterion will be to close the gate subject to RTO for purposes of water quality, stage, and flood control considerations.
- **February–June 15th:** The gate will be closed, but subject to RTO for purposes of water quality, stage, and flood control considerations. The agencies will actively explore the implementation of reliable juvenile salmonid tracking technology that may enable shifting to a more flexible real time operating criterion based on the presence/absence of listed fishes.
- **June 16 to September 30, December:** Operable gates will be open.

3.3.4 Operation of South Delta Facilities

This section describes how the existing South Delta facilities, including the CVP's C.W. "Bill" Jones Pumping Plant and Tracy Fish Collection Facility and the SWP's Harvey O. Banks Pumping Plant and Skinner Delta Fish Protective Facility, are operated to minimize the risks of predation and entrainment of listed species of fish, and how the Clifton Court Forebay is managed for control of invasive aquatic vegetation. These operations are unchanged from those described in and regulated by the USFWS (2008) and NMFS (2009) BiOps.

3.3.4.1 C.W. "Bill" Jones Pumping Plant and Tracy Fish Collection Facility

The CVP and SWP use the Sacramento River, San Joaquin River, and Delta channels to transport water to export pumping plants located in the south Delta. The CVP's Jones Pumping Plant, about five miles north of Tracy, consists of six available pumps. The Jones Pumping Plant is located at the end of an earth-lined intake channel about 2.5 miles in length. At the head of the intake channel, louver screens (that are part of the Tracy Fish Collection Facility) intercept fish, which are then collected, held, and transported by tanker truck to release sites far away from the pumping plants.

Jones Pumping Plant has a permitted diversion capacity of 4,600 cfs with maximum pumping rates capable of achieving that capacity.

The Tracy Fish Collection Facility is located in the south-west portion of the Sacramento-San Joaquin Delta and uses behavioral barriers consisting of primary louvers and secondary screens to guide entrained fish into holding tanks before transport by truck to release sites within the Delta. The primary louvers are located in the primary channel just downstream of a trashrack structure. The secondary screens consist of a travelling positive barrier fish screen. The louvers and screens allow water to pass through into the pumping plant but the openings between the slats are tight enough and angled against the flow of water such a way as to prevent most fish from passing between them and instead enter one of four bypass entrances along the louver arrays.

There are approximately 52 different species of fish entrained into the TFCF per year; however, the total numbers are significantly different for the various species salvaged. Also, it is difficult if not impossible to determine exactly how many safely make it all the way to the collection tanks awaiting transport back to the Delta. Hauling trucks used to transport salvaged fish to release sites inject oxygen and contain an eight parts per thousand salt solution to reduce stress. The CVP uses two release sites, one on the Sacramento River near Horseshoe Bend and the other on the San Joaquin River immediately upstream of the Antioch Bridge. The transition boxes and conduits between the louvers and fish screens were rehabilitated during the San Joaquin pulse period of 2004.

When south Delta hydraulic conditions allow, and within the original design criteria for the TFCF, the louvers are operated with the D-1485 and NMFS (2009) BiOp objectives of achieving water approach velocities: for striped bass of approximately 1 foot per second (ft/s) from May 15 through October 31, and for salmon of approximately 3 ft/s from November 1 through May 14. Channel velocity criteria are a function of bypass ratios through the facility. Due to changes in south Delta hydrology and seasonal fish protection regulations over the past twenty years, the present-day TFCF is able to meet these conditions approximately 55% of the time.

Fish passing through the facility are sampled at intervals of no less than 30 minutes every 2 hours when listed fish are present, generally December through June. When listed fish are not present, sampling intervals are 10 minutes every 2 hours. Fish observed during sampling intervals are identified by species, measured to fork length, examined for marks or tags, and placed in the collection facilities for transport by tanker truck to the release sites in the North Delta away from the pumps. In addition, TFCF personnel are currently required, per the court order, to monitor for the presence of spent female delta smelt in anticipation of expanding the salvage operations to include sub-20 mm larval delta smelt detection.

CDFW is leading studies of fish survival during the collection, handling, transportation, and release process, examining delta smelt injury, stress, survival, and predation. Thus far it has presented initial findings at various interagency meetings (Interagency Ecological Program [IEP], Central Valley Fish Facilities Review Team, and American Fisheries Society) showing relatively high survival and low injury. DWR has concurrently been conducting focused studies examining the release phase of the salvage process including a study examining predation at the point of release and a study examining injury and survival of delta smelt and Chinook salmon through the release pipe. Based on these studies, improvements to release operations and/or facilities, including improving fishing opportunities in Clifton Court Forebay (CCF) to reduce populations of predator fish, are being implemented.

CDFW and USFWS evaluated pre-screen loss and facility/louver efficiency for juvenile and adult delta smelt at the Skinner Delta Fish Protective Facility. DWR has also conducted pre-screen loss and facility efficiency studies for steelhead.

3.3.4.2 Harvey O. Banks Pumping Plant and Skinner Delta Fish Protective Facility

SWP facilities in the southern Delta include Clifton Court Forebay, John E. Skinner Delta Fish Protective Facility (Skinner), and the Banks Pumping Plant (Banks PP).

- Clifton Court Forebay will be extensively modified and repurposed under the PA, as described in Section 3.2.5, *Clifton Court Forebay*, however, the modifications will not impact or change operations of the existing Banks and Skinner facilities.

- Skinner is located west of the CCF, two miles upstream of the Banks PP. Skinner screens fish away from the pumps that lift water into the California Aqueduct. Large fish and debris are directed away from the facility by a 388-foot long trash boom. Smaller fish are diverted from the intake channel into bypasses by a series of metal louvers, while the main flow of water continues through the louvers and towards the pumps. The diverted fish pass through a secondary system of screens and pipes into seven holding tanks, where a sub-sample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.

- The Banks PP is in the South Delta, about eight miles northwest of Tracy, and marks the beginning of the California Aqueduct. By means of 11 pumps, including two rated at 375 cfs capacity, five at 1,130 cfs capacity, and four at 1,067 cfs capacity, the plant provides the initial lift of water 244 feet into the California Aqueduct. The nominal capacity of the Banks Pumping Plant is 10,300 cfs, although Corps permits restrict 3- and 7-day averages to 6,680 cfs.

3.3.4.3 Clifton Court Forebay Aquatic Weed Control Program

DWR will apply herbicides or will use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in CCF. Herbicides may include Komeen®, a chelated copper herbicide (copper-ethylenediamine complex and copper sulfate pentahydrate) and Nautique®, a copper carbonate compound. These products are used to control algal blooms that can degrade drinking water quality through tastes and odors and production of algal toxins. Dense growth of submerged aquatic weeds, predominantly *Egeria densa*, can cause severe head loss and pump cavitation at Banks Pumping Plant when the stems of the rooted plant break free and drift into the trashracks. This mass of uprooted and broken vegetation essentially forms a watertight plug at the trashracks and vertical louver array. The resulting blockage necessitates a reduction in the pumping rate of water to prevent potential equipment damage through cavitation at the pumps. Cavitation creates excessive wear and deterioration of the pump impeller blades. Excessive floating weed mats also reduce the efficiency of fish salvage at the Skinner Fish Facility. Ultimately, this all results in a reduction in the volume of water diverted by the SWP. Herbicide treatments will occur only in July and August on an as needed basis in the CCF, dependent upon the level of vegetation biomass in the enclosure.

3.3.4.4 Contra Costa Canal Rock Slough Intake

The CCWD diverts water from the Delta for irrigation and M&I uses under its CVP contract and under its own water right permits and license, issued by SWRCB for users. CCWD's water system includes the Mallard Slough, Rock Slough, Old River, and Middle River (on Victoria Canal) intakes; the Contra Costa Canal and shortcut pipeline; and the Los Vaqueros Reservoir. The Rock Slough Intake facilities, the Contra Costa Canal, and the shortcut pipeline are owned by Reclamation, and operated and maintained by CCWD under contract with Reclamation. Reclamation completed construction of the fish screen at the Rock Slough intake in 2011, and testing and the transfer of operation and maintenance to CCWD is ongoing. Mallard Slough Intake, Old River Intake, Middle River Intake, and Los Vaqueros Reservoir are owned and operated by CCWD. The operation of the Rock Slough intake is included in the PA; the operation of the other intakes, and Los Vaqueros Reservoir, are not included in the PA.

The Rock Slough Intake is located about four miles southeast of Oakley, where water flows through a positive barrier fish screen into the earth-lined portion of the Contra Costa Canal. The fish screen at this intake was constructed by Reclamation in accordance with the CVPIA and the 1993 USFWS BiOp for the Los Vaqueros Project to reduce take of fish through entrainment at the Rock Slough Intake. The Canal connects the fish screen at Rock Slough to Pumping Plant 1, approximately four miles to the west. The Canal is earth-lined and open to tidal influence for approximately 3.7 miles from the Rock Slough fish screen. Approximately 0.3 miles of the Canal immediately east (upstream) of Pumping Plant 1 have been encased in concrete pipe, the first portion of the Contra Costa Canal Encasement Project to be completed. When fully completed, the Canal Encasement Project will eliminate tidal flows into the Canal because the encased pipeline will be located below the tidal range elevation. Pumping Plant 1 has capacity to pump up to 350 cfs into the concrete-lined portion of the Canal. Diversions at Rock Slough Intake are typically taken under CVP contract. With completion of the Rock Slough fish screen, CCWD can divert approximately 30% to 50% of its total annual supply (approximately 127 TAF) through the Rock Slough Intake depending upon water quality there.

The Rock Slough fish screen has experienced problems; the current rake cleaning system on the screens is unable to handle the large amounts of aquatic vegetation that end up on the fish screen (National Marine Fisheries Service 2015: 2). Reclamation is testing alternative technology to improve vegetation removal, an action that NMFS (2015: 4) has concluded will improve screen efficiency by minimizing the risk of fish entrainment or impingement at the fish screen. Reclamation's testing program is expected to continue at least until 2018. The PA presumes continued operation and maintenance of the fish screen design that is operational when north Delta diversion operations commence, subject to any constraints imposed pursuant to the ongoing ESA Section 7 consultation on Rock Slough fish screen operations.

3.3.5 Water Transfers

California Water Law and the CVPIA promote water transfers as important water resource management measures to address water shortages provided certain protections to source areas and users are incorporated into the water transfer. Parties seeking water transfers generally acquire water from sellers who have available contract water and available stored water; sellers who can pump groundwater instead of using surface water; or sellers who will fallow crops or substitute a crop that uses less water in order to reduce normal consumptive use of surface diversions.

Water transfers occur when a water right holder within the Sacramento-San Joaquin River watershed undertakes actions to make water available for transfer. The PA does not address the upstream operations and authorizations (e.g., consultations under ESA Section 7) that may be necessary to make water available for transfer.

Transfers requiring export from the Delta are done at times when pumping and conveyance capacity at the CVP or SWP export facilities is available to move the water. Additionally, operations to accomplish these transfers must be carried out in coordination with CVP/SWP operations, such that the capabilities of the projects to exercise their own water rights or to meet their legal and regulatory requirements are not diminished or limited in any way. In particular, parties to the transfer are responsible for providing for any incremental changes in flows required to protect Delta water quality standards. All transfers will be in accordance with all existing regulations and requirements.

Purchasers of water for transfers may include Reclamation, CVP contractors, DWR, SWP entitlement holders, other State and Federal agencies, and other parties. DWR and Reclamation have operated water acquisition programs in the past to provide water for environmental programs and additional supplies to SWP entitlement holders, CVP contractors, and other parties. Past transfer programs include the following.

- DWR administered the 1991, 1992, 1994, and 2009 Drought Water Banks and Dry Year Programs in 2001 and 2002.
- Water transfers in the Delta watershed.
- Reclamation operated a forbearance program in 2001 by purchasing CVP contractors' water in the Sacramento Valley to support CVPIA instream flows and to augment water supplies for CVP contractors south of the Delta and wildlife refuges. Reclamation administers the CVPIA Water Acquisition Program for Refuge Level 4 supplies and fishery instream flows.
- DWR is a signatory to the Yuba River Accord Water Transfer Agreement through 2025 that provides fish flows on the Yuba River and water supply that is exported at DWR and Reclamation Delta Facilities. Reclamation may also become a signatory to that agreement in the future.
- Reclamation and the San Luis Delta-Mendota Water Authority issued a ROD and NOD for the Long-term Transfers Program, which addressed water transfers from water agencies in northern California to water agencies south of the Sacramento-San Joaquin Delta (Delta) and in the San Francisco Bay Area. Water transfers will occur through various methods, including, but not limited to, groundwater substitution and cropland idling, and will include individual and multiyear transfers from 2015 through 2024.
- In the past, CVP contractors and SWP entitlement holders have independently acquired water and arranged for pumping and conveyance through CVP/SWP facilities.

3.3.6 Maintenance of the Facilities

The PA includes the maintenance of the new north Delta facilities (intakes, conveyance facilities, and appurtenance structures), the HOR gate, and the south Delta facilities, as described below.

3.3.6.1 North Delta Intakes

Appendix 3.B, *Conceptual Engineering Report, Volume 1*, Section 6.3, *Maintenance Considerations*, discusses maintenance needs at the intakes. These include intake dewatering, sediment removal, debris removal, biofouling, corrosion, and equipment needs.

3.3.6.1.1 Intake Dewatering

The intake structure on the land side of each screen bay group (i.e., a group of 6 fish screens) will be dewatered by closing the slide gates on the back wall of the intake structure, installing bulkheads in guides at the front of the structure, and pumping out the water with a submersible pump; see Appendix 3.C, *Conceptual Engineering Report, Volume 2*, drawings 15, 16, 17, 19, and 22, for illustrations of this structure. The intake collector box conduits can be dewatered by closing the gates on both sides of the flow control sluice gates and flowmeter and pumping out the water between the gates. Dewatering could be done to remove accumulated sediment (described below) or to repair the fish screens.

Intake dewater would likely be disposed by discharge to conveyance, an activity which would have to potential to affect listed species. Any discharge of dewatering waters to surface water (the Sacramento River) would occur only in accordance with the terms and conditions of a valid NPDES permit and any other applicable Central Valley Regional Water Quality Control Board requirements.

3.3.6.1.2 Sediment Removal

Sediment can bury intakes, reduce intake capability, and force shutdowns for restoration of the intake. Maintenance sediment removal activities include activities that will occur on the river side of the fish screens, as well as activities that will occur on the land side of the fish screens. The former have the potential to affect listed species. They include suction dredging around the intake structure, and mechanical excavation around intake structures using track-mounted equipment and a clamshell dragline. Mechanical excavation will occur behind a floating turbidity control curtain. These maintenance activities will occur on an approximately annual basis, depending upon the rates of sediment accumulation.

Sediment will also be annually dredged from within the sedimentation basins using a barge mounted suction dredge, will periodically be removed from other piping and conduits within the facility by dewatering, and will be annually removed from the sediment drying lagoons using equipment such as a front-end loader. Since these activities will occur entirely within the facility, they have no potential to affect listed species. The accumulated sediment will be tested and disposed in accordance with the materials reuse provisions of AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*.

Maintenance dredging will occur only during NMFS- and USFWS-approved in-water work windows. Potential effects to listed species from maintenance dredging will be further minimized by compliance with terms and conditions issued pursuant to regulatory authorizations for the dredging work. These authorizations typically include a permit for in-water work from the USACE and a water quality certification from the Central Valley Regional Water Quality Control Board. Such certifications include provisions minimizing the risk of turbidity, mobilization of contaminated sediment, or spill of hazardous material (such as diesel fuel).

3.3.6.1.3 Debris Removal

After heavy-to-extreme hydrologic events, the intake structures will be visually inspected for debris. If a large amount of debris has accumulated, the debris must be removed. Intake screens, which remove debris from the surface of the water, are maintained by continuous traveling cleaning mechanisms, or other screen cleaning technology. Cleaning frequency depends on the debris load.

A log boom system will be aligned within the river alongside the intake structure to protect the fish screens and fish screen cleaning systems from being damaged by large floating debris. Spare parts for vulnerable portions of the intake structure will be kept available to minimize downtime, should repairs be needed.

3.3.6.1.4 Biofouling

Biofouling, the accumulation of algae and other biological organisms, could occlude the fish screens and impair function. A key design provision for intake facilities is that all mechanical elements can be moved to the top surface for inspection, cleaning, and repairs. The intake facilities will have top-side gantry crane systems for removal and insertion of screen panels, tuning baffle assemblies, and bulkheads. All panels will require periodic removal for pressure washing. Additionally, screen bay groups will require periodic dewatering (as described above) for inspection and assessment of biofouling rates. With the prospective invasion of quagga and zebra mussels into inland waters, screen and bay washing will become more frequent. Coatings and other deterrents to reduce the need for such maintenance will be investigated during further facility design. In-water work is not expected to be necessary to address biofouling, as the potentially affected equipment is designed for ready removal. However, if needed, in-water work would be performed consistent with NMFS- and USFWS-approved in-water work windows.

3.3.6.1.5 Corrosion

Materials for the intake screens and baffles will consist of plastics and austenitic stainless steels. Other systems will be constructed of mild steel, provided with protective coatings to preserve the condition of those buried and submerged metals and thereby extend their service lives. Passive (galvanic) anode systems can also be used for submerged steel elements. Maintenance consists of repainting coated surfaces and replacing sacrificial (zinc) anodes at multi-year intervals.

3.3.6.1.6 Equipment Needs

Operation and maintenance equipment for the intake facilities include the following.

- A self-contained portable high-pressure washer unit to clean fish screen and solid panels, concrete surfaces, and other surfaces.
- Submersible pumps for dewatering.

- A floating work platform for accessing, inspecting, and maintaining the river side of the facility.
- A hydraulic suction dredge.
- A man basket or bridge inspection rig to safely access the front of the intake structure from the upper deck.

3.3.6.1.7 Sedimentation Basins and Drying Lagoons

The sedimentation system at each intake will consist of a jetting system in the intake structure that will resuspend accumulated river sediment through the box conduits to two unlined earthen sedimentation basins where it will settle out, and then on to four drying lagoons (Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Sheets 10-13, 18-21, and 28-30; see also Appendix 3.B, *Conceptual Engineering Report, Volume 1,* Section 6.1.2, *Sedimentation System General Arrangement*, for detailed description of the sedimentation system). Sediment particles larger than 0.002 mm are expected to be retained (settle out) in the sedimentation basins, while particles smaller than 0.002 mm (i.e., colloidal particles) will flow through to the tunnel system to the IF.

At each intake, a barge-mounted suction dredge will hydraulically dredge the sedimentation basins through a dedicated dredge discharge pipeline to 4 drying lagoons. Dredging will occur annually. Dredged material will be disposed at an approved upland site.

3.3.6.2 Tunnels

Maintenance requirements for the tunnels have not yet been finalized. Some of the critical considerations include evaluating whether the tunnels need to be taken out of service for inspection and, if so, how frequently. Typically, new water conveyance tunnels are inspected at least every 10 years for the first 50 years and more frequently thereafter. In addition, the equipment that the facility owner must put into the tunnel for maintenance needs to be assessed so that the size of the tunnel access structures can be finalized. Equipment such as trolleys, boats, harnesses, camera equipment, and communication equipment will need to be described prior to finalizing shaft design, as will ventilation requirements. As described above, it is anticipated that, following construction, large-diameter construction shafts will be modified to approximately 20-foot diameter access shafts.

At the time of preparation of this Biological Assessment, the use of remotely operated vehicles or autonomous underwater vehicles is being considered for routine inspection, reducing the number of dewatering events and reserving such efforts for necessary repairs.

3.3.6.3 Intermediate Forebay

The IF embankments will be maintained to control vegetation and rodents (large rodents, such as muskrat and beaver, have been known to undermine similarly constructed embankments, causing embankment failure.) Embankments will be repaired in the event of island flooding and wind/wave action. Maintenance of control structures could include roller gates, radial gates, and stop logs. Maintenance requirements for the spillway will include the removal and disposal of any debris blocking the outlet culverts.

The majority of easily settled sediments are removed at the sedimentation basins at each intake facility (see Section 3.3.6.1.2 *Sediment Removal*). The IF provides additional opportunity to settle sediment. It is anticipated that over a 50-year period, sediments will accumulate to a depth of approximately 4.1 feet, which is less than one-half the height of the overflow weir at the outlet of the IF. Thus maintenance dredging of the IF is not expected to be necessary during the term of the proposed action.

3.3.6.4 Clifton Court Forebay and Pumping Plant

The CCF embankments and grounds, including the vicinity of the consolidated pumping plant as well as the NCCF and SCCF, will all be maintained to control of vegetation and rodents (large rodents, such as muskrat and beaver, have been known to undermine similarly constructed embankments, causing embankment failure). They will also be subject to embankment repairs in the event of island flooding and wind/wave action. Maintenance of forebay control structures could include roller gates, radial gates, and stop logs. Maintenance requirements for the spillway will include the removal and disposal of any debris blocking the structure. Riprap slope protection on the water-side of the embankments will require periodic maintenance to monitor and repair any sloughing. In-water work, if needed (e.g. to maintain riprap below the ordinary high-water mark), would be performed during NMFS- and USFWS-approved in-water work windows.

The small fraction of sediment passing through the IF is transported through the tunnels to NCCF. Given the upstream sediment removal and the large storage available at the forebay, sediment accumulation at NCCF is expected to be minimal over a even 50-year period, and no maintenance dredging is expected to be needed during the life of the facility.

3.3.6.5 Connections to Banks and Jones Pumping Plants

Maintenance requirements for the canal will include erosion control, control of vegetation and rodents, embankment repairs in the event of island flooding and wind wave action, and monitoring of seepage flows. Sediment traps may be constructed by over-excavating portions of the channel upstream of the structures where the flow rate will be reduced to allow suspended sediment to settle at a controlled location. The sediment traps will be periodically dredged to remove the trapped sediment.

3.3.6.6 Power Supply and Grid Connections

Three utility grids could supply power to the PA conveyance facilities: Pacific Gas and Electric Company (PG&E) (under the control of the California Independent System Operator), the Western Area Power Administration (Western), and/or the Sacramento Municipal Utility District (SMUD). The electrical power needed for the conveyance facilities will be procured in time to support construction and operation of the facilities. Purchased energy may be supplied by existing generation, or by new generation constructed to support the overall energy portfolio requirements of the western electric grid. It is unlikely that any new generation will be constructed solely to provide power to the PA conveyance facilities. It is anticipated the providers of the three utility grids that supply power to the PA will continue to maintain their facilities.

3.3.6.7 Head of Old River Gate

For the operable barrier proposed under the PA, maintenance of the gates will occur every 5 to 10 years. Maintenance of the motors, compressors, and control systems will occur annually and require a service truck.

Each miter or radial gate bay will include stop log guides and pockets for stop log posts to facilitate the dewatering of individual bays for inspection and maintenance. Each gate bay will be inspected annually at the end of the wet season for sediment accumulation. Maintenance dredging around the gate will be necessary to clear out sediment deposits. Dredging around the gates will be conducted using a sealed clamshell dredge. Depending on the rate of sedimentation, maintenance dredging is likely to occur at intervals of 3 to 5 years, removing no more than 25% of the original dredged amount. The timing and duration of maintenance dredging will comply with applicable in-water work windows imposed by CDFW, NMFS, and USFWS. Spoils will be dried in the areas adjacent to the gate site. A formal dredging plan with further details on specific maintenance dredging activities will be developed prior to dredging. Guidelines related to dredging are given in Appendix 3.F, *General Avoidance and Minimization Measures,* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material.* AMM6 requires preparation of a sampling and analysis plan; compliance with relevant NPDES and SWRCB requirements; compliance with applicable in-water work windows established by CDFW, NMFS, and USFWS; and other measures intended to minimize risk to listed species.

3.3.6.8 Existing South Delta Export Facilities

The PA will include maintenance of CVP/SWP facilities in the south Delta after the proposed intakes become operational.

Maintenance means those activities that maintain the capacity and operational features of the CVP/SWP water diversion and conveyance facilities described above. Maintenance activities include maintenance of electrical power supply facilities; maintenance as needed to ensure continued operations; replacement of facility or system components when necessary to maintain system capacity and operational capabilities; and upgrades and technological improvements of facilities to maintain system capacity and operational capabilities, improve system efficiencies, and reduce operations and maintenance costs.

3.4 Conservation Measures

Conservation measures are actions intended to avoid, minimize, and offset effects of the PA on listed species, and to provide for their conservation and management. This section describes the types of effects that require avoidance or minimization, and conservation measures to offset effects by providing compensatory habitat. This section also summarizes the protection and restoration required to meet the species-specific compensation commitments. The compensation commitments provided in this section are based on discussions with CDFW, NMFS, and USFWS and on typical species compensation provided through past Section 7 consultations, including programmatic BiOps, and taking into account the quality of habitat to be impacted relative to quality of the proposed compensation areas.

The PA includes a number of activities that are expected to cause few to no effects on listed species and therefore will not require compensation. These activities include acquisition and protection of mitigation lands for listed species of wildlife, the enhancement and management of protected and restored lands, and monitoring for listed species of fish and wildlife.

The protection of land requires no on-the-ground action or disturbance and thus has no potential to adversely affect species. Properly sited land protection will benefit listed species of wildlife by expanding and connecting existing protected lands. Grassland and vernal pool habitats will be protected to benefit San Joaquin kit fox, California tiger salamander, California red-legged frog, vernal pool fairy shrimp, and vernal pool tadpole shrimp. For details regarding the siting of lands that will be protected to benefit these species, see Section 3.4.6, *Terrestrial Species Conservation*.

Enhancement and management, and monitoring on protected and restored lands have potential to have some minor effects. For example, individuals could be harmed or harassed by management vehicles or personnel. These effects will be minimized through education and training, as described in Appendix 3.F, *General Avoidance and Minimization Measures*. Monitoring will be performed by qualified biologists. If handling of the species is necessary, this work will be done by qualified personnel with appropriate scientific collection permits.

Construction associated with the PA (Section 3.2, *Conveyance Facility Construction*) will result in the permanent and temporary removal of suitable habitat for listed species. Construction-related effects will be minimized through design, and through avoidance and minimization measures (Appendix 3.F, *General Avoidance and Minimization Measures*). The water conveyance facility design has considered and incorporated elements intended to minimize the total extent of the built facilities footprint, minimize loss of sensitive wildlife habitat, protect water quality, reduce noise and lighting effects, and reduce the total amount of transmission lines. In addition, there are commitments to entirely avoid the loss of habitat from certain activity types. Similarly, a number of operational and design features associated with the new intake facilities, and operational features of the PA, have been designed to minimize effects on fish and their critical habitat. These avoidance and minimization measures, as well as the proposed compensation for the loss of suitable habitat, are described for each species in Section 3.4.4, *Fish Species Conservation,* and Section 3.4.6, *Terrestrial Species Conservation*.

The conservation measures include compensation for the loss of habitat for listed species that occurs as a result of restoration actions to be implemented for the mitigation of effects of construction and/or operation of the proposed facilities on listed species and wetlands. These restoration actions are components of the PA and are intended to meet requirements pursuant to various laws and regulations including the California Endangered Species Act, the California Environmental Quality Act, the National Environmental Policy Act, and the Clean Water Act. All lands protected as compensation for effects on habitat will be owned in fee title or through conservation easements, or will be included in approved conservation banks. All such lands will be protected and maintained, in the manner described in this section, in perpetuity. The methods for quantifying loss of listed species habitat from restoration activities are described in Appendix 6.B, *Terrestrial Effects Analysis Methods*.

3.4.1 Restoration and Protection Site Management Plans

DWR, as project applicant, will prepare and implement a management plan for each listed species habitat restoration and protection site. Management plans may be for an individual parcel or for multiple parcels that share common management needs. Reclamation and DWR will conduct surveys to collect the information necessary to assess the ecological condition and function of conserved species habitats and supporting ecosystem processes, and based on the results, will identify actions necessary to achieve the desired habitat condition at each site.

Management plans will be prepared in collaboration with CDFW, NMFS, and USFWS, consistent with their authority, and submitted to those agencies for approval within 2 years of the acquisition of each site. This schedule is designed to allow time for site inventories and identification of appropriate management techniques. During the interim period, management of the site will occur using best practices and based on successful management at the same site prior to acquisition or based on management at other similar sites. The plans will be working documents that are updated and revised as needed to incorporate new acquisitions suitable for coverage under the same management plan and to document changes in management approach that have been agreed to by Reclamation, DWR, and the appropriate wildlife agency or agencies (CDFW, NMFS, and USFWS), consistent with their authority.

Each management plan will include, but not be limited to, descriptions of the following elements.

- The species-specific objectives to be achieved with management of each site covered by the plan.
- Baseline ecological conditions (e.g., habitat maps, assessment of listed species habitat functions, occurrence of listed species and other native wildlife species, vegetation structure and composition, assessment of nonnative species abundance and effect on habitat functions, occurrence and extent of nonnative species).
- Vegetation management actions that benefit natural communities and listed species and reduce fuel loads, as appropriate, and that are necessary to achieve the management plan objectives.
- If applicable, a fire management plan developed in coordination with the appropriate agencies and, to the extent practicable, consistent with achieving the management plan objectives.
- Infrastructure, hazards, and easements.
- Existing and adjacent land uses and management practices and their relationship to listed species habitat functions.

- Applicable permit terms and conditions.
- Terms and conditions of conservation easements when applicable.
- Management actions and schedules.
- Monitoring requirements and schedules.
- Established data acquisition and analysis protocols.
- Established data and report preservation, indexing, and repository protocols.
- Adaptive management approach.
- Any other information relevant to management of the preserved parcels.

Management plans will be periodically updated to incorporate changes in maintenance, management, and monitoring requirements as they may occur.

Based on the assessment of existing site conditions (e.g., soils, hydrology, vegetation, occurrence of listed species) and site constraints (e.g., location and size), and depending on biological objectives of the restoration sites, management plans will specify measures for enhancing and maintaining habitat as appropriate.

3.4.2 Conservation Banking

To provide protection and restoration in a timely manner without incurring temporal loss of listed species habitat, DWR may use existing conservation banks, establish its own conservation banks, or provide habitat protection/restoration in advance of anticipated impacts.

DWR may opt to use existing conservation banks to meet its mitigation needs for listed species. An example is the Mountain House Conservation Bank in eastern Alameda County. This bank has available conservation credits for San Joaquin kit fox, California tiger salamander, California red-legged frog, and vernal pool fairy shrimp; and the PA is in the service area for this bank for all four species. However, no approved conservation banks in the action area could address the needs of listed species of fish.

DWR may also opt to create its own conservation banks, subject to conclusion of appropriate agreements with USFWS (noting that no such banks are included in the PA and no such agreements have yet been concluded). If such banks are operational at the time impacts accrue under the PA, DWR may then use bank credits to mitigate for impacts incurred under the PA. Protection and restoration of grasslands, riparian woodlands, and nontidal wetlands may be suitable subjects for this approach.

3.4.3 Spatial Extent, Location, and Design of Restoration for Fish Species

Similar to the listed species of wildlife, the precise siting of parcels used to achieve habitat restoration for listed species of fish has yet to be determined. However, given species occurrence locations and habitat requirements, the regions where restoration is likely to occur can be generally defined. Impact maximums have been determined for each species and summarized in Table 3.4-1. If, during construction, impacts exceed the limits set forth here, the Section 7 consultation will need to be reinitiated. The conservation measures provide for the restoration of suitable habitat for Delta Smelt, Chinook salmon, steelhead, and green sturgeon.

The PA would occur, and its effects would be expressed, within designated critical habitat for each of the fish species, which encompasses waters throughout the entire legal Delta. The primary loss of habitat would occur in and around the proposed NDD. DWR and/or Reclamation will develop the siting and design of each individual tidal and channel margin restoration site consistent with the performance standards set by FWS and/or NMFS; final selection of restoration sites will be subject to NMFS and FWS concurrence as applicable. Each restoration site will be managed in accordance with a site-specific management plan, as described in Section 3.4.1, *Restoration and Protection Site Management Plans*. The following sections describe the siting and design considerations for tidal wetland and channel margin restoration activities.

3.4.3.1 Tidal Wetland Restoration

The PA includes 305 acres of tidal wetland restoration to offset permanent and temporary impacts to existing tidal and subtidal habitats, assuming green sturgeon and salmonid tidal restoration occurs at the same site(s).

Tidal wetland site selection and design would occur in coordination with FWS and NMFS. Restoration will primarily occur through breaching or setback of levees, thereby restoring tidal fluctuation to land parcels currently isolated behind those levees. Restored shallow subtidal aquatic areas are expected to support—depending on the location as well as the frequency, extent, and duration of inundation—habitat for Delta Smelt, juvenile salmonid rearing, and green sturgeon. Examples of factors that will be considered when evaluating sites for potential location and design of tidal wetland restoration include the following.

- Extensive occurrence of listed species of fish adjacent to areas that could be restored.
- For Delta Smelt, the potential to create desirable habitat features, as summarized by Sommer and Mejia (2013) in their suggestions for pilot Delta Smelt restoration projects: low salinity (< 6 ppt); moderate temperature (7–25°C); high turbidity (>12 NTU); sand-dominated substrate; at least moderately tidal; high copepod density; low SAV; low *Microcystis*; and open water habitat adjacent to long residence time habitat.
- For juvenile salmonids, principally Chinook salmon, the potential to create small (1st and 2nd order) dendritic tidal channels (channels that end in the upper marsh) for rearing (Fresh 2006); tidal freshwater sloughs with rich production of such insects as chironomid (midge) larvae; brackish marshes with emergent vegetation providing insect larvae, mysids, and epibenthic amphipods; and open-water habitats with drifting insects, zooplankton such as crab larvae, pelagic copepods, and larval fish (Quinn 2005).
- For green sturgeon, the potential to create intertidal and subtidal areas for foraging (Israel and Klimley 2008).

Shallow subtidal areas in large portions of the Delta support extensive beds of nonnative SAV that adversely affect listed species of fish (Nobriga et al. 2005; Brown and Michniuk 2007; Grimaldo et al. 2012). In other portions of the Delta, shallow subtidal areas provide suitable habitat for native species, such as Delta Smelt in the Liberty Island/Cache Slough area, and do not promote the growth of nonnative SAV (Nobriga et al. 2005; McLain and Castillo 2009). This conservation measure is not intended to restore large areas of shallow subtidal aquatic habitat, which would collaterally create habitat for nonnative predators; rather, shallow subtidal aquatic habitat restoration will result in portions of restored tidal marsh plain that are subsided below elevations that support tidal marsh vegetation. Additionally, bench habitats would be incorporated into the site selection and design to provide added specific benefits to salmonids. Areas potentially suitable for tidal wetland restoration for the PA include Sherman Island and Cache Slough areas, as well as at other sites in the northern Delta, and tidal wetland restoration will occur within one or more of these areas.

The conceptual approach to tidal habitat restoration is that, where practicable and appropriate, portions of restoration sites will be raised to elevations that will support tidal marsh vegetation following levee breaching. Depending on the degree of subsidence and location, lands may be elevated by grading higher elevations to fill subsided areas, importing clean dredged or fill material from other locations, or planting tules or other appropriate vegetation to raise elevations in shallowly subsided areas over time through organic material accumulation (Ingebritsen et al. 2000). Surface grading will provide for a shallow elevation gradient from the marsh plain to the upland transition habitat. Based on assessments of local hydrodynamic conditions, sediment transport, and topography, restoration activities may be designed and implemented in a manner that accelerates the development of tidal channels within restored marsh plains. Following reintroduction of tidal exchange, tidal marsh vegetation is expected to establish and maintain itself naturally at suitable elevations relative to the tidal range. Depending on site-specific conditions and monitoring results, patches of native emergent vegetation may be planted to accelerate the establishment of native marsh vegetation on restored marsh plain surfaces. A conceptual illustration of restored tidal freshwater emergent wetland natural community is presented in Figure 3.4-1.

USFWS and NMFS will be consulted with for site selection, site design, and site-specific success criteria. Completion of construction at each site will precede impacts associated with conveyance facility construction, but full compliance with the conservation measures in this biological assessment will be based on performance of the completed site consistent with the success criteria stated in the site-specific design documents, as demonstrated in reports to be provided to USFWS and NMFS by Reclamation.

General AMMs described in Appendix 3.F, *General Avoidance and Minimization Measures*, such as in-water work windows[26] and best management practices, will be implemented during tidal restoration construction. General AMMs applicable to tidal restoration work include AMMs 1 to 10, AMM14, AMM15, and AMM17.

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[26] Proposed in-water work windows vary within the Delta: June 1 to October 31 at the NDDs, June 1 to November 30 at the CCF, and August 1 to November 30 at the HOR Gate.

Construction of tidal wetland restoration could affect listed fish species by potential spills of construction equipment fluids; increased turbidity; increased exposure to methylmercury, pesticides and other contaminants when upland soils are inundated; and increased exposure to contaminants from disturbed aquatic sediments. However, these effects would be temporary and typically offset by the long-term benefits of the restored habitat.

Actions to be taken during restoration are expected to include pre-breach management of the restoration site to promote desirable vegetation and elevations within the restoration area and levee maintenance, improvement, or redesign. This may require substantial earthwork outside but adjacent to tidal and other aquatic environments. Levee breaching will require removing levee materials from within and adjacent to tidal and other aquatic habitats. Levee breaching is an activity that would entail in-water work using construction equipment such as bulldozers and backhoes; any in-water work would be performed during an in-water work window approved by NMFS and USFWS[1], as described in relevant general AMMs noted below. These materials will be placed on the remaining levee sections, placed within the restoration area, or hauled to a disposal area. Construction at tidal habitat restoration sites is expected to involve the following activities.

- Excavating channels to encourage the development of sinuous, high-density dendritic channel networks within restored marsh plain.
- Modifying ditches, cuts, and levees to encourage more natural tidal circulation and better flood conveyance based on local hydrology.
- Removal or breaching of existing levees or embankments or creation of new structures to allow restoration to take place while protecting adjacent land.
- Prior to breaching, recontouring the surface to maximize the extent of surface elevation suitable for establishment of tidal marsh vegetation by scalping higher elevation land to provide fill for placement on subsided lands to raise surface elevations.
- Prior to breaching, importing dredge or fill and placing it in shallowly subsided areas to raise ground surface elevations to a level suitable for establishment of tidal marsh vegetation.
- Tidal habitat restored adjacent to farmed lands may require construction of dikes to maintain those land uses.

3.4.3.2 Channel Margin Siting and Design Considerations

The PA includes restoration of 4 linear miles of channel margin to offset shoreline effects caused by the reduction in frequency of inundation of existing restored benches and habitat loss due to the new in-water structures (i.e., NDD, HOR gate, and barge landings). This would be accomplished by improving channel geometry and restoring riparian, marsh, and mudflat habitats on the water side of levees along channels that provide rearing and outmigration habitat for juvenile salmonids, similar to what is current done by the USACE and others when implementing levee improvements. Channel margin enhancements associated with federal project levees will not be implemented on the levee, but rather on benches to the waterward side of such levees, and flood conveyance will be maintained as designed. Channel margin enhancements associated with federal project levees may require permission from USACE in accordance with USACE's authority under the Rivers and Harbors Act (33 USC Section 408) and USACE levee vegetation policy. Accordingly, sites for the channel margin enhancements have not yet been determined, but they will be sited within the action area at locations along the Sacramento River, Steamboat and Sutter Sloughs, or in other areas subject to approval by NMFS and CDFW. On behalf of the State of California, DWR and the Central Valley Flood Protection Board are in coordination with USACE to minimize issues and identify a pathway for compliance. Any such enhancements would be designed, constructed, and maintained to ensure no reduction in performance of the federal flood project. Linear miles of enhancement will be measured along one side of a given channel segment (e.g., if both sides of a channel were enhanced for a length of 1 mile, this would account for a total of 2 miles of channel margin enhancement).

Chinook salmon and steelhead use channel margin habitat for rearing and protection from predators, and the primary purpose of channel margin habitat restoration is to offset shoreline effects caused by permanent habitat removal. Vegetation along channel margins contributes woody material, both instream and on channel banks, which increases instream cover for fish and enhances habitat for western pond turtle. Channel margin habitat is expected to provide rearing habitat and improve conditions along important migration corridors by providing increased habitat complexity, overhead and in-water cover, and prey resources for listed species of fish. Channel margin habitat is expected to increase rearing habitat for Chinook salmon fry in particular, through enhancement and creation of additional shallow-water habitat that will provide foraging opportunities and refuge from unfavorable hydraulic conditions and predation.

Channel margin enhancement will be achieved by implementing site-specific projects. The following habitat suitability factors will be considered when evaluating sites for potential location and design of enhanced channel margins.

- Existing poor habitat quality and biological performance for listed species of fish combined with extensive occurrence of listed species of fish.
- Locations where migrating salmon and steelhead are likely to require rest during high flows.
- The length of channel margin that can be practicably enhanced and the distance between enhanced areas (there may be a tradeoff between enhancing multiple shorter reaches that have less distance between them and enhancing relatively few longer reaches with greater distances between them).
- The potential for native riparian plantings to augment breeding and foraging habitat for listed species using riparian habitat, such as Swainson’s hawk, western yellow-billed cuckoo, tricolored blackbird, or riparian brush rabbit, in proximity to known occurrences.
- The potential cross-sectional profile of enhanced channels (elevation of habitat, topographic diversity, width, variability in edge and bench surfaces, depth, and slope).

- The potential amount and distribution of installed woody debris along enhanced channel margins.
- The extent of shaded riverine aquatic overstory and understory vegetative cover needed to provide future input of large woody debris.

Prior to channel margin enhancement construction (the on-the-ground activities that will put the channel margin enhancements in place) for each project, preparatory actions will include interagency coordination, feasibility evaluations, site acquisition, development of site-specific plans, and environmental compliance. USFWS and NMFS will be coordinated with during site selection, site design, and site-specific success criteria. Completion of construction at each site will precede impacts associated with conveyance facility construction, but full compliance with the conservation measures in this biological assessment will be based on performance of the completed site consistent with the success criteria stated in the site-specific design documents, as demonstrated in reports to be provided to USFWS and NMFS by Reclamation.

General AMMs described in Appendix 3.F, *General Avoidance and Minimization Measures*, such as in-water work windows[1] and best management practices, would be implemented during implementation of channel margin enhancement. General AMMs applicable to tidal restoration work include AMMs 1 to 10, AMM14, AMM15, and AMM17. After construction, each project will be monitored and adaptively managed to ensure that the success criteria outlined in the site-specific restoration plan are met.

Channel margin enhancement actions are expected to be performed in the following manner.

- Use large mechanized equipment (typically, a trackhoe) to remove riprap from channel margins.
- Use grading equipment such as trackhoes and bulldozers to modify the channel margin side of levees or setback levees to create low floodplain benches with variable surface elevations that create hydrodynamic complexity and support emergent vegetation.
- Use construction equipment such as trackhoes, bulldozers and cranes to install large woody material (e.g., tree trunks and stumps) into constructed low benches or into existing riprapped levees to provide physical complexity.
- Use personnel and small powered equipment such as off-road vehicles (ORV) to plant riparian and emergent wetland vegetation on created benches.

3.4.4 Fish Species Conservation

The following sections detail aspects of the PA intended to avoid and minimize adverse effects on listed species of fish and describe offsetting measures intended to compensate for adverse effects on listed species of fish (Table 3.4-1). In addition to species-specific avoidance and minimization measures (AMMs) discussed below, general avoidance and minimization measures that would be implemented uniformly during construction and maintenance/management of proposed water facilities and performance of conservation measures are fully detailed in Appendix 3.F, *General Avoidance and Minimization Measures*.

Table 3.4-1 relies on the analyses presented in Chapters 5 and 6 pertaining to the permanent and temporary construction and operation effects on fish habitat. A GIS analysis was used to determine the acreage of effect for each structure, including areas located in designated critical habitat that could be affected by placement of permanent in-water structures, and the temporary areas of effect (i.e., areas that would only be affected during construction activities; although all Delta Smelt habitat impacts are considered permanent because they are typically an annual fish.) A portion of this tidal wetland area is comprised of the bank habitat that juvenile salmon use for refuge and rearing, in addition to the open channel portions of the tidal wetlands. As such, the tidal wetland conservation for salmonids would include bank habitat as appropriate. The proposed 3:1 ratio is consistent with other projects in the Delta. Although there would be dredging and other construction-related disturbances in the Clifton Court Forebay, it is not considered high-quality or critical habitat for any of the species, it is assumed that any affected species could avoid the construction activity, and the AMMs associated with construction would minimize effects.

The effect of construction and operation on the frequency of inundation of previously-restored bench habitat would be compensated through 4 miles of channel margin habitat. The proposed compensation is based on the GIS analysis described above, and a review of the magnitude of change for the select benches in the analysis. The construction-related portion reflects the footprint of the combined three NDD (per Table 3.2-5: 4,707 linear feet, or 0.89 miles). The operations-related portion reflects potentially less frequent inundation of riparian benches because of NDD water diversions. The total linear extent of effect (2,212 feet, or 0.42 miles) was derived as follows, based on the greatest differences between NAA and PA from the analysis presented in Section 5.4.1.3.1.2.2.1.1, *Operational Effects*, in Chapter 5, *Effects Analysis for Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*:

- 29% lower riparian bench inundation index under PA in the Sacramento River from Sutter Steamboat sloughs to Rio Vista (1,685 feet of bench): 0.29 × 1,685 = 489 feet;

- 24% lower riparian bench inundation index under PA in the Sacramento River below the NDD to Sutter/Steamboat sloughs (3,037 feet of bench): 0.24 × 3,037 = 729 feet;

19% lower riparian bench inundation index under PA in Sutter/Steamboat Sloughs (5,235 feet of bench): 0.19 × 5,235 = 995 feet.

Table 3.4-1. Summary of Maximum Direct Impact, Proposed Compensation, and Potential Location of Restoration for State and Federally Listed Fish Species

Resource	Location of Impact	Maximum Direct Impacts – Total Impacts: Permanent	Maximum Direct Impacts – Total Impacts: Temporary	Mitigation Ratio	Total Compensation, Restoration	Potential Location of Proposed Restoration
Chinook salmon and CCV steelhead						
Channel Margin habitat (linear miles)	North Delta Diversions	Construction: 0.89; operations: 0.42	0	3:1	4	Sacramento River, Steamboat and Sutter Sloughs, or other areas agreed to by NMFS and CDFW[1]
Tidal wetland (acres)	North Delta Diversions	6.6	29.9	3:1	109.5	Sherman Island, Cache Slough, North Delta
	Head of Old River[2]	2.9	0	3:1	7.5	
	Barge Landings	22.4	0	3:1	67.2	
Green sturgeon						
Tidal wetland (acres)	North Delta Diversions	6.6	29.9	3:1	109.5	Sherman Island, Cache Slough, North Delta
	Head of Old River[2]	2.9	0	3:1	7.5	
	Barge Landings	22.4	0	3:1	67.2	
Delta smelt[3]						
Shallow water habitat (acres)	North Delta Diversions	13.1	0	5:1[4]	65.5	Sherman Island, Cache Slough, North Delta
Shallow water spawning beach habitat (acres)	Spawning habitat near North Delta Diversions	55	0	1:1	55	
Tidal wetland (acres)	Head of Old River[2]	2.9	0	3:1	7.5	
	Barge Landings	22.4	0	3:1	67.2	

[1] For purposes of estimating impacts of proposed restoration, it was assumed restoration will occur on the Sacramento River or Sutter or Steamboat Sloughs.
[2] The impacts of the temporary rock barrier have been mitigated, and therefore approximately 0.5 acres of impact is not assigned to the PA.
[3] All impacts on Delta Smelt habitat are assumed permanent since they would occur over multiple years and would therefore be experienced as a permanent effect to individuals, since delta smelt is typically an annual fish species.
[4] The 5:1 mitigation ratio assumes in-water work in June; should work not occur in June, the ratio would be 3:1. This may vary by intake.

3.4.4.1 Chinook Salmon and CCV Steelhead

3.4.4.1.1 Avoidance and Minimization Measures

AMMs that will be implemented to avoid or minimize effects on Chinook salmon and steelhead are detailed in Appendix 3.F, *General Avoidance and Minimization Measures*, and are summarized in Table 3.2-2. General AMMs specifically applicable to Chinook salmon and CCV steelhead include AMMs 1 to 10, AMM14, AMM15, and AMM17. In addition, the following species-specific avoidance and minimization measures will be implemented to minimize the potential for adverse effects on Chinook salmon and CCV steelhead.

3.4.4.1.1.1 Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities

The primary purpose of the predator reduction AMM is to contribute to improved survival (and thereby to contribute to increased abundance) of listed species of salmonids emigrating through the Delta, by locally reducing predation by nonnative predatory fishes (Lindley and Mohr 2003; Perry et al. 2010; Cavallo et al. 2012; Singer et al. 2012). This conservation measure is intended to benefit listed species of salmonids by reducing mortality rates of outmigrating juveniles that are particularly vulnerable to predatory fishes at the CVP and SWP export locations (i.e., the north Delta intakes and the CCF) during the main December through June migratory period. Physical reduction methods would be used for implementation of this measure, including boat electrofishing, hook-and-line fishing, passive capture by net or trap (e.g., gillnetting, hoop net, fyke trap), and active capture by net (e.g., beach seine). Predators are a natural part of the Delta ecosystem. Therefore, this AMM is not intended to entirely remove predators at these locations, or to substantially alter the abundance of predators at the scale of the Delta ecosystem. This AMM will also not remove piscivorous birds, which appear to prey opportunistically on hatchery salmon (Evans et al. 2011). Because of uncertainties regarding reduction methods and efficacy, implementation of this AMM will involve discrete study projects and research actions coupled with an adaptive management and monitoring program (Section 3.4.7, *Collaborative Science and Adaptive Management and Monitoring Program*) to evaluate effectiveness.

The purpose of a predatory fish reduction program is to reduce the abundance of predators, thereby reducing the mortality rates of protected or target species (in this case, listed salmonids) and increasing their abundance. To achieve this goal, the predator control programs will aim to limit the overall opportunity for fish predators to consume listed salmonids, potentially by decreasing predator numbers, modifying habitat features that provide an advantage to predators over prey, reducing encounter frequency between predators and prey, or reducing capture success of predators. Beamesderfer (2000) proposed the following decision-making process to determine where intervention measures in a predatory fish control program may prove effective and appropriate.

- Are one or more species significantly reducing the abundance of covered fish species, either directly by predation or indirectly by competition for a limited resource?
- Is it feasible to affect potential predators or competitors enough to provide benefits to the covered species?
- Do biological benefits outweigh costs and social/political considerations?

For listed salmonids, a high degree of uncertainty exists, which limits the ability to predict whether reducing predator numbers will yield a measurable benefit to listed salmonids in the Delta. Furthermore, some actions may not be acceptable for social, legal, or policy reasons. A recent review of the effects of fish predation on salmonids in the Bay Delta concluded:

"Although it is assumed that much of the short-term (<30 d) mortality experienced by these fish is likely due to predation, there are few data establishing this relationship. Juvenile salmon are clearly consumed by fish predators and several studies indicate that the population of predators is large enough to effectively consume all juvenile salmon production. However, given extensive flow modification, altered habitat conditions, native and non-native fish and avian predators, temperature and dissolved oxygen limitations, and overall reduction in historical salmon population size, it is not clear what proportion of juvenile mortality can be directly attributed to fish predation" (Grossman et al. 2013).

Given these uncertainties and constraints, the predator reduction AMM will initially be implemented as an experimental feasibility assessment study and a series of connected research actions. Actions will be designed both to reduce uncertainties about the efficacy of this conservation measure and to increase its likelihood of desirable outcomes. The most plausible and feasible initial actions would be localized reduction of selected predatory fish species in known predation hotspots, and modification of habitat features that tend to increase predation risk. The goal would be to reduce loss of listed salmonids, principally juvenile salmonids migrating through the Delta. The following sites are currently considered hotspots of predator aggregation or activity.

- **Clifton Court Forebay.** Native fish entrained in Clifton Court Forebay experience high prescreen losses (75 to 100%), presumably due to predation (Gingras 1997; Clark et al. 2009; Castillo et al. 2012). Striped bass are known to readily enter and leave through the radial gates (Gingras 1997).

- **CVP intakes.** Salmon experience approximately 15% prescreen loss at the south Delta CVP intakes, attributed to predation (Gingras 1997; Clark et al. 2009).

- **Head of Old River.** Nonphysical barriers have been tested here to prevent juvenile salmonids from entering Old River and continuing to the South Delta pumping plants. However, acoustic-tagging studies of juvenile hatchery salmon documented very high predation losses to striped bass patrolling the area and swimming along the barrier infrastructure (Bowen et al. 2009). The scour hole at the head of Old River can allow predators such as striped bass and catfish to congregate and ambush prey.

- **Georgiana Slough.** Acoustic-tagging studies indicate that survival rates of juvenile salmon released near Walnut Grove are much greater for juveniles traveling down the Sacramento River mainstem instead of down Georgiana Slough (Vogel 2008; Perry et al. 2010). It is assumed that the lower survival of juvenile salmon in Georgiana Slough is a result of greater predation because there are no other known plausible mechanisms for such large differences in survival.

- **Salvage release sites.** The fish salvaged from CVP/SWP South Delta export facilities are released daily via pipes located at only a few Delta locations. Over time, this has provided a limited number of obvious places that predators can aggregate and wait for dead, dying, and disoriented prey fishes. Refinements of release operations may provide some additional benefits to reduce predation.

In addition to these existing predation hotspots, the PA is expected to create a new hotspot.

- **North Delta water diversion facilities.** The three intakes included in *CM1 Water Facilities and Operation* would be likely predator hotspots. Large intake structures have been associated with increased predation by creating predator ambush opportunities and flow fields that disorient juvenile fish (Vogel 2008).

3.4.4.1.1.1.1 Implementation

This AMM includes the following two elements.

- Hotspot feasibility assessment study. Implement experimental treatment at NDD and CCF, monitor effectiveness, assess outcomes, and revise operations with guidance from the Policy Group (Section 3.4.7, *Collaborative Science and Adaptive Management and Monitoring Program*).

- Research actions. Via the adaptive management program, support focused studies to quantify the population-level efficacy of the feasibility assessment study and any program expansion(s) intended to increase salmonid smolt survival through the Delta.

The hotspot feasibility assessment study will be developed in three successive stages. During the first stage, a few treatment sites will be experimentally evaluated to test the general viability of various predator reduction methods. After the initial scoping stage is complete, and if shown to be effective, the second stage will consist of implementation of a feasibility assessment study with a larger range of treatment sites and refined techniques, incorporating what is learned from the first stage. The main focus at this stage is to study the efficacy of predator reduction on a larger scale to determine whether it is making a demonstrable difference and/or has any unintended ecological consequences (i.e., unexpected changes to foodweb dynamics that may have negative effects on covered fish species). The feasibility assessment study may include such activities as direct predator reduction at hotspots (e.g., Clifton Court Forebay, head of Old River scour hole, the Georgiana Slough sites, and SWP/CVP salvage release sites) and removal of old human-made structures (e.g., pier pilings, abandoned boats).

The feasibility assessment study will begin with a preliminary assessment phase to test general predator reduction in reaches with known high predation loss. To minimize uncertainty about the appropriate management regime necessary to maintain and enhance survival of covered salmonids, effectiveness monitoring will be implemented with the feasibility assessment study. Several metrics of actions and outcomes will be used. Effectiveness metrics include:

- Reduced abundance of predators – number of predatory fish removed or relocated from a reach (catch per unit effort), and abundance of predatory fishes in a locality after treatment compared to before-treatment conditions and reference sites (CPUE, hydroacoustic visualization of predator distribution). Document magnitude and duration of any potential effect.

- Increased survival of migrating salmonids – document survivorship of juveniles migrating through treated areas compared to pre-treatment conditions, and survivorship through the Delta (tagged fish study).

- Reduced habitat features that favor predation – modify, remove or reduce physical conditions and habitat features that increase risk for detection and capture by predators. Document the number of hotspots removed or modified, assess underwater conditions and fish distribution using hydroacoustic technology, and/or conduct a tagged fish study for survival across the Clifton Court Forebay into the salvage facility.

If the feasibility assessment study shows that the main issues are resolvable, the third stage will consist of a defined predator reduction program (i.e., defined in terms of predator reduction techniques and the sites where techniques will be employed). Research and monitoring will continue throughout the duration of the program to address remaining uncertainties and ensure the measures are effective (i.e., that they reduce local abundance of predators and increase survival of covered salmonids). If the feasibility assessment study shows no benefits, or shows adverse effects on covered species, the Reclamation, DWR, USFWS, NMFS, CDFW, and the public water agencies will, under the terms of the MOA described in Section 3.4.7, *Collaborative Science and Adaptive Management Program*, refine operations and decide whether and in what form predator reduction and further adaptive management will continue.

Due to the uncertainties regarding the approach for implementation of the predator reduction AMM, incidental take authorization for this AMM will be secured through a Section 10(A)(1)a) scientific collection permit, or through a separate Section 7 consultation, to be performed at the time the initial feasibility assessment study is begun.

3.4.4.1.1.2 Nonphysical Fish Barrier at Georgiana Slough

The need to reduce juvenile salmonid entry into the interior Delta was recognized in the NMFS BiOp (2009a, 2011), which requires that engineering solutions be investigated to achieve a reduction. Since 2011, DWR has been testing various engineering solutions in the Sacramento River at Georgiana Slough. Installation and seasonal operation of nonphysical barriers are hypothesized to improve survival of juvenile salmonids migrating downstream by guiding fish into channels in which they experience lower mortality rates (Welton et al. 2002; Bowen et al. 2012; Bowen and Bark 2012; Perry et al. 2014; California Department of Water Resources 2012b). A true nonphysical barrier functions by inducing behavioral aversion to a noxious stimulus, e.g., visual or auditory deterrents (Noatch and Suski 2012). One type of nonphysical barrier that has been tested at this site is the BioAcoustic Fish Fence (BAFF), which employs a three-component system comprising an acoustic deterrent within a bubble curtain that is illuminated by flashing strobe lights. As discussed further below, this type of nonphysical barrier has shown promising results in field studies at this site, as well as at other locations such as a field experiment on Atlantic salmon (*Salmo salar*) smolts in the River Frome, UK (Welton et al. 2002).

DWR has undertaken a pilot study using a BAFF at the Georgiana Slough–Sacramento River divergence to determine the effectiveness of the BAFF in preventing outmigrating juvenile Chinook salmon from entering Georgiana Slough (California Department of Water Resources 2012b; Perry et al. 2014). Approximately 1,500 acoustically tagged juvenile late fall–run Chinook salmon produced at the Coleman National Fish Hatchery were released into the Sacramento River upstream of Georgiana Slough and their downstream migrations past the BAFF and divergence with Georgiana Slough were monitored (California Department of Water Resources 2012b; Perry et al. 2014). During the 2011 study period, the nonphysical barrier reduced the percentage of salmon smolts passing into Georgiana Slough from 22.1% (barrier off) to 7.4% (barrier on), a reduction of approximately two-thirds of the fish that would have been entrained into Georgiana Slough (California Department of Water Resources 2012b; Perry et al. 2014). This improvement produced an overall efficiency rate of 90.8%; that is, 90.8% of fish that entered the area when the barrier was on exited by continuing down the Sacramento River. There was some indication that the behavior and movement patterns of juvenile salmon were influenced by the high river flows that occurred in spring 2011. However, at high (> 0.25 meter per second) and low (< 0.25 meter per second) across-barrier velocities, BAFF operations resulted in statistically significant increases in overall efficiency for juvenile salmon. A second evaluation of the BAFF system at this location in 2012, a much drier year than 2011, showed somewhat lower fish exclusion rates into Georgiana Slough, indicating a reduction in the percentage of fish that otherwise would be entrained into Georgiana Slough by about one-half (California Department of Water Resources 2015). This lower rate may be because of the lower river flow conditions in 2012 compared to 2011 (California Department of Water Resources 2015). The 2012 study also showed an approximately 50% reduction in entry into Georgiana Slough for juvenile steelhead when the BAFF was in place.

The uncertainties regarding the effectiveness of nonphysical barriers on all listed species, and at different flow rates, are continuing to be evaluated. While the response by juvenile hatchery-origin late fall–run Chinook salmon to the nonphysical barrier at Georgiana Slough appears positive, it does not necessarily reflect the response of other salmonids, particularly the smaller wild-origin winter-run Chinook salmon (California Department of Water Resources 2012b).

Perry et al. (2014) observed that fish more distant (i.e., across the channel) from the BAFF were less likely to be entrained into Georgiana Slough than those closer to the BAFF as they passed the slough, suggesting that guiding fish further away from the Georgiana Slough entrance would reduce entrainment into the slough. In essence, fish on the Georgiana Slough side of the critical streakline (the streamwise division of flow vectors entering each channel, or the location in the channel cross section where the parcels of water entering Georgiana Slough or remaining in the Sacramento River separate) have a higher probability of entering Georgiana Slough; the BAFF increases the likelihood that fish remain on the Sacramento River side of the critical streakline. In addition to the BAFF system evaluations of what may be considered true nonphysical barriers, studies are also underway to determine the effectiveness of a floating fish guidance structure at Georgiana Slough (California Department of Water Resources 2013). This structure uses steel panels suspended from floats to change water currents so that fish are guided towards the center of the river (away from the entrance to Georgiana Slough), but does not substantially change the amount of water entering the slough. Studies of this technology in other locations have found it to be successful for guiding fish toward more desirable routes, e.g., at the Lower Granite Dam on the Snake River, Washington (Adams et al. 2001, as cited by Schilt 2007). For this reason, although not a true nonphysical barrier in that a small portion of flow is redirected, this technology is presented as a potential design for this AMM because the large majority of flow does not change its destination; as with the BAFF, the objective essentially is to keep fish on the Sacramento River side of the critical streakline.

The nonphysical barrier proposed under this action will consist of technology determined to be appropriate for this site, which may be a combination of sound, light, and bubbles, similar to the BAFFs tested at the head of Old River and at Georgiana Slough (Bowen et al. 2012; Bowen and Bark 2012; California Department of Water Resources 2012b; Perry et al. 2014); or a floating fish guidance structures similar to that tested at Georgiana Slough in 2014 (California Department of Water Resources 2013). It is anticipated that design and permitting for the initial barrier installations will take approximately 2 years, with installation and operation beginning the following year. Construction and removal would likely be similar to the pilot studies undertaken in 2011, 2012, and 2014, (see biological opinions by USFWS [2011, 2012, 2014] and NMFS [2011, 2012, 2014]), with the exception of timing, which would occur during the typical in-water work window[1] in order to minimize the potential for adverse effects to listed fishes[27]. The PA includes operation of the proposed barrier, however, construction of the barrier will be subject to a separate Section 7 consultation to be performed prior to the initiation of NDD operations. At that time, the results of the pilot project will be used to develop a proposal for barrier design and the seasonal installation and removal of the barrier, along with a detailed statement of protocols for barrier operation. These design and operation specifics will be detailed in a biological assessment supporting what is expected to be a formal consultation. There are several possible nexuses that will drive the need for such a consultation; for example, a Corps permit will be needed for installation and removal of the barrier.

3.4.4.1.2 Restoration Actions

Based on the current estimate of effects, the PA includes restoration of 185 acres of tidal wetland habitat suitable for Chinook salmon and steelhead and 4 miles of channel margin habitat.

3.4.4.2 Green Sturgeon

3.4.4.2.1 Avoidance and Minimization Measures

The AMMs shown in Table 3.2-2 also apply to green sturgeon. Details of each of these measures are provided in Appendix 3.F, *General Avoidance and Minimization Measures*.

3.4.4.2.2 Restoration Actions

Based on the current estimate of effects, the PA includes restoration of 185 acres of tidal wetland habitat suitable for green sturgeon.

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[27] Construction of the NPBs in the pilot studies occurred during winter.

3.4.4.3 Southern Resident Killer Whale

3.4.4.3.1 Avoidance and Minimization Measures

Since the proposed action is not identified as having adverse effects on Southern Resident killer whale, and the species is not known to occur in the action area, no avoidance and minimization measures are proposed for this species.

3.4.4.3.2 Restoration Actions

Since the proposed action is not identified as having adverse effects on Southern Resident killer whale, and the species is not known to occur in the action area, no compensation measures are proposed for this species.

3.4.4.4 Delta Smelt

3.4.4.4.1 Avoidance and Minimization Measures

The following general AMMs are proposed for Delta Smelt. These AMMs are briefly described in Table 3.2-2 and fully detailed in Appendix 3.F, *General Avoidance and Minimization Measures*.

- AMM1, Worker Awareness Training
- AMM2, Construction Best Management Practices (BMPs) and Monitoring
- AMM3, Stormwater Pollution Prevention Plan
- AMM4, Erosion and Sediment Control Plan
- AMM5, Spill Prevention, Containment, and Countermeasure Plan
- AMM6, Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material
- AMM7, Barge Operations Plan
- AMM8, Fish Rescue and Salvage Plan
- AMM9, Underwater Sound Control and Abatement Plan
- AMM10, Methylmercury Management
- AMM14, Hazardous Material Management
- AMM15, Construction Site Security
- AMM17, Notification of Activities in Waterways

3.4.4.4.2 Conservation Measures

The following conservation measures are proposed for Delta Smelt:

- An in-water work window of June 1 to October 31 at the NDDs, June 1 to November 30 at the CCF, and August 1 to November 30 at the HOR Gate.
- Restoration of 159 acres of tidal wetland habitat suitable for Delta Smelt, of which 114 acres is intended to offset construction impacts on Delta Smelt and their habitat, and 55 acres are intended to offset impaired Delta Smelt access to critical habitat in the vicinity of the NDDs. Restoration would be performed at a site in the north or west Delta to be approved by USFWS, as described in Section 3.4.3.1, *Tidal Wetland Restoration*.

3.4.5 Spatial Extent, Location, and Design of Restoration for Listed Species of Wildlife

The spatial extent of restoration and protection activities will be determined by the spatial extent of impacts and the applied mitigation ratios. While actual impacts and compensation will be determined on an annual basis during construction of the PA, as detailed in Section 3.4.1, *Restoration and Protection*, maximum impact limits will be set to define the upper bounds of effects on suitable habitat for listed species of wildlife. Table 3.4-2 summarizes the maximum impact limit, mitigation ratios, and total proposed compensation. This includes compensation for species protected under CESA because this compensation is a component of the PA. The maximum impact on habitat for listed species is estimated using the methods described in Appendix 6.B, *Terrestrial Effects Analysis Methods*. The total compensation proposed to offset effects if all impacts occur is described in Section 3.4.6, *Terrestrial Species Conservation*. The results of the impact analysis are summarized in Chapter 6, *Effects Analysis for Delta Smelt and Terrestrial Species*.

The precise siting of parcels used to achieve habitat restoration and protection has yet to be determined. Compensation will be sited near the location of impacts if and when practicable and feasible. Given species occurrence locations and habitat requirements, the regions where restoration and protection are likely to occur can be generally defined. The regions are summarized in Table 3.4-2 and further described below. Impacts on habitat for listed species of wildlife as a result of conservation measures are described and quantified in Chapter 6, *Effects Analysis for Delta Smelt and Terrestrial Species*. If, during construction, impacts exceed the limits set forth here, the Section 7 consultation will need to be reinitiated. The conservation measures provide for the restoration of suitable habitat for giant garter snake, valley elderberry longhorn beetle, vernal pool fairy shrimp, and vernal pool tadpole shrimp.

Restoration of nontidal wetlands for the giant garter snake is likely to occur in the central or east central portion of the legal Delta, or to the east of the legal Delta. Recent sightings of giant garter snake on Webb Island, Empire Tract, Bacon Island, and Decker Island suggest the species could benefit from nontidal wetland restoration in the central or east central Delta. Other potential locations for restoration include the Stone Lakes Wildlife Refuge, the Cosumnes-Mokelumne area, and the Caldoni Marsh/White Slough region.

Restoration of valley elderberry longhorn beetle suitable habitat will likely occur in the north Delta. This region includes several known occurrences (just southwest of West Sacramento) and will allow riparian restoration to be part of a larger tidal or riparian restoration effort as part of the California WaterFix. Valley elderberry longhorn beetle restoration could also be achieved as part of channel margin enhancement efforts as part of the California WaterFix (Section 3.4.3, *Spatial Extent, Location, and Design of Restoration for Fish Species*).

Vernal pool restoration to compensate for effects on vernal pool fairy shrimp and vernal pool tadpole shrimp will be prioritized in the Altamont Hills recovery area, just northwest of the Clifton Court Forebay, which also coincides with the vernal pool fairy shrimp critical habitat unit that will be affected by the PA. Other restoration opportunities might exist in this region, but outside the recovery area. This region is nearest the impact location, includes occurrences of these two species, and is located at the urban edge of a larger complex of protected, intact vernal pools where restoration opportunities likely exist. There is also potential to mitigate effects on these species through use of a conservation bank. The restoration locations for all listed species will be determined in coordination with USFWS staff. Siting criteria for restoration activities is detailed in Section 3.4.6, *Terrestrial Species Conservation*.

Table 3.4-2. Summary of Maximum Direct Impact, Proposed Compensation, and Potential Location of Restoration and Protection for State and Federally Listed Species of Wildlife[28][29]

Resource	Total Modeled Habitat in the Action Area (Acres)	Maximum Direct Impacts		Mitigation Ratios		Total Proposed Compensation if All Impacts Occur		Potential Location of Proposed Restoration and Protection
		Total Impacts						
		Permanent (Acres)	Temporary (Acres)	Protection	Restoration	Total Compensation, Protection	Total Compensation, Restoration	
San Joaquin kit fox	5,192	285	70	2:1	-	570	0	Byron Hills Region, East Contra Costa County
Sandhill Crane[f]								
Foraging habitat[g]	240,475	3,333	988	1:1	-	3,333	0	Central Delta
Roosting and foraging habitat (permanent and temporary)	23,919	16	85	n/a[i]	n/a[i]	95	500	Central Delta
Swainson's hawk								
Foraging habitat	433,972	4,033	980	1:1	-	4,033	0	North, east, and south Delta
Nesting habitat	9,087	21	8	1:1	1:1	21	21	North or east Delta
Giant garter snake							0	
Aquatic - High	13,598	61	29	-	3:1	0	183	
Aquatic - moderate	12,095	93	7	-	2:1	0	186	
Aquatic - low	635	88	19	-	1:1	0	88	
Upland - high	32,216	154	46	-	2:1[a]/ 3:1[b]	0	1,462/156[a,b]	Northeast and Central Delta
Upland - moderate	8,357	429	108	-	-	0	0	
Upland - low	22,046	105	12	-	-	0	0	
California red-legged frog								
Aquatic habitat	118	1[i]	1	2:1	1:1	0	0	
Upland cover and dispersal habitat	3,498	104	19	3:1	-	312	0	Byron Hills Region, East Contra Costa County
Aquatic habitat (miles)	26	0	0	-	-	0	0	
California tiger salamander	12,724	104	9	3:1	-	312	0	Byron Hills Region, East Contra Costa County
Valley elderberry longhorn beetle								

[28] State listed species are included here because mitigation under 2081 is a component of the proposed action.

[29] Maximum direct impacts presented here do not include effects from restoration except for tidal restoration impacts on giant garter snake and valley elderberry longhorn beetle as described in Section 6.7.9.1, *Habitat Conversion,* and Section 6.10.9.1.1, *Tidal Restoration*, respectively.

Resource	Total Modeled Habitat in the Action Area (Acres)	Maximum Direct Impacts		Mitigation Ratios		Total Proposed Compensation if All Impacts Occur		Potential Location of Proposed Restoration and Protection
		Total Impacts		Protection	Restoration	Total Compensation, Protection	Total Compensation, Restoration	
		Permanent (Acres)	Temporar y (Acres)					
Riparian vegetation	16,300	49	19	-	- [c]	0	70[c]	North, east, and south Delta
Nonriparian channels and grasslands	15,195	227	87	-	- [c]	0	- [c]	
Vernal pool fairy shrimp								
Vernal pool complex - Direct	89	6	0	-	2:1/3:1[d]	0	12/18 [d]	Byron Hills Region, west of Clifton Court Forebay, prioritizing Altamont Hills Recovery Area
Vernal pool tadpole shrimp								
Vernal pool complex - Direct	89	6	0	-	2:1/3:1[d]	0	12/18 [d]	Byron Hills Region, west of Clifton Court Forebay, prioritizing Altamont Hills Recovery Area
Mason's lilaeopsis total	-[e]	1.51	0	-	1:1	0	1.51	North, central, or west Delta

a. Giant garter snake upland habitat will be created or protected in association with the protected and restored aquatic habitat at a ratio of 2 acres of upland for each acre of aquatic habitat protected or restored. Total aquatic compensation is 731 acres therefore 1,462 acres of upland compensation is proposed.

b. Aquatic and upland compensation is primarily based on the loss of aquatic habitat, however, the loss of upland habitat patches that are not adjacent to effected aquatic habitat will be mitigated 3:1. There is 52 acres of upland habitat loss that is not adjacent to effected aquatic habitat therefore 156 acres of protection and restoration is required for compensation. 1/3 (52 acres) of the 156 acres of compensation will be achieved through aquatic protection and restoration and 2/3 (104 acres) will be achieved by upland protection and restoration.

c. The impact assessment is based on the loss of elderberry bush stems and the compensation is based on the required number of transplants, elderberry seedlings, and native plant plantings.

d. Compensation varies for vernal pool crustaceans, depending on whether the compensation is achieved with by conservation bank/or non-bank means.

e. Mason's lilaeopsis habitat was not modeled.

f. Lesser sandhill crane impacts are slightly greater than those of greater sandhill crane. Because mitigation ratios for both species are the same and because both species will benefit for the mitigation, impacts and mitigation are presented together here.

g. Permanent and temporary effects from conveyance construction from Table 12-4-32 of the REIR/SEIS, 1,495 acres of tidal restoration effects also assumed.

i. Roosting habitat compensation from Chapter 12 of the BDCP/CWF REIR/SEIS.

3.4.6 Terrestrial Species Conservation

The following sections detail aspects of the PA intended to avoid and minimize adverse effects on listed species of wildlife and describe offsetting measures intended to compensate for adverse effects on listed species of wildlife. In addition to species-specific avoidance and minimization measures (AMMs) discussed below, general avoidance and minimization measures that would be implemented uniformly during construction and maintenance/management of proposed water facilities and performance of conservation measures are fully detailed in Appendix 3.F, *General Avoidance and Minimization Measures*.

3.4.6.1 Riparian Brush Rabbit

3.4.6.1.1 Habitat Description

Riparian brush rabbit suitable habitat is defined in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.5.6, *Suitable Habitat Definition*. Within the action area, based on the known distribution of the species, suitable habitat is defined to include the area south of SR 4 and Old River Pipeline. Within this area, suitable riparian habitat includes the vegetation types that comprise a dense, brushy understory shrub layer with a minimum patch size of 0.05 acres. Riparian brush rabbit grassland habitat includes grasslands with a minimum patch size of 0.05 acres that are adjacent to riparian brush rabbit riparian habitat. As described in Section 4.A.5.7, *Head of Old River Gate Habitat Assessment*, there is no suitable habitat within the project footprint.

3.4.6.1.2 Avoidance and Minimization Measures

3.4.6.1.2.1 Head of Old River Gate

Construction of the HOR gate will fully avoid loss of riparian brush rabbit habitat. As described in Section 4.A.5.7, *Head of Old River Gate Habitat Assessment*, there is no potentially suitable habitat for riparian brush rabbit within the construction footprint. As stated in Section 3.2.8.2.2, *Gate Construction*, the gate construction site, including the temporary work area, has for many years been used for seasonal construction and removal of a temporary rock barrier, and all proposed work will occur within the area that is currently seasonally disturbed for temporary rock barrier construction. Site access roads and staging areas used in the past for rock barrier installation and removal will be used for construction, staging, and other construction support facilities for the proposed barrier.

DWR will implement the following measures to avoid and minimize noise and lighting related effects on riparian brush rabbit:

- Establish a 1,200-foot nondisturbance buffer between any project activities and potentially suitable habitat.
- Establish a 1,400-foot buffer between any lighting and pile driving and potentially suitable habitat.
- Screen all lights and direct them down toward work activities away from potential occupied habitat. A biological construction monitor will ensure that lights are properly directed at all times.

- Operate portable lights at the lowest allowable wattage and height, while in accordance with the National Cooperative Highway Research Program's *Report 498: Illumination Guidelines for Nighttime Highway Work*.
- Limit construction during nighttime hours (10:00 p.m. to 7:00 a.m.) such that construction noise levels do not exceed 50 dBA L_{max}[30] at the nearest residential land uses.
- Limit pile driving to daytime hours (7:00 a.m. to 6:00 p.m.).

3.4.6.1.2.2 Geotechnical Exploration
Geotechnical exploration for the PA will not occur in or near riparian brush rabbit suitable riparian habitat.

3.4.6.1.2.3 Power Supply and Grid Connections
Power supply and gird connections for the PA will not occur within or near riparian brush rabbit suitable riparian habitat.

3.4.6.1.2.4 Restoration Activities
Restoration activities for the PA will not occur within or near riparian brush rabbit suitable riparian habitat.

3.4.6.2 San Joaquin Kit Fox

3.4.6.2.1 Habitat Definition
San Joaquin kit fox suitable habitat is defined in Section 4.A.6.6, *Suitable Habitat Definition*. Within the action area, based on the known distribution of the species, suitable habitat is defined as grassland habitats south and west of SR 4 from Antioch (Bypass Road to Balfour Road to Brentwood Boulevard) to Middle River, then south along Middle River to Clifton Court Forebay, then along the western and southern sides of Clifton Court Forebay to Old River; from there, south along the county line to Byron Highway, and from west of Byron Highway to I-205 and also from north of I-205 to I-580, and west of I-580. San Joaquin kit fox preconstruction surveys will be required for activities occurring on, or within 200 feet[31] of, suitable habitat. A USFWS-approved biologist will conduct these pre-construction surveys.

3.4.6.2.2 Avoidance and Minimization Measures
AMMs are described below first for activities with fixed locations including the Clifton Court Forebay canal, Clifton Court expansion area and embankment, and the reusable tunnel material placement area. Additional AMMs are then described for activities with flexible locations: habitat restoration, transmission lines, and geotechnical investigations. General AMMs are discussed in Appendix 3.F, *General Avoidance and Minimization Measures*.

[31] 200 feet is the distance from the activity within which a natal/pupping den survey is required as stated in the *Standardized Recommendations for Protection of the Endangered San Joaquin Kit Fox prior to or during Ground Disturbance* (U.S. Fish and Wildlife Service 2011).

3.4.6.2.2.1 Activities with Fixed Locations

Construction of the Clifton Court Forebay canal and Clifton Court expansion area and embankment, activities associated with the reusable tunnel material site near Clifton Court Forebay, and any operations and maintenance activities involving use of heavy equipment associated with these facilities in the vicinity of San Joaquin kit fox habitat, will follow the avoidance and minimization measures described below. Additionally, once the transmission lines and vernal pool restoration locations have been sited, construction associated with these activities will follow the avoidance and minimization measures described below.

Workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. Additionally, to avoid direct effects of the PA on San Joaquin kit fox, the following measures will be implemented. These measures are based on USFWS's *Standardized Recommendations for Protection of the Endangered San Joaquin Kit Fox prior to or during Ground Disturbance* (U.S. Fish and Wildlife Service 2011).

3.4.6.2.2.1.1 San Joaquin Kit Fox Surveys

Within 14 to 30 days prior to ground disturbance related to PA activities, a USFWS-approved biologist with experience surveying for and observing the species will conduct preconstruction surveys in those areas identified as having suitable habitat per the habitat model described in Section 4.A.6.6, *Suitable Habitat Definition*, or per the recommendation of the USFWS approved biologist. The USFWS-approved biologist will survey the worksite footprint and the area within 200 feet beyond the footprint to identify known or potential San Joaquin kit fox dens. Adjacent parcels under different land ownership will not be surveyed unless access is granted within the 200-foot radius of the construction activity. The USFWS-approved biologists will conduct these searches by systematically walking 30- to 100-foot-wide transects throughout the survey area; transect width will be adjusted based on vegetation height and topography (California Department of Fish and Game 1990). The USFWS-approved biologist will conduct walking transects such that 100% visual coverage of the worksite footprint is achieved. Dens will be classified in one of the following four den status categories outlined in the *Standardized Recommendations for Protection of the Endangered San Joaquin Kit Fox Prior to or During Ground Disturbance* (U.S. Fish and Wildlife Service 2011).

- **Potential den.** Any subterranean hole within the species' range that has entrances of appropriate dimensions for which available evidence is sufficient to conclude that it is being used or has been used by a kit fox. Potential dens comprise any suitable subterranean hole or any den or burrow of another species (e.g., coyote, badger, red fox, or ground squirrel) that otherwise has appropriate characteristics for kit fox use. If a potential den is found, the biologist will establish a 50-foot buffer using flagging.

- **Known den.** Any existing natural den or artificial structure that is used or has been used at any time in the past by a San Joaquin kit fox. Evidence of use may include historical records; past or current radiotelemetry or spotlighting data; kit fox sign such as tracks, scat, and/or prey remains; or other reasonable proof that a given den is being or has been used by a kit fox.

- **Natal or pupping den.** Any den used by kit foxes to whelp and/or rear their pups. Natal/ pupping dens may be larger with more numerous entrances than dens occupied exclusively by adults. These dens typically have more kit fox tracks, scat, and prey remains near the den and may have a broader apron of matted dirt and/or vegetation at one or more entrances. A natal den, defined as a den in which kit fox pups are actually whelped but not necessarily reared, is a more restrictive version of the pupping den. In practice, however, it is difficult to distinguish between the two; therefore, for purposes of this definition, either term applies. If a natal den is discovered, a buffer of at least 200 feet will be established using fencing.

- **Atypical den.** Any artificial structure that has been or is being occupied by a San Joaquin kit fox. Atypical dens may include pipes, culverts, and diggings beneath concrete slabs and buildings. If an atypical den is discovered, the biologist will establish a 50-foot buffer using flagging.

The USFWS-approved biologist will flag all potential small mammal burrows within 50 feet of the worksite to alert biological and work crews of their presence.

3.4.6.2.2.1.2 Avoidance of San Joaquin Kit Fox Dens

Disturbance to all San Joaquin kit fox dens will be avoided, to the extent possible. Limited den destruction may be allowed, if avoidance is not a reasonable alternative, provided the following procedures are observed.

- If an atypical, natal, known or potential San Joaquin kit fox den is discovered at the worksite, the den will be monitored for three days by a USFWS-approved biologist using a tracking medium or an infrared beam camera to determine if the den is currently being used.

- Unoccupied potential, known, or atypical dens will be destroyed immediately to prevent subsequent use. The den will be fully excavated by hand, filled with dirt, and compacted to ensure that San Joaquin kit foxes cannot reenter or use the den during the construction period.

- If an active natal or pupping den is found, USFWS will be notified immediately. The den will not be destroyed until the pups and adults have vacated and then only after further coordination with USFWS. All known dens will have at least a 100-foot buffer established using fencing.

- If kit fox activity is observed at the potential, known, or atypical den during the pre-construction surveys, den use will be actively discouraged, as described below, and monitoring will continue for an additional five consecutive days from the time of the first observation to allow any resident animals to move to another den. For dens other than natal or pupping dens, use of the den can be discouraged by partially plugging the entrance with soil such that any resident animal can easily escape. Once the den is determined to be unoccupied, it may be excavated under the direction of the Service-approved biologist. Alternatively, if the animal is still present after five or more consecutive days of plugging and monitoring, the den may have to be excavated by hand when, in the judgment of a Service-approved biologist, it is temporarily vacant (i.e., during the animal’s normal foraging activities). If at any point during excavation a kit fox is discovered inside the den, the excavation activity will cease immediately and monitoring of the den, as described above, will be resumed. Destruction of the den may be completed when, in the judgment of the biologist, the animal has escaped from the partially destroyed den.

- Construction and operational requirements from *Standardized Recommendations for Protection of the San Joaquin Kit Fox prior to or during Ground Disturbance* (U.S. Fish and Wildlife Service 2011) or the latest guidelines will be implemented.

- If potential, known, atypical, or natal or pupping dens are identified at the worksite or within a 200-foot buffer, exclusion zones around each den entrance or cluster of entrances will be demarcated. The configuration of exclusion zones will be circular, with a radius measured outward from the den entrance(s). No activities will occur within the exclusion zones. Exclusion zone radii for atypical dens and suitable dens will be at least 50 feet and will be demarcated with four to five flagged stakes. Exclusion zone radii for known dens will be at least 100 feet and will be demarcated with staking and flagging that encircle each den or cluster of dens but do not prevent access to the den by the foxes.

Written results of the surveys will be submitted to USFWS within five calendar days of the completion of surveys and prior to the beginning of ground disturbance and/or construction activities in San Joaquin kit fox modeled habitat.

3.4.6.2.2.1.3 Construction Related Avoidance and Minimization Measures

During construction, the following measures will be implemented for all activities in suitable San Joaquin kit fox habitat (as determined by a USFWS-approved biologist):

- Vehicles will observe a daytime speed limit of 20-mph throughout the worksite, where it is practical and safe to do so, except on county roads and state and Federal highways; vehicles will observe a nighttime speed limit of 10-mph throughout the worksite; this is particularly important at night when kit foxes are most active. Nighttime construction in or adjacent to San Joaquin kit fox habitat will be minimized to the greatest extent practicable.

- To prevent inadvertent entrapment of kit foxes or other animals during construction, all excavated, steep-walled holes or trenches more than 2 feet deep will be covered at the close of each working day by plywood or similar materials. If the trenches cannot be closed, one or more escape ramps constructed of earthen-fill or wooden planks will be installed. Before such holes or trenches are filled, they will be thoroughly inspected for trapped animals. If at any time a trapped or injured kit fox is discovered, USFWS will be contacted.

- Kit foxes are attracted to den-like structures such as pipes and may enter stored pipes and become trapped or injured. All construction pipes, culverts, or similar structures with a diameter of 4 inches or greater that are stored at a construction site within suitable kit fox habitat for one or more overnight periods will be thoroughly inspected for kit foxes before the pipe is subsequently buried, capped, or otherwise used or moved in any way. If a kit fox is discovered inside a pipe, that section of pipe will not be moved until USFWS has been consulted. If necessary, and under the direct supervision of the USFWS-approved biologist, the pipe may be moved only once to remove it from the path of construction activity until the fox has escaped.

- All food-related trash items such as wrappers, cans, bottles, and food scraps will be disposed of in securely closed containers and removed at least once a week from a construction site in suitable kit fox habitat.

- No firearms will be allowed at worksites.

- No pets, such as dogs or cats, will be permitted at worksites to prevent harassment, mortality of kit foxes, or destruction of dens.

- Use of rodenticides and herbicides in areas that are in modeled kit fox habitat will be prohibited.

- The USFWS-approved biologist for San Joaquin kit fox will be the contact source for any employee or contractor who might incidentally kill or injure a kit fox or who finds a dead, injured, or entrapped kit fox.

- An employee education program (AMM1 *Worker Awareness Training*) will be conducted for any activities that will be conducted in San Joaquin kit fox habitat. The program will consist of a brief presentation by the USFWS-approved biologist for San Joaquin kit fox to explain endangered species concerns to all personnel who will be working in the construction area. The program will include the following: A description of the San Joaquin kit fox and its habitat needs; a report of the occurrence of kit fox at the worksite; an explanation of the status of the species and its protection under the Endangered Species Act; and a list of measures being taken to reduce impacts on the species during construction and operations. A fact sheet conveying this information will be prepared for distribution to all worksite personnel.

- Upon completion of construction at a worksite, all areas subject to temporary ground disturbances will be re-contoured if necessary, and revegetated to promote restoration of the area to pre-construction conditions. An area subject to “temporary” disturbance means any area that is disturbed during construction, but after construction will be revegetated. Appropriate methods and plant species used to revegetate such areas will be determined on a site-specific basis in consultation with USFWS.

- Any personnel who are responsible for incidentally killing or injuring a San Joaquin kit fox will immediately report the incident to the USFWS-approved biologist. The USFWS-approved biologist will contact USFWS immediately in the case of a dead, injured, or entrapped kit fox. USFWS will be contacted at the numbers below.

- The San Francisco- Bay -Delta Fish and Wildlife Office will be notified immediately of the accidental death or injury to a San Joaquin kit fox. Notification must include the date, time, and location of the incident or of the finding of a dead or injured animal and any other pertinent information. The USFWS contact is the Assistant Field Supervisor of Endangered Species, at the addresses and telephone numbers below.

- New sightings of kit fox will be reported to the California Natural Diversity Database (CNDDB). A copy of the reporting form and a topographic map clearly marked with the location of where the kit fox was observed will also be provided to USFWS at the address below.

Any information required by USFWS or questions concerning the above conditions or their implementation may be directed in writing to USFWS at: Bay-Delta Fish & Wildlife Office, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814, (916) 930-5604 office).

3.4.6.2.2.2 Activities with Flexible Locations

3.4.6.2.2.2.1 Geotechnical Exploration

- Vehicles will access the work site following the shortest possible route from the levee road. All site access and staging shall limit disturbance to the riverbank, or levee as much as possible and avoid sensitive habitats. When possible, existing ingress and egress points shall be used. The USFWS-approved biologist for San Joaquin kit fox will survey the sites for kit fox no less than 14 days and no more than 30 days prior to beginning of Geotechnical exploration activities.

- Project activities will not take place at night when kit foxes are most active.

- Off-road traffic outside of designated project areas will be prohibited.

- A USFWS-approved biological monitor will be stationed near the work areas to assist the construction crew with environmental issues as necessary. If kit foxes are encountered by a USFWS-approved biological monitor during construction, activities shall cease until appropriate corrective measures have been completed or it has been determined that the species will not be harmed.

- To prevent inadvertent entrapment of kit foxes or other animals during the construction phase of a project, all excavated, steep-walled holes or trenches more than 2 feet (0.6 m) deep will be covered at the close of each working day by plywood or similar materials, or provided with one or more escape ramps constructed of earth fill or wooden planks. Before such holes or trenches are filled, they will be thoroughly inspected for trapped animals.

- All construction pipes, culverts, or similar structures with a diameter of 4 inches (10 cm) or greater that are stored at a construction site for one or more overnight periods should be thoroughly inspected for kit foxes before the pipe is used or moved in any way. If a kit fox is discovered inside a pipe, construction activities will be halted and that section of pipe will not be moved until the USFWS-approved biologist monitoring the project construction site has contacted the USFWS. Once the Service has given the construction monitor instructions on how to proceed or the kit fox has escaped on its own volition, the pipe may be moved.

- No firearms shall be allowed on the project site.
- Noise will be minimized to the extent possible at the work site to avoid disturbing kit foxes.
- To prevent harassment, mortality of kit foxes or destruction of dens by dogs or cats, no pets are permitted on project sites.
- Rodenticides and herbicides will not be used during geotechnical exploration.
- If a San Joaquin kit fox is incidentally injured or killed or entrapped, the USFWS-approved biological monitor shall immediately report the incident to the USWFS. Notification must include the date, time, and location of the incident or of the finding of a dead or injured animal and any other pertinent information.

3.4.6.2.2.2.2 Power Supply and Grid Connections

Prior to final design for the transmission line alignments, a USFWS-approved biologist will survey potential transmission line locations where suitable San Joaquin kit fox habitat is present. These surveys will be conducted as described in Section 3.4.7.2.2.1.1, *San Joaquin Kit Fox Surveys,* except that the surveys will be conducted early enough to inform the final transmission line design but no less than 14 days and no more than 30 days prior to beginning of PA activities. Therefore, multiple surveys may be required.

If any occupied dens are found, USFWS will be immediately contacted and the project will be designed to avoid the occupied dens by 200 feet. After the final transmission line alignment has been determined, the avoidance and minimization measures described in Section 3.4.7.2.1.1, *Activities with Fixed Locations,* will be followed.

3.4.6.2.2.2.3 Restoration

Prior to final design for vernal pool restoration, a USFWS-approved biologist will survey potential restoration locations where suitable San Joaquin kit fox habitat is present. These surveys will be conducted as described in Section 3.4.7.2.2.1.1, *San Joaquin Kit Fox Surveys,* except that the surveys will be conducted early enough to inform the restoration design but no less than 14 days and no more than 30 days prior to beginning of PA activities. Therefore, multiple surveys may be required. If any occupied dens are found, USFWS will be immediately contacted and the project will be designed to avoid the occupied dens by 200 feet. After the final restoration design is completed, the avoidance and minimization measures described in Section 3.4.7.2.1.1, *Activities with Fixed Locations,* will be followed.

3.4.6.2.3 Compensation for Effects

DWR will protect San Joaquin kit fox habitat at a ratio of 2:1 (protected: lost) at a location subject to USFWS approval, adjacent to other modeled San Joaquin kit fox habitat to provide a large, contiguous habitat block. 293 acres of suitable San Joaquin kit fox habitat will be affected and therefore 586 acres of habitat will be protected (Table 3.4-3). San Joaquin kit fox protection will be accomplished either through the purchase of mitigation credits through an existing, USFWS-approved conservation bank or will be purchased in fee-title by DWR or a DWR partner organization with approval from the USFWS. If purchased in fee-title, a permanent, USFWS-approved conservation easement will be placed on the property.

Table 3.4-3. Compensation for Effects on San Joaquin Kit Fox Habitat.

San Joaquin Kit Fox Modeled Habitat	Maximum Total Impact (Acres)	Habitat Protection Compensation Ratio	Total Habitat Protection (Acres)
Breeding, Foraging, and Dispersal Habitat	293	2:1	586

3.4.6.2.4 Siting Criteria for Compensation of Effects

Suitable San Joaquin kit fox habitat will be acquired for protection in the Byron Hills area, subject to USFWS approval, where there is connectivity to existing protected habitat and to other adjoining kit fox habitat. Grassland protection will focus in particular on acquiring the largest remaining contiguous patches of unprotected grassland habitat, which are located south of SR 4. This area connects to over 620 acres of existing habitat that was protected under the East Contra Costa County HCP/NCCP. Grasslands will also be managed and enhanced to increase prey availability and to increase mammal burrows, which could benefit the San Joaquin kit fox by increasing potential den sites, which are a limiting factor for the kit fox in the northern portion of its range. These management and enhancement actions are expected to benefit the San Joaquin kit fox by increasing the habitat value of the protected grasslands.

3.4.6.2.5 Management and Enhancement

Management and enhancement activities on protected San Joaquin kit fox habitat will be designed and conducted in coordination with (or by) the East Contra Costa County Habitat Conservancy or East Bay Regional Park District. Both of these entities have extensive experience conducting successful grassland management and to benefit San Joaquin kit fox in the area where this habitat will be protected to mitigate the effects of the PA. Management plans on San Joaquin kit fox conservation land will be subject to Service approval.

- **Vegetation management.** Vegetation will be managed to reduce fuel loads for wildfires, reduce thatch, minimize nonnative competition with native plant species, increase biodiversity, and provide suitable habitat conditions for San Joaquin kit fox. Grazing will be the primary mechanism for vegetation management on protected San Joaquin kit fox habitat.

- **Burrow availability.** Grasslands (including the grassland natural community and grasslands within vernal pool complex and alkali seasonal wetland complex natural communities) will be enhanced and managed to increase the availability of burrows and to increase prey availability for San Joaquin kit fox). Ground-dwelling mammals are important prey for San Joaquin kit fox, and kit foxes in the northern extent of their range often modify ground squirrel burrows for their own use. Some rodent control measures will likely remain necessary in certain areas where dense rodent populations may compromise important infrastructure (e.g., pond berms, road embankments, railroad beds, levees, dam faces). The land manager will introduce livestock grazing (where it is not currently used) to reduce vegetative cover and thus encourage ground squirrel expansion and colonization. Burrow availability may also be increased on protected grasslands by encouraging ground squirrel occupancy through the creation of berms, mounds, edges, and other features designed to attract and encourage burrowing activity. The use of any rodenticides on San Joaquin kit fox conservation lands is prohibited as its use does not meet the general standards for San Joaquin kit fox conservation areas and does not align with San Joaquin kit fox management.

3.4.6.3 California Least Tern

3.4.6.3.1 Habitat Definition

California least tern suitable habitat is defined in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.7.6, *Suitable Habitat Definition*. The implementation of general construction avoidance and minimization measures including best management practices and worker awareness training (Appendix 3.F, *General Avoidance and Minimization Measures*) will minimize the effects of construction on California least tern foraging habitat.

3.4.6.3.2 Avoidance and Minimization Measures

If suitable nesting habitat for California least tern (flat, unvegetated areas near aquatic foraging habitat) is identified during planning-level surveys, at least three preconstruction surveys for this species will be conducted during the nesting season by a qualified biologist with experience observing the species and its nests. Projects will be designed to avoid loss of California least tern nesting colonies. No construction will take place within 200 feet of a California least tern nest during the nesting season (April 15 to August 15, or as determined through surveys).

Only inspection, maintenance, research, or monitoring activities may be performed during the least tern breeding season in occupied least tern nesting habitat with USFWS and CDFW approval under the supervision of a qualified biologist. General AMMs are discussed in Appendix 3.F, *General Avoidance and Minimization Measures*.

3.4.6.4 Western Yellow-Billed Cuckoo

3.4.6.4.1 Habitat Definition

AMMs for western yellow-billed cuckoo will be required for activities occurring within suitable habitat, or in the vicinity of suitable habitat, as defined in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.8.6, *Suitable Habitat Definition*. To conservatively estimate effects of the PA on western yellow-billed cuckoo, a model for western yellow-billed cuckoo migratory habitat was created (Appendix 4.A, Section 4.A.8.7, *Species Habitat Suitability Model*). Prior to disturbing an area potentially supporting habitat for the species, a USFWS approved biologist will evaluate the area to identify suitable habitat as described in Section 3.4.8.2, *Required Compliance Monitoring.* The following avoidance and minimization measures will be applied within suitable habitat for western yellow-billed cuckoo.

3.4.6.4.2 Avoidance and Minimization Measures

3.4.6.4.2.1 Activities with Fixed Locations

Activities with fixed locations include all construction activities described in Section 3.2, *Conveyance Facility Construction* except geotechnical exploration, safe haven intervention sites, and transmission lines. The following measures will be required for construction, operation, and maintenance related to fixed location activities in suitable migratory habitat. The following measures will also be required for activities with flexible locations once their locations have been fixed, if they occur in suitable habitat. Permanent or temporary loss of all suitable migratory habitat will be minimized by all activities associated with the PA through project design and no more than 33 acres of migratory habitat will be removed by activities associated with the PA.

- Prior to construction, all suitable western yellow-billed cuckoo habitat in the construction area will be surveyed, with surveys performed in accordance with any required USFWS survey protocols and permits applicable at the time of construction.

- If surveys find cuckoos in the area where vegetation will be removed, vegetation removal will be done outside the cuckoo nesting season.

- To the extent feasible, the contractor will employ best practices to reduce construction noise during daytime and evening hours (7:00 a.m. to 10:00 p.m.) such that construction noise levels do not exceed 60 dBA (A-weighted decibel) L_{eq} (1 hour) at the nearest western yellow-billed cuckoo migratory habitat during migration periods.

- Limit construction during nighttime hours (10:00 p.m. to 7:00 a.m.) such that construction noise levels do not exceed 50 dBA L_{max}[32] at the nearest residential land uses. Limit pile driving to daytime hours (7:00 a.m. to 7:00 p.m.).

- Locate, store, and maintain portable and stationary equipment as far as possible from suitable western yellow-billed cuckoo habitat.

- Employ preventive maintenance including practicable methods and devices to control, prevent, and minimize noise.

- Route truck traffic in order to reduce construction noise impacts and traffic noise levels within 1,200 feet of suitable western yellow-billed cuckoo migratory habitat during migration periods.

- Limit trucking activities (e.g., deliveries, export of materials) to the hours of 7:00 a.m. to 10:00 p.m.

- Screen all lights and direct them down toward work activities away from migratory habitat. A biological construction monitor will ensure that lights are properly directed at all times.

- Operate portable lights at the lowest allowable wattage and height, while in accordance with the National Cooperative Highway Research Program's *Report 498: Illumination Guidelines for Nighttime Highway Work*.

[32] L_{max} is the maximum sound level measured for a given interval of time.

3.4.6.4.2.2 Activities with Flexible Locations

3.4.6.4.2.2.1 Geotechnical Exploration

During geotechnical activities, a USFWS approved biologist will be onsite to avoid the loss or degradation of suitable western yellow-billed cuckoo migratory habitat by exploration activities.

3.4.6.4.2.2.2 Safe Haven Work Areas

During the siting phase of safe haven construction, a USFWS approved biologist will work with the engineers to minimize the loss or degradation of suitable western yellow-billed cuckoo migratory habitat. No more than one acre of migratory habitat will be removed for safe haven work areas.

3.4.6.4.2.2.3 Power Supply and Grid Connections

The final transmission line alignment will be designed to minimize removal of western yellow-billed cuckoo migratory habitat by removing no more than four acres of this habitat. To minimize the chance of western yellow-billed cuckoo bird strikes at transmission lines, bird strike diverters will be installed on project and existing transmission lines in a configuration that research indicates will reduce bird strike risk by at least 60% or more. Bird strike diverters placed on new and existing lines will be periodically inspected and replaced as needed until or unless the project or existing line is removed. The most effective and appropriate diverter for minimizing strikes on the market according to best available science will be selected.

3.4.6.4.2.2.4 Restoration Activities

A USFWS biologist will work with the restoration siting and design team to avoid the permanent loss of suitable western yellow-billed cuckoo migratory habitat.

3.4.6.4.3 Compensation to Offset Impacts

DWR will offset the loss of 33 acres of western yellow-billed cuckoo migratory habitat through the creation or restoration at a 2:1 ratio, for a total of 66 acres of riparian habitat creation or restoration in the action area. DWR will develop a riparian restoration plan that will identify the location and methods for riparian creation or restoration, and this plan will be subject to USFWS approval.

3.4.6.5 Giant Garter Snake

3.4.6.5.1 Habitat Definition

Giant garter snake suitable habitat is defined in Appendix 4.A, *Status of the Species and Critical Habitat Accounts,* Section 4.A.9.6, *Suitable Habitat Definition*. The giant garter snake habitat model, described in Appendix 4.A, Section 4.A.9.2, *Life History and Habitat Requirements*, was created to conservatively estimate effects to habitat, because access to activity areas is not possible at this time.

During project implementation and prior to project construction, DWR, in agreement with CDFW and USFWS, will:

1. Develop a giant garter snake habitat description to be used to identify suitable habitat within the area of modeled habitat at each site, when each site becomes available for surveys.

2. When each site is available for surveys, a giant garter snake expert, approved by USFWS and CDFW, will then use the agreed habitat description to delineate giant garter snake habitat at each project site, including both aquatic and upland habitat.

3. Once habitat has been delineated, the giant garter snake expert may use giant garter snake surveys performed using a method approved by the USFWS to determine presence/absence of the species on the project site to enable further determination of mitigation requirements as described below in Section 3.4.7.5.3, *Compensation for Effects*.

4. For sites where such surveys are performed, the surveys will conform to protocol and reporting need per a plan to be jointly developed by DWR and USFWS to provide population and occurrence data for the species in the Delta.

5. To the greatest extent possible, identified and delineated habitat will be completely avoided.

6. When avoidance is not possible, the measures discussed below in Section 3.4.7.5.2, *Avoidance and Minimization Measures,* are required.

3.4.6.5.2 Avoidance and Minimization Measures

AMMs for giant garter snakes will be required for activities occurring within suitable aquatic and upland habitat. For general AMMs see Appendix 3F, *General Avoidance and Minimization Measures*).

3.4.6.5.2.1 Activities with Fixed Locations

Activities with fixed locations include all construction activities described in Section 3.2, *Conveyance Facility Construction,* except geotechnical exploration, safe haven intervention sites, and transmission lines. DWR will implement the following AMMs for construction, operation, and maintenance related to fixed location activities in delineated habitat. DWR will also implement the following measures for activities with flexible locations once their locations have been fixed, if they occur in delineated habitat.

- To the extent practicable, minimize construction or operations and maintenance activities on suitable giant garter snake upland habitat within 200 feet of the banks of suitable giant garter snake aquatic habitat, during periods of aestivation (between October 1 and May 1). Suitability of aquatic and upland habitat characteristics will be determined by the USFWS-approved biologist consistent with the USFWS habitat description outlined in Section 4.A.9.6, *Suitable Habitat Definition*.

- To the extent practicable, conduct all activities within paved roads, farm roads, road shoulders, and similarly disturbed and compacted areas; confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities.

- For construction activities, dredging, and any conveyance facility maintenance involving heavy equipment, giant garter snake aquatic and upland habitat that can be avoided will be clearly delineated on the work site, with exclusionary fencing and signage identifying these areas as sensitive. The exclusionary fencing will be installed during the active period for giant garter snake (May 1–October 1) and will consist of 3-foot-tall non-monofilament silt fencing extending to 6 inches below ground level.

- For activities requiring exclusionary fencing, the biological monitor and construction supervisor will be responsible for checking the exclusionary fences around the work areas daily to ensure that they are intact and upright. Any necessary repairs will be immediately addressed. The exclusionary fencing will remain in place for the duration of construction. For additional detail on exclusionary fencing type, size, and height, see Appendix 3.F, *General Avoidance and Minimization Measures,* Section 3.F.2.2, *AMM2 Construction Best Management Practices and Monitoring*.

- The USFWS-approved biologist will also survey suitable aquatic and upland habitat in the entire work site for the presence of giant garter snakes.

- If exclusionary fencing is found to be compromised, a survey of the exclusion fencing and the area inside the fencing will be conducted immediately preceding construction activity that occurs in delineated giant garter snake habitat or in advance of any activity that may result in take of the species. The biologist will search along exclusionary fences, in pipes, and beneath vehicles before they are moved. Any giant garter snake found will be captured and relocated to suitable habitat a minimum of 200 feet outside of the work area in a location that is approved by USFWS and CDFW prior to resumption of construction activity.

- All construction personnel, and personnel involved in operations and maintenance in or near giant garter snake habitat, will attend worker environmental awareness training as described in Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM1 Worker Awareness Training*. This training will include instructions to workers on how to recognize giant garter snakes, their habitat(s), and the nature and purpose of protection measures.

- Within 24 hours prior to construction activities, dredging, or maintenance activities requiring heavy equipment, a USFWS-approved biologist will survey all of the activity area not protected by exclusionary fencing where giant garter snake could be present. This survey of the work area will be repeated if a lapse in construction or dredging activity of two weeks or greater occurs during the aestivation period (October 1 through May 1) or if the lapse in construction activity is more than 12 hours during active season (May 1–October 1). If a giant garter snake is encountered during surveys or construction, cease activities until appropriate corrective measures have been completed, it has been determined that the giant garter snake will not be harmed, or the giant garter snake has left the work area.

- The USFWS-approved biological monitor will help guide access and construction work around wetlands, active rice fields, and other sensitive habitats capable of supporting giant garter snake, to minimize habitat disturbance and risk of injuring or killing giant garter snakes.

- Report all observations of giant garter snakes to the USFWS-approved biological monitor.

- Maintain all construction and operations and maintenance equipment to prevent leaks of fuel, lubricants, and other fluids and use extreme caution when handling and or storing chemicals (such as fuel and hydraulic fluid) near waterways, and abide by all applicable laws and regulations. Follow all applicable hazardous waste best management practices (BMPs) and keep appropriate materials on site to contain, manage, and clean up any spills as described in Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM5 Spill Prevention, Containment, and Countermeasure Plan.*

- Conduct service and refueling procedures in uplands in staging areas and at least 200 feet away from giant garter snake upland habitat and waterways when practicable. See also Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM5, Spill Prevention, Containment, and Countermeasure Plan*.

- During construction and operation and maintenance activities in and near giant garter snake habitat, employ erosion (non-monofilament silt fence), sediment, material stockpile, and dust control (BMPs on site). Avoid fill or runoff into wetland areas or waterways to the extent practicable.

- Return temporary work areas to pre-existing contours and conditions upon completion of work. Where re-vegetation and soil stabilization are necessary in non-agricultural habitats, revegetate with appropriate non-invasive native plants at a density and structure similar to that of pre-construction conditions.

- Properly contain and remove from the worksite all trash and waste items generated by construction and crew activities to prevent the encouragement of predators such as raccoons and coyotes from occupying the site.

- Permit no pets, campfires, or firearms at the worksite.

- Store equipment in designated staging area areas at least 200 feet away from giant garter snake aquatic habitat to the extent practicable.

- Confine any vegetation clearing to the minimum area necessary to facilitate construction activities.

- Limit vehicle speed to 10 miles per hour (mph) on access routes (except for public roads and highways) and within work areas that are within 200 feet of giant garter snake aquatic habitat but not protected by exclusion fencing to avoid running over giant garter snakes.

- Visually check for giant garter snake under vehicles and equipment prior to moving them. Cap all materials onsite (conduits, pipe, etc.), precluding wildlife from becoming entrapped. Check any crevices or cavities in the work area where individuals may be present including stockpiles that have been left for more than 24 hours where cracks/crevices may have formed.

For activities that will occur within the giant garter snake inactive season (October 2 through April 30), and will last more than two weeks, DWR will implement the following additional avoidance and minimization measures.

- For proposed activities that will occur within suitable aquatic giant garter snake habitat, during the active giant garter snake season (May 1 through October 1) prior to proposed construction activities that will commence during the inactive period, and when unavoidable, all aquatic giant garter snake habitat will be dewatered for at least 14 days prior to excavating or filling the dewatered habitat. De-watering is necessary because aquatic habitat provides prey and cover for giant garter snake; de-watering serves to remove the attractant, and increase the likelihood that giant garter snake will move to other available habitat. Any deviation from this measure will be done in coordination with, and with approval of, the U.S. Fish and Wildlife Service.

- Following de-watering of aquatic habitat, all potential impact areas that provide suitable aquatic or upland giant garter snake habitat will be surveyed for giant garter snake by the USFWS-approved biologist. If giant garter snakes are observed, they will be passively allowed to leave the potential impact area, or the USFWS will be consulted to determine the appropriate course of action for removing giant garter snake from the potential impact area.

Maintenance activities such as vegetation and rodent control, embankment repair, and channel maintenance will occur at conveyance facilities with permanent structures (e.g., NDD, pumping plant, etc.). The following avoidance and minimization measures will be applied to maintenance activities in suitable aquatic habitat and uplands within 200 feet of suitable aquatic habitat, to minimize effects on the giant garter snake.

- Vegetation control will take place during the active period (May 1 through October 1) when snakes are able to move out of areas of activity.

- Trapping or hunting methods will be used for rodent control, rather than poison bait. All rodent control methods will be approved by USFWS. If trapping or other non-poison methods are ineffective, the USFWS will be consulted to determine the best course of action.

- Movement of heavy equipment will be confined to outside 200 feet of the banks of giant garter snake aquatic habitat to minimize habitat disturbance.

- All construction personnel, and personnel involved in operations and maintenance in or near giant garter snake habitat, will attend worker environmental awareness training as described in Appendix 3.F *General Avoidance and Minimization Measures*, *AMM1 Worker Awareness Training*. This training will include instructions to workers on how to recognize giant garter snakes, their habitat(s), and the nature and purpose of protection measures.

3.4.6.5.2.2 Activities with Flexible Locations

Activities with flexible locations are activities that cannot yet be precisely sited because they require design or site-specific information that will not be available until the PA is already in progress. These include geotechnical exploration, safe haven intervention sites, transmission lines, and habitat restoration.

Geotechnical Activities

Geotechnical activities will avoid giant garter snake aquatic habitat. To the extent practicable, all activities within giant garter snake habitat, as delineated by a USFWS approved biologist, will avoid impacts to suitable uplands within 200 feet of suitable aquatic habitat. The following avoidance and minimization measures will be used to minimize effects on the giant garter snake.

- If construction takes place outside the giant garter snake's active period (May 1 through October 1), activities on suitable upland giant garter snake habitat within 200 feet from the banks of giant garter snake aquatic habitat will be avoided.
- Movement of heavy equipment will avoid suitable upland giant garter snake habitat within 200 feet of the banks of suitable giant garter snake aquatic habitat to minimize habitat disturbance.
- Construction personnel will receive USFWS-approved worker environmental awareness training instructing workers to recognize giant garter snakes and their habitat.

Safe Haven Work Areas

Workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. Once the safe havens are sited, activities will conform to the AMMs described above under Section 3.4.7.5.2.1, *Activities with Fixed Locations.*

Power Lines and Grid Connections

Giant garter snake avoidance and minimization measures for transmission lines will be the same as described in Section 3.4.7.5.2.1, *Activities with Fixed Locations.*

Restoration

Restoration activities will be designed to fully avoid giant garter snake habitat, with the exception of tidal restoration, riparian restoration, and channel margin enhancement, which may affect giant garter snake habitat. These types of restoration will be designed to minimize effects in giant garter snake habitat. Restoration activities that cannot avoid giant garter snake habitat will implement the avoidance and minimization measures described in Section 3.4.7.5.2.1, *Activities with Fixed Locations*.

Maintenance

Maintenance activities such as vegetation and rodent control, embankment repair, and channel maintenance will occur at conveyance facility and restoration sites with flexible locations (e.g., transmission line right of ways, restoration locations, etc.). The following avoidance and minimization measures will be applied to maintenance activities in suitable aquatic habitat, as delineated by an USFWS approved biologist, and uplands within 200 feet of suitable aquatic habitat, to minimize effects on the giant garter snake.

- Vegetation control will take place during the active period (May 1 through October 1) when snakes are able to move out of areas of activity.

- Trapping or hunting methods will be used for rodent control, rather than poison bait. All rodent control methods will be approved by USFWS. If trapping or other non-poison methods are ineffective, the USFWS will be consulted to determine the best course of action.

- Movement of heavy equipment will be confined to outside 200 feet of the banks of potential giant garter snake habitat to minimize habitat disturbance.

- Construction personnel will receive USFWS-approved worker environmental awareness training instructing workers to recognize giant garter snakes and their habitat.

Maintenance activities that cannot avoid giant garter snake habitat will implement the avoidance and minimization measures described in Section 3.4.7.5.2.1, *Activities with Fixed Locations*.

3.4.6.5.3 Compensation for Effects

- Where identified and delineated giant garter snake habitat cannot be avoided, compensation for the loss of the habitat will occur at a rate of 3:1 for each, aquatic and upland habitat, with in-kind habitat type compensation (Table 3.4-4). If 243 acres of giant garter snake aquatic habitat will be affected of which 61 acres are high quality, 94 acres are moderate quality, and 88 acres are low quality habitat, then 729 acres of aquatic habitat will be protected or restored. Insofar as mitigation is created/protected in a USFWS agreed-to high-priority conservation area, such as the eastern protection area between Caldoni Marsh and Stone Lakes, a mitigation rate of 2:1 for each, aquatic and upland habitat type, will apply which may lower the above example to 486 acres of mitigation.

- Giant garter snake upland mitigation will be placed and protected adjacent to aquatic habitat protected for giant garter snake. In some cases, due to the restoration design constraints, the amount of giant garter snake upland mitigation may be slightly less than 2:1 in relation to aquatic mitigation. This exception will be made with the approval of the USFWS. However, the upland habitat will not exceed 200 feet from protected aquatic habitat (unless research shows a larger distance is appropriate and USFWS agrees).

- Incidental injury and/or mortality of giant garter snakes within protected and restored habitat will be avoided and minimized by establishing 200-foot buffers between protected giant garter snake habitat and roads (other than those roads primarily used to support adjacent cultivated lands and levees).

- Habitat compensation through protection will constitute no more than 1/3 of the total compensation.

- Protected and restored giant garter snake habitat will be at least 2,500 feet from urban areas or areas zoned for urban development.

Table 3.4-4. Compensation for Direct Effects on Giant Garter Snake Habitat

	Permanent Habitat Loss	Compensation Ratios		Total Compensation	
	Total Maximum Habitat Loss (Acres)	**Protection**	**Restoration**	**Protection[2]**	**Restoration[2]**
Aquatic, High	61	3:1 or 2:1[1]		183 or 122	
Aquatic, Moderate	94	3:1 or 2:1[1]		282 or 188	
Aquatic, Low	88	3:1 or 2:1[1]		264 or 176	
Upland, High	154	3:1 or 2:1[1]		462 or 308	
Upland, Moderate	430	3:1 or 2:1[1]		1,290 or 860	
Upland, Low	107	3:1 or 2:1[1]		321 or 642	
Aquatic Total	**243**	**3:1 or 2:1[1]**		**729 or 486**	
Upland Total	**691**			**2,073 or 1,382**	
TOTAL	**934**			**2,802 or 1,868**	

[1] The 3:1 mitigation ratio will be applied when "in-kind" mitigation is used. In-kind mitigation is that mitigation that replaces a habitat of similar quality, character, and location as that which was lost within the known range of the giant garter snake as described in Section 4.A.9.6, *Suitable Habitat Definition*. DWR will mitigate at a rate of 2:1 for each acre of lost aquatic and upland habitat if the mitigation is created/protected in a USFWS agreed-to high-priority conservation location for GGS, such as the eastern protection area between Caldoni Marsh and Stone Lakes

[2] Compensation can be achieved through restoration or protection. The protection component of habitat compensation will be limited to up to 1/3 of the total compensation.

3.4.6.5.4 Siting Criteria for Compensation for Effects

Siting and design requirements for the restoration and protection of giant garter snake nontidal wetland habitat are listed below.

- For in-kind mitigation sites, those site mitigated at a ratio of 3:1, the aquatic and upland habitat quality, character, and location must be of equal or greater value than the habitat quality which was lost.

- For conservation mitigation sites, those sites mitigated at a 2:1 ratio, restored or protected giant garter snake habitat will either be adjacent to, or connected to, Caldoni Marsh or the White Slough Wildlife Area, or will create connections from the White Slough population to other areas in the giant garter snake's historical range in the Stone Lakes vicinity or at another location, to be selected by DWR, subject to USFWS approval.

- Conservation mitigation sites, those mitigated at a 2:1 ratio, will be characterized as nontidal marsh and will meet the following design criteria.

    - Restored nontidal marsh will be characterized by sufficient water during the giant garter snake's active summer season (May 1 –October 1) to supply constant, reliable cover and sources of food such as small fish and amphibians.

    - Restored nontidal marsh will consist of still or slow-flowing water over a substrate composed of soil, silt, or mud characteristic of those observed in marshes, sloughs, or irrigation canals.

- Restoration designs will not create large areas of deep, perennial open water that will support nonnative predatory fish. The restored marsh will be characterized by a heterogeneous topography providing a range of depths and vegetation profiles consisting of emergent, herbaceous aquatic vegetation that will provide suitable foraging habitat and refuge from predators.

- Aquatic margins or shorelines will transition to uplands consisting of grassy banks, with the dense grassy understory required for sheltering. These margins will consist of approximately 200 feet of high ground or upland habitat above the annual high water mark to provide cover and refugia from floodwaters during the dormant winter season.

- The upland habitat will have ample exposure to sunlight to facilitate giant garter snake thermoregulation and will be characterized by low vegetation, bankside burrows, holes, and crevices providing critical shelter for snakes throughout the day. All giant garter snake upland and aquatic habitat will be established at least 2,500 feet from urban areas or areas zoned for urban development.

The loss of tidal aquatic habitat for giant garter snake may be mitigated through restoration of tidal habitat, provided it meets the following design criteria. These design criteria are necessary to ensure that the tidally restored areas contributing to giant garter snake conservation provide functional habitat for the species.

- The restored wetlands will provide sufficient water during the active summer season (May 1 – October 1) to supply constant, reliable cover and sources of food (e.g., small fish and amphibians) for giant garter snake.

- The restored wetlands will be designed to mute or reduce flows; provide still or slow-flowing water over a substrate composed of soil, silt, or mud characteristic of those observed in marshes, sloughs, or irrigation canals; and avoid fast-flowing water over sand, gravel, or rock substrate.

- The restored wetlands will be designed (e.g., through grading) to facilitate extended hydroperiods in shallow basins that experience only small, gradual (i.e., slower than tidal flooding/draining) changes in inundation. Design features may include notched or lowered levees that prevent full draining during low tides, intertidal dendritic channels with variable bottom elevations, and other features that retain water such as potholes, ponds/pannes, and shallow isolated backwaters.

- The restored wetlands will not include large areas of deep, open water that will support nonnative predatory fish.

- The restored wetlands will be characterized by a heterogeneous topography that provides the range of depths and vegetation profiles (i.e., emergent, herbaceous aquatic) required for suitable foraging habitat and refuge from predators at all tide levels.

- The restored wetlands will be designed to provide adjacent terrestrial refuge—grasslands above the high water mark—for giant garter snake.

Topography of the restored wetlands will be designed to provide adjacent terrestrial refuge persisting above the high water mark. Terrestrial features will be sited in close proximity to aquatic foraging areas at all tide levels, with slopes and grading designed to avoid exposing largely denuded intertidal mud flats during low tide. Management and Enhancement

The following management actions will be implemented for giant garter snake habitat to be restored. If a USFWS approved mitigation bank is used to fulfill the restoration requirement, then the management and enhancement that is in place for that mitigation bank will suffice.

- Manage vegetation density (particularly nonnatives such as water primrose) and composition, water depth, and other habitat elements to enhance habitat values for giant garter snakes.
- Maintain upland refugia (islands or berms) within the restored marsh.
- Maintain permanent upland habitat at least 200 feet wide around all restored nontidal freshwater emergent wetland habitats to provide undisturbed (uncultivated) upland cover, basking and overwintering habitat immediately adjacent to aquatic habitat.
- Manage bank slopes and upland habitats to enhance giant garter snake use, provide cover, and encourage burrowing mammals for purposes of creating overwintering sites for giant garter snake.

3.4.6.6 California Red-Legged Frog

3.4.6.6.1 Habitat Definition

AMMs for California red-legged frogs will be required for activities occurring within suitable aquatic and upland habitat, and also, whenever the species is incidentally encountered. Within the action area, based on the known distribution of the species, suitable habitat is defined to include the area south and west of SR 4 from Antioch (Bypass Road to Balfour Road to Brentwood Boulevard) to Byron Highway; then south and west along the county line to Byron Highway; then west of Byron Highway to I-205, north of I-205 to I-580, and west of I-580. Within this area, suitable aquatic habitat is defined to include perennial and intermittent streams, managed wetland, freshwater emergent wetland, and perennial aquatic natural communities. Suitable upland habitat is defined as upland areas within 300 feet of the top of bank of a creek, stream, waterbody, or wetlands that provide aquatic habitat for the species (U.S. Fish and Wildlife Service 2014). A USFWS-approved biologist will conduct a field evaluation of the California red-legged frog modeled habitat to ascertain the distribution of suitable upland and aquatic habitat in the worksite vicinity. Surveys within suitable upland habitat will identify suitable aquatic features that may not have been identified during the habitat modeling.

Modeled upland dispersal habitat includes agricultural lands within the area described above and within 1 mile of aquatic habitat, except for agricultural lands where dispersal is bounded on the west by Byron Highway. There is no known, high-value breeding habitat east of that significant boundary.

3.4.6.6.2 Avoidance and Minimization Measures

AMMs are described below first for activities with fixed locations including the Clifton Court Forebay canal and the Clifton Court Embankment. Additional AMMs are then described for activities with uncertain locations: habitat restoration, transmission lines, and geotechnical investigations.

3.4.6.6.2.1 Activities with Fixed Locations

If aquatic habitat cannot be avoided, aquatic habitats in potential work areas, will be surveyed for tadpoles and egg masses. If California red-legged frog tadpoles or egg masses are found, and the aquatic habitat cannot be avoided, USFWS will be contacted, and if determined to be appropriate, measures will be developed to relocate tadpoles and eggs to the nearest suitable aquatic habitat, as determined by the USFWS-approved biologist.

If the PA does not fully avoid effects on suitable habitat, the following measures will be required.

- The USFWS-approved biologist will conduct employee education training for employees working on earthmoving and/or construction activities. Personnel will be required to attend the presentation that will describe the California red-legged-frog avoidance, minimization, and conservation measures, legal protection of the animal, and other related issues. All attendees will sign an attendance sheet along with their printed name, company or agency, email address, and telephone number. The original sign-in sheet will be sent to the USFWS within seven (7) calendar days of the completion of the training.

- Preconstruction surveys will be implemented after the planning phase and prior to any ground-disturbing activity.

- The biological monitor and construction supervisor will be responsible for checking the exclusion fences around the work areas daily to ensure that they are intact and upright. This will be especially critical during rain events, when flowing water can easily dislodge the fencing. Any necessary repairs will be immediately addressed. The amphibian exclusion fencing will remain in place for the duration of construction.

- If the exclusion fence is found to be compromised at any time, a survey will be conducted immediately preceding construction activity that occurs in designated California red-legged frog habitat or in advance of any activity that may result in take of the species. The USFWS-approved biologist will search along exclusion fences, in pipes, and beneath vehicles before they are moved. The survey will include a careful inspection of all potential hiding spots, such as along exclusion fencing, large downed woody debris, and the perimeter of ponds, wetlands, and riparian areas. Any California red-legged frogs found will be captured and relocated to suitable habitat, a minimum of 300 feet outside of the work area that has been identified in the relocation plan (described below) and approved by a USFWS-approved biologist prior to commencement of construction.

- To the extent practicable, initial ground-disturbing activities will not be conducted between November 1 and March 31 in areas identified during the planning stages as providing suitable California red-legged frog habitat, to avoid the period when they are most likely to be moving through upland areas. When ground-disturbing activities must take place between November 1 and March 31, daily monitoring by the USFWS-approved biologist for the California red-legged frog will be required.

- Surface-disturbing activities will be designed to minimize or eliminate effects on rodent burrows that may provide suitable cover habitat for California red-legged frog. Surface-disturbing activities will avoid areas with a high concentration of burrows to the greatest extent practicable. In addition, when a concentration of burrows is present in a worksite, the area will be staked or flagged to ensure that work crews are aware of their location and to facilitate avoidance of the area.

- To the maximum extent practicable, no construction activities will occur during rain events or within 24-hours following a rain event. Following a rain event, a USFWS-approved biologist will inspect suitable habitat and all equipment/materials within the work area for the presence of California red-legged frogs, prior to construction activities resuming. The animals will be allowed to move away from the worksite of their own volition or moved by the biologist.

- To the maximum extent practicable, nighttime construction will be minimized or avoided by DWR, as project applicant, when working in suitable California red-legged frog habitat. Because dusk and dawn are often the times when the California red-legged frog is most actively moving and foraging, to the greatest extent practicable, earthmoving and construction activities will cease no less than 30 minutes before sunset and will not begin again prior to no less than 30 minutes after sunrise. Except when necessary for driver or pedestrian safety artificial lighting at a worksite will be prohibited during the hours of darkness when working in suitable where California red-legged frog habitat. No more than 24 hours prior to any ground disturbance that could affect potential California red-legged frog habitat, preconstruction surveys for California red-legged frog will be conducted by a USFWS-approved biologist. These surveys will consist of walking the worksite limits. The USFWS-approved biologists will investigate all potential areas that could be used by the California red-legged frog for feeding, breeding, sheltering, movement or other essential behaviors. This includes an adequate examination of mammal burrows, such as California ground squirrels or gophers. If any adults, subadults, juveniles, tadpoles, or eggs are found, the USFWS-approved biologist will contact the USFWS to determine if moving any of the individuals to pre-approved location within the relocation plan is appropriate. If the USFWS approves moving animals, the USFWS-approved biologist will be given sufficient time to move the animals from the work site before ground disturbance is initiated. Only USFWS-approved biologists will capture, handle, and monitor the California red-legged frog.

- At least 15 days prior to any ground disturbance activities, DWR, as project applicant, will prepare and submit a relocation plan for USFWS's written approval. The relocation plan will contain the name(s) of the USFWS-approved biologist(s) to relocate California red-legged frogs, the method of relocation (if different than described), a map, and a description of the proposed release site(s) within 300 feet of the work area or at a distance otherwise agreed to by USFWS, and written permission from the landowner to use their land as a relocation site.

- Aquatic habitats within the areas that will be permanently affected by the proposed action will be surveyed for California red-legged frog adults and metamorphs. Any California red-legged frog adults or metamorphs found will be captured and held for a minimum amount of time necessary to relocate the animal to suitable habitat a minimum of 300 feet outside of the work area. Prior to and after handling frogs, the biologist will observe the appropriate decontamination procedures to ensure against spread of chytrid fungus or other pathogens.

- If construction activities will occur in streams, temporary aquatic barriers such as hardware cloth will be installed both up and downstream of the stream crossing, and animals will be relocated and excluded from the work area. The USFWS-approved biologists will establish an adequate buffer on both sides of creeks and around potential aquatic habitat and will restrict entry during the construction period.

- The USFWS-approved biologist(s) will kill any aquatic exotic wildlife species, such as bullfrogs and crayfish from the worksite, to the greatest extent practicable.

- Each encounter with the California red-legged frog will be treated on a case-by-case basis in coordination with the USFWS, but the procedure will follow the pre-approved Relocation Plan and will be conducted is as follows: (1) the animal will not be disturbed if it is not in danger; or (2) the animal will be moved to a secure location if it is in any danger. These procedures are further described below:

  - When a California red-legged frog is encountered, all activities that have the potential to result in the harassment, injury, or death of an individual will cease immediately and the Onsite Project Manager and USFWS-approved biologist will be notified. The USFWS-approved biologist will then assess the situation and select a course of action to avoid or minimize adverse effects to the animal. To the maximum extent possible, contact with the frog will be avoided and the applicant will allow it to move out of the potentially hazardous situation to a secure location on its own volition. This measure does not apply to animals that are uncovered or otherwise exposed or in areas where there is not sufficient adjacent habitat to support the species should the individual move away from the hazardous location.

  - California red-legged frogs that are at risk of being injured or killed will be relocated and released by the USFWS-approved biologist outside the construction area within the same riparian area or watershed. If such relocation is not feasible (e.g., there are too many individuals observed per day), the USFWS-approved biologist will relocate the animals to a location previously approved by USFWS. Prior to the initial ground disturbance, DWR, as project applicant, will obtain approval of the relocation plan from the USFWS in the event that a California red-legged frog is encountered and needs to be moved away from the worksite. Under no circumstances will a California red-legged frog be released on a site unless the written permission of the landowner has been obtained.

- The USFWS-approved biologist will limit the duration of the handling and captivity of the California red-legged frog to the minimum amount of time necessary to complete the task. If the animal must be held in captivity, it will be kept in a cool, dark, moist, aerated environment, such as a clean and disinfected bucket or plastic container with a damp sponge. The container used for holding or transporting the individual will not contain any standing water.

- The USFWS will be immediately notified once the California red-legged frog and the site is secure.

- For onsite storage of pipes, conduits and other materials that could provide shelter for California red-legged frogs, an open-top trailer will be used to elevate the materials above ground. This is intended to reduce the potential for animals to climb into the conduits and other materials.

- Plastic monofilament netting (erosion control matting), loosely woven netting, or similar material in any form will not be used at the worksite because California red-legged frogs can become entangled and trapped in such materials. Any such material found on site will be immediately removed by the USFWS-approved biologist or construction personnel. Materials utilizing fixed weaves (strands cannot move), polypropylene, polymer or other synthetic materials will not be used.

- Dust control measures will be implemented during construction, or when necessary in the opinion of the USFWS-approved biologist, USFWS, or their authorized agent. These measures will consist of regular truck watering of construction access areas and disturbed soil areas with water or organic soil stabilizers to minimize airborne dust and soil particles generated from graded areas. Regular truck watering will be a requirement of the construction contract. Guidelines for truck watering will be established to avoid any excessive runoff that may flow into contiguous or adjacent areas containing potential habitat for the California red-legged frog.

- Trenches or pits one (1) foot or deeper that are going to be left unfilled for more than forty eight (48) hours will be securely covered with boards or other material to prevent the California red-legged frog from falling into them. If this is not possible, DWR, as project applicant, will ensure wooden ramps or other structures of suitable surface that provide adequate footing for the California red-legged frog are placed in the trench or pit to allow for their unaided escape. Auger holes or fence post holes that are greater than 0.10 inch in diameter will be immediately filled or securely covered so they do not become pitfall traps for the California red-legged frog. The USFWS-approved biologist will inspect the trenches, pits, or holes prior to their being filled to ensure there are no California red-legged frogs in them. The trench, pit, or hole also will be examined by the USFWS- and CDFW-approved biologist each workday morning at least one hour prior to initiation of work and in the late afternoon no more than one hour after work has ceased to ascertain whether any individuals have become trapped. If the escape ramps fail to allow the animal to escape, the biologist will remove and transport it to a safe location, or contact the USFWS for guidance.

- To minimize harassment, injury death, and harm in the form of temporary habitat disturbances, all vehicle traffic related to the PA will be restricted to established roads, construction areas, equipment staging, and storage, parking, and stockpile areas. These areas will be included in pre-construction surveys and, to the maximum extent possible, established in locations disturbed by previous activities to prevent further adverse effects.

- All vehicles will observe a 20-mile per hour speed limit within construction areas where it is safe and feasible to do so, except on County roads, and state and Federal highways. Off-road traffic outside of designated and fenced work areas will be prohibited.

- If a work site is to be temporarily dewatered by pumping, intakes shall be completely screened with wire mesh not larger than five millimeters to prevent California red-legged frogs from entering the pump system. Water shall be released or pumped downstream at an appropriate rate to maintain downstream flows during construction. Upon completion of construction activities, any barriers to flow shall be removed in a manner that would allow flow to resume with the least disturbance to the substrate.

- Uneaten human food and trash attracts crows, ravens, coyotes, and other predators of the California red-legged frog. A litter control program will be instituted at each worksite. All workers will ensure their food scraps, paper wrappers, food containers, cans, bottles, and other trash are deposited in covered or closed trash containers. The trash containers will be removed from the worksite at the end of each working day.

- All grindings and asphaltic-concrete waste may be temporally stored within previously disturbed areas absent of habitat and at a minimum of 150 feet from any culvert, pond, creek, stream crossing, or other waterbody. On or before the completion of work at the site, the waste will be transported to an approved disposal site.

- Loss of soil from runoff or erosion will be prevented with straw bales, straw wattles, or similar means provided they do not entangle, block escape or dispersal routes of the California red-legged frog.

- Insecticides or herbicides will not be applied at the worksite during construction or long-term operational maintenance where there is the potential for these chemical agents to enter creeks, streams, waterbodies, or uplands that contain potential habitat for the California red-legged frog.

- No pets will be permitted at the worksite, to avoid and minimize the potential for harassment, injury, and death of the California red-legged frog.

- No firearms will be allowed at the worksite except for those carried by authorized security personnel, or local, state, or Federal law enforcement officials to avoid and minimize the potential for harassment, injury, and death of the California red-legged frog.

3.4.6.6.2.2 Activities with Flexible Locations

3.4.6.6.2.2.1 Geotechnical Exploration

Geotechnical exploration will be sited outside of California red-legged aquatic habitat. Geotechnical exploration within suitable upland habitat will include the following measures, adopted from the September 3, 2010 BiOp on *Engineering Geotechnical Studies for the Bay Delta Conservation Plan (BDCP) and/or the Preliminary Engineering Studies for the Delta Habitat Conservation and Conveyance Program (DHCCP)* (81410-2010-F-0022).

- To the extent practicable, all activities will avoid impacts to adjacent uplands within 100 feet (30 m) that possesses cracks or burrows that could be occupied by California red-legged frogs.
- Pre-construction surveys will be conducted by a qualified biologist. A biological monitor will be present during all drilling activities in California red-legged frog upland habitat to ensure there are no significant impacts to California red-legged frog.
- Work will be done outside the wet season and measures, such as having vehicles follow shortest possible routes from levee road to the drill or CPT sites, will be taken to minimize the overall project footprint.

3.4.6.6.2.2.2 Power Lines and Grid Connections

The final transmission line alignments will be designed to avoid California red-legged frog aquatic habitat, and to minimize effects on upland habitat. The transmission lines will be sited at least 300 feet from occupied California red-legged frog aquatic habitat as determined through protocol-level surveys of any suitable aquatic habitat in the potential transmission line alignment. Occupancy may be assumed, in order to forego the need for protocol-level surveys. After the final transmission line alignment has been determined, the avoidance and minimization measures described in Section 3.4.7.6.2.1, *Activities with Fixed Locations,* will be followed.

3.4.6.6.2.2.3 Restoration

Restoration activities will avoid effects on California red-legged frog and its habitat with the exception of vernal pool complex restoration that may occur in California red-legged frog upland habitat. Any vernal pool creation or restoration will be sited at least 300 feet from occupied California red-legged frog aquatic habitat as determined through protocol-level surveys of any suitable aquatic habitat in the potential restoration area. Occupancy may be assumed to forego the need for protocol-level surveys.

3.4.6.6.3 Compensation to Offset Impacts

California red-legged frog upland habitat will be protected at a ratio of 3:1 within the East San Francisco Bay core recovery area, at locations subject to USFWS approval. This compensation ratio is typically applied to upland habitat within 300 feet of aquatic habitat, based on the Programmatic Biological Opinion for Issuance of Permits under Section 404 for the species (U.S. Fish and Wildlife Service 2014). For the purposes of the PA, this compensation ratio is applied to all modeled upland cover and dispersal habitat, regardless of its distance to aquatic habitat. Therefore, 57 acres of upland cover and dispersal habitat will be affected and 171acres of upland cover and dispersal habitat will be protected.

California red-legged frog aquatic breeding habitat will be protected at a ratio of 3:1 within the East San Francisco Bay core recovery area as described in the Recovery Plan for the California Red-Legged Frog (U.S. Fish and Wildlife Service 2002), at a location subject to USFWS approval. The increased habitat extent and connectivity will increase opportunities for genetic exchange and allow for colonization of extirpated populations and restored habitats. Therefore, 1 acres of aquatic habitat will be affected and 3 acres of aquatic habitat will be protected (Table 3.4-5).

The above compensation ratios apply only if protection occurs prior to or concurrent with the impact. If protection occurs after an impact, the ratio will increase as shown in Table 3.4-5.

All lands protected and restored for compensation of effects on California red-legged frog habitat will be protected and managed in perpetuity. Adequate funds will be provided by DWR to ensure that the Conservation Area is managed in perpetuity. DWR, as project applicant, will dedicate an endowment fund or similar perpetual funding mechanism for this purpose, and designate the party or entity that will be responsible for long-term management of the Conservation Area. USFWS will be provided with written documentation that funding and management of the Conservation Area will be provided in perpetuity.

Improve habitat linkages by controlling the height and density of grassland and improving culverts to facilitate California red-legged frog movement across the landscape and thus enhance habitat linkages. Increasing opportunities for California red-legged frog to move through grassland habitats will enhance genetic exchange and the ability to recolonize any areas where the species may have been locally extirpated.

Table 3.4-5. Compensation for Direct Effects on California Red-Legged Frog Habitat.

California Red-Legged Frog Modeled Habitat	Maximum Total Impact (Acres)	Habitat Protection Compensation Ratio	Total Habitat Protection if all Direct Impacts Occur (Acres)
Upland and dispersal	57	3:1	171
Aquatic	1	3:1	3
Total	**58**	**–**	**174**

3.4.6.6.4 Siting Criteria for Compensation for Effects

Grassland (and associated vernal pools and alkali seasonal wetlands) protection to benefit California red-legged frog will be prioritized based on the following characteristics.

- Grasslands containing stock ponds and other aquatic features that provide aquatic breeding habitat for California tiger salamander.
- Lands that connect with existing protected grassland, vernal pool complex, and alkali seasonal wetland complex landscapes, including those in the East San Francisco Bay core recovery area for California red-legged frog.

3.4.6.6.5 Management and Enhancement

The following management and enhancement measures will be implemented on protected California red-legged frog habitat. These management and enhancement activities will be designed and conducted in coordination with (or by) the East Contra Costa County Habitat Conservancy or East Bay Regional Park District. Both of these entities have extensive experience conducting successful grassland and aquatic habitat management and restoration to benefit California red-legged frog in the area where this habitat will be protected to mitigate the effects of the PA.

Aquatic features in protected grasslands will be maintained and enhanced for California red-legged frog to provide suitable inundation depth and duration and suitable composition of vegetative cover to support breeding for California red-legged frog. Stock ponds, intermittent drainages, and other aquatic features are common in grasslands throughout the Byron Hills area. Grasslands that support suitable aquatic features for California red-legged frog will be prioritized for acquisition.

California red-legged frogs require vegetation, usually emergent vegetation, on which to deposit egg masses and cattle using a pond can trample the necessary vegetation. Stock ponds within grasslands protected for California red-legged frog will be managed for livestock exclusion to promote growth of aquatic emergent vegetation with appropriate characteristics favorable to breeding California red-legged frogs and other native amphibians and aquatic reptiles. The surrounding grassland will provide dispersal and aestivation habitat.

The appropriate depth and duration of aquatic features will be maintained for California red-legged frog to ensure that conditions are favorable for supporting the entire aquatic life cycle from breeding through metamorphosis from larval to adult stages. If appropriate, aquatic features may be managed such that they are dry in late summer, to reduce habitat suitability for bullfrogs and nonnative fish that prey on California red-legged frog.

3.4.6.7 California Tiger Salamander

3.4.6.7.1 Habitat Definition

AMMs for California tiger salamander will be required for activities occurring within suitable aquatic or upland habitat, or wherever the species is encountered. Within the action area, based on the known distribution of the species, suitable habitat is defined to occur within the area west of the Yolo Basin but including the Tule Ranch Unit of the California Department of Fish and Wildlife (CDFW) Yolo Basin Wildlife Area; east of the Sacramento River between Freeport and Hood-Franklin Road; east of I-5 between Twin Cities Road and the Mokelumne River; and in the area south and west of SR 4 from Antioch (Bypass Road to Balfour Road to Brentwood Boulevard) to Byron Highway; then south and west along the county line to Byron Highway; then west of Byron Highway to Interstate 205 (I 205), north of I-205 to Interstate 580 (I 580), and west of I-580. Within this area, suitable terrestrial cover and aestivation habitat is defined as grassland with a minimum patch size of 100 acres (40.5 hectares), and suitable aquatic habitat is defined to consist of vernal pools and stock ponds.

A USFWS-approved biologist familiar with the species and its habitat will conduct a field evaluation of suitable upland or aquatic habitat for California tiger salamander for all activities in the PA that occur within modeled habitat (as described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.11, *California Tiger Salamander*), or within areas of suitable habitat located by a USFWS-approved biologist during the field evaluation.

3.4.6.7.2 Avoidance and Minimization Measures

3.4.6.7.2.1 Activities with Fixed Locations

AMMs are described below first for activities with known locations including the Clifton Court Forebay canal. Additional AMMs are then described for activities with uncertain locations: habitat restoration, transmission lines, and geotechnical exploration.

3.4.6.7.2.2 Activities with Fixed Locations

The following measures will be implemented for activities with known locations:

- Construction activities within 1.3 miles of California tiger salamander aquatic habitat will be scheduled to minimize adverse effects to California tiger salamander and its habitat. Except for limited vegetation clearing necessary to minimize effects to nesting birds, disturbance to upland habitat will be confined to the dry season, generally May through October 15. However, grading and other disturbance in pools and ponds, if unavoidable, shall be conducted only when they are dry, typically between July 15 and October 15. Work within a pool or wetland may begin prior to July 15 if the pool or wetland has been dry for a minimum of 30 days prior to initiating work. All work will be limited to periods of no or low rainfall (less than 0.08 inches per 24-hour period and less than 40% chance of rain). Construction activities within 1.3 miles of California tiger salamander aquatic habitat will cease 24 hours prior to a 40% or greater forecast of rain from the closest National Weather Service (NWS) weather station. Construction may continue 24 hours after the rain ceases, if no precipitation is in the 24-hour forecast. If work must continue when rain is forecast (greater than 40% chance of rain), a USFWS-approved biologist will survey the worksite before construction begins each day rain is forecast. If rain exceeds 0.5 inches during a 24-hour period, work will cease until the NWS forecasts no further rain. Modifications to this timing may be approved by USFWS based on site conditions and expected risks to California tiger salamanders.

- Earthmoving and construction activities will cease no less than 30 minutes before sunset and will not begin again until no less than 30 minutes after sunrise. Except when necessary for driver or pedestrian safety, to the greatest extent practicable, artificial lighting at a worksite will be prohibited during the hours of darkness.

- No rodenticides will be used during construction or long-term operational maintenance in areas that support suitable upland habitat for California tiger salamander.

- To prevent California tiger salamander from becoming entangled, trapped, or injured by erosion control structures, erosion control measures that use plastic or synthetic monofilament netting will not be used within areas designated to have suitable California tiger salamander habitat. This includes products that use photodegradable or biodegradable synthetic netting, which can take several months to decompose. Acceptable materials include natural fibers such as jute, coconut, twine, or other similar fibers. Following site restoration, erosion control materials, such as straw wattles, will be placed so as not to block movement of the California tiger salamander.

- The perimeter of construction sites will be fenced with amphibian exclusion fencing by October 15 or prior to the start of construction. The Onsite Project Manager and the

USFWS-approved biologist (in cooperation with USFWS) will determine where exclusion fencing will be installed to protect California tiger salamander habitat adjacent to the defined site footprint and to minimize the potential for California tiger salamanders to enter the construction work area. The locations of exclusion fencing will be determined, in part, by the locations of modeled habitat for the species. A conceptual fencing plan will be submitted to USFWS prior to the start of construction and the California tiger salamander exclusion fencing will be shown on the final construction plans. DWR, as project applicant, will include the amphibian exclusion fence specifications including installation and maintenance criteria in the bid solicitation package special provisions. The amphibian exclusion fencing will remain in place for the duration of construction and will be regularly inspected and fully maintained. The biological monitor and construction supervisor will be responsible for checking the exclusion fencing around the work areas daily to ensure that they are intact and upright. This will be especially critical during rain events, when flowing water can easily dislodge the fencing. Repairs to the amphibian exclusion fence will be made within 24 hours of discovery. Where construction access is necessary, gates will be installed with the exclusion fence.

- If the exclusion fence is compromised during the rainy season, when California tiger salamanders are likely to be active, a survey will be conducted immediately preceding construction activity that occurs in modeled or suitable California tiger salamander habitat, as determined by a USFWS-approved biologist, or in advance of any activity that may result in take of the species. The biologist will search along exclusion fences, in pipes, and beneath vehicles each morning before they are moved. The survey will include a careful inspection of all potential hiding spots, such as along exclusion fencing, large downed woody debris, and the perimeter of ponds, wetlands, and riparian areas. Any tiger salamanders found will be captured and relocated to suitable habitat with an active rodent burrow system at a location predetermined prior to commencement of construction in the Relocation Plan (as described below).

- To avoid entrapment of animals during construction, pipes or similar structures will be capped if stored overnight. Excavated holes and trenches will have escape ramps, and any open holes and trenches more than 6 inches deep will be closed with plywood at the end of each workday. The USFWS-approved biologist will inspect all holes and trenches at the beginning of each workday and before the holes and trenches are filled. All pipes, culverts, or similar structures sored in the work area overnight will be inspected before they are subsequently moved, capped, and/or buried. If a California tiger salamander is discovered, the Onsite Project Manager and USFWS-approved biologist will be notified immediately, and the USFWS-approved biologist will move the animal to a safe nearby location (as described by the species observation and handling protocol below) and monitor it until it is determined that it is not imperiled by predators, or other dangers.

- If verbally requested before, during, or upon completion of ground disturbance and construction activities where suitable California tiger salamander habitat is present, DWR, as project applicant, will ensure that USFWS can immediately access and inspect the worksite for compliance with the description of the PA, and avoidance and minimization measures, and to evaluate effects on the California tiger salamander and its habitat.

- Preconstruction surveys will be conducted by a USFWS-approved biologist immediately prior to the initiation of any ground disturbing activities or vegetation clearing in areas identified as having suitable California tiger salamander habitat. The USFWS-approved biologist shall conduct clearance surveys at the beginning of each day and regularly throughout the workday when construction activities are occurring that may result in take of California tiger salamander. These surveys will consist of walking surveys within the worksites and investigating suitable aquatic and upland habitat including refugia habitat such as small woody debris, refuse, burrow entries, etc. All mammal burrows within the worksite limits that cannot be avoided will be hand-excavated and collapsed so that they do not attract California tiger salamanders during construction.

- A USFWS-approved biologist will be onsite during all activities that may result in take of California tiger salamander. This biologist will carry a working mobile phone whose number will be provided to USFWS prior to the start of construction and ground disturbance. USFWS will consider the implementation of specific activities without the oversight of an onsite USFWS-approved biologist on a case-by-case basis.

- The USFWS-approved biologist will have the authority to stop activities at the worksite if they determine that any of avoidance and minimization measures are not being fulfilled.

- The USFWS-approved biologist will maintain monitoring records that include (1) the beginning and ending time of each day's monitoring effort; (2) a statement identifying the covered species encountered, including the time and location of the observation; (3) the time the specimen was identified and by whom and its condition;(4) the capture and release locations of each individual; (5) photographs and measurements (snout to vent and total length) of each individual; and (6) a description of any actions taken. The USFWS-approved biologist will maintain complete records in their possession while conducting monitoring activities and will immediately provide records to USFWS upon request. If requested, all monitoring records will be provided to USFWS within 30 days of the completion of monitoring work.

- At least 15 days prior to any ground disturbance activities, DWR, as project applicant, will prepare and submit a Relocation Plan for USFWS's written approval. The Relocation Plan will contain the name(s) of the USFWS-approved biologist(s) to relocate California tiger salamanders, the method of relocation (if different than described), a map, and a description of the proposed release site(s) within 300 feet of the work area or at a distance otherwise agreed to by USFWS, and written permission from the landowner to use their land as a relocation site.

- If a California tiger salamander is observed, the USFWS-approved biologist will implement the following species observation and handling protocol. Only USFWS-approved biologists will participate in activities associated with the capture, handling, and monitoring of California tiger salamanders. If a California tiger salamander is encountered in a construction area, activities within 50 feet of the individual will cease immediately and the Onsite Project Manager and USFWS-approved biologist will be notified. Based on the professional judgment of the USFWS-approved biologist, if activities at the worksite can be conducted without harming or injuring the California tiger salamander, it may be left at the location of discovery and monitored by the USFWS-approved biologist. All personnel on site will be notified of the finding and at no time will work occur within 50 feet of the California tiger salamander without a USFWS-approved biologist present. If it is determined by the USFWS-approved biologist that relocating the California tiger salamander is necessary, the following steps will be followed:

- Prior to handling and relocation, the USFWS-approved biologist will take precautions to prevent introduction of amphibian diseases in accordance with the *Interim Guidance on Site Assessment and Field Surveys for Determining Presence or a Negative Finding of the California Tiger Salamander* (U.S. Fish and Wildlife Service 2003). Disinfecting equipment and clothing is especially important when biologists are coming to the action area to handle amphibians after working in other aquatic habitats. California tiger salamanders will also be handled and assessed according to the *Restraint and Handling of Live Amphibians* (U.S. Geological Survey National Wildlife Health Center 2001).

- California tiger salamanders will be captured by hand, dipnet, or other USFWS-approved methodology, transported, and relocated to nearby suitable habitat outside of the work area and released as soon as practicable the same day of capture. Individuals will be relocated no greater than 300 feet outside of the work area to areas with an active rodent burrow or burrow system (unless otherwise approved by USFWS). Holding/transporting containers and dipnets will be thoroughly cleaned, disinfected, and rinsed with freshwater prior to use within the action area. USFWS will be notified within 24 hours of all capture, handling, and relocation efforts. USFWS- and CDFW-approved biologists will not use soaps, oils, creams, lotions, repellents, or solvents of any sort on their hands within two hours before and during periods when they are capturing and relocating individuals. To avoid transferring disease or pathogens of handling of the amphibians, USFWS-approved biologists will follow the Declining Amphibian Populations Task Force's "Code of Practice."

- If an injured Central California tiger salamander is encountered and the USFWS--approved biologist determines the injury is minor or healing and the salamander is likely to survive, the salamander will be released immediately, consistent with the pre-approved Relocation Plan as described above. The California tiger salamander will be monitored until it is determined that it is not imperiled by predators or other dangers.

- If the USFWS-approved biologist determines that the California tiger salamander has major or serious injuries because of activities at the worksite, the USFWS-approved biologist, or designee, will immediately take it to a USFWS-approved facility. If taken into captivity, the individual will not be released into the wild unless it has been kept in quarantine and the release is authorized by USFWS. DWR, as project applicant, will bear any costs associated with the care or treatment of such injured California tiger salamanders. The circumstances of the injury, the procedure followed and the final disposition of the injured animal will be documented in a written incident report. Notification to USFWS of an injured or dead California tiger salamander in the action area will be made as described under the Reporting Requirements measure (described above), and reported whether or not its condition resulted from activities related to the PA. In addition, the USFWS-approved biologist will follow up with USFWS in writing within two calendar days of the finding. Written notification to USFWS will include the following information: the species, number of animals taken or injured, sex (if known), date, time, location of the incident or of the finding of a dead or injured animal, how the individual was taken, photographs of the specific animal, the names of the persons who observe the take and/or found the animal, and any other pertinent information. Dead specimens will be preserved, as appropriate, and held in a secure location until instructions are received from the USFWS regarding the disposition of the specimen.

3.4.6.7.2.3 Activities with Flexible Locations

3.4.6.7.2.3.1 Geotechnical Exploration

Geotechnical exploration will be sited outside of California tiger salamander aquatic habitat. Geotechnical exploration within suitable upland habitat will include the following measures, adopted from the September 3, 2010 BiOp on *Engineering Geotechnical Studies for the Bay Delta Conservation Plan (BDCP) and/or the Preliminary Engineering Studies for the Delta Habitat Conservation and Conveyance Program (DHCCP)* (81410-2010-F-0022).

- To the extent practicable, all project activities will avoid impacts to grassland habitat within 100 feet (30 m) that possesses cracks or burrows that could be occupied by California tiger salamanders.
- Pre-construction surveys will be conducted by a qualified biologist. A biological monitor will be present during all drilling activities to ensure there are no significant impacts to California tiger salamander.
- Work will be done outside the wet season and measures, such as having vehicles follow shortest possible routes from levee road to the drill or CPT sites, will be taken to minimize the overall project footprint.

3.4.6.7.2.3.2 Power Supply and Grid Connections

The final transmission line alignments will be sited to avoid California tiger salamander aquatic habitat, and to minimize effects on upland habitat. The transmission lines will be sited at least 300 feet from occupied California tiger salamander aquatic habitat as determined through protocol-level surveys of any suitable aquatic habitat within the potential transmission line alignment. Occupancy may be assumed, in order to forego the need for protocol-level surveys. After the final transmission line alignment has been determined, the avoidance and minimization measures described in Section 3.4.7.7.2.1, *Activities with Fixed Locations,* will be followed.

3.4.6.7.2.3.3 Restoration

3.4.6.7.2.3.3.1 Vernal Pool Restoration

Vernal pool complex restoration may result in temporary effects on California tiger salamander upland habitat. These effects will be minimized to the greatest extent practicable. Vernal pool restoration is expected to provide long-term benefit to California tiger salamander.

During the restoration planning phase, suitable habitat in potential work areas will be surveyed for California tiger salamander larvae, eggs, and adults. If California tiger salamander larvae or eggs are found, the restoration will be designed to avoid impacts on the aquatic habitat and these life stages.

Vernal pool restoration activities in upland habitat will be minimized during the wet season. Surface-disturbing activities will be designed to minimize or eliminate effects on rodent burrows that may provide suitable aestivation habitat. Areas with a high concentration of burrows will be avoided by surface-disturbing activities to the greatest extent practicable. In addition, when a concentration of burrows is present at a worksite, the area will be staked or flagged to ensure that work crews are aware of their location and to facilitate avoidance of the area.

After the restoration design is completed, the avoidance and minimization measures described in Section 3.4.7.7.2.1, *Activities with Fixed Locations,* will be followed.

3.4.6.7.2.3.3.2 Tidal Restoration

Tidal restoration activities have potential to affect California tiger salamander habitat in the Jepson Prairie area. This includes portions of critical habitat that overlap with the western terminus of Lindsey Slough, west of Rio Dixon Road. Tidal restoration projects will be designed to avoid areas within 250 feet of any of the primary constituent elements (PCEs) of California tiger salamander habitat within the designated critical habitat unit, or some lesser distance if it is determined through project review and concurrence by USFWS that tidal restoration actions will not result in changes in hydrology or soil salinity that could adversely modify these PCEs. With the application of the AMM, adverse modification to California tiger salamander critical habitat PCEs will be avoided.

3.4.6.7.3 Compensation for Effects

DWR will protect California tiger salamander habitat at a ratio of 3:1 (protected to lost) at locations subject to USFWS approval, adjacent to or near occupied upland habitat that is on a conservation easement, has a management plan, and endowment, or similar funding mechanism, to fund management in perpetuity. The 3:1 ratio applies if protection occurs prior to or concurrent with the impacts. If protection occurs after the impacts, the ratio will increase as shown in Table 3.4-6. California tiger salamander habitat protection will be located in the Byron Hills area, west of the worksite. While there is no recovery plan available for California tiger salamander to inform the location of conservation lands, conservation in this area will benefit the California tiger salamander by providing habitat in a region where high-quality habitat and extant occurrences are known to exist. Grasslands targeted for protection will be located near important areas for conservation that were identified in the *East Contra Costa County HCP/NCCP* (East Contra Costa County Habitat Conservancy 2006) (not all of which will be acquired by that plan) and will include appropriate upland and aquatic features, e.g., rodent burrows, stock ponds, intermittent drainages, and other aquatic features, etc. An estimated 57 acres of habitat will be affected; therefore, 171 acres of habitat will be protected.

Table 3.4-6. Compensation for Direct Effects on California Tiger Salamander Habitat.

	Maximum Total Impact (Acres)	Habitat Protection Compensation Ratio	Total Habitat Protection if all Direct Impacts Occur (Acres)
Terrestrial cover and aestivation	57	3:1	171
Total	**57**	**-**	**171**

3.4.6.7.4 Siting Criteria for Compensation for Effects

Grasslands, associated vernal pools, and alkali seasonal wetlands will be protected in perpetuity as compensation for effects on California tiger salamander. Land acquisition for California tiger salamander grassland habitat management lands will be prioritized based on the following characteristics:

- Large contiguous landscapes that consist of grasslands, vernal pool complex, and alkali seasonal wetland complex and encompass the range of vegetation, hydrologic, and soil conditions that characterize these communities.
- Lands that maintain connectivity with protected grassland, vernal pool complex, and alkali seasonal wetland complex landscapes near proposed construction sites, including connectivity with lands that have been protected or may be protected in the future under the East Contra Costa County HCP/NCCP.
- Grasslands containing stock ponds and other aquatic features that provide aquatic breeding habitat for California tiger salamander.

3.4.6.7.5 Management and Enhancement

The following management and enhancement activities will be implemented on grasslands protected to benefit California tiger salamander. These management and enhancement activities will be designed and conducted in coordination with (or by) the East Contra Costa County Habitat Conservancy or East Bay Regional Park District. Both of these entities have extensive experience conducting successful grassland and aquatic habitat management and restoration to benefit California tiger salamander in the area where this habitat will be protected to mitigate the effects of the PA.

- Maintain hydrology and water quality. Hydrologic functions to be maintained within vernal pool and alkali seasonal wetland complexes include surface water storage in the pool, subsurface water exchange, and surface water conveyance (Butterwick 1998:52). Aspects of surface water storage such as timing, frequency, and duration of inundation will be monitored, enhanced, and managed to benefit California tiger salamander. Techniques used to enhance and manage hydrology may include invasive plant control, removal of adverse supplemental water sources into reserves (e.g., agricultural or urban runoff), and topographic modifications. Any pesticides used for invasive plant control will be applied during the dry season (typically between July 15 and October 15) when ponds and other aquatic features are not inundated. Disking or mowing will not be used to control vegetation in California tiger salamander habitat.

Repairs may be made to improve water retention in stock ponds that are not retaining water due to leaks and, as a result, not functioning properly as habitat for California tiger salamander. Additionally, pond capacity and water duration may be increased (e.g., by raising spillway elevations) to support California tiger salamander populations. To the greatest extent practicable, repairs will be implemented outside the California tiger salamander breeding season to minimize effects on the species[33].

To retain the habitat quality of stock ponds over time, occasional sediment removal may be needed to address the buildup of sediment that results from adjacent land use or upstream factors. To the greatest extent practicable, dredging will be conducted during the nonbreeding periods for California tiger salamander to minimize impacts on the species.

- Control nonnative predators. Habitat management and enhancement will include trapping and other techniques to control the establishment and abundance of bullfrogs, barred tiger salamander, and other nonnative predators that threaten wildlife species in vernal pools, seasonal wetlands, and stock ponds. DWR, as project applicant, or the land manager will work to reduce and, where possible, eradicate invasive species that adversely affect native species. These efforts will include prescribed methods for removal of bullfrogs, mosquitofish, and nonnative predatory fish from stock ponds and wetlands in the habitat management lands, including limiting the hydroperiod of stock ponds.

  DWR, as project applicant, will work to reduce, and if possible eradicate, nonnative predators (e.g., bullfrogs, barred tiger salamander, nonnative predatory fish) from aquatic habitat for covered amphibian species through habitat manipulation (e.g., periodic draining of ponds), trapping, hand-capturing, electroshocking, or other control methods. These activities will be carried out by qualified biologists familiar with California tiger salamander, and will be conducted in a manner that avoids take of California tiger salamanders. Draining ponds annually, sterilizing or removing subsoil, and removing bullfrogs can be effective at reducing predation by bullfrogs and other invasive species on covered amphibians and reptiles (Doubledee et al. 2003). Some ponds in the habitat management lands might be retrofitted with drains if the nonnative species populations cannot be controlled by other means. Ponds without drains and that do not drain naturally may need to be drained annually using pumps. Drainage of stock ponds and other wetlands will be carried out during the summer or fall dry season. Models predict that draining ponds every 2 years will decrease the likelihood that bullfrogs will persist in ponds (Doubledee et al. 2003). Limiting the hydroperiod of stock ponds also shifts the

[33] Maintaining California tiger salamander use of stock ponds on livestock ranches for breeding appears to be a critical link in the conservation and recovery of this species. In 2004, because of the conservation benefit to the species, USFWS under Section 4(d) of the ESA (Federal Register 69(149):47212-47248), determined that routine management and maintenance activities of stock ponds on private lands are exempt from the take prohibitions under section 9 of the ESA.

competitive balance from nonnative barred tiger salamander and hybrid salamanders in favor of native California tiger salamanders (Johnson et al. 2010).

- Maintain or enhance burrow availability. Ground-dwelling mammals such as California ground squirrel provide burrows for California tiger salamander. Historically, ground squirrel populations were controlled by ranchers and public agencies. Eliminating ground squirrel control measures on habitat management lands may enable increased squirrel populations in some areas. However, some rodent control measures will likely remain necessary in certain areas where dense rodent populations may compromise important infrastructure (e.g., pond berms, road embankments, railroad beds, levees, dam faces). The use of rodenticides or other rodent control measures will be prohibited in habitat management lands except as necessary to address adverse impacts on essential structures in or immediately adjacent to these lands, including recreational facilities incorporated into the reserve system. DWR or the land manager will introduce livestock grazing (where it is not currently used, and where conflicts with worksite activities will be minimized) to reduce vegetative cover and thus encourage ground squirrel expansion and colonization.

- Manage livestock grazing. Grazing by livestock and native herbivores is proposed to manage grassland vegetation and thatch to facilitate dispersal of California tiger salamander, for which dense vegetation may hinder movement. Appropriate grazing programs will be developed for enhancing and maintaining habitat for California tiger salamanders based on site-specific characteristics of the community, the spatial location of important ecological features in each pasture, the history of grazing on the site, species composition of the site, grazer vegetation preference, and other relevant information. Grazing exclusion will be used as a management alternative where appropriate.

3.4.6.8 Valley Elderberry Longhorn Beetle

3.4.6.8.1 Habitat Definition

Valley elderberry longhorn beetle suitable habitat is defined in Section 4.A.12.6, *Suitable Habitat Definition*, of Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, AMMs for valley elderberry longhorn beetle will only be required for activities occurring within suitable habitat. Suitable habitat is defined as elderberry shrubs within the action area. Elderberry shrubs in the action area could be found in riparian areas, along levee banks, grasslands, and in agricultural settings where vegetation is not being maintained (e.g., fence rows, fallow fields) (Appendix 4.A, Section 4.A.12.6, *Suitable Habitat Definition*).

3.4.6.8.2 Avoidance and Minimization Measures

AMMs are described below first for activities with fixed locations including the intake facilities, reusable tunnel material placement areas, intermediate forebay, Clifton Court Forebay expansion area, vent shafts, and retrieval shafts. Additional AMMs are then described for activities with flexible locations: habitat restoration, safe haven intervention sites, transmission lines, and geotechnical investigations.

3.4.6.8.2.1 Activities with Fixed Locations

The following measures will be required for construction, operation, and maintenance related to fixed location activities. The following measures will also be required for activities with flexible locations once their locations have been determined.

Preconstruction surveys for elderberry shrubs will be conducted within all facility footprints and areas within 100 feet by a USFWS-approved biologist familiar with the appearance of valley elderberry longhorn beetle exit holes in elderberry shrubs. Preconstruction surveys will be conducted in the calendar year prior to construction and will follow the guidance of USFWS's *Conservation Guidelines for the Valley Elderberry Longhorn Beetle* (U.S. Fish and Wildlife Service 1999), herein referred to as the 1999 VELB Conservation Guidelines. The results of preconstruction surveys will be reported to USFWS. Elderberry shrubs will be avoided to the greatest extent practicable. Complete avoidance (i.e., no adverse effects) may be assumed when a buffer of at least a 100 feet is established and maintained around elderberry plants containing stems measuring 1 inch or greater in diameter at ground level. Firebreaks may not be included in the buffer zone. USFWS will be consulted before any disturbances, including construction, within the 100-foot buffer area are considered. Any damaged area within the buffer zones will be restored following the conclusion of construction in the work area.

Elderberry shrubs that must be removed will be transplanted to USFWS-approved Conservation Areas (the areas where plantings will occur to offset impacts). Transplanting, avoidance measures, and associated compensation will follow the 1999 VELB Conservation Guidelines except where modified with site specificity as stated herein. Avoidance measures for shrubs not directly affected by construction but within 100-feet of ground disturbing activities will follow the guidance outline in the 1999 VELB Conservation Guidelines as well.

- For shrubs not directly affected by construction but that occur between 20 feet and 100 feet from ground-disturbing activities, the following measures will be implemented.
    - Fence and flag areas to be avoided during construction activities. In areas where encroachment on the 100-foot buffer has been approved by USFWS, provide a minimum setback of at least 20 feet from the dripline of each elderberry plant.
    - To the greatest extent practicable, construction will be limited during the valley elderberry longhorn beetle active season, March 15th through June 15th.
    - Brief contractors on the need to avoid damaging the elderberry plants and the possible penalties for not complying with these requirements (see AMM1 in Appendix 3.F, *General Avoidance and Minimization Measures,* for more detail).
    - Erect signs every 50 feet along the edge of the avoidance area with the following information: "This area is habitat of the valley elderberry longhorn beetle, a threatened species, and must not be disturbed. This species is protected by the Endangered Species Act of 1973, as amended. Violators are subject to prosecution, fines, and imprisonment." The signs will be clearly readable from a distance of 20 feet, and must be maintained for the duration of construction.

- Instruct work crews about the status of the beetle and the need to protect its elderberry host plant.

- During construction activities, no insecticides, herbicides, fertilizers, or other chemicals that might harm the beetle or its host plant will be used in the 100-foot buffer area.

- To the greatest extent practicable, nighttime construction will be minimized or avoided by DWR, as project applicant, between March 15th and June 15th where valley elderberry longhorn beetle is likely to be present. Because there is potential for valley elderberry valley longhorn beetles to be attracted to nighttime light and thus increase the potential for predation, activities will cease no less than 30 minutes before sunset and will not begin again prior to no less than 30 minutes after sunrise. Except when necessary for driver or pedestrian safety, to the greatest extent practicable, artificial lighting at a construction site will be prohibited during the hours of darkness where valley elderberry longhorn beetle is likely to be present.

- Night lighting of valley elderberry beetle habitat will be minimized to the extent practicable. If night lighting is to be used, to the greatest extent possible it will be pointed toward work areas and way from riparian, other sensitive habitats, and other areas that contain elderberry shrubs.

- Restore any damage done to the buffer area (area within 100 feet of elderberry plants) during construction. Provide erosion control and re-vegetate with appropriate native plants.

- For those parts of the water conveyance facility that will require ongoing maintenance (e.g., intake facilities, pump facilities at Clifton Court Forebay, in right of ways around permanent transmission lines, around vent shafts, etc.), buffer areas must continue to be maintained for the protection of the species after construction with measures such as fencing, signs, weeding, and trash removal as appropriate.

- A written description of how the buffer areas are to be restored and maintained for the protection of the species will be provided to USFWS.

- To prevent fugitive dust from drifting into adjacent habitat, all clearing, grubbing, scraping, excavation, land leveling, grading, cut and fill, demolition activities, or other dust generating activities will be effectively controlled for fugitive dust emissions utilizing application of water or by presoaking work areas.

- For shrubs directly affected by construction, and within 20 feet of disturbance activities if this area is also disturbed, the following measures will be followed for transplantation.

    - A USFWS-approved biologist (monitor) must be onsite for the duration of the transplanting of the elderberry plants to ensure that no unauthorized take of the valley elderberry longhorn beetle occurs. If unauthorized take occurs, the monitor must have the authority to stop work until corrective measures have been completed. The monitor must immediately report any unauthorized take of the beetle or its habitat to the USFWS and to the CDFW.

- Elderberry shrubs will be transplanted during their dormant season, which occurs from November, after they have lost their leaves, through the first two weeks in February. If transplantation occurs during the growing season, increased compensation ratios will apply. Compensation ratios could be up to three times the standard compensation ratios as determined in consultation with USFWS staff.

- Transplantation procedure will be as specified in the 1999 VELB Conservation Guidelines.

- Elderberry shrubs will be transplanted into the area where plantings will occur to offset impacts (Section 3.4.5, *Spatial Extent, Location, and Design of Restoration for Terrestrial Species*), referred to in the 1999 VELB Conservation Guidelines as the *Conservation Area*.

- If a plant appears to be unlikely to survive transplantation, then transplantation is not required, but a higher compensation ratio may be applied. In this instance, the USFWS will be contacted to determine the appropriate action.

3.4.6.8.2.2 Activities with Flexible Locations

Activities with flexible locations are activities that cannot yet be precisely sited because they require design or site-specific information that will not be available until the PA is already in progress. These include geotechnical exploration, safe haven intervention sites, transmission lines, and habitat restoration.

During the planning phase, for these not fully sited activities, preconstruction surveys for elderberry shrubs will be conducted in potential work areas by a USFWS-approved biologist familiar with the appearance of valley elderberry longhorn beetle exit holes in elderberry shrubs. Preconstruction surveys will be conducted in accordance with the protocol provided in the 1999 VELB Conservation Guidelines, and survey results will be reported to USFWS. Elderberry shrubs will be avoided to the greatest extent practicable. Complete avoidance (i.e., no adverse effects) may be assumed when a buffer of at least a 100 feet is established and maintained around elderberry plants containing stems measuring 1 inch or greater in diameter at ground level. Firebreaks may not be included in the buffer zone. USFWS will be consulted before any disturbances, including construction, within the 100-foot buffer area are considered. Any damaged area within the buffer zones will be restored following the conclusion of construction in work areas.

3.4.6.8.2.2.1 Geotechnical Activities

Based on the planning level surveys, geotechnical exploration activities for the PA will fully avoid effects on valley elderberry longhorn beetle and its habitat. Valley elderberry longhorn beetle avoidance and minimization measures for geotechnical activities will be the same as described in Section 3.4.7.8.2.1, *Activities with Fixed Locations.*

3.4.6.8.2.2.2 Safe Haven Work Areas

Workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. In addition, avoidance and minimization measures for safe haven interventions will be the same as described in Section 3.4.7.8.2.1, *Activities with Fixed Locations.*

3.4.6.8.2.2.3 Power Lines and Grid Connections

Based on the planning level surveys, the siting of transmission towers and poles will avoid elderberry shrubs to the extent practicable. Valley elderberry longhorn beetle avoidance and minimization measures for transmission lines will be the same as described in Section 3.4.7.8.2.1, *Activities with Fixed Locations.*

3.4.6.8.2.2.4 Restoration

Selection of restoration sites will be by DWR, subject to approval by the jurisdictional fish and wildlife agencies (CDFW, NMFS, and USFWS). Based on planning level surveys, restoration activities will be designed to fully avoid valley elderberry longhorn beetle habitat, with the exception of tidal restoration and channel margin enhancement, which may affect elderberry shrubs. These types of restoration will be designed to minimize effects in valley elderberry longhorn beetle habitat. Restoration activities that cannot avoid habitat will implement the avoidance and minimization measures described in Section 3.4.7.8.2.1, *Activities with Fixed Locations*.

3.4.6.8.3 Compensation to Offset Impacts

DWR will offset impacts on elderberry shrubs by either creating valley elderberry longhorn beetle habitat or by purchasing the equivalent credits at a USFWS approved conservation bank with a service area that overlaps with the action area consistent with the 1999 VELB Conservation Guidelines. These guidelines require replacement of each impacted elderberry stem measuring one inch or greater in diameter at ground level, in the Conservation Area, with elderberry seedlings or cuttings at a ratio ranging from 1:1 to 8:1 (new plantings to affected stems), and planting of associated native riparian plants. These ratios will apply if compensation occurs prior to or concurrent with the impacts. If compensation occurs after the impacts, a higher ratio may be required by USFWS. Table 3.4-7 provides these ratios and the number of elderberry shrubs and associated native riparian plants that will be required to mitigate for the estimated 107 elderberry shrubs that will be affected by fully sited construction activities if all impacts occur. Table 3.4-8 through Table 3.4-15 provide the estimated number of shrubs that will be affected by each covered activity. The planting area will provide at a minimum 1,800 square feet for each transplanted shrub. As many as five additional elderberry plantings (cuttings or seedlings) and up to five associated native species plantings may also be planted within the 1,800 square foot area with the transplant. An additional 1,800 square feet will be provided for every additional 10 conservation plants. Additional detail regarding the Conservation Area within which these plantings will take place is provided in the 1999 VELB Conservation Guidelines and below under Section 3.4.7.8.4, *Siting Criteria for Compensation for Effects*.

Table 3.4-7. Compensation for Direct Effects from All Activities

Location of Affected Plants	Stems (maximum diameter at ground level) of Affected Plants		Exit Holes on Affected Shrub (Yes/No)[1]		Elderberry Seedling Ratio[2]	Associated Native Plant Ratio[3]	Elderberry Seedling Requirement[4]	Associated Native Plant Requirement[4]	
Non-riparian (25 shrubs, 500 stems)	Greater than or equal to 1 inch, less than 3 inches	280	No	151	1:1	1:1	151	151	
			Yes	129	2:1	2:1	258	516	
	Greater than or equal to 3 inches, less than 5 inches	115	No	62	2:1	1:1	124	124	
			Yes	53	4:1	2:1	212	424	
	Greater than or equal to 5 inches	105	No	57	3:1	1:1	170	170	
			Yes	48	6:1	2:1	291	582	
Riparian (82 shrubs, 1,738 stems)	Greater than or equal to 3 inches, less than 5 inches	1,154[d]	No	413	2:1	1:1	826	826	
			Yes	378	4:1	2:1	1,512	3,024	
	From 3 to 5 inches	300[d]	No	90	3:1	1:1	271	271	
			Yes	115	6:1	2:1	693	1,385	
	Greater than or equal to 5 inches	187[d]	No	90	4:1	1:1	361	361	
			Yes	88	8:1	2:1	701	1,600	
						Total	**5,569**	**9,433**	**15,002**

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring one inch or greater in diameter at ground level on a single shrub are considered occupied when exit holes are present anywhere on the shrub.

[2] Ratios in this column correspond to the number of cuttings or seedlings to be planted per elderberry stem (one inch or greater in diameter at ground level) affected by a covered activity.

[3] Ratios in this column correspond to the number of associated native species to be planted per elderberry seedling or cutting planted.

[4] Numbers of elderberry seedlings and associated native plants are the required numbers of plantings for compensation if impacts on all 107 shrubs occur. Total seedlings/cuttings and associated natives = 15,002

107 transplants plus 1,070 seedlings/cuttings and natives x 1,800 sq ft = 192,600 sq ft = 4.42 acres

13,905 remaining seedlings/cuttings and natives and 10 per 1,800 sq ft = 2,502,827sq ft = 57.5 acres

Total area = 61.9 acres

Table 3.4-8. Compensation for Direct Effects from North Delta Intakes

Location of Affected Plants	Stems (maximum diameter at ground level) of Affected Plants		Exit Holes on Affected Shrub (Yes/No)[1]		Elderberry Seedling Ratio[2]	Associated Native Plant Ratio[3]	Elderberry Seedling Requirement[4]	Associated Native Plant Requirement[4]	
Non-riparian (3 shrubs, 60 stems)	Greater than or equal to 1 inch, less than 3 inches	34	No	18	1:1	1:1	18	18	
			Yes	16	2:1	2:1	31	62	
	Greater than or equal to 3 inches, less than 5 inches	14	No	7	2:1	1:1	15	15	
			Yes	6	4:1	2:1	25	51	
	Greater than or equal to 5 inches	13	No	7	3:1	1:1	20	20	
			Yes	6	6:1	2:1	35	70	
Riparian (12 shrubs, 240 stems)	Greater than or equal to 3 inches, less than 5 inches	161	No	79	2:1	1:1	157	157	
			Yes	82	4:1	2:1	329	658	
	From 3 to 5 inches	41	No	20	3:1	1:1	60	60	
			Yes	21	6:1	2:1	125	250	
	Greater than or equal to 5 inches	38	No	19	4:1	1:1	75	75	
			Yes	20	8:1	2:1	157	314	
						Total	**1,048**	**1,751**	**2,799**

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring one inch or greater in diameter at ground level on a single shrub are considered occupied when exit holes are present anywhere on the shrub.

[2] Ratios in this column correspond to the number of cuttings or seedlings to be planted per elderberry stem (one inch or greater in diameter at ground level) affected by a covered activity.

[3] Ratios in this column correspond to the number of associated native species to be planted per elderberry seedling or cutting planted.

[4] Numbers of elderberry seedlings and associated native plants are the required numbers of plantings for compensation if impacts on all 15 shrubs occur. Total seedlings/cuttings and associated natives = 2,799.

15 transplants plus 150 seedlings/cuttings and natives X 1,800 sq ft = 27,000 sq ft = 0.6198 acres.

2,649 remaining seedlings/cuttings and natives and 10 per 1,800 sq ft = 476,814 sq ft = 10.946 acres.

Total area = 11.566 acres.

Table 3.4-9. Compensation for Direct Effects from RTM Storage Areas

Location of Affected Plants	Stems (maximum diameter at ground level) of Affected Plants		Exit Holes on Affected Shrub (Yes/No)[1]		Elderberry Seedling Ratio[2]	Associated Native Plant Ratio[3]	Elderberry Seedling Requirement[4]	Associated Native Plant Requirement[4]	
Non-riparian (6 shrubs, 120 stems)	Greater than or equal to 1 inch, less than 3 inches	67	No	36	1:1	1:1	36	36	
			Yes	31	2:1	2:1	62	124	
	Greater than or equal to 3 inches, less than 5 inches	28	No	15	2:1	1:1	30	30	
			Yes	13	4:1	2:1	51	102	
	Greater than or equal to 5 inches	25	No	14	3:1	1:1	41	41	
			Yes	12	6:1	2:1	70	140	
Riparian (13 shrubs, 260 stems)	Greater than or equal to 3 inches, less than 5 inches	174	No	85	2:1	1:1	170	170	
			Yes	89	4:1	2:1	357	713	
	From 3 to 5 inches	44	No	22	3:1	1:1	65	65	
			Yes	23	6:1	2:1	136	271	
	Greater than or equal to 5 inches	42	No	20	4:1	1:1	81	81	
			Yes	21	8:1	2:1	170	341	
						Total	**1,268**	**2,113**	**3,381**

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring one inch or greater in diameter at ground level on a single shrub are considered occupied when exit holes are present anywhere on the shrub.

[2] Ratios in this column correspond to the number of cuttings or seedlings to be planted per elderberry stem (one inch or greater in diameter at ground level) affected by a covered activity.

[3] Ratios in this column correspond to the number of associated native species to be planted per elderberry seedling or cutting planted.

[4] Numbers of elderberry seedlings and associated native plants are the required numbers of plantings for compensation if impacts on all 19 shrubs occur. Total seedlings/cuttings and associated natives = 3,381.

19 transplants plus 190 seedlings/cuttings and natives = 34200 sq. feet = 0.785123967 acres.

3,191 remaining seedlings/cuttings and native and 10 per 1,800 square foot = 574,425 sq ft =13.187 acres.

Total area = 13.972 acres.

Table 3.4-10. Compensation for Direct Effects from HOR Gate

Location of Affected Plants	Stems (maximum diameter at ground level) of Affected Plants		Exit Holes on Affected Shrub (Yes/No)[1]		Elderberry Seedling Ratio[2]	Associated Native Plant Ratio[3]	Elderberry Seedling Requirement[4]	Associated Native Plant Requirement[4]	
Non-riparian (1shrub, 20 stems)	Greater than or equal to 1 inch, less than 3 inches	11	No	6	1:1	1:1	6	6	
			Yes	5	2:1	2:1	10	21	
	Greater than or equal to 3 inches, less than 5 inches	5	No	2	2:1	1:1	5	5	
			Yes	2	4:1	2:1	8	17	
	Greater than or equal to 5 inches	4	No	2	3:1	1:1	7	7	
			Yes	2	6:1	2:1	12	23	
Riparian (no shrubs)	Greater than or equal to 3 inches, less than 5 inches	0	No	0	2:1	1:1	0	0	
			Yes	0	4:1	2:1	0	0	
	From 3 to 5 inches	0	No	0	3:1	1:1	0	0	
			Yes	0	6:1	2:1	0	0	
	Greater than or equal to 5 inches	0	No	0	4:1	1:1	0	0	
			Yes	0	8:1	2:1	0	0	
						Total	**48**	**79**	**127**

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring one inch or greater in diameter at ground level on a single shrub are considered occupied when exit holes are present anywhere on the shrub.

[2] Ratios in this column correspond to the number of cuttings or seedlings to be planted per elderberry stem (one inch or greater in diameter at ground level) affected by a covered activity.

[3] Ratios in this column correspond to the number of associated native species to be planted per elderberry seedling or cutting planted.

[4] Numbers of elderberry seedlings and associated native plants are the required numbers of plantings for compensation if impacts on 1 shrub occurs. Total seedlings/cuttings and associated natives = 127.

1 transplants plus 10 seedlings/cuttings and natives = 1,800 sq ft = 0.041 acres.

117 remaining seedlings/cuttings and natives and 10 per 1,800 sq ft = 21,046 sq ft = 0.483 acres.

Total area = 0.524 acres.

Table 3.4-11. Compensation for Direct Effects from Water Conveyance Facilities

Location of Affected Plants	Stems (maximum diameter at ground level) of Affected Plants		Exit Holes on Affected Shrub (Yes/No)[1]		Elderberry Seedling Ratio[2]	Associated Native Plant Ratio[3]	Elderberry Seedling Requirement[4]	Associated Native Plant Requirement[4]	
Non-riparian (5 shrubs, 100 stems)	Greater than or equal to 1 inch, less than 3 inches	56	No	30	1:1	1:1	30	30	
			Yes	26	2:1	2:1	52	103	
	Greater than or equal to 3 inches, less than 5 inches	23	No	12	2:1	1:1	25	25	
			Yes	11	4:1	2:1	42	85	
	Greater than or equal to 5 inches	21	No	11	3:1	1:1	34	34	
			Yes	10	6:1	2:1	58	116	
Riparian (18 shrubs, 360 stems)	Greater than or equal to 3 inches, less than 5 inches	241	No	118	2:1	1:1	236	236	
			Yes	123	4:1	2:1	494	987	
	From 3 to 5 inches	61	No	30	3:1	1:1	90	90	
			Yes	31	6:1	2:1	188	376	
	Greater than or equal to 5 inches	58	No	28	4:1	1:1	113	113	
			Yes	29	8:1	2:1	236	472	
						Total	**1,596**	**2,666**	**4,262**

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring one inch or greater in diameter at ground level on a single shrub are considered occupied when exit holes are present anywhere on the shrub.

[2] Ratios in this column correspond to the number of cuttings or seedlings to be planted per elderberry stem (one inch or greater in diameter at ground level) affected by a covered activity.

[3] Ratios in this column correspond to the number of associated native species to be planted per elderberry seedling or cutting planted.

[4] Numbers of elderberry seedlings and associated native plants are the required numbers of plantings for compensation if impacts on all 23 shrubs occur. Total seedlings/cuttings and associated natives = 4,262.

23 transplants plus 230 seedlings/cuttings and natives x 1,800 sq ft = 41,400 sq ft = 0.950 acres.

4,032 remaining seedlings/cuttings and natives and 10 per 1,800 sq ft = 725,744 sq ft = 16.661 acres.

Total area = 17.611 acres.

Table 3.4-12. Compensation for Direct Effects from Clifton Court Forebay Modifications

Location of Affected Plants	Stems (maximum diameter at ground level) of Affected Plants		Exit Holes on Affected Shrub (Yes/No)[1]		Elderberry Seedling Ratio[2]	Associated Native Plant Ratio[3]	Elderberry Seedling Requirement[4]	Associated Native Plant Requirement[4]	
Non-riparian (6 shrubs, 120 stems)	Greater than or equal to 1 inch, less than 3 inches	67	No	36	1:1	1:1	36	36	
			Yes	31	2:1	2:1	62	124	
	Greater than or equal to 3 inches, less than 5 inches	28	No	15	2:1	1:1	30	30	
			Yes	13	4:1	2:1	51	102	
	Greater than or equal to 5 inches	25	No	14	3:1	1:1	41	41	
			Yes	12	6:1	2:1	70	140	
Riparian (1 shrub, 20 stems)	Greater than or equal to 3 inches, less than 5 inches	13	No	7	2:1	1:1	13	13	
			Yes	7	4:1	2:1	27	55	
	From 3 to 5 inches	3	No	2	3:1	1:1	5	5	
			Yes	2	6:1	2:1	10	21	
	Greater than or equal to 5 inches	3	No	2	4:1	1:1	6	6	
			Yes	2	8:1	2:1	13	26	
						Total	**365**	**598**	**963**

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring one inch or greater in diameter at ground level on a single shrub are considered occupied when exit holes are present anywhere on the shrub.

[2] Ratios in this column correspond to the number of cuttings or seedlings to be planted per elderberry stem (one inch or greater in diameter at ground level) affected by a covered activity.

[3] Ratios in this column correspond to the number of associated native species to be planted per elderberry seedling or cutting planted.

[4] Numbers of elderberry seedlings and associated native plants are the required numbers of plantings for compensation if impacts on all 7 shrubs occur. Total seedlings/cuttings and associated natives = 963.

7 transplants plus 70 seedlings/cuttings and natives x 1,800 sq ft = 12,600 sq ft = 0.289 acres.

893 remaining seedlings/cuttings and natives and 10 per 1,800 sq ft = 160,750 sq ft = 3.690 acres.

Total area = 3.980 acres.

Table 3.4-13. Compensation for Direct Effects from Transmission Lines

Location of Affected Plants	Stems (maximum diameter at ground level) of Affected Plants		Exit Holes on Affected Shrub (Yes/No)[1]		Elderberry Seedling Ratio[2]	Associated Native Plant Ratio[3]	Elderberry Seedling Requirement[4]	Associated Native Plant Requirement[4]	
Non-riparian (3 shrubs, 60 stems)	Greater than or equal to 1 inch, less than 3 inches	34	No	18	1:1	1:1	18	18	
			Yes	16	2:1	2:1	31	62	
	Greater than or equal to 3 inches, less than 5 inches	14	No	7	2:1	1:1	15	15	
			Yes	6	4:1	2:1	25	51	
	Greater than or equal to 5 inches	13	No	7	3:1	1:1	20	20	
			Yes	6	6:1	2:1	35	70	
Riparian (8 shrubs, 160 stems)	Greater than or equal to 3 inches, less than 5 inches	107	No	52	2:1	1:1	105	105	
			Yes	55	4:1	2:1	219	439	
	From 3 to 5 inches	27	No	13	3:1	1:1	40	40	
			Yes	14	6:1	2:1	83	167	
	Greater than or equal to 5 inches	26	No	13	4:1	1:1	50	50	
			Yes	13	8:1	2:1	105	210	
						Total	**747**	**1,246**	**1,993**

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring one inch or greater in diameter at ground level on a single shrub are considered occupied when exit holes are present anywhere on the shrub.

[2] Ratios in this column correspond to the number of cuttings or seedlings to be planted per elderberry stem (one inch or greater in diameter at ground level) affected by a covered activity.

[3] Ratios in this column correspond to the number of associated native species to be planted per elderberry seedling or cutting planted.

[4] Numbers of elderberry seedlings and associated native plants are the required numbers of plantings for compensation if impacts on all 11 shrubs occur. Total seedlings/cuttings and associated natives = 1,993.

11 transplants plus 110 seedlings/cuttings and natives = 19,800 sq ft = 0.455 acres.

1,883 remaining seedlings/cuttings and natives and 10 per 1,800 sq ft = 338,922 sq ft = 7.781 acres.

Total area = 8.235 acres.

Table 3.4-14. Compensation for Direct Effects from Safe Haven Work Areas

Location of Affected Plants	Stems (maximum diameter at ground level) of Affected Plants		Exit Holes on Affected Shrub (Yes/No)[1]		Elderberry Seedling Ratio[2]	Associated Native Plant Ratio[3]	Elderberry Seedling Requirement[4]	Associated Native Plant Requirement[4]	
Non-riparian (1 shrub, 20 stems)	Greater than or equal to 1 inch, less than 3 inches	11	No	6	1:1	1:1	6	6	
			Yes	5	2:1	2:1	10	21	
	Greater than or equal to 3 inches, less than 5 inches	5	No	2	2:1	1:1	5	5	
			Yes	2	4:1	2:1	8	17	
	Greater than or equal to 5 inches	4	No	2	3:1	1:1	7	7	
			Yes	2	6:1	2:1	12	23	
Riparian (6 shrubs, 120 stems)	Greater than or equal to 3 inches, less than 5 inches	13	No	7	2:1	1:1	13	13	
			Yes	7	4:1	2:1	27	55	
	From 3 to 5 inches	3	No	2	3:1	1:1	5	5	
			Yes	2	6:1	2:1	10	21	
	Greater than or equal to 5 inches	3	No	2	4:1	1:1	6	6	
			Yes	2	8:1	2:1	13	26	
						Total	**124**	**205**	**328**

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring one inch or greater in diameter at ground level on a single shrub are considered occupied when exit holes are present anywhere on the shrub.

[2] Ratios in this column correspond to the number of cuttings or seedlings to be planted per elderberry stem (one inch or greater in diameter at ground level) affected by a covered activity.

[3] Ratios in this column correspond to the number of associated native species to be planted per elderberry seedling or cutting planted.

[4] Numbers of elderberry seedlings and associated native plants are the required numbers of plantings for compensation if impacts on all 7 shrubs occur. Total seedlings/cuttings and associated natives = 1,336.

2 transplants plus 20 seedlings/cuttings and natives = 1,800 sq ft = 3,600sq ft = 0.0826acres.

308 remaining seedlings/cuttings and natives and 10 per 1,800 sq ft = 55,519 sq ft = 1.274acres.

Total area = 1.357 acres.

Table 3.4-15. Compensation for Direct Effects from Restoration

Location of Affected Plants	Stems (maximum diameter at ground level) of Affected Plants		Exit Holes on Affected Shrub (Yes/No)[1]		Elderberry Seedling Ratio[2]	Associated Native Plant Ratio[3]	Elderberry Seedling Requirement[4]	Associated Native Plant Requirement[4]	
Non-riparian (0)	Greater than or equal to 1 inch, less than 3 inches	0	No	0	1:1	1:1	0	0	
			Yes	0	2:1	2:1	0	0	
	Greater than or equal to 3 inches, less than 5 inches	0	No	0	2:1	1:1	0	0	
			Yes	0	4:1	2:1	0	0	
	Greater than or equal to 5 inches	0	No	0	3:1	1:1	0	0	
			Yes	0	6:1	2:1	0	0	
Riparian (29)	Greater than or equal to 3 inches, less than 5 inches	444	No	64	2:1	1:1	132	132	
			Yes	15	4:1	2:1	59	118	
	From 3 to 5 inches	120	No	2	3:1	1:1	7	7	
			Yes	24	6:1	2:1	150	300	
	Greater than or equal to 5 inches	17	No	9	4:1	1:1	35	35	
			Yes	1	8:1	2:1	7	14	
						Total	**390**	**606**	**996**

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring one inch or greater in diameter at ground level on a single shrub are considered occupied when exit holes are present anywhere on the shrub.

[2] Ratios in this column correspond to the number of cuttings or seedlings to be planted per elderberry stem (one inch or greater in diameter at ground level) affected by a covered activity.

[3] Ratios in this column correspond to the number of associated native species to be planted per elderberry seedling or cutting planted.

[4] Numbers of elderberry seedlings and associated native plants are the required numbers of plantings for compensation if impacts on all 29 shrubs occur.
Total seedlings/cuttings and associated natives = 996.
29 transplants plus 290 seedlings/cuttings and natives = 1.20 acres.
706 remaining seedlings/cuttings and natives and 10 per 1,800 sq ft = 127,151 sq ft = 2.9 acres.
Total area = 4.11 acres.

3.4.6.8.4 Siting Criteria for Compensation for Effects

Each Conservation Area will provide at least 1,800 square feet for each transplanted elderberry plant. As many as 10 conservation plantings (i.e., elderberry cuttings or seedlings and/or associated native plants) may be planted within the 1,800 square foot area with each transplanted elderberry. An additional 1,800 square feet will be provided for every additional 10 conservation plants. Each planting will have its own watering basin measuring approximately three feet in diameter. Watering basins will be constructed with a continuous berm measuring approximately eight inches wide at the base and six inches high.

Depending on adjacent land use, a buffer area may also be needed between the Conservation Area and the adjacent lands. For example, herbicides and pesticides are often used on orchards or vineyards. These chemicals may drift or run off onto the Conservation Area if an adequate buffer area is not provided.

3.4.6.8.4.1 Long-Term Protection

Each Conservation Area will be protected in perpetuity as habitat for the valley elderberry longhorn beetle. A conservation easement or deed restrictions to protect the Conservation Area must be arranged. Conservation Areas may be transferred to a resource agency or appropriate private organization for long-term management. USFWS must be provided with a map and written details identifying the Conservation Area; and DWR, as project applicant, must receive approval from USFWS that the Conservation Area is acceptable prior to initiating the conservation program. A true, recorded copy of the deed transfer, conservation easement, or deed restrictions protecting the Conservation Area in perpetuity must be provided to USFWS before construction activities begin.

Adequate funds must be provided to ensure that the Conservation Area is managed in perpetuity. DWR, as project applicant, must dedicate an endowment fund, or similar perpetual funding mechanism, for this purpose, and designate the party or entity that will be responsible for long-term management of the Conservation Area. USFWS will be provided with written documentation that funding and management of the Conservation Area will be provided in perpetuity.

3.4.6.8.5 Management and Enhancement

The following management and enhancement activities will be implemented to benefit valley elderberry longhorn beetle. If a mitigation bank is used to offset effects, it will be USFWS-approved and will meet the requirements set forth above.

3.4.6.8.5.1 Levee Maintenance

All levee maintenance that involves ground-disturbing activities will implement relevant measures described above under Section 3.4.7.8.2, *Avoidance and Minimization Measures*. Vegetation burning or nonselective herbicide use kills elderberry shrubs required by the valley elderberry longhorn beetle. Other methods such as managed goat grazing may be an effective and biologically preferred vegetation management method along levees (with goatherds used to limit grazing on desirable species).

3.4.6.8.5.2 Weed Control

Weeds and other plants that are not native to the Conservation Area will be removed at least once a year, or at the discretion of the USFWS. Mechanical means will be used; herbicides are prohibited unless approved by the USFWS.

3.4.6.8.5.3 Pesticide and Toxicant Control

Measures will be taken to insure that no pesticides, herbicides, fertilizers, or other chemical agents enter the Conservation Area. No spraying of these agents will be done within 100 feet of the Conservation Area, or if they have the potential to drift, flow, or be washed into the area in the opinion of biologists or law enforcement personnel from the USFWS.

3.4.6.8.5.4 Litter Control

No dumping of trash or other material may occur within a Conservation Area. Any trash or other foreign material found deposited within a Conservation Area will be removed within 10 working days of discovery.

3.4.6.8.5.5 Fencing

Permanent fencing will be placed completely around each Conservation Area to prevent unauthorized entry by off-road vehicles, equestrians, and other parties that might damage or destroy the habitat of the beetle, unless approved by the USFWS. DWR will obtain written approval from the USFWS that the fencing is acceptable prior to initiation of the conservation program. The fence will be maintained in perpetuity, and will be repaired or replaced within 10 working days if it is found to be damaged. Some Conservation Areas may be made available to the public for appropriate recreational and educational opportunities, subject to written approval from the USFWS. In these cases appropriate fencing and signs informing the public of the beetle's threatened status and its natural history and ecology will be used and maintained in perpetuity.

3.4.6.8.5.6 Signs

A minimum of two prominent signs will be placed and maintained in perpetuity at each Conservation Area, unless otherwise approved by the USFWS. The signs will note that the site is habitat of the federally threatened valley elderberry longhorn beetle and, if appropriate, include information on the beetle's natural history and ecology. The signs will be subject to USFWS approval. The signs will be repaired or replaced within 10 working days if they are found to be damaged or destroyed.

3.4.6.9 Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

3.4.6.9.1 Habitat Definitions

Vernal pool fairy shrimp and vernal pool tadpole shrimp suitable habitat is defined in Section 4.A.13.6, *Suitable Habitat Definition*, and Section 4.A.14.6, *Suitable Habitat Definition*, of Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, respectively. AMMs are described below first for activities with known locations including the CCF canal, Clifton Court expansion area, and RTM placement areas. Additional AMMs are then described for activities with uncertain locations: habitat restoration, transmission lines, and geotechnical investigations. The AMMs listed in Appendix 3.F, *General Avoidance and Minimization Measures*, will also be applicable to all construction activities.

The AMMs below and those listed in Appendix 3.F, *General Avoidance and Minimization Measures,* will also be applicable to all operations and maintenance activities. AMMs that require exclusion fencing or monitoring will not be required for routine operations and maintenance activities but will be implemented for maintenance activities that involve ground disturbance and/or vegetation removal in suitable habitat for the species.

3.4.6.9.2 Avoidance and Minimization Measures

3.4.6.9.2.1 Activities with Known Locations

Habitat for vernal pool fairy shrimp and vernal pool tadpole shrimp in the action area is defined as vernal pools, seasonal wetlands, and alkali seasonal wetlands. Vernal pool fairy shrimp can also be found in artificial features such as seasonal ditches and un-vegetated low spots that pool during the winter, though these areas may not be suitable for vernal pool tadpole shrimp if they are not inundated for a sufficient period of time.

- Staging areas will be designed so that they are more than 250 feet from vernal pool fairy shrimp or vernal pool tadpole shrimp habitat. All vehicles will access the work site following the shortest possible route from the levee road. All site access and staging shall limit disturbance to the riverbank, or levee as much as possible and avoid sensitive habitats. When possible, existing ingress and egress points shall be used.

- A vehicle inspection and fueling area will be established at least 250 ft away from any vernal pools or seasonal wetlands to reduce the potential for chemical pollution such as oil, diesel, or hydraulic fluid. An inspection and fueling plan will be developed and construction workers trained so that any contamination is minimized. An emergency spill response plan will be completed and all workers will be trained on how to respond to emergency spills of chemicals.

- If habitat is avoided (preserved) at the site, a USFWS-approved biologist (monitor) will inspect any construction-related activities at the activity site to ensure that no unnecessary take of listed species or destruction of their habitat occurs. The USFWS-approved biologist will have the authority to stop all activities that may result in take or destruction until appropriate corrective measures have been completed. The USFWS-approved biologist also will be required to immediately report any unauthorized impacts to USFWS.

- Topographic depressions that are likely to serve as seasonal vernal pools will be flagged and avoided where possible.

- Silt fencing will be installed wherever activities occur within 250 ft of vernal pool type seasonal wetlands. To avoid additional soil disturbances caused by silt fence installation, the bottom portion of the fence will be secured by waddles instead of buried.

- All onsite construction personnel will receive instruction regarding the presence of listed species and the importance of avoiding impacts on the species and their habitat (AMM1 in Appendix 3.F, *General Avoidance and Minimization Measures*).

- DWR, as project applicant, will ensure that activities that are inconsistent with the maintenance of the suitability of remaining habitat and associated onsite watershed that supports vernal pool fairy shrimp or vernal pool tadpole shrimp habitat are prohibited. This includes, but is not limited to (1) alteration of existing topography or any other alteration or uses for any purposes; (2) placement of any new structures on these parcels; (3) dumping, burning, and/or burying of rubbish, garbage, or any other wastes or fill materials; (4) building of any new roads or trails; (5) killing, removal, alteration, or replacement of any existing native vegetation; (6) placement of storm water drains; (7) fire protection activities not required to protect existing structures at the site; and (8) use of pesticides or other toxic chemicals.

3.4.6.9.2.2 Activities with Uncertain Locations

Geotechnical exploration activities, the construction and operation and maintenance of transmission lines, and restoration activities for the PA will fully avoid effects on vernal pool fairy shrimp and vernal pool tadpole shrimp and their habitat. Full avoidance requires a minimum 250-foot no-disturbance buffer around all vernal pools and other aquatic features potentially supporting vernal pool fairy shrimp or vernal pool tadpole shrimp.

3.4.6.9.3 Compensation for Effects

Conservation measures for vernal pool fairy shrimp and vernal pool tadpole shrimp are listed below.

- For every acre of habitat directly or indirectly affected, at least two vernal pool credits will be purchased within a USFWS-approved ecosystem preservation bank. Alternatively, based on USFWS evaluation of site-specific conservation values, three acres of vernal pool habitat may be preserved at the affected site or on another non-bank site as approved by the USFWS (Table 3.4-16).

- For every acre of habitat directly affected, at least one vernal pool creation credit will be dedicated within a USFWS-approved habitat mitigation bank, or, based on USFWS evaluation of site-specific conservation values, two acres of vernal pool habitat will be created and monitored at the affected site or on another non-bank site as approved by the USFWS (Table 3.4-16).

- Compensation ratios for non-bank compensation may be adjusted to approach those for banks if the USFWS considers the conservation value of the non-bank compensation area to approach that of USFWS-approved conservation banks.

Table 3.4-16. Compensation for Effects on Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp Habitat

Covered Activity/Proposed Compensation	Direct Effect (Acres)	Indirect Effect (Acres)	Habitat Compensation Ratio		Total Habitat Compensation if all Impacts Occur (Acres)	
			Conservation Bank[1]	Non-bank Site[2, 3]	Conservation Bank[1]	Non-bank Site[2, 3]
RTM Storage Areas	0	0.2	NA	NA	NA	NA
Clifton Court Forebay Modifications	6	0	NA	NA	NA	NA
Protection (direct and indirect effects)	6	0.2	2:1	3:1	12	18
Restoration/Creation (direct effects only)	6	NA	1:1	2:1	6	12

[1] Compensation ratios for credits dedicated in Service-approved mitigation banks
[2] Compensation ratios for acres of habitat outside of mitigation banks
[3] Compensation ratios for non-bank compensation may be adjusted to approach those for banks if the Service considers the conservation value of the non-bank compensation area to approach that of Service-approved mitigation banks.

3.4.6.9.4 Siting Criteria for Compensation for Effects

3.4.6.9.4.1 Protection

If protection occurs outside a USFWS-approved conservation bank, protection will be prioritized in the Livermore recovery unit, which is one of the core recovery areas identified in the *Vernal Pool Recovery Plan* (U.S. Fish and Wildlife Service 2005) and is adjacent to existing protected vernal pool complex. Protected sites will be prioritized within the affected critical habitat unit for vernal pool fairy shrimp, unless rationale is provided to USFWS for lands to be protected outside of the critical habitat unit. Protected sites will include the surrounding upland watershed necessary to sustain the vernal pool functions (e.g., hydrology, uplands to provide for pollinators, etc.)

3.4.6.9.4.2 Restoration

If vernal pool restoration is conducted outside of a USFWS-approved conservation bank, the restoration sites will meet the following site selection criteria.

- The site has evidence of historical vernal pools based on soils, remnant topography, remnant vegetation, historical aerial photos, or other historical or site-specific data.
- The site supports suitable soils and landforms for vernal pool restoration.
- The adjacent land use is compatible with restoration and long-term management to maintain natural community functions (e.g., not adjacent to urban or rural residential areas).
- Sufficient land is available for protection to provide the necessary vernal pool complex restoration and surrounding grasslands to provide the local watershed for sustaining vernal pool hydrology, with a vernal pool density representative of intact vernal pool complex in the vicinity of the restoration site.

Acquisition of vernal pool restoration sites will be prioritized based on the following criteria.

- The site will contribute to establishment of a large, interconnected vernal pool and alkali seasonal wetland complex reserve system (e.g., adjacent to existing protected vernal pool complex or alkali seasonal wetland complex).
- The site is close to known populations of vernal pool fairy shrimp or vernal pool tadpole shrimp.

3.4.6.9.4.3 Site-Specific Restoration Plans

A site-specific restoration plan will be developed for the vernal pool restoration site. The restoration plan will include the following elements.

- A description of the aquatic functions, hydrology/topography, soils/substrate, and vegetation, for the design reference site, the existing condition of the restoration site, and the anticipated condition of the restored site.
- Success criteria for determining whether vernal pool or alkali seasonal wetland functions have been successfully restored.
- A description of the restoration monitoring, including methods and schedule consistent with relevant monitoring actions, metrics, and timing and duration, for determining whether success criteria have been met.
- An implementation and management plan and schedule that includes a description of site preparation, seeding, and irrigation.
- A management plan which includes a description of maintenance activities and a maintenance schedule to be implemented until success criteria are met.

Contingency measures will be implemented if success criteria are not met within the established monitoring timeframe.

3.4.6.9.5 Management and Enhancement

The following management and enhancement activities will be provided to USFWS for review in a management plan and implemented to benefit vernal pool fairy shrimp and vernal pool tadpole shrimp, subject to USFWS approval. These management and enhancement activities will be designed and conducted in coordination with (or by) the East Contra Costa County Habitat Conservancy or East Bay Regional Park District. Both of these entities have extensive experience conducting successful habitat management to benefit vernal pool fairy shrimp in the area where this habitat will be protected to mitigate the effects of the PA. If a USFWS-approved mitigation bank is used to fulfill the restoration requirement, then the management and enhancement that is in place for that mitigation bank will suffice.

3.4.6.9.5.1 Vegetation Management

On sites where vernal pools are protected or restored, vegetation will be managed to control invasive species and minimize thatch build-up. Grazing will be the preferred approach for vegetation management. Mechanical control may be employed as needed for highly invasive species: this method involves the use of machinery such as bulldozers, backhoes, cable yarders, and loaders, and may be used where invasive plant density is high and it would not result in adverse effects on sensitive resources such as rare plant populations or critical habitat for vernal pool species.

3.4.6.9.5.2 Hydrologic Function of Vernal Pools

Hydrologic functions to be maintained within vernal pool wetland complexes include surface water storage in the pool, subsurface water exchange, and surface water conveyance (Butterwick 1998:52). Aspects of surface water storage such as timing, frequency, and duration of inundation will be monitored, enhanced, and managed to benefit the vernal pool crustaceans. Techniques used to enhance and manage hydrology may include invasive plant control, removal of adverse supplemental water sources into restored or protected vernal pool complexes (e.g., agricultural or urban runoff), and topographic modifications.

3.4.7 Collaborative Science and Adaptive Management Program

Considerable scientific uncertainty exists regarding the Delta ecosystem, including the effects of CVP/SWP operations and the related operational criteria. To address this uncertainty, Reclamation, DWR, USFWS, NMFS, CDFW, and the public water agencies will establish a robust program of collaborative science, monitoring, and adaptive management in accordance with the Memorandum of Agreement (see below).

Collaborative science and adaptive management will support the PA by helping to address scientific uncertainty where it exists, and as it relates to the benefits and impacts of the construction and operations of the new water conveyance facility and existing CVP/SWP facilities. Specifically, collaborative science and adaptive management will, as appropriate, develop and use new information and insight gained during the course of construction and operation of the PA, and to inform and improve the following aspects of the California WaterFix program.

- Design of fish facilities including the intake fish screens.
- Operation of the water conveyance facilities under the BiOps and 2081(b) permit (California Department of Fish and Game 2009, National Marine Fisheries Service 2009, U.S. Fish and Wildlife Service 2008).
- Habitat restoration and other mitigation measures conducted under the BiOps and 2081(b) permit (California Department of Fish and Game 2009, National Marine Fisheries Service 2009, U.S. Fish and Wildlife Service 2008).

In summary, the broad purposes of the program will be to: (1) undertake collaborative science, (2) guide the development and implementation of scientific investigations and monitoring for both permit compliance and adaptive management, and (3) apply new information and insights to management decisions and actions. Each purpose is further described below.

3.4.7.1 Collaborative Science

The program will provide guidance and recommendations on relevant science related to the operations of the CVP/SWP within the Delta to inform implementation of the existing BiOps for the coordinated operations of the CVP/SWP, as well as for the new BiOp and 2081(b) permit for this PA. The collaborative science effort will build on the progress being made by the existing Collaborative Science and Adaptive Management Program (CSAMP) that was established to make recommendations on the science needed to inform implementation of or potential changes to the existing BiOps for the CVP/SWP operations, and proposed alternative management actions. The CSAMP process and its Collaborative Adaptive Management Team (CAMT) rely on the Delta Science Program to provide independent peer review of both science proposals and products.

Results from the collaborative science produced under the program would inform policy makers from the agencies implementing or overseeing the PA. These policy makers would determine whether and how to act on the information within the regulatory contexts of the BiOps, 2081(b) permit, and other relevant authorizations (e.g., USACE permits, State Board authorizations).

3.4.7.2 Monitoring

Monitoring is a critical element of the adaptive management program and a required component of ESA Section 7 BiOps and CESA 2081(b) permits. In addition, monitoring is a critical element of the collaborative science process that informs adaptive management decision-making. The proposed compliance and effectiveness monitoring program for the CESA 2081(b) permit is described in Chapter 6 of that permit application. The proposed monitoring program for the BiOp is described in Section 3.4.8, *Monitoring and Research Program*. These monitoring programs overlap but have distinct elements owing to their overlapping but distinct species lists. Collaborative science for the PA will have the following primary functions.

- Lead active evaluation through studies, monitoring, and testing of current and new hypotheses associated with key water operating parameters, habitat restoration, and other mitigation.
- Gather and synthesize relevant scientific information.
- Develop new modeling or predictive tools to improve water management in the Delta.
- Inform the testing and evaluation of alternative operational strategies and other management actions to improve performance from both biological and water supply perspectives.

Monitoring is essential to carry out this collaborative science process.

3.4.7.3 Management Recommendations, Decisions, and Actions

The collaborative science effort is expected to inform operational decisions within the ranges established by the BiOp and 2081(b) permit for the PA. The Collaborative Science and Adaptive Management Program shall be responsible for coordinating monitoring and research to assess the efficacy of the water operations criteria including:

- Existing operational criteria

- Operational criteria proposed to take effect at the time of commencement of north Delta operations, and
- alternative criteria that may provide equivalent or superior biological benefits while maximizing water supplies.

If prior to or at the time the new conveyance facilities become operational, Reclamation will, if necessary, reinitiate consultation pursuant to Section 7 of the ESA if it determines that one or more of the water operations criteria should be eliminated or modified, and/or DWR will, if necessary, commence a permit amendment process under California law, if it determines that one or more of the water operations criteria should be eliminated or modified.

Conversely, if new science suggests that operational changes may be appropriate that fall outside of and are more restrictive than the operational ranges evaluated in the BiOp and authorized by the 2081(b) permit, the appropriate agencies will determine, within their respective authorities, whether those changes should be implemented. An analysis of the biological effects of any such changes will be conducted to determine if those effects fall within the range of effects analyzed and authorized under the BiOp and 2081(b) permit. If NMFS, USFWS, or CDFW determine that impacts to listed species are greater than those analyzed and authorized under the BiOp and 2081(b) permit or the reinitiation criteria in 50 CFR § 402.16 are otherwise met, consultation may need to be reinitiated and/or the permittees may need to seek a 2081(b) permit amendment. Likewise, if an analysis shows that impacts on water supply are greater than those analyzed in the EIR/EIS, it may be necessary to complete additional environmental review to comply with CEQA or NEPA.

The collaborative science process will also inform the design and construction of the fish screens on the new intakes. This requires active study to maximize water supply, ensure flexibility in their design and operation, and minimize effects to listed species, as discussed in Section 3.4.8, *Monitoring and Research Program*. The collaborative science process will similarly inform adaptive management of habitat restoration and other mitigation measures required by the existing and new BiOp and 2081(b) permit.

3.4.7.3.1 Structure of Collaborative Science

As mentioned above, the collaborative science elements of the program will build on the experience gained in the CSAMP process. CSAMP employs a two-tiered organizational structure comprising: (1) a Policy Group made up of agency directors and top-level executives from participating entities, and (2) the CAMT, including designated managers and scientists to serve as a working group functioning under the direction of the Policy Group. Collaborative science for the PA is expected to follow a similar model in which management decisions are made by the appropriate agencies within their authorities and collaborative science is undertaken by managers and scientists from participating entities, and other stakeholders as will be described in the Memorandum of Agreement (MOA, see below). In keeping with the existing CSAMP model, future members of the collaborative science process will have expertise or technical skills that would enable them to contribute to the tasks outlined above. Membership from each group will be limited to maintain the effectiveness of the group. Other senior scientists may be invited to participate by mutual consent. If useful, the group could form technical subgroups or use existing subgroups to inform its work. Decisions about what science to pursue would be made by consensus. The group will integrate the work of relevant existing groups and processes (e.g., Delta Science Program and Interagency Ecological Program) to avoid duplicating work.

3.4.7.3.2 Funding for Collaborative Science

Collaborative science and monitoring conducted to support the PA will be implemented, when feasible, using existing resources from state, Federal, and other programs, and the mitigation program of the water conveyance facility. The mitigation program of the water conveyance facility has money dedicated to the monitoring necessary to support effective implementation of mitigation actions.

Proponents of the collaborative science and monitoring program will agree to provide or seek additional funding when existing resources are insufficient to complete the goals and tasks outlined above. The budget for collaborative science will be based on annual workplans that establish approved costs, identify funding sources, and serve as the basis for tracking actual performance. Contracting mechanisms would be developed to facilitate delivery of funding to meet short-term and long-term needs of the collaborative science program to the maximum extent possible while maintaining compliance with applicable contracting laws and regulations. In addition, the program proponents will ensure the availability of funding for monitoring and other requirements defined in the BiOp and 2081(b) permit.

3.4.7.3.3 Memorandum of Agreement

Commitments to adaptive management and collaborative science will be secured through a MOA between Reclamation, DWR, the public water agencies, NMFS, USFWS, and CDFW. Details of the collaborative science and adaptive management process, including adaptive management decision-making, an organizational structure for adaptive management decisions, and funding for collaborative science will be developed through the MOA, as needed. The MOA will incorporate the concepts described in this document as well as the attached "Adaptive Management Plan Process for Delta Operations Key Concepts" document developed in collaboration with the above mentioned entities.

3.4.7.3.4 Scientific Basis for Adaptive Management

Adaptive management is a systematic process to continually improve management policies and practices by learning from our actions (Holling 1978; Walters 1986). It requires well-articulated management objectives to guide decisions about what science to try, and explicit assumptions about expected outcomes to compare against actual outcomes (Williams et al. 2009). Adaptive management uses a process to clearly articulate objectives, identify management alternatives, predict management consequences, recognize key uncertainties in advance, and monitor and evaluate outcomes. This structured and systematic process is what differentiates adaptive management from a trial and error approach (National Research Council 2004a; Williams 2011a). Learning, facilitated through deliberate design and testing, is an integral component of adaptive management (Williams et al. 2009; Allen et al. 2011; Williams 2011a).

Adaptive management is a particularly useful framework in the face of scientific uncertainty. The principles of adaptive management lend themselves to water management and ecological restoration in the Bay-Delta (CALFED Bay-Delta Program 2000; Reed et al. 2007, 2010; Healey 2008; Dahm et al. 2009; National Research Council 2011; Parker et al. 2011, 2012). In particular, a National Research Council (2011) panel found that despite the challenges, there often is no better option for implementing water management regimes. The adaptive management program for the PA will be designed and implemented with these principals and scientific guidance in mind.

3.4.8 Monitoring and Research Program

Monitoring will be performed to measure a population's state and structure, to characterize the condition of a species' habitat and to detect and track presence or occupancy by listed species. Four general types of monitoring will occur:

- Continuation of existing monitoring required by the current BiOps (U.S. Fish and Wildlife Service 2008; National Marine Fisheries Service 2009) related to continuing operations of existing facilities and their effects on listed species.

- Monitoring required by permits and authorizations for construction of the proposed new facilities, including the MMRP that will be required under CEQA approvals.

- Monitoring and studies related to operation of the proposed new facilities that must occur prior to operation of the new facilities, including those necessary to inform design of the proposed NDD.

- Monitoring and studies related to operation of the proposed new facilities that must occur after operation of the new facilities has commenced.

In addition to the monitoring commitments specified in the remainder of this section, monitoring under the PA could also be initiated by direction of the Policy Group (described in Section 3.4.7, *Collaborative Science and Adaptive Management and Monitoring Program*). Under this process, a monitoring or research action would be designed and specified by collaborative agreement between DWR, Reclamation, and the jurisdictional fish and wildlife agencies (CDFW, NMFS, USFWS). Implementation of such monitoring actions would only occur if take authorization for the action were approved by the jurisdictional fish and wildlife agencies.

3.4.8.1 Impacts of Continued Monitoring and Operations on Listed Species

Existing monitoring, which has been mandated under existing BiOps and authorizations (U.S. Fish and Wildlife Service 2008; California Department of Fish and Game 2009; National Marine Fisheries Service 2009), includes monitoring to track the status of each listed species of fish, and also monitoring to ascertain performance of minimization measures associated with operations of the south Delta export facilities and their fish salvage programs. Existing monitoring programs will continue, and information from these programs will facilitate tracking status of listed species of fish and evaluating effectiveness of minimization measures. This existing monitoring to track the status of listed species of fish is performed by the Interagency Ecological Program[34], and incidental take associated with this monitoring is authorized via ESA Section 10(a)(1)(A) Research and Enhancement Permits and state Scientific Collection Permits. Monitoring to track

[34] This program is described and data are archived at http://www.water.ca.gov/iep/activities/monitoring.cfm

performance of the south Delta export facilities and their fish salvage programs is authorized through the existing BiOps (National Marine Fisheries Service 2009, Section 13.4; U.S. Fish and Wildlife Service 2008, *Monitoring Requirements*). Use of scientific collection permits constitutes a conservative approach to take authorization associated with monitoring activities because such permits need periodic renewal, at which time methodology can be updated to ensure that incidental take is minimized consistent with available knowledge and techniques. Thus it is expected that continuation of existing monitoring would receive take authorization either through issuance of scientific collection permits, or through an alternative consultation pathway.

3.4.8.2 Required Compliance Monitoring

Monitoring required by permits and authorizations for construction of proposed new facilities consists of compliance monitoring. Fulfillment of compliance monitoring and reporting requirements is solely the responsibility of Reclamation, DWR, and their contractors. Reclamation and DWR will track and ensure compliance monitoring is conducted in accordance with provisions of all permits and authorizations provided to the PA, and will provide results to NMFS and the USFWS at their request.

The principal permits and authorizations requiring monitoring are those related to ESA, CESA, NEPA and CEQA authorizations. Authorizations related to ESA include the terms and conditions of the BiOp for the PA, as well as the take limits identified in the incidental take statement within the BiOp. Authorizations related to CESA include the terms of the incidental take permit issued for the PA by the CDFW. That permit will be issued subsequent to the record of decision and its terms are additional to those of the other authorizations issued to the PA. Authorizations related to NEPA and CEQA include, respectively, a Record of Decision and a Notice of Determination. Most notably, the CEQA authorization includes a requirement to implement all provisions of the Mitigation Monitoring and Reporting Program (MMRP), as required by CCC §18.04. At this time an MMRP has not been prepared for the PA, but it is a required component prior to issuance of a Notice of Determination; a draft MMRP will be provided to USFWS and NMFS prior to issuance of the BiOp for the PA.

Although the terms and conditions of the BiOp are not known at this time, DWR, as the project applicant, will commit to track impacts of the PA on suitable habitat and the type and extent of habitat protection and restoration completed, and report the results to the jurisdictional fish and wildlife agencies (NMFS, USFWS) on an annual basis. Additionally, DWR will assess impacts anticipated for the following year and determine the type, extent, and timing of future habitat protection and restoration needs. DWR will also perform monitoring to ascertain performance relative to the limits identified in the BiOp incidental take statement. This monitoring will be achieved by performance, on an ongoing basis during the operational life of the facility, as specified in items 4, 5 and 10 in Table 3.4-18. Those items deal with monitoring of incidental take in the vicinity of the NDDs through the mechanisms of entrainment, impingement, and predation.

The effects of the proposed action in this biological assessment have been estimated conservatively to provide an analysis of the maximum potential adverse effects to the listed species. DWR, as the project applicant, has incorporated measures into the description of the proposed action to adequately offset the potential maximum adverse effects to the listed species.

DWR will implement the required mitigation commensurate to the level of the actual effect to the listed species, provided that effects remain below the allowable take limits (otherwise reinitiation of consultation would be required, per 50 CFR 402.16).

DWR will ground-truth impact areas prior to initiating proposed actions to determine the extent of suitable habitat present. Suitable habitat is defined for each species in Appendix 4.A, *Status of the Species and Critical Habitat Accounts.* After work is complete, DWR will field-verify the amount of impacts that have actually occurred with implementation of avoidance and minimization measures. DWR will track predicted and actual impacts at each project site and provide that information in annual compliance reporting.

3.4.8.3 Monitoring Prior to Operations

Monitoring and studies related to operation of the proposed new facilities, that must occur prior to operation of the new facilities, is focused on the conveyance facilities and their potential effects on listed fish species.

Specific monitoring studies focused on preconstruction conditions and on design of the north Delta diversions will be developed in collaboration with USFWS, CDFW, and NMFS. The Fish Facilities Technical Team (2011) identifies monitoring associated with the north Delta intakes and their effects. The pre-construction studies identified by this group are focused on specific key questions rather than monitoring and are listed in Table 3.4-17. Monitoring studies focused on the NDDs were developed during the BDCP process and include items 7 and 8 as listed in Table 3.4-18.

Table 3.4-17. Preconstruction Studies at the North Delta Diversions

Potential Research Action[1]	Key Uncertainty Addressed	Timeframe
1. This action includes preconstruction study 1, *Site Locations Lab Study* as described by the Fish Facilities Working Team (2013). The purpose of this study is to develop physical hydraulic models to optimize hydraulics and sediment transport at the selected diversion sites.	What is the relationship between proposed north Delta intake design features and expected intake performance relative to minimization of entrainment and impingement risks?	Ten months to perform study; must be complete prior to final intake design.
2. This action includes preconstruction study 2, *Site Locations Numerical Study* as described by the Fish Facilities Working Team (2013). The purpose of this study is to develop site-specific numerical studies (mathematical models) to characterize the tidal and river hydraulics and the interaction with the intakes under all proposed design operating conditions.	How do tides and diversion rates affect flow conditions at the north Delta intake screens and at the Georgiana Slough junction?	Eight months to perform study; must be complete prior to final intake design.
3. This action includes preconstruction study 3, *Refugia Lab Study* as described by the Fish Facilities Working Team (2013). The purpose of this study is to test and optimize the final recommendations for fish refugia that will be incorporated in the design of the north Delta intakes.	How should north Delta intake refugia be designed in principle to achieve desired biological function?	Nine months to perform study; must be complete prior to final intake design.
4. This action includes preconstruction study 4,	How do alternative north	Two years to perform study;

Potential Research Action[1]	Key Uncertainty Addressed	Timeframe
Refugia Field Study as described by the Fish Facilities Working Team (2013). The purpose of this study is to evaluate the effectiveness of using refugia as part of north Delta intake design for the purpose of providing areas for juvenile fish passing the screen to hold and recover from swimming fatigue and to avoid exposure to predatory fish.	Delta intake refugia designs perform with regard to desired biological function?	must be complete prior to final intake design.
5. This action includes preconstruction study 5, *Predator Habitat Locations* as described by the Fish Facilities Working Team (2013). The purpose of this study is to perform field evaluation of similar facilities (e.g., Freeport, RD108, Sutter Mutual, Patterson Irrigation District, and Glenn Colusa Irrigation District) and identify predator habitat areas at those facilities.	Where is predation likely to occur near the new North Delta intakes?	One to two years to perform study; must be complete prior to final intake design.
6. This action includes preconstruction study 6, *Baseline Fish Surveys* as described by the Fish Facilities Working Team (2013), somewhat modified based on discussions with NMFS during 2014. The purpose of this study is to perform literature search and potentially field evaluations at similar facilities (e.g., Freeport, RD108, Sutter Mutual, Patterson Irrigation District, and Glenn Colusa Irrigation District), to determine if these techniques also take listed species of fish, and to assess ways to reduce such by-catch, if necessary.	What are the best predator reduction techniques, i.e., which techniques are feasible, most effective, and best minimize potential impacts on listed species?	Two years to perform study; must be complete prior to final intake design.
7. This action includes preconstruction study 7, *Flow Profiling Field Study* as described by the Fish Facilities Working Team (2013). The purpose of this study is to characterize the water velocity distribution at river transects within the proposed diversion reaches for differing flow conditions. Water velocity distributions in intake reaches will identify how hydraulics change with flow rate and tidal cycle, and this information will be used in fish screen final design and in model-based testing of fish screen performance (preconstruction study 8, below).	What is the water velocity distribution at river transects within the proposed intake reaches, for differing river flow conditions?	One year to perform study; must be complete prior to final intake design.
8. This action includes preconstruction study 8, *Deep Water Screens Study* as described by the Fish Facilities Working Team (2013). The purpose of this study is to use a computational fluid dynamics model to identify the hydraulic characteristics of deep fish screen panels.	What are the effects of fish screens on hydraulic performance?	Nine months to perform study; must be complete prior to final intake design.
9. This action includes preconstruction study 9, *Predator Density and Distribution* as described by the Fish Facilities Working Team (2013); and includes post-construction study 9, *Predator Density and Distribution*, as described by the Fish Facilities Technical Team (2011). The purpose of this study is to use an appropriate technology (to be identified in the detailed study plan) at two to three proposed screen locations; the study will also perform velocity evaluation of eddy zones, if needed. The study will	What are predator density and distribution in the north Delta intake reaches of the Sacramento river?	Start in 2016 to collect multiple annual datasets before construction begins. The post-construction study will cover at least 3 years, sampling during varied river flows and diversion rates.

Potential Research Action[1]	Key Uncertainty Addressed	Timeframe
also collect baseline predator density and location data prior to facility operations, compare that to density and location of predators near the operational facility; and identify ways to reduce predation at the facilities.		
10. This action includes preconstruction study 10, *Reach-Specific Baseline Juvenile Salmonid Survival Rates* as described by the Fish Facilities Working Team (2013); and includes post-construction study 10, *Post-Construction Juvenile Salmon Survival Rates* as described by the Fish Facilities Technical Team (2011). The purpose of this study is to determine baseline rates of survival for juvenile Chinook salmon and steelhead within the Sacramento River near proposed north Delta diversion sites for comparison to post-project survival in the same area, with sufficient statistical power to detect a 5% difference in survival. Following initiation of project operations, the study will continue, using the same methodology and same locations. The study will identify the change in survival rates due to construction/operation of the intakes.	How will the new north Delta intakes affect survival of juvenile salmonids in the affected reach of the Sacramento River?	The pre-construction study will cover at least 3 years and must be completed before construction begins. The post-construction study will cover at least 3 years, sampling during varied river flows and diversion rates.
11. This action includes preconstruction study 11, *Baseline Fish Surveys* as described by the Fish Facilities Working Team (2013) and includes post-construction study 11, *Post-Construction Fish Surveys* as described by the Fish Facilities Technical Team (2011). The purpose of this study is to determine baseline densities and seasonal and geographic distribution of all life stages of delta and longfin smelt inhabiting reaches of the lower Sacramento River where the north Delta intakes will be sited. Following initiation of diversion operations, the study will continue sampling using the same methods and at the same locations. The results will be compared to baseline catch data to identify potential changes due to intake operations.	How will the new north Delta intakes affect delta and longfin smelt density and distribution in the affected reach of the Sacramento River?	Pre-construction study will cover at least 3 years. Post-construction study will be performed for duration of project operations (or delisting of species), with timing and frequency to be determined.

Notes

1. All research actions listed in this table are part of the PA. For all proposed research actions, a detailed study design must be developed prior to implementation. The study design must be reviewed and approved by CDFW, NMFS, and USFWS prior to implementation.

Table 3.4-18. Monitoring Actions for Listed Species of Fish for the North Delta Intakes

Monitoring Action(s)	Action Description[1]	Timing and Duration
1. Fish screen hydraulic effectiveness	This action includes post-construction study 2, *Long-term Hydraulic Screen Evaluations*, combined with post-construction study 4, *Velocity Measurement Evaluations,* as described by the Fish Facilities Technical Team (2011). The purpose of this monitoring is to confirm screen operation produces approach and sweeping velocities consistent with design criteria, and to measure flow velocities within constructed refugia. Results of this monitoring will be used to “tune” baffles and other components of	Approximately 6 months beginning with initial facility operations.

Monitoring Action(s)	Action Description[1]	Timing and Duration
	the screen system to consistently achieve compliance with design criteria.	
2. Fish screen cleaning	This action includes post-construction study 3, *Periodic Visual Inspections* as described by the Fish Facilities Technical Team (2011). The purpose of this monitoring is to perform visual inspections to evaluate screen integrity and the effectiveness of the cleaning mechanism, and to determine whether cleaning mechanism is effective at protecting the structural integrity of the screen and maintaining uniform flow distribution through the screen. Results of this monitoring will be used to adjust cleaning intervals as needed to meet requirements.	Initial study to occur during first year of facility operation with periodic re-evaluation over life of project.
3. Refugia effectiveness	This action includes post-construction study 5, *Refugia Effectiveness* as described by the Fish Facilities Technical Team (2011). The purpose is to monitor refugia to evaluate their effectiveness relative to design expectations. This includes evaluating refugia operation at a range of river stages and with regard to effects on target species or agreed proxies. Results of this monitoring will be used to "tune" the screen system to consistently achieve compliance with design criteria.	Approximately 6 months beginning with initial facility operations.
4. Fish screen biological effectiveness	This action includes post-construction study 7, *Evaluation of Screen Impingement* as described by the Fish Facilities Technical Team (2011). The purpose of this monitoring is to observe fish activity at the screen face (using technology to be identified in the detailed study plan) and use an appropriate methodology (to be identified in the detailed study plan) to evaluate impingement injury rate. Results of this monitoring are to be used to assess facility performance relative to take allowances, and otherwise as deemed useful via the collaborative adaptive management process.	Study to be performed at varied river stages and diversion rates, during first 2 years of facility operation.
5. Fish screen entrainment	This action includes post-construction study 8, *Screen Entrainment* as described by the Fish Facilities Technical Team (2011). The purpose of this monitoring is to measure entrainment rates at screens using fyke nets located behind screens, and to identify the species and size of entrained organisms. Results of this monitoring are to be used to assess facility performance relative to take allowances, and otherwise as deemed useful via the collaborative adaptive management process.	Study to be performed at varied river stages and diversion rates, during first 2 years of facility operation.
6. Fish screen calibration	Perform hydraulic field evaluations to measure velocities over a designated grid in front of each screen panel. This monitoring will be conducted at diversion rates close to maximum diversion rate. Results of this monitoring will be used to set initial baffle positions and confirm compliance with design criteria.	Initial studies require approximately 3 months beginning with initial facility operations.
7. Fish screen construction	Document north Delta intake design and construction compliance with fish screen design criteria (note, this is simple compliance monitoring).	Prior to construction and as-built.
8. Operations independent measurement	Document north Delta intake compliance with operational criteria, with reference to existing environmental monitoring programs including (1) IEP Environmental Monitoring Program: Continuous Multi-parameter Monitoring, Discrete Physical/ Chemical Water Quality Sampling; (2) DWR and Reclamation: Continuous Recorder Sites; (3) Central Valley RWQCB: NPDES Self-Monitoring Program; and (4) USGS Delta Flows Network and	Start prior to construction of water diversion facilities and continue for the duration of the PA.

Monitoring Action(s)	Action Description[1]	Timing and Duration
	National Water Quality Assessment Program. The purpose of this monitoring is to ensure compliance and consistency with other relevant monitoring programs, and to ensure that this information is provided to CDFW, NMFS, and USFWS in association with other monitoring reporting.	
9. Operations measurement and modeling	Document north Delta intake compliance with the operational criteria using flow monitoring and models implemented by DWR. The purpose of this monitoring is to ensure and demonstrate that the intakes are operated consistent with authorized flow criteria.	Start prior to completion of water diversion facilities and continue for the duration of the permit term.
10. North Delta intake reach salmonid survivorship	Determine the overall impact on survival of juvenile salmonids through the diversion reach, related to the operation of the new north Delta intakes. Use mark/recapture and acoustic telemetry studies (or other technology to be identified in the detailed study plan) to evaluate effects of facility operations on juvenile salmonids, under various pumping rates and flow conditions. Results of this monitoring are to be used to assess whether survival objectives for juvenile salmonids traversing the diversion reach are being met, to determine whether take allowances are exceeded, and otherwise as deemed useful via the collaborative adaptive management process	Study to be performed at varied river flows and diversion rates, during first 2 to 5 years of facility operation.

Notes
1. All monitoring actions are part of the PA. For all proposed monitoring actions, a detailed study design must be developed prior to implementation. The study design must be reviewed and approved by CDFW, NMFS, and USFWS prior to implementation.

3.4.8.4 Monitoring after Operations Commence

Monitoring and studies related to CVP and SWP Delta operations, that must occur after operation of the new facilities has commenced, broadly consists of two types of monitoring, both performed to assess system state and effects on listed species: monitoring addressing the conveyance facilities, and monitoring addressing the habitat protection and restoration sites.

3.4.8.4.1 Monitoring Addressing Conveyance Facilities

Monitoring and studies related to operation of the proposed new facilities, that must occur after operation of the new facilities has commenced, is focused on potential effects on listed fish species.

Specific monitoring studies focused on the effects of operating the north Delta diversions will be developed in collaboration with USFWS, CDFW, and NMFS. The Fish Facilities Technical Team (2011) identifies monitoring associated with the north Delta intakes and their effects. Some of this work is focused on specific key questions rather than monitoring and is described in Section 3.4.11, *Research Program*, while the monitoring studies include items 1-6 and 8-10 as listed in Table 3.4-18. Items 6-10 in Table 3.4-18 are studies focused on NDD performance, which were developed after the Fish Facilities Technical Team work, during the BDCP process.

3.4.8.4.2 Monitoring Addressing Habitat Protection and Restoration Sites

Metrics and protocols for wildlife species effectiveness monitoring will be developed after land acquisition but before restoration actions or enhancement and management activities are begun.

Table 3.4-19 details the proposed effectiveness monitoring actions and success criteria relevant to listed species of wildlife. Effectiveness monitoring actions listed in Table 3.4-19 would be implemented for the duration of the incidental take authorizations provided in the BiOps for the PA.

Research under the PA could also by initiated by direction of the Policy Group (described in Section 3.4.7, *Collaborative Science and Adaptive Management and Monitoring Program*). Under this process, a monitoring or research action would be designed and specified by collaborative agreement between DWR, Reclamation, and the jurisdictional find and wildlife agencies (CDFW, NMFS, USFWS). Implementation of such research actions would only occur if take authorization for the action were approved by the jurisdictional fish and wildlife agencies.

Table 3.4-19. Proposed Effectiveness Monitoring Actions and Success Criteria

Monitoring Type	Action Description	Metric	Success Criteria	Protected Lands Timing and Duration	Restoration Site Timing and Duration
Valley Elderberry Longhorn Beetle – Valley Foothill Riparian	Representative/rotating sampling to assess health of shrubs; survey for signs of valley elderberry longhorn beetle. Survey for stem counts and increased density of shrubs on restoration site.	Health assessment of shrub(s); Dispersal and expansion of valley elderberry longhorn beetle where there are known source populations. Overall shrub health and number of stems and shrubs at restoration locations.	Growth and range expansion of populations above baseline.	All shrubs during the first year; 50% of the shrubs for each of the next two years; every five years thereafter, randomly sampled subset.	All shrubs during each of the first three years; 50% of the shrubs for each of the next six years; every five years thereafter, randomly sampled subset.
San Joaquin Kit Fox – Grasslands	Camera trap for San Joaquin kit fox, depending on site topography and access. Spotlighting will not be used (Fiehler pers. comm.). Protocol will consist of camera stations baited with a cat food can staked to the ground, on which San Joaquin kit fox will readily deposit scat. Camera station details will be consistent with the methods used by Constable et al. (2009), including tracking of competitors and prey.	Number of individuals; Growth and range expansion of populations.	Growth and range expansion of populations above baseline.	Annual surveys for at least 5 years to establish a baseline of whether or not the action area supports persistent populations (Fiehler pers. comm.). At least 5 years of baseline surveys will be repeated after habitat has been restored or conserved. Additionally, whenever a sighting is reported, baited cameras will be placed in the area to confirm the detection. Surveys must be conducted between May 1 and November 1 (U.S. Fish and Wildlife Service 1999).	Annual surveys for at least 5 years to establish a baseline of whether or not the action area supports persistent populations (Fiehler pers. comm.). At least 5 years of baseline surveys will be repeated after habitat has been restored or conserved. Additionally, whenever a sighting is reported, baited cameras will be placed in the area to confirm the detection. Surveys must be conducted between May 1 and November 1 (U.S. Fish and Wildlife Service 1999).
California Tiger Salamander – Grasslands	Dip netting and visual surveys.	Number of individuals per site.	Growth and range expansion of populations above baseline.	One year of surveys at each site; 50% in the second year, and 50% in the third year; two of the four sites randomly sampled for presence every three years for 10 years and then every five years thereafter.	One year of surveys at each site; 50% in the second year, and 50% in the third year; two of the four sites randomly sampled for presence every three years for 10 years and then every five years thereafter.

Monitoring Type	Action Description	Metric	Success Criteria	Protected Lands Timing and Duration	Restoration Site Timing and Duration
California Red-Legged Frog – Grasslands	Eye shine and call surveys for California red-legged frog.	Number of individuals per site.	Growth and range expansion of populations above baseline.	One year of surveys at each site; 50% in the second year, and 50% in the third year; two of the four sites randomly sampled for presence every three years for 10 years and then every five years thereafter.	One year of surveys at each site; 50% in the second year, and 50% in the third year; two of the four sites randomly sampled for presence every three years for 10 years and then every five years thereafter.
Branchiopods – Vernal Pools/Alkali Seasonal Wetlands	Sample for individuals.	Number of individuals per site.	Growth and range expansion of populations above baseline; self-sustaining populations.	Two branchiopod surveys per site; all pools/wetlands sampled the first year; 50% second year; 50% third year; then 50% sampled every five years thereafter.	Two branchiopod surveys per site; all pools/wetlands sampled the first year; 50% second year; 50% third year; then 50% sampled every five years thereafter.
Giant Garter Snakes – Nontidal Freshwater Perennial Emergent Wetland	Trapping surveys to detect presence of individuals; measure giant garter snake habitat connectivity.	Number of individuals at each restored site; acreage of connected habitat	Growth and range expansion of populations above baseline; increase in connectivity from baseline.	One year of trapping at each site; 50% of sites sampled in the second year, and 50% of sites sampled in the third year; two of the four sites randomly sampled for presence every three years for 10 years and then every five years thereafter.	One year of trapping at each site; 50% of sites sampled in the second year, and 50% of sites sampled in the third year; two of the four sites randomly sampled for presence every three years for 10 years and then every five years thereafter.

3.5 Reinitiation of Consultation

As provided in 50 CFR 402.16:

> *Reinitiation of formal consultation is required and shall be requested by the Federal agency or by the Service where discretionary Federal involvement or control over the action has been retained or is authorized by law and:*
>
> *(a) If the amount or extent of taking specified in the incidental take statement is exceeded;*
>
> *(b) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;*
>
> *(c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or*
>
> *(d) If a new species is listed or critical habitat designated that may be affected by the identified action.*

Reclamation or USACE as the federal action agencies, with DWR as the project applicant, will re-initiate consultation with USFWS and/or NMFS if any of these circumstances occur. Reinitiation of formal consultation may also be appropriate if there are indications that water operations flow criteria may be eliminated or otherwise modified while maintaining the requirements of Section 7 of the ESA and Section 2081 of the Fish and Game Code.

3.6 Interrelated or Interdependent Actions

Interrelated actions are defined under ESA as actions that are part of a larger action and depend on the larger action for their justification. Interdependent actions are defined as actions that have no independent utility apart from the action under consideration (50 CFR 402.02). To determine if an action is interrelated to or interdependent with a proposed action, the agency "should ask whether another activity in question would occur 'but for' the proposed action under consultation" (FWS Consultation Handbook at 4-26). In doing so, the agency must be "careful not to reverse the analysis by analyzing the relationship of the proposed action against the other activity." *Id*. For instance, "if the proposed action is the addition of a second turbine to an existing dam, the question is whether the dam (the other activity) is interrelated to or interdependent with the proposed action (the addition of the turbine), not the reverse." *Id*. In this case, the PA is the proposed action under consultation, so the agency should determine whether any other action in question would occur "but for" the PA.

Potential interrelated or interdependent actions were evaluated by considering actions that are ongoing or reasonably foreseeable, that occur wholly or in part within the action area, and that are functionally related to the PA. Functional relationship was defined as applying to projects dealing with surface water resource management and/or habitat protection or restoration actions affecting listed species. Examples of functionally related projects include management of upstream reservoirs, of levees and other flood control works in the Delta, of other surface water intakes located in the action area; and planned habitat protection restoration connected, for instance, with existing and proposed habitat conservation plans in the action area. With one exception, described below, none of these actions part of the PA, and their utility does not depend upon the PA, in whole or in part.

Given the close coordination of reservoir operations and Delta operations for the CVP and SWP, the upstream operations have received particular attention in the BA. However, upstream operations of the CVP and SWP (the other activity) will continue—consistent with existing biological opinions--whether or not the PA (the action under consultation) is authorized, constructed, and operated. Thus, under the FWS Handbook, upstream actions are not interrelated to or interdependent with the PA.

That is consistent with relevant case law in the Ninth Circuit, *Am. Rivers v. National Oceanic and Atmospheric Administration Fisheries*, 2006 U.S. Dist. LEXIS 48195, at *9-10 (D. Or. July 14, 2006). In that case, the court held that Reclamation's operation of the Upper Snake River Project was not interrelated to or interdependent with the downstream Federal Columbia River Power System (FCRPS). The court opined that the "but for" test requires more than a mutual relationship between the two actions, "[case law] does not support Plaintiff's suggestion that simply because one federal action causes a discrete component of another to occur differently, the actions are 'interrelated.' If that were the case, it would be difficult to imagine any federal action in the Columbia Basin that is not interrelated with the downstream dams." *Id*. Here, there is also some relationship between the PA and upstream operations, but the later are not interrelated to or interdependent with the PA.

Additionally,

- the PA does not include any changes in the applicable operating criteria of upstream reservoirs;
- the effects of these operations are evaluated and authorized in the existing Biological Opinion (National Marine Fisheries Service 2009) and would continue unless and until Reclamation proposes changes to the criteria and/or re-initiation is triggered; and
- none of the Delta operational changes included in this PA necessitate changes in upstream criteria or operations.

Therefore, continued operations of upstream reservoirs is not considered, for purposes of ESA, interdependent or interrelated to the PA.

The management of levees and other flood works in the action area is also not interdependent or interrelated to the PA. Water diversions and flow changes that would occur under the PA have no potential to alter flood frequency or severity. Although the PA would replace some existing flood control facilities with new engineered structures, the structures would be functionally equivalent in terms of their utility for flood control, and thus would not alter the distribution or utility of flood control infrastructure, or of any planned flood control facilities.

One interrelated or interdependent action has been identified in connection with the PA. As described in Section 3.3.4.4, *Contra Costa Canal Rock Slough Intake,* and in Section 4.3.2.2.3, *Water Supply Facilities and Facility Operations*, CCWD's water system includes the Mallard Slough, Rock Slough, Old River, and Middle River (on Victoria Canal) intakes. The PA includes Reclamation's operation of the Rock Slough intake to the Contra Costa Canal, but CCWD operates the Mallard Slough, Old River, and Middle River intakes. CCWD can divert approximately 30% to 50% of its total annual supply (approximately 127 TAF) through the Rock Slough Intake, depending upon water quality there; the remainder of their total annual withdrawal (i.e., 50% to 70% of the total) would thus use the CCWD-owned intakes. Most of this diversion would occur at the Old River intake (250 cfs capacity), which is used year-round, and the Middle River intake (250 cfs capacity), used primarily in late summer and fall to provide better water quality than is obtainable from the other three intakes. Note that these capacities and seasonal variations in diversion use have been incorporated in the hydrodynamic modeling used to develop the effects analysis for listed fish species.

The Mallard Slough intake (39 cfs capacity) is used primarily in winter and spring during wet periods when water quality is sufficiently high. Thus diversions at the three CCWD-owned intakes are primarily determined by seasonal fluctuations in water quality, rather than by the availability of the Rock Slough diversion. Nonetheless, increased withdrawals at the other intakes, insofar as they provide acceptable water quality, would result if withdrawals at Rock Slough were curtailed for any reason; similarly, increased withdrawals at Rock Slough could result in reduced withdrawals at the other intakes.

3.7 Drought Procedures

Drought is a gradual phenomenon and can best be thought of as a condition of water shortage for a particular user in a particular location. Although persistent drought may be characterized as an emergency, it differs from typical emergency events. Most natural disasters, such as floods or forest fires, occur relatively rapidly and afford little time for preparing for disaster response. Droughts occur slowly, over a period of time. There is no universal definition of when a drought begins or ends. Impacts of drought are typically felt first by those most reliant on annual rainfall -- ranchers engaged in dryland grazing, rural residents relying on wells in low-yield rock formations, or small water systems lacking a reliable water source. Drought impacts increase with the length of a drought, as carry-over supplies in reservoirs are depleted and water levels in groundwater basins decline.

Measurements of California water conditions cover only a small slice of the past. Widespread collection of rainfall and streamflow information began around the turn of the 20th century. During our period of recorded hydrology, the most significant statewide droughts occurred during 1928-34, 1976-77, 1987-92, and 2007-09. Historical data combined with estimates created from indirect indicators such as tree rings suggest that the 1928-34 event may have been the driest period in the Sacramento River watershed since about the mid-1550s.

California is currently in its fourth consecutive year of below-average rainfall and very low snowpack. Water Year 2015 is also the eighth of 9 years with below-average runoff, which has resulted in chronic and significant shortages to municipal and industrial, agricultural, and refuge water supplies and historically low levels of groundwater. As of September 2015, 66 percent of the state was experiencing an Extreme Drought and 46 percent was experiencing an Exceptional Drought, as recorded by the National Drought Mitigation Center, U.S. Drought Monitor. Of particular concern has been the state's critically low snow pack which typically provides much of California's seasonal water storage. On April 1, 2015, DWR found no snow at the Phillips snow course. This was the first time in 75 years of early-April measurements. The lack of precipitation the last several years has also contributed to low reservoir storage levels in the Sacramento watershed. Shasta Reservoir on the Sacramento River, Oroville Reservoir on the Feather River, and Folsom Reservoir on the American River were at 55, 46, and 57 percent of capacity, respectively, on September 30, 2015 (64, 55, and 70 percent of average for February, respectively). Trinity Lake (water from the Trinity system is transferred to the Sacramento River system) on the Trinity River is at 36 percent of capacity and 48 percent of the February average. The San Joaquin River Watershed in particular has experienced severely dry conditions for the past three years (State Water Resources Control Board 2015).

3.7.1 Water Management in Drought Conditions

3.7.1.1 Historic Drought Management Actions

Previous droughts that have occurred throughout California's history continue to shape and spur innovation in the ways in which DWR and Reclamation handle both public health standards and urban and agricultural water demand, as well as protecting the Delta ecosystem and its inhabitants. The most notable droughts in recent history are the droughts that occurred in 1976-77, 1987-92, and 2014-15. These periods of drought have helped shape legislation and stressed the importance of maintaining water supplies for all water users.

The impacts of a dry hydrology in 1976 were mitigated by reservoir storage and groundwater availability. The immediate succession of an even drier 1977, however, set the stage for widespread impacts. In 1977 CVP agricultural water contractors received 25 percent of their allocations, municipal contractors received 25 to 50 percent, and the water rights or exchange contractors received 75 percent. SWP agricultural contractors received 40 percent of their allocations and urban contractors received 90 percent.

Managing Delta salinity was a major challenge, given the competing needs to preserve critical carry-over storage and to release water from storage to meet Bay-Delta water quality standards. At this time the present-day Coordinated Operation Agreement between DWR and USBR was not in effect. In February 1977, the SWRCB adopted an interim water quality control plan to modify Delta standards to allow the SWP to conserve storage in Lake Oroville. As extremely dry conditions continued that spring, the SWRCB subsequently adopted an emergency regulation superseding its interim water quality control plan, temporarily eliminating most water quality standards and forbidding the SWP to export stored water. As a further measure to conserve reservoir storage, DWR constructed temporary facilities (i.e., rock barriers, new diversions for Sherman Island agricultural water users, and facilities to provide better water quality for duck clubs in Suisun Marsh) in the Delta to help manage salinity with physical, rather than hydraulic, approaches.

In 1977, SWP and CVP contractors used water exchanges to respond to drought; one of the largest exchanges involved 435 TAF of SWP entitlement made available by MWD and three other SWP Southern California water contractors for use by San Joaquin Valley irrigators and urban agencies in the San Francisco Bay area. The MWD entitlement supplied water to Marin

Municipal Water District via an emergency pipeline laid across the San Rafael Bridge and a complicated series of exchanges under which DWR delivered the water to the Bay Area via the South Bay Aqueduct. Public Law 95-18, the Emergency Drought Act of 1977, authorized Reclamation to purchase water from willing sellers on behalf of its contractors; Reclamation purchased about 46 TAF of water from sources including groundwater substitution and the SWP. Reclamation's ability to operate the program was facilitated by CVP water rights that broadly identified the project's service area as the place of use, allowing transfers within the place of use. Institutional constraints and water rights laws limited the transfer/exchange market at this time, and transfer activity outside of those exchanges arranged by DWR and Reclamation's drought water bank was relatively small-scale.

The Western Governors' Conference named a western regional drought action task force in 1977 and used that forum to coordinate state requests for federal assistance. Multi-state drought impacts led to increased appropriations for traditional federal financial assistance programs (e.g., USDA assistance programs for agricultural producers), and two drought-specific pieces of federal legislation. The Emergency Drought Act of 1977 authorized the Department of the Interior to take temporary emergency drought mitigation actions and appropriated $100 million for activities to assist irrigated agriculture, including Reclamation's water transfers programs. The Community Emergency Drought Relief Act of 1977 authorized $225 million for the Economic Development Agency's drought program, of which $175 million was appropriated ($109 million for loans and $66 million for grants) to assist communities with populations of 10,000 or more, tribes, and special districts with urban water supply actions. Projects in California received 41 percent of the funding appropriated pursuant to this act.

Within California, the Governor signed an executive order naming a drought emergency task force in 1977. Numerous legislative proposals regarding drought were introduced, about one-third of which became law. These measures included: authorization of a loan program for emergency water supply facilities; authorization of funds for temporary emergency barriers in the Delta (the barriers were ultimately funded by the federal Emergency Drought Act instead); prohibition of public agencies' use of potable water to irrigate greenbelt areas if the SWRCB found that recycled water was available; authorization for water retailers to adopt conservation plans; addition of drought to the definition of emergency in the California Emergency Services Act.

During the 1987-92 drought, the state's 1990 population was close to 80 percent of present amounts and irrigated acreage was roughly the same as that of the present, but the institutional setting for water management differed significantly. Delta regulatory constraints affecting CVP and SWP operations were based on SWRCB water right decision D-1485, which had taken effect in 1978 immediately following the 1976-77 drought. In addition to D-1485 requirements on SWP and CVP operations in the Delta, other operational constraints included temperature standards imposed by the SWRCB through Orders WR 90-5 and 91-01 for portions of the Sacramento and Trinity Rivers. On the Sacramento River below Keswick Dam, these orders included a daily average water temperature objective of 56°F during periods when high temperatures could be detrimental to survival of salmon eggs and pre-emergent fry. As part of managing salinity during the drought, DWR installed temporary barriers at two South Delta locations – Middle River and Old River near the Delta-Mendota Canal intake — to improve water levels and water quality/water circulation for agricultural diverters.

In response to Executive Order W-3-91 in 1991, DWR developed a drought water bank that operated in 1991 and 1992. The bank bought water from willing sellers and made it available for purchase to agencies with critical water needs. Critical water needs were understood to be basic domestic use, health and safety, fire protection, and irrigation of permanent plantings.

In 1992, NMFS issued its first biological opinion for the Sacramento River winter-run Chinook salmon, which had been listed as threatened pursuant to the ESA in 1989. The Central Valley Project Improvement Act of 1992 (CVPIA) was enacted just at the end of the drought, so provisions reallocating project yield for environmental purposes were not in effect for 1992 water operations. The CVPIA dedicated 800,000 acre-feet of project yield for environmental purposes. The regulatory framework for the SWP and CVP has changed significantly in terms of new ESA requirements to protect certain fish species, and SWRCB water rights decisions governing the water projects' operations in the Delta.

When executed in 1994 the Monterey amendments provided that an equal annual allocation would be made to urban and agricultural contractors. The prior provisions in effect during the 1987-92 drought called for agricultural contractors to take a greater reduction in their allocations during shortages than urban contractors, which had resulted in the zero allocation to the agricultural contractors in 1991.

The institutional setting for water management has changed greatly since the 1987-92 drought. Some of the most obvious changes have affected management of the state's largest water projects, such as the CVP, SWP, Los Angeles Aqueduct, or Colorado River system. New listings and management of fish populations pursuant to the ESA have impacted operations of many of the state's water projects, including the large projects affected by listing of Central Valley fish species as well as smaller projects on coastal rivers where coho salmon populations have been listed.

The present regulatory framework for CVP and SWP operations is distinctly different from that of 1987-92. The first biological opinion for the then-threatened winter-run Chinook salmon was issued in 1992, just at the end of the drought; in 1994 winter-run were reclassified as endangered. A significant provision of the initial 1992 biological opinion for winter-run salmon, and also of subsequent opinions, was a requirement to provide additional cold water in Sacramento River spawning areas downstream of Shasta Dam, resulting in increased late-season reservoir storage. Delta smelt were listed as threatened in 1993. Subsequently, other fish species listed pursuant to the federal ESA or the California ESA included the longfin smelt, Central Valley spring-run Chinook salmon, Central Valley steelhead, and green sturgeon.

The biological opinions for these species, together with changes in SWRCB Bay-Delta requirements, represent a major difference between 1986-92, when SWRCB's Water Rights Decision D-1485 governed the projects' Delta operations, and the present. SWRCB's Water Rights Decision D-1641 reduced water project exports in order to provide more water for Delta outflow. Requirements of the most recent biological opinions for listed fish species modify D-1641 requirements, further reducing the water projects' delivery capabilities by imposing greater pumping curtailments and Delta outflow requirements. Additionally, the CVPIA mandate to reallocate 800 TAF of CVP yield for environmental purposes and to provide a base water supply for wildlife refuges was not in effect for 1987-92 water operations.

3.7.1.2 Recent Drought Management Actions

As a result of more recent drought conditions, California Governor Edmund G. Brown issued a Drought Emergency Proclamation on January 17, 2014 that is effective through May 31, 2016, and which directs the SWRCB to, among other things, consider petitions, such as Temporary Urgency Change Petitions (TUCP), to modify requirements for reservoir releases or diversion limitations that were established to implement a water quality control plan.

On January 29, 2014, Reclamation and DWR sought a temporary modification to their water rights permits and licenses through a TUCP, allowing the CVP and SWP to reduce Delta outflow and thus conserve upstream storage for later use. The resultant January 31, 2014, Executive Order also allowed the projects to pump at a minimum level (1,500 cfs) to supply essential public health and safety needs when Delta outflow was lower than would typically allow such pumping. Reclamation and DWR convened a Real Time Drought Operations Management Team (RTDOT) comprised of representatives from Reclamation, DWR, fisheries agencies, and the SWRCB to discuss more flexible operations of the projects while protecting beneficial uses. Throughout 2014, the federal and state fish and wildlife agencies worked in close coordination with Reclamation and DWR to receive, analyze, and respond to the project operators' requests for additional operational flexibility while the effects remained consistent with those already evaluated within the applicable biological opinions.

The January Order was amended several times to allow project operators to pump at higher levels to capture storm run-off. The January Order was also extended and/or amended to modify D-1641 Delta Outflow requirements. The *CPV and SWP Drought Operations Plan and Operational Forecast for April 1, 2014 through November 15, 2014 (DOP),* outlined critical CVP/SWP operational considerations including providing for essential human health and safety needs; maintaining salinity control; planning for installation of three emergency drought barriers; maintaining adequate water supply reserves for 2015; providing for cold water species' needs, CVP and SWP water supplies, and refuge water supplies; and providing for operational flexibility, exchanges, and transfers. The DOP included upstream tributary operations as well as further modifications to D-1641 provisions associated with Delta outflow levels, maximum export limits, Delta E/I averaging period, combined export limitations, Vernalis base and pulse flows, and agricultural salinity compliance locations. The DOP also addressed modifications to DCC gate operations; potential operations with and without installation of three emergency drought barriers; measures to offset effects to San Joaquin River steelhead; and emergency fisheries monitoring, technology improvement, and science planning. Modifications to the DOP were requested in September 2014, regarding modification of the San Joaquin River flows and Vernalis and extension of the water transfer window.

The *CVP and SWP Drought Contingency Plan for October 15, 2014 through January 15, 2015*, was prepared by Reclamation and DWR in response to the SWRCB October 7, 2014 Modified Order. This Plan provided an overview of current conditions and available supplies as they related to projected flow and storage conditions using 50 percent, 90 percent, and 99 percent exceedance probabilities for assumed hydrology, and addressed projected water operations based on various hydrologic scenarios and potential adjustments to regulatory requirement through January 15, 2015. A subsequent *Drought Contingency Plan for January 15, 2015 through September 30, 2015*, was prepared to incorporate changes in snowpack, reservoir storage, and updated hydrologic forecasts. The January 15, 2015, *Drought Contingency Plan* appended a December 12, 2014 working draft of the *Interagency 2015 Drought Strategy for the CVP and SWP*. The 2015 Drought Strategy described the anticipated coordination, process, planning, and potential drought response actions for 2015.

On January 23, 2015, DWR and Reclamation jointly filed a TUCP pursuant to Water Code section 1435 et seq., to temporarily modify requirements in their water right permits and license for the SWP and CVP for 180 days, with specific requests for February and March of 2015. The TUCP requested temporary modification of requirements included in SWRCB Revised D-1641 to meet water quality objectives in the *Water Quality Control Plan (Plan) for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary*. Specifically, the TUCP requested modifications to Delta outflow, San Joaquin River flow, DCC gate operation, and export limit requirements. The TUCP also identified possible future modification requests for the period from April to September (SWRCB 2015a).

On March 24, 2015, Reclamation and DWR proposed a suite of modifications to upstream tributary operations and D-1641 water rights requirements for April 1 through September 30, 2014. This TUCP included continuation of provisions in the current TUC Order regarding Delta outflow requirements, as well as modifications to San Joaquin River flows, export limits, DCC gate operations, Rio Vista flows, western Delta salinity, and San Joaquin River salinity requirements. Reclamation also requested modification of the Ripon dissolved oxygen requirement specified by D-1422.

On May 21, Reclamation and DWR submitted a request to the SWRCB to modify and renew the TUC Order that was issued in response to the March request. The May 21 request revised the proposed water operations from July through November. The primary focus in the May 21 request sought modifications to Delta outflow, Rio Vista flow standards, and the western agriculture salinity standard at Emmaton. These modifications created operational flexibility and allowed conservation of the cold water pool in Lake Shasta. The cold water pool was used to manage drought effects to winter-run Chinook salmon.

The combination of virtually no snowpack and diminished reservoir storage in the spring of 2015 convinced federal and state wildlife and water agency managers that an emergency salinity barrier on West False River in the Sacramento-San Joaquin Delta was needed to repel salinity that could threaten a source of water used by 25 million Californians. Installation of a single emergency salinity barrier across West False River began in early May; with removal scheduled by mid-November. The barrier helped to limit the tidal push of saltwater from San Francisco Bay into the central Delta and helped minimize the amount of fresh water that must be released during the summer from upstream reservoirs to repel saltwater. Sufficient reserves in upstream reservoirs are needed to repel saltwater and prevent the contamination of water supplies for residents of the Delta; Contra Costa, Alameda and Santa Clara counties, and the 25 million people who rely on the Delta-based federal and state water projects for at least some of their supplies. Removal of the emergency barrier by November 15 is needed to avoid the flood season and harm to migratory fish. While it was in place, boaters used alternative routes between the San Joaquin River and the Delta's interior.

3.7.1.3 Recent Drought Management Processes and Tools

Following is a summary of the processes that were followed and the tools that were used by Reclamation and DWR to address drought conditions in WY 2014 and 2015.

Reclamation and DWR reviewed the ability of the CVP and SWP to meet existing regulatory standards and objectives contained in their water rights permits and licenses, as well as environmental laws and regulations, based on the current and projected hydrology, exceedance forecasts, reservoir levels, etc. This included consideration of the requirements of D-1641, and the 2008 USFWS and 2009 NMFS Biological Opinions on the Coordinated Long-term Operation of the CVP and SWP (BiOps). Reclamation and DWR then jointly developed proposed modifications to D-1641 and adjustments to the BiOps and prepared appropriate documentation to support the permitting and consultation processes. This included preparation of TUPCs for submittal to the SWRCB, and Endangered Species Act (ESA) consultation letters/memorandums for exchange with USFWS and NMFS. These documents typically included the following elements: 1) proposed action description, 2) hydrologic forecasts, 3) modeling output, and 4) biological review. The process relied heavily on on-going communication and coordination among six agencies (Reclamation, DWR, USFWS, NMFS, CDFW, and SWRCB) through the RTDOT and frequent calls between the Regional Directors of these agencies. The process concluded with implementation of the drought response actions, including construction and installation of the West False River Emergency Drought Barrier in 2015, and incorporation of ongoing monitoring and modeling often before, during, and after implementation. The effectiveness of the actions and results of the monitoring activities were reviewed in light of the species responses.

A variety of tools were used to plan for, implement, and monitor WY 2014 and 2015 drought response actions. These included participation by technical staff, managers, and directors in various multi-agency teams, modeling efforts, and on-going monitoring activities including:

a. Multi-agency communication and coordination teams, including but not limited to:
    i. RTDOT
    ii. Delta Operations for Salmon and Sturgeon (DOSS)
    iii. Water Operations Management Team (WOMT)
b. Modeling
    i. Hydrologic forecasts and exceedances (50%, 90%, 99%)
    ii. Operations plans
        1. Reservoir releases
        2. Salinity levels
        3. Storage levels
        4. Projected inflows and depletions
    iii. Fish survival models

c. Monitoring, including but not limited to:
    i. Fish
        1. Redd surveys
        2. Fall mid water trawl
        3. Spring Kodiak trawl
        4. Rotary screw trap
    ii. Sediment
        1. Turbidity plume
    iii. First flush events

3.7.2 Proposed Future Drought Procedures

The following is a list of generalized procedures for implementation of future drought response actions for operations of Delta Facilities:

a. If on October 1st, if the prior water year was dry or critical[35], Reclamation and DWR will convene a multi-agency "drought exception procedures" technical team to include representatives from Reclamation, DWR, USFWS, NMFS, SWRCB, and CDFW.
b. If, by December 1st, hydrologic forecasts predict dry or critical water year conditions, Reclamation and DWR, in coordination with the Drought Exceptions Procedure Team, will prepare a Drought Contingency Plan Framework outlining Proposed Drought Response Actions that may be requested by the Projects.
c. If the February 1st hydrologic forecast indicates the potential for a dry or critical water year, Reclamation and DWR, in coordination with the Drought Exceptions Procedures Team, will prepare a Drought Contingency Plan, which includes current and/or updated hydrologic forecasts (50%, 90%, 99% exceedances) and operations plan.
d. Reclamation will prepare a draft biological review (including a description of the Proposed Drought Response Actions, current status of the species, modeling outputs, and potential effects of those Actions) and transmit to a technical team of agency biologists for review and comment.
e. Reclamation will prepare a letter to NMFS and memorandum to USFWS outlining its request and including the appropriate documentation and submit the packages to NMFS and the USFWS, respectively, with copies to DWR, SWRCB, and CDFW.
f. NMFS and USFWS will issue letters/memorandums with their conclusions

[35] For either Sacramento Valley or San Joaquin Water Year classifications

g. DWR would need to get Consistency Determinations under the California Endangered Species Act.

h. Reclamation and DWR will prepare TUCPs, as needed, for submittal to the SWRCB

3.8 References

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EXHIBIT B

March 11, 2016

SENT VIA EMAIL: CWFhearing@waterboards.ca.gov

Hearing Chair Tam Doduc
Hearing Officer Felicia Marcus
State Water Resources Control Board
P.O. Box 100
Sacramento, California 95812-0100

Re: Written Response to March 4 Requirement to Address Information Requests from California Water Research and Sacramento Valley Water Users

In the March 4, 2016 Revised Hearing Schedule, Revised Notices of Intent to Appear, Electronic Service and Submissions, and Other Procedural Issues Concerning the California WaterFix (CWF) Water Right Change Petition Hearing the State Water Resources Control Board (State Water Board) required that the Petitioners respond within seven days of that revised pre-hearing ruling "identifying how the concerns identified in the letters [February 4, 2016 from California Water Research, and February 17, 2016 and February 25, 2016 from Sacramento Valley Water Users] will be addressed." This letter provides information in response to the State Water Board March 4 notice.

On March 10, 2016, California Water Research submitted to the Department of Water Resources (DWR) and U.S. Bureau of Reclamation (USBR) a request for further information, which we are reviewing to develop an appropriate response.

The questions raised in the February letters from California Water Research and the Sacramento Valley Water Users are summarized by the State Water Board as a request to provide additional information on the hydrologic modeling used to support the CWF analyses for the EIR/S and the petition hearing. Specifically the Board requested "a complete list of the versions of all computer models used in producing analyses for the WaterFix". The three Tables provided below list this information.

Several models and analytical methods were used to characterize and analyze the operational changes in water operations in the State Water Project (SWP) and Central Valley Project (CVP) systems. These tools represent the best available technical tools for purposes of conducting the analyses at issue. The overall flow of information between the models is shown in Figure 1.

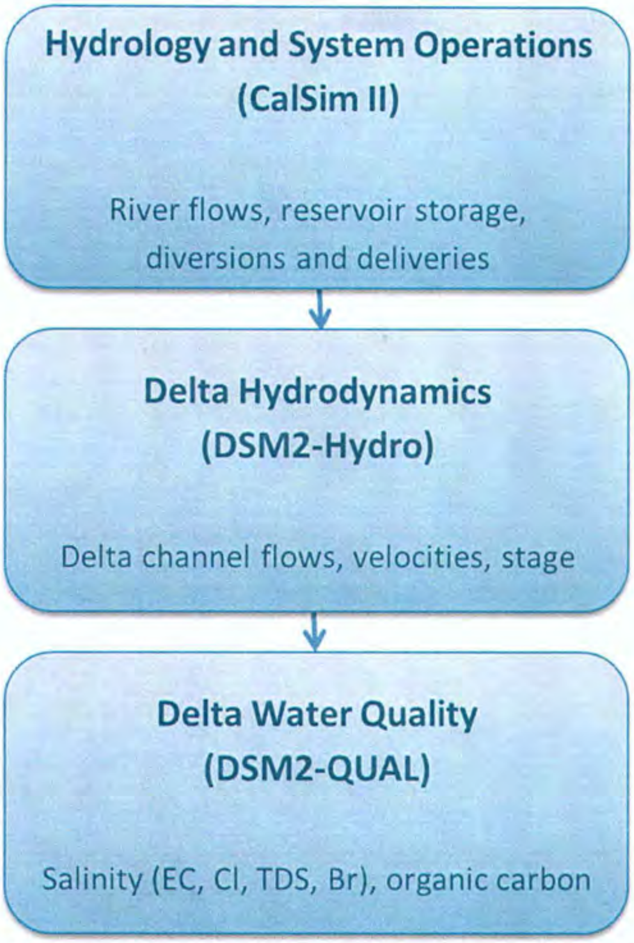

Figure 1. Use of Modeling Tools and Results in CWF Analyses

In general, CALSIM II is used to simulate the operations of the SWP and CVP. The output of this model is then used by the DSM2 model to simulate the hydrodynamics, water quality, and particle tracking. With the information generated from these models, the water supply, flows, and water quality can be compared under different operating scenarios. See Section 4.3 and Appendix 5A of the Draft BDCP EIR/S (Nov 2013) for a more detailed description of the various models.

CALSIM II and DSM2 are both public models and are available for download on DWR's Bay-Delta Office website http://baydeltaoffice.water.ca.gov/modeling/index.cfm. Consistent with DWR's policy of ensuring a transparent process, both the CALSIM II and DSM2 modeling input and output data used to support the CWF environmental impact analyses have been released to the public. Table 1 provides a summary of the data developed, including the CALSIM II version used, for the currently proposed CWF project (Alternative 4A) and the associated No Action Alternative for each of the environmental documents (including Final EIR/EIS that is in preparation), as well as information on when the information was made available to the public.

Table 1. Model Data and Availability Used in Developing BDCP/CWF Environmental Analyses

	Recirculated DEIR/SDEIS	Final EIR/EIS	CWF Biological Assessment for ESA Section 7	Change Petition
No Action Alternative	No Action Alternative at Early Long Term (ELT)	No Action Alternative at ELT with Fremont Weir updates	No Action Alternative at ELT revised per ESA requirements	Same as Biological Assessment (BA)
Alternative 4A	Modeled as a range between Alternative 4 H3 and H4 operations at ELT	Alternative 4A H3+ operations at ELT	Alternative 4A H3+ operations at ELT	Same as BA
CALSIM Version	2010	2010	2015	2015
Date Data Available	November 2011 (model runs developed for administrative record)	February 2016	February 2016	February 2016

Table 2 provides a summary of the hydrological models used for all the alternatives considered in the BDCP/CWF EIR/EIS as well as the ESA Section 7 draft Biological Assessment, including both the CALSIM II version and the DSM2 timespan. Table 3 includes the list of climate change sensitivity analyses that were conducted for the ESA Section 7 draft Biological Assessment.

Table 2: Summary of the CALSIM II and DSM2 models used for Alternatives evaluation in the BDCP/CWF EIR/EIS (2013 Draft, 2015 Recirculated Draft, and Preparation of Final) and CWF ESA Section 7 Biological Assessment

Alternative	**Used in 2013 Draft EIR/EIS**	**Used in 2015 Recirculated Draft EIR/SDEIS**	**Used in Preparation Final EIR/EIS**	**Used in Biological Assessment**	**Calsim II version**	**DSM2 time span**	**Date Available to Public**
Existing Conditions	X	X	X		2010	16 years	April 2012
No Action Alternative at Late Long Term (LLT)	X				2010	16 years	Nov 2011
No Action Alternative at ELT		X			2010	16 years	Nov 2011
Updated No Action Alternative at ELT			X		2010	16 years	Feb 2016
CWF Sec 7 BA Base Model				X	2015	82 years	Feb 2016
Alternative 1 A/B/C at LLT	X				2010	16 years	Nov 2011
Alternative 2 A/B/C at LLT	X				2010	16 years	Nov 2011
Alternative 2D at ELT – used Alternative 2 A/B/C at LLT as surrogate		X			2010	16 years	Nov 2011
Alternative 2D at ELT			X		2010	16 years	Feb 2016

Alternative	Used in 2013 Draft EIR/EIS	Used in 2015 Recirculated Draft EIR/SDEIS	Used in Preparation Final EIR/EIS	Used in Biological Assessment	Calsim II version	DSM2 time span	Date Available to Public
Alternative 3 at LLT	X				2010	16 years	Nov 2011
Alternative 4 H1 at LLT	X				2010	16 years	Dec 2013
Alternative 4 H2 at LLT	X				2010	16 years	Dec 2013
Alternative 4 H3 at LLT	X				2010	16 years	Nov 2011
Alternative 4 H4 at LLT	X				2010	16 years	Dec 2013
Alternative 4A at ELT – Used Alternative 4 H3 at ELT as a bookend		X			2010	16 years	Nov 2011
Alternative 4A at ELT – Used Alternative 4 H4 at ELT as a bookend		X			2010	16 years	Dec 2013
Alternative 4A at ELT			X		2010	16 years	Feb 2016
CWF Sec 7 BA Proposed Action (Alternative 4A)				X	2015	82 years	Feb 2016

Alternative	Used in 2013 Draft EIR/EIS	Used in 2015 Recirculated Draft EIR/SDEIS	Used in Preparation Final EIR/EIS	Used in Biological Assessment	Calsim II version	DSM2 time span	Date Available to Public
Alternative 5 at LLT	X				2010	16 years	Nov 2011
Alternative 5A at ELT - Alternative 5 at ELT as a surrogate		X			2010	16 years	Nov 2011
Alternative 5A at ELT			X		2010	16 years	Feb 2016
Alternative 6 A/B/C at LLT	X				2010	16 years	Nov 2011
Alternative 7 at LLT	X				2010	16 years	Nov 2011
Alternative 8 at LLT	X				2010	16 years	Nov 2011
Alternative 9 at LLT	X				2010	16 years	Nov 2011

Table 3: Summary of the models used for climate change sensitivity analysis in the CWF Section 7 Biological Assessment

Alternative	Calsim II version	DSM2 time span	Date Available to Public	Purpose
CWF Sec 7 BA Base Model – at ELT under Q5 climate projection	2015	82 years	Feb 2016	Effects Analysis; Climate change sensitivity Analysis
CWF Sec 7 BA Base Model under current climate	2015	N/A	Feb 2016	Climate change sensitivity Analysis
CWF Sec 7 BA Base Model at ELT under Q2 climate projection	2015	N/A	Feb 2016	Climate change sensitivity Analysis
CWF Sec 7 BA Base Model at ELT under Q4 climate projection	2015	N/A	Feb 2016	Climate change sensitivity Analysis
CWF Sec 7 BA Proposed Action (Alternative 4A) – at ELT under Q5 climate projection	2015	82 years	Feb 2016	Effects Analysis; Climate change sensitivity Analysis
CWF Sec 7 BA Proposed Action (Alternative 4A) under current climate	2015	N/A	Feb 2016	Climate change sensitivity Analysis
CWF Sec 7 BA Proposed Action (Alternative 4A) at ELT under Q2 climate projection	2015	N/A	Feb 2016	Climate change sensitivity Analysis
CWF Sec 7 BA Proposed Action (Alternative 4A) at ELT under Q4 climate projection	2015	N/A	Feb 2016	Climate change sensitivity Analysis

In order to ensure consistency and comparability between alternatives for the EIR/EIS it was important to use the same version of the models for all alternatives. Therefore, although the CA WaterFix and other non-HCP/NCCP Alternatives were developed after release of the Draft EIR/EIS, and a slightly modified version of CALSIM II was available, it was decided to use the same base model of CALSIM II (2010) and patterning period for DSM2 (16 year record) for analysis of *all* new alternatives in both the 2015 Recirculated Draft EIR/SDEIS and forthcoming Final EIR/EIS. However, because the Endangered Species Act has a requirement to use Best Commercially Available Scientific Data, it was decided among USBR, USFWS, NMFS and DWR to use the most recent version of CALSIM II (2015) and a longer patterning period for DSM2 (82-year record) for the Biological Assessment. As noted in Table 1 above, the modeling conducted for the BA is the basis of the information that will be used in the case-in-chief in the Hearing process.

Due to the volume of data and the complexity of the associated models, the Department has found it more user-friendly to work with the requestor to ensure they have the information needed to utilize the data. It appears that this process is, in the words of Deirdre Des Jardins, "a major improvement." In some cases where the user is experienced and familiar with CALSIM II and/or DSM2 it has been efficient to provide a link allowing them to download the data directly. In either case, the Department has strived to provide the data in an effective and efficient manner.

Sincerely,

Tripp Mizell
Senior Attorney
Office of the Chief Counsel
CA Department of Water Resources

Amy L. Aufdemberge
Assistant Regional Solicitor
Office of the Regional Solicitor
U.S. Department of the Interior

cc: *Electronic Service*
Tom Howard, Executive Officer, State Water Resources Control Board
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EXHIBIT C

Independent Review Panel Report for the 2016 California WaterFix Aquatic Science Peer Review

Prepared by

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Scope and Purpose of the Review: This report presents the findings of the 2016 California WaterFix Aquatic Science Peer Review. An Independent Review Panel was convened by the Delta Science Program to provide the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and California Department of Fish and Wildlife (CDFW) with an independent scientific evaluation of the methods and approaches for developing the joint Biological Opinion requirements and analyses prepared for the CDFW 2081(b) Incidental Take Permit application for the California WaterFix.

The Panel was charged with reviewing: (1) selected sections of the Biological Assessment (BA) that seeks to predict the effects of the WaterFix project on Endangered Species Act (ESA)-listed species and their designated critical habitats, (2) the draft Analytical Approach to developing the joint Biological Opinion (AABO) and (3) the proposed methods for assessing project effects on Longfin Smelt.

After reviewing a set of documents (Appendix 1), the Panel participated in a public meeting in Sacramento, CA on April 5-6, 2016. On the first day of this meeting, the Panel interacted with agency representatives following their presentations on the three topics above. On day 2, the Panel communicated and discussed its preliminary findings to agency representatives and the public. This report summarizes the Panel's findings and recommendations in full detail.

Executive Summary

The new water dual conveyance facilities proposed as part of the CA WaterFix (WaterFix or CWF) project would create substantial changes in the aquatic environment of the lower San Joaquin and Sacramento Rivers, the Delta, and downstream estuarine areas. The construction and operation of the Waterfix facilities must comply with U.S. Endangered Species Act (ESA) Section 7(a)(2). As part of the ESA consultation, the US Bureau of Reclamation (Reclamation) and the CA Department of Water Resources (DWR) have written an extensive Biological Assessment (BA) that projects the future effects of the new facilities on ESA-listed species and their designated critical habitats. In addition, National Oceanographic Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) are evaluating the effects of the proposed CWF on listed species and their designated critical habitats and are working towards the development of a joint Biological Opinion (BO). Further assessment under the California Endangered Species Act (CESA) also includes the analytical framework proposed for the incidental take analysis for Longfin Smelt that is listed under CESA.

The Independent Review Panel (Panel) was charged with reviewing sections of the BA, as well as the draft Analytical Approach to developing the BO. The Panel was asked to focus on those BA sections (Appendix 1) that project the future effects of facility construction and the completed, operational project on listed salmonids and smelt species. Potential effects during operation could arise from withdrawals at the new water intakes on the Sacramento River, altered physical structure and water flow patterns at the existing southern Delta pumping facilities, altered spawning and rearing habitat in the rivers, Delta, and estuary, altered river-flow regimes, changing future climate, and other future changes in the aquatic environment. The Panel was charged with evaluating whether the models, analytical methods, and assumptions used in the BA, and their uncertainties, were clearly described and were based on the best available science.

The Panel finds that the best available science was generally used as a basis for the BA's models and analytical methods and that these were adequately described. The Panel also supports the BA's consistent strategy of comparing the projected effects on fish of the Proposed Action (PA) versus a No Action Alternative (NAA), under future scenarios of environmental conditions that were constructed from historical time series and adjusted to include likely trends of climate change.

However, the best available science for the greater Delta area is inhibited by important knowledge gaps and that science often provides only piecemeal and quantitatively uncertain projections of future environmental conditions in the Delta area and of fish responses to those conditions. In this report, the Panel identifies many of these knowledge gaps and uncertainties in the BA, some of which could be addressed during the development of the BO. Most of the gaps, however, can only be addressed by extended future research, monitoring, and adaptive management in construction and operational phases. As a result, a BA written in 2016 cannot realistically reduce the uncertainties of most of its model projections. And, while the BA acknowledges many uncertainties about species response to direct impacts (e.g., entrainment at North Delta Diversions or southern Delta facilities), the systematic and cumulative effects from more indirect sources (e.g., food web, predators) have equally great uncertainties and require more consideration.

The Panel finds that the best available models are currently being used to simulate water transport throughout the Delta and its watershed, with some concern expressed for reliability of these models. However, the Panel had greater concerns about future sediment movement and water quality, and in particular, about whether the North Delta Diversions (NDD) might exacerbate the downstream sediment starvation that is already occurring. The Panel also feels that the BO should consider potential changes to fluvial and tidal fish habitat throughout the Delta and not just near the NDD and southern Delta facilities, due to systematic changes in inundation and salinity that would be caused by PA operations. Finally, the Panel suggests that projected climate change influences should extend beyond 2030, in spite of their significantly greater uncertainties.

The Panel finds that the salmonid survival models are generally adequate, although they do not capture the relative timings of peak flows and outmigration of the more vulnerable life history stages. In addition, possible depensatory mortality is not considered, nor is the cumulative effect, over a sequence of dry years, of predicted greater mortality under the PA, for juvenile Chinook Salmon. The Panel also finds that possible screen-impingement and predation effects on salmonids at the NDD are likely to require targeted adaptive management experimentation. We are also concerned that important changes in location and timing of available rearing and migratory habitat under the PA are not being captured by BA model projections, nor are the effects of the PA on salmonid predators such as Striped Bass. The Panel approves of using the Viable

Salmonid Population framework (McElhany et al. 2000) in the draft AABO. However, the data are limited and the uncertainty is high for applying that framework to Delta salmonids.

The BA analyses for Delta Smelt comprehensively addressed the effects of numerous factors on all life stages. However, as with salmonids, each of the single-factor analyses was independent of the others and no analysis assessed cumulative effects in the context of a full life cycle/population model. The Panel noted the uncertainties surrounding potential beneficial effects of the PA, potential negative effects, and probable neutral effects. The key projected beneficial effects are reduced entrainment at the southern Delta facilities. The BA's considerations of screen impingement effects at the NDD, potential habitat loss, and turbidity reductions were felt to be highly uncertain. In particular, the Panel recommends additional evaluation of PA effects in the Suisun Marsh area which studies have identified as high-abundance Delta Smelt habitat. The Panel also finds high uncertainties about the PA's effects on Delta Smelt's predators and food sources.

The draft Analytical Approach for Longfin Smelt is hampered by little information on Longfin Smelt population dynamics and abundance. The Panel finds that this knowledge gap results in high uncertainty of the BA's comparisons of PA and NAA effects, particularly on Longfin Smelt entrainment at the southern Delta facilities. The BA and the Analytical Approach also employ a particle tracking model (PTM) to estimate the fate of smelt larvae as passive drifters; however, the Panel has highlighted some known concerns about the PTM analyses. Because so little quantitative knowledge exists about the Delta's Longfin Smelt population, the Panel reinforces the BA's emphasis on real-time operational management and monitoring to minimize Longfin Smelt entrainment effects under the PA.

The Panel noted that the BA's quantitative comparisons of PA and NAA effects have two major sources of uncertainty: the uncertainty of future environmental conditions, and the model-prediction uncertainty of how fish will respond to those conditions. Although the BA does a good job of representing the first source, the Panel finds that the BA often understates and misinterprets model-prediction uncertainty. The Panel recommends specific methods to increase the realism of uncertainty estimates and interpretations in the BA. Because high uncertainty is a pervasive issue in the BA comparisons of NAA and PA, the Panel also recommends that the Analytical Approach to the BO should describe how this uncertainty will be formally and quantitatively incorporated into the BO's decision-making process.

The substantial uncertainties of nearly all BA analyses are the dominant theme of the Panel's findings. If the WaterFix project goes forward, the Panel believes that its uncertain impacts on ESA-listed fish species can only be addressed by a vigorous, well-supported, protective program of "active" adaptive management (AM), and by application of the precautionary principle when developing the BO. The Panel articulates this view more fully within the report and outlines the essential components of a successful AM program. The Panel also recommends that the Analytical Approach to the BO describe how the AM design and implementation for WaterFix will be evaluated.

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1. Introduction

1.1 Background

As part of its formal charge, the Panel was given the following background for its review, which we quote in its entirety:

> “The Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) coordinate the operation of the Central Valley Project (CVP) and the State Water Project (SWP). As part of the California WaterFix (CWF), DWR proposes to construct and operate new water conveyance facilities in the Sacramento–San Joaquin River Delta, including three intakes, two tunnels, associated facilities, and a permanent head of Old River gate; as well as operate existing southern Delta facilities in coordination with these new facilities.
>
> Because the operation of the CVP/SWP is coordinated, Reclamation is the lead agency for the Endangered Species Act (ESA) Section 7 consultation. This consultation is also intended to address consultation with the U.S. Army Corps of Engineers to issue permits pursuant to Rivers and Harbors Act Section 10, Clean Water Act Section 404, and 33 United States Code 408. It is understood that additional consultation on the U.S. Army Corps of Engineers permitting may be required as the CWF is more fully developed.
>
> As noted above, the construction and operation of the new dual conveyance facilities will need to comply with ESA Section 7(a)(2). As part of the CWF ESA consultation, Reclamation and DWR have written a Biological Assessment (BA) that summarizes the effects of the action on ESA-listed species and their designated critical habitats. NOAA’s National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) are evaluating the effects of the proposed CWF on listed species and their designated critical habitats and are working towards the development of a joint Biological Opinion (BO).

In addition to complying with ESA, DWR intends to obtain California Endangered Species Act (CESA) authorization from the California Department of Fish and Wildlife (CDFW) under Fish and Game Code section 2081(b) for incidental take related to the construction and operation of the CWF and modified operations of the SWP. DWR will submit an application which will include an analysis of the effects of the proposed action on CESA listed species. CDFW will review the CESA-specific analysis of the perceived impacts for state-listed species and may issue a permit if conditions in Fish and Game Code sections 2081(b) and (c) are met.

The purpose of this independent review is to obtain the views of experts not involved in the ESA consultation and 2081(b) permit on the use of the best available scientific information, as it pertains to aquatic ESA and CESA listed species (aquatic species) in the development of the NMFS/FWS BO and the CDFW 2081(b) permit."

End of quote.

1.2 Charge to the Panel, with Panel Responses

In this section, we state the Charge to the Panel, in bold. We also give a brief Panel response, in italics, to each of the specific Charge items. Details of Panel responses are given in Chapter 2.

The Charge was stated as follows:

The Panel will review 1) the draft BO analytical approach (AABO), 2) specific BA analyses (which have been agreed upon by the fisheries agencies and identified in the Panel charge), and 3) the approach to analyzing the effects to Longfin Smelt. Since these items will provide the basis of the joint BO and 2081(b) permit, the review should evaluate whether the items are of sufficient robustness and scientific quality to serve their intended purposes. The Panel members will have at least 30 days to familiarize themselves with the materials. The Panel will

also be given relevant background information to consider and will receive presentations from the relevant agencies at the public meeting.

Specific scientific questions for review of the AABO, specific BA analyses, and Longfin Smelt analytical approach:

BO Analytical Approach

1. **How well is the AABO designed to adequately assess potential responses of the target listed species to the effects of the proposed action (i.e., both direct and indirect effects of the project)? In answering this question, please consider the following:**

How well the analytical approach for salmonids incorporates the Viable Salmonid Populations framework presented in McElhany et al. (2000), "Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units", and aligns with viability assessment approaches in Lindley et al. (2007), "Framework for Assessing Viability of Threatened and Endangered Chinook and steelhead in the Sacramento-San Joaquin Basin".

Panel response: The viable salmonid population (VSP) framework (McElhany et al. 2000) and the manuscript by Lindley et al. (2007) are excellent documents to guide the AABO for salmonids. The AABO is generally patterned on these documents. However, available information is likely insufficient to adequately address all VSP criteria, leading to high uncertainty of the PA effects on species viability. In addition, the AABO needs to heed the uncertainty issues raised by the McElhany et al. (2000) guidelines for the VSP framework.

How effectively conceptual models for target aquatic species are incorporated into the AABO.

Panel response: This could be improved. Several conceptual models are presented in the draft AABO that outline the assessment approach (e.g., Fig. 2-1, 2-2) and show how impacts on individuals can lead to impacts on populations and ESUs. A conceptual *model for factors affecting salmon in the southern Delta was also provided to the Panel (labeled as Fig. 1-4 from an unnamed Bay Delta Conservation Plan (BDCP) document). What is missing is a detailed conceptual model and description of how each ESA-listed species uses the Delta, including factors affecting growth and survival during each life history stage.*

How well the analytical approach for target aquatic species explains how the exposure, response, and risk to listed individuals, populations, and diversity groups resulting from project operations will be assessed, and whether quantitative and qualitative methods and risk assessment tools are used appropriately.

Panel response: The AABO needs to address how its decisions will be made in the face of the high uncertainties in its quantitative projections of PA effects.

Whether the approach for assessing effects provides a scientifically defensible approach for evaluating new adverse effects to aquatic species in the north Delta in addition to any changes in adverse effects at existing south Delta facilities, and what improvements could be made.

Panel response: The BO will draw from the BA projections of new, future adverse effects in the northern Delta due to the PA. These projections do use the best available science. However, the uncertainty of such projections is especially high because there is no local precedent for a project of this type and scale and because existing models of fish response are uncertain. In other words, the best available science regarding northern Delta effects is quite speculative. Because of this uncertainty, we recommend that the AABO describe an approach that includes both active and passive adaptive management.

<u>**Supporting Analyses for Target Aquatic Species**</u>

2. How complete are the selected target aquatic species analyses in the BA for evaluating the potential effects of the project on the target listed species? In answering this question, please consider the following:

Whether the appropriate analytical tools (i.e., models) were used for the selected analysis and what, if any, additional currently available tools should be used.

Panel response: The BA models represent the ‘best science available’ for predictive purposes. However, it is widely believed that mechanistic, process-based models, such as life cycle/population dynamics models for fish, are capable of extrapolating biological responses to novel environmental conditions, such as those projected to result from the CWF project. Process-based population models have indeed been developed for ESA-listed fish species in the Bay Delta system. And yet, the BA is unable to use these models, because of their quantitative immaturity and lack of supporting data. Instead the BA relies heavily on simplistic noisy regression models of fish responses, a model structure widely viewed as unreliable for extrapolations. In addition, fish response models are only available for selected ESA-listed species and selected life-history stages. These limitations underscore the Panel’s concern with the uncertainties of the BA’s projected fish responses to future PA and NAA scenarios.

Whether assumptions are plainly stated and scientifically sound, and whether analytical uncertainties and limitations of methods in the BA aquatic species analyses and Longfin Smelt analytical approach are clearly stated.

Panel response: The assumptions are often clear and sound, but we note several exceptions below. In addition, quantitative uncertainties of fish response models are often understated. As a result, projected similarities of NAA and PA effects are less reliable than they appear.

External forcings of climate and sea level are represented by the central tendency (i.e., the “Q5 climate change scenario”) of several climate projections for 2030. Whether the assumptions of that characterization are adequately described in the BA. Note what, if any, additional analyses would help to incorporate effects of climate change.

Panel response: The application of the Q5 scenario is sensible and adequately described. However, the Panel recommends that climate projections be made beyond

2030, because by that time the project will have only recently become operational. We recognize the greater uncertainty of longer-term climate projections, but at least they might suggest whether future conditions will still be within the operating range of current hydrodynamic and fish response models. Furthermore, with increasing climate effects, the magnitude of changes will increase after 2030.

How well the analyses incorporate information from existing synthesis reports (e.g., Management Analysis and Synthesis Team, Long-term Operations Biological Opinions reviews, species recovery plans, 2010 State Water Resources Control Board flow criteria report, etc.) and from responses to recommendations of past independent reviews (e.g., BDCP Effects Analysis review and ICF/DWR responses, etc.)

Panel response: We note that several concerns identified in BDCP reviews (e.g., Parker et al. 2014) have not been resolved by the BA, such as: (1) substantial and understated uncertainties about project effects on ESA species, (2) the lack of an integrated or quantitative assessment of net effects, and (3) the use of "passive learning" instead of a rigorous, institutionalized active and passive adaptive management process.

How adequately the BA analyses and Longfin Smelt analytical approach support a scientifically defensible approach for evaluating new adverse effects to aquatic species in the north Delta, and how adequately they support evaluating any changes in effects at existing south Delta facilities. Note what, if any, additional or alternative analyses are needed. How well the Longfin Smelt analytical approach supports evaluation of combined project operations effects on the target listed species.

Panel response: The best available science is generally used by the BA. However, that science is at best speculative when applied to the magnitude and novelty of change envisioned for the northern Delta. Substantial uncertainties and knowledge gaps remain concerning Longfin Smelt.

1.3 Acknowledgements

The Panel appreciates and acknowledges the substantial effort made by the agency and technical team representative and contractors who prepared the extensive BA and BO documents. We also thank them for their quick responses to Panel requests for additional information. The Panel is also indebted to Cliff Dahm (Lead Scientist), Sam Harader (Program Manager), and the select staff from the Delta Science for their logistical and organizational support. We especially thank Lindsay Correa for patiently addressing our questions about the complex and subtle institutional context of the Bay Delta system, and to Yumiko Henneberry for her rapid and efficient handling of logistics and communications.

2.0 General Comments from the Panel

This section contains detailed comments from the Panel on the Biological Assessment (BA) and on the draft Analytical Approach for the Biological Opinion (AABO). Our comments include specific recommendations to the agencies, labeled ***in bold italics.*** Some of these recommendations could be addressed as part of the BO. However, we recognize that others can only be addressed over a longer term; during planning, construction, and operations of the Proposed Action (PA).

Citations of the form "BA 6-20" refer to page 20 of Chapter 6 of the BA. Likewise, the form "BA A.5.G-30" denotes page 30 of BA Appendix 5.G. Finally, "AABO-40" cites page 40 of the AABO.

2.1 Modeling of Hydrodynamics, Climate Change, and Habitat

The Panel believes that the PA will create more than an incremental change to the Bay Delta system. It will effect major changes in hydrodynamics and associated transport throughout the system downstream of the North Delta Diversion (NDD), with uncertain consequences for fish and their critical habitats. For example, the PA would reduce the Sacramento River sediment load by 10%, and turbidity is known to be a key abiotic habitat factor for Delta Smelt.

In this section, we discuss hydrodynamics, sediment transport, habitat, and climate-change issues of relevance to the PA.

2.1.1 Hydrodynamics

Model output from the water transport models at both the watershed level (CalSim-II) and the Delta level (DSM2) are used as input in many of the other models used in the BA. Therefore, it is important that these models be applied appropriately.

The CalSim-II model is the best tool available for flow-routing optimization because it is specifically designed for the Sacramento and San Joaquin watersheds and incorporates their specific reservoir operating criteria and regulatory restrictions. There is no alternative model that could be considered for this application. During the public portion of the review meeting, the calibration/validation of the CalSim-II model was questioned (Des Jardins 2016). The claims presented to the Panel related to the nuances in the validation process may be valid. However, the details of CalSim-II model calibration and validation are beyond the scope of this Panel's review. It may be of benefit in the future to have the CalSim-II model verification reviewed by a group such as the California Water and Environmental Modeling Forum.

The DSM2 model is a valid approach to predict salt concentrations in the Delta when large numbers of simulations are necessary, assuming that the bathymetry is not altered from the configuration used in the current calibration and verification of the model. However, there are limitations to how the model results can be interpreted, especially when adding particle tracking simulations. Particle tracking limitations will be discussed in more detail in the Longfin Smelt section of this report (Section 2.4).

The multi-dimensional hydrodynamic models of San Francisco Bay and the Delta are powerful tools that should be used in some cases where the DSM2 has limitations. As an example, it was appropriate to use the UnTRIM model to predict salinity intrusion due to sea-level rise (see section 2.1.4 for more discussion.) Unfortunately, multi-dimensional models take longer to run than the 1-D DSM2 model. In addition, the multi-dimensional models are only available through consultants. Therefore, the use of the multi-dimensional hydrodynamic models is limited even though these types of models are the best available science to address some questions.

2.1.2 Sediment and water quality

Changing the primary point of diversion of water export of the Delta to three inlet facilities in the northern Delta along the Sacramento River rather than from the southern Delta will result in major change in the circulation patterns and associated transport of water and constituents throughout the entire Delta system. Three physical parameters of ecological importance that will be altered are the distribution of sediment, salinity intrusion, and the ratio of source waters (Sacramento vs. San Joaquin) in the central Delta.

The Panel is concerned that NDD operations will increase the sediment starvation that is already occurring in the Delta (Schoellhamer et al. 2013), where approximately two-thirds of the sediment that enters the Delta is deposited in and sustains its marshes, sloughs, and mudflats. More than 80% of this sediment load originates from the Sacramento River, with the remainder from the San Joaquin River (Wright and Schoellhamer 2005). Therefore, it is important to consider not only how much sediment is exported from the Delta as a whole, but also consider whether there are critical habitats in the region of influence of that export site. Based on current water circulation patterns, the suspended sediment in the southern Delta has a low potential of being transported to the Cache Slough complex in the northern Delta, where large wetland restoration projects are being constructed. However, suspended sediment in the Sacramento River, where the proposed north Delta facilities will export water and sediment, is highly likely to be transported to the Cache Slough complex.

BA Appendix 3.B, Conceptual 1 Engineering Report, Volume 1, Section 6.1.2 describes the NDD sedimentation system that is designed to reduce sediment delivery through the dual conveyance system. It cites "normal settling depth and the design WSE depth that will enable sands and coarse silt materials (particle size between 1.75 mm and 0.075 mm) to settle in the basins". However, note that particle sizes 0.075-1.75 mm are usually considered to be all sand, not "coarse silt". Table 6.5 in that document provides estimates of sediment loading to each intake and Table 6.6, showing the river's actual sediment particle distribution, suggests that more than 61% will not settle in the basins. Thus, only about 40% of the sediment load captured by the NDD will be available for “recycling” back into the system, given the caveat that contaminant levels of the retained coarse materials would allow such reuse. Furthermore, the material that will be exported to the southern Delta through the PA’s dual conveyance system will be the fine suspended sediments that provide the greatest benefits through accretion in tidal wetlands, to sustain elevation increases commensurate with sea level rise (Swanson et al. 2015), further starving the northern Delta tidal marsh habitat of juvenile Sacramento Winter-run Chinook Salmon, as well as turbidity, a key abiotic habitat characteristic for Delta Smelt.

One of the key ecological gauges for the Delta is X2. This is the distance in kilometers from the Golden Gate to the 2 ppt isohaline. One of the limitations of this parameter is that it does not accurately communicate salt intrusion once X2 is greater than 81 km. This location (Sacramento River at Collinsville, 81 km upstream of the Golden Gate) is the confluence of the Sacramento and San Joaquin Rivers. For values of X2 greater than 81 km, the parameter really should be reported for each river stem as X2-SAC and X2-SJR because salt intrudes up the Sacramento and San Joaquin stems of the Delta differently depending on magnitude of the flow coming from the San Joaquin and the Sacramento. Therefore, for dry or critically dry conditions with X2 > 81 km, the comparison of X2_SAC and X2_SJR would better report differences salinity intrusion along the Sacramento and San Joaquin stems. For the NAA scenario, the primary water export is on the San Joaquin stem. In contrast, the PA scenario primary exports water from the Sacramento stem.

The Sacramento and San Joaquin Rivers have significantly different water qualities, and the distribution of these sources waters in the central Delta is highly dependent on pumping operations (Monsen et al. 2007). As the system is operated now, the Franks Tract region is currently dominated by Sacramento-sourced water. Mildred Island can be either Sacramento- or San Joaquin-sourced water depending on export pump rates and temporary barrier configuration. With the PA, the likely water source in Franks Tract will likely shift to San Joaquin-dominated water. This shift in water source can be easily simulated with Delta hydrodynamic models.

2.1.3 Habitat

The analytical approach, particularly as expressed in the BA, emphasizes the footprint of the PA installations as the primary areas of Delta habitat changes. However, the BO should apply equal consideration to potential systematic changes to tidal-fluvial inundation and salinity intrusion as a result of the NDD. The BO needs to assure protection and recovery actions for at-risk fish populations throughout the Delta to address indirect effects, such as maintenance and expansion of the fishes' habitats both within the Delta and downstream where salinity intrusion is an important habitat attribute. The only other habitat issue discussed In the BA was the potential inundation of "low floodplain habitat benches" as possible mitigation of fish habitat lost to NDD construction. Yet, the quantity and quality of fish habitat in the Delta and at the transition between the western Delta and upper San Francisco Bay (specifically Suisun Marsh), is fundamentally dependent on Sacramento River inflow that should be considered both under current Delta hydrogeomorphology as well as future conditions above and beyond NDD operations.

Specifically, the BO should provide evidence that NDD planning, operations and adaptive management (AM) monitoring will take into account flooding regimes of both existing and future tidal wetland habitat (e.g., EcoRestore restoration of over 30,000 ac in next five years) and salinity intrusion under predicted climate change scenarios (i.e., sea level rise in the Delta on the order of 43 to 179 cm from 2000 to 2100 (Swanson et al. 2015). See also Section 2.1.4 for discussion on the timeframe to consider NDD operations under accelerated sea level rise and other climate factors). Salinity intrusion should also be a primary habitat factor for four fish species of concern—for juvenile Sacramento River Winter-run and Wpring-run Chinook Salmon because their ocean-type life history behavior is usually associated with extensive rearing in oligohaline habitats of the estuary until they have reached smoltification state, and for Delta Smelt and Longfin Smelt because spawning and rearing habitats are suspected to be associated and expanded by extent of X2 positions at the edge of the western Delta.

Hydrodynamic modeling of the broader Delta system's response to NDD should also inform the BO of the effect of the NDD operational (rule-based) scenarios on tidal-fluvial flooding regimes in regions of fish spawning and rearing. For instance, ecological monitoring in the Cache Slough region, and specifically at Liberty Island, indicates that Delta Smelt spawning and rearing may be important in that region. Some of the key questions to ask are: (a) Will the post-PA sediment load at Liberty Island be sufficient for wetland restoration? (b) How will the tidal range change in the region?, and (c) What is the effect of changes in circulation on the beach regions in Liberty Island? Understanding the potential hydrological changes to the flooding regime and salinity intrusion due to the NDD in sensitive seasons of the Delta Smelt life cycle is fundamental to the BO. Furthermore, cumulative changes due to large-scale tidal wetland restoration in that region, which could progressively alter the tidal prism, should be incorporated into that modeling.

Channel junctions that link the Sacramento River to the central Delta should also be considered critical habitat. Currently, the Sacramento River junctions at the Delta Cross Channel and Georgiana Slough are hydrodynamically critical junctions. In current operations, these junctions are located at the transition point between uni-directional flow and bi-directional flow. When the NDD starts operating, this junction area will likely have primarily a tidal bi-directional flow. Therefore, fish will experience this decision point multiple times, which could divert the fish into the central Delta where mortality is likely to be higher.

2.1.4 Modeling Climate Change

Several steps are necessary to incorporate climate change into the hydrologic and hydrodynamic modeling. The charge question only asked about one sub-step, the "Q5 climate change scenario" selection. However, it is important to understand that there is a full suite of inter-related modeling steps that must occur to incorporate climate change.

Step 1 - The BA used a "Q5 climate change scenario" to identify a sub-set of all available General Circulation Models (GCM) to use. The GCM models in this sub-set projected time series of precipitation and temperature at locations throughout the watershed. The Q5 approach achieves the stated goal of capturing the "middle" (median) temperature and precipitation changes, projected by a large number of differing climate projections (Figure 5.A.A.1-1, from A.5.A-788). The Q5 box of selected GCM models captures reasonable middle-of-the-road variation around these medians. The idea of using "averages" from a large number of climate projections is reasonable. It assumes only that the 112 projections, taken as a group, are not biased - that is, that their average does indeed represent something close to what the future will be. The Q5 box defines a Q5 "sub-ensemble" of GCM runs (all the points inside the box). The Panel assumes that all required statistics defining the Q5 scenario (e.g., temperature and precipitation yearly time series) are then derived by averaging the corresponding statistics from only those GCM runs in the Q5 sub-ensemble.

Step 2 - In the BA, sea level is assumed to rise 15 cm at the Golden Gate in 2030. Sea- level rise is expected to alter salinity intrusion into the Delta. As a result, the X2-Flow relationship used in the CalSim-II (watershed flow routing optimization model) for current climate needs to be modified for the 2030 scenario.

Because the DSM2 Delta hydrodynamic model is a 1-D (i.e., channel model) with a seaward boundary at the western end of Suisun Bay, the DSM2 model cannot directly incorporate sea level rise. Instead, the UnTRIM, a commercial 3D hydrodynamic model that has a modeling domain extending from the Golden Gate through the Delta, was used to create datasets to “corroborate” the salinity intrusion results of DSM2 with the UnTRIM simulation results for a 15 cm rise in sea level (BA - A.5.B, Attachment 3). Note that during this modeling exercise, the UnTRIM model was also run to simulate salinity intrusion into the Delta for a range of sea-level rise scenarios. See in particular Figure 5.2-4 (BA - A.5.B, Attachment 2, p. 189).

After the DSM2 model was “corroborated” for 15 cm of sea-level rise, the DSM2 model drove a series of simulations to train an artificial neural net to create a relationship between flow and X2. This resulting flow-X2 relationship is how 15 cm of sea level rise is accounted for in the CalSim-II simulations.

Step 3 - The precipitation time series generated from the Q5 GCM models (Step 1) are downscaled to a regional watershed model. The Variable Infiltration Capacity (VIC) model then creates flow routing inputs for key rivers.

Step 4 - The CaLSim-II optimization operations model is then driven with flow inputs from the key rivers (Step 3), Delta X2-Flow criteria (Step 2), and other reservoir criteria and regulatory restrictions (specified in A.5.a.5).

Finally, the results of the CalSim-II model drive the DSM2 model and other ecosystem/fish models used in the BA.

The Panel recommends that the evaluation of the influence of climate change on the PA operations should be longer than 2030. The Panel recognizes that projections beyond 2030 are subject to rapidly increasing uncertainties. However, projecting only to 2030 does not evaluate how the project will operate under climate change conditions. The 2030 scenario is only just the start of PA operations since construction is expected to take a decade. The Panel also notes the NMFS policy guidance stating that, "When evaluating effects of the action in Sections 7 and 10 decisions, NMFS will use the time period corresponding to the duration of direct and indirect effects of the action" (Sobeck 2016). The NMFS policy also states that "NMFS consultations and permits covering a long time period during which climate change is likely to exacerbate the adverse effects of an action, should incorporate an adaptive approach that includes: adequate monitoring of climate and biological variables; identification of appropriate triggers related to those variables; and identification of protective measures that can be implemented without reinitiating when triggers are reached or, alternatively, triggers then inform the decision to reinitiate."

As was just explained, a significant amount of modeling effort would be required to incorporate climate change for a different time period farther into the future (i.e., 2100) because multiple models would need to be adjusted. This modeling effort would take longer than the projected fast-track revision of the BO technical approach in summer 2016. Therefore, funds and personnel need to be committed to continue to develop these model simulations (e.g., DSM2 "corroboration" with NDD project operations and various levels of sea level rise, training of the artificial neural network model for other future time periods and multiple sea-level rise scenarios) as part of the Adaptive Management (AM) plan.

2.2 Effects on Salmonids

2.2.1 Winter-Run Chinook Spawning, Egg Incubation, and Alevins

The Winter-run Chinook Salmon Evolutionarily significant units (ESU) presently spawns in only one area (below Keswick Dam on the Sacramento River), indicating that the ESU is highly vulnerable to adverse effects (Lindley et al. 2007). The BA concludes that there is potential for changes in reservoir operations, instream flows, and water temperatures in the Sacramento River and American River in response to the PA. However, the BA (BA 5-179) did not describe the management guidelines and actions for these reservoirs that are linked to conditions in the Delta, such that flows released from the reservoirs would be altered in response to the PA. If these actions involve real-time management of the reservoirs, what are the conditions in the Delta that would cause change in water released from the reservoirs?

Sections 3.1.5 and 3.3.3 of the BA describe the real-time decision process, but there is no information to judge how effective this process would be under the PA. Given the lack of information on the real time process, including the effectiveness of current real-time management efforts, the BA did not consider the effects of real time management instead deferring such assessment to the future. The BA says that "the operating criteria will be periodically evaluated and possibly modified through the adaptive management process" (BA 3-97), however, it did not include details about monitoring plans and triggers (see Section 2.6).

We also note that Kneib et al. (2015) recommended development of a much more detailed temperature model for Shasta Reservoir to improve management of cold water releases into the Sacramento River to better support Winter-run Chinook Salmon.

2.2.2 Salmonid Survival Models

Trawl data show that peak catches of juvenile winter-run Chinook Salmon in the lower Sacramento River (Chipps Island and Sherwood Harbor) are closely associated with initial spikes in peak flow at or above 400 $m^3 s^{-1}$ at Wilkins Slough (del Rosario et al. 2013, Israel et al. 2015). Average residence time of juvenile Winter-run Chinook Salmon in the Delta appears to be 41 to 117 days, with longer apparent residence time for juveniles arriving earlier at Knights Landing (del Rosario et al. 2013). Departure date at Chipps Island was fairly consistent across the nine years of investigation (e.g., ~March). Researchers highlight the need for genetic analysis to identify juvenile Winter-, Spring-, and Fall-run Chinook Salmon in the Delta but most studies rely upon non-genetic tools to identify Chinook Evolutionary Significant Units (ESUs). Accurate identification of Winter-, Spring-, Fall-, and Late Fall-run Chinook Salmon emigration through the Delta is critical for evaluating project impacts because the amount of water diverted varies considerably over the juvenile out-migration period (Figure 1, Section 2.2.5). The Panel suggests that genetic identification of Chinook Salmon ESUs could more accurately evaluate habitat utilization and migration patterns of each ESU in the Delta.

The Delta Passage Model, the Interactive Object-oriented Salmon Simulation model (IOS; Cavallo, et al. 2011) , and the Oncorhynchus Bayesian Analysis model for Winter-run Chinook Salmon smolts (OBAN; Hendrix 2008) should consider these findings on migration patterns. In addition, we suggest that the simulated survival estimates from the Perry (2010) model (Figures A.5.D-66 to 70) be double-checked, because we do not find it clear how the weighted, summed survival rates below about 0.10 shown on those plots could have been predicted from a model (Figure A.5.D-65) whose smallest possible predicted values within the 95%CI is about 0.10. Also, OBAN simply examined how the PA would alter water exports at the southern Delta relative to the NAA, while assuming that circulation patterns and physics remain unchanged. However, the PA will also effect major changes in hydrodynamics and transport downstream of the NDD, and these changes should be considered in the model.

The Delta Passage Model assumes a fixed time of entry to the Delta (peaks during mid-January and late February for Winter-run Chinook Salmon) whereas the IOS model allows timing to vary depending on "egg and fry rearing upstream" (BA A.5.D). Assumptions about time of entry of juvenile salmonids to the Delta and residence time in the Delta have important consequences for survival because project operations change month to month depending on the type of water year (Appendix 2). Most of the models do not incorporate the flow/migration timing relationship presented by del Rosario et al. (2013) i.e., the effect of peak flows on movement into the Delta.

The salmon survival models are based on acoustic tagging of large (>140 mm) late fall-run hatchery smolts emigrating through the Delta rather than on smaller fry migrants, parr migrants, and smolts that are produced by winter- and spring-run Chinook Salmon (BA A.5.D - 208). The text did not mention if it incorporated relatively new findings based on smaller Chinook Salmon, e.g., Buchanan et al. (2013: Fall/Spring-run hybrids), Cavallo et al. (2013; 86-121 mm Fall-run Chinook). As noted above, the modeling focus on exceptionally large hatchery smolts leads to considerable uncertainty in how the PA affects other life stages that are critical to the viability of Winter- and Wpring-run Chinook Salmon. Use of the estuarine habitats and residence time will vary considerably with life history stage and species, with smaller, ocean-type life histories demonstrating greater and longer associations of shallow-water habitats in the Delta (e.g., Williams 2006).

The BA suggests that the survival model results for juvenile Winter- and Spring-run Chinook Salmon may be applicable to juvenile steelhead. This assumption in the BA may be too simplistic. Although steelhead smolts emigrate during winter and spring, as do most Chinook Salmon, they may have somewhat different migratory patterns that are not recognized in the BA analyses, including Table 5.4-1(BA 5-71). Steelhead reportedly occur in the Delta from October through July, which spans a longer period than Chinook Salmon. Furthermore, the rate of water diversion from the northern Delta, under the PA, is predicted to be highly variable from month to month depending on type of water year (see Appendix 2). The BA assumption that findings for Chinook Salmon represent PA effects on steelhead further increases the already high uncertainty in PA effects on salmonids.

2.2.3 Density Dependence

The VSP report by McElhany et al. (2000) recognizes the importance of density dependence when evaluating population viability. Compensatory density dependence occurs when there is competition for limited resources as the population grows. For ESA species, this form of density dependence can be very important because it provides population resilience, i.e., productivity (survival) is higher at lower abundances. In contrast, depensatory density dependence is destabilizing and highly undesirable, because lower abundance leads to a higher risk of further declines. For example, depensation may occur when a predator consumes a fixed number of prey such that a higher percentage of the prey population is killed at lower prey abundances.

A misconception is that density dependence is weak among ESA-listed species, whose abundance is low. This was the perception in the Columbia Basin when salmon were initially listed under the ESA. However, a review by the Columbia River Independent Scientific Advisory Board (ISAB 2015) found strong evidence for density dependence in nearly all populations that were examined. Compensatory density dependence was high, in part because habitat quantity and quality had declined and many hatchery spawners supplemented the natural spawning populations. However, depensatory predation was observed in some areas.

A recent review of juvenile salmon foraging performance in estuaries revealed that density dependence was evident in estuaries that have lost wetland habitat (David et al. 2016), suggesting density dependence is likely an important factor in the Delta. High abundances of piscivorous fishes in the Delta, especially non-indigenous species, may contribute to depensatory mortality of ESA species. An important question is whether the PA may enhance abundances of predators that consume ESA-listed fishes.

2.2.3.1 Would the PA Cause Depensatory Mortality?

Examination of juvenile Winter-run Chinook Salmon survival in the Delta, based on the Delta Passage Model, suggests that the PA might cause depensatory mortality, which could destabilize the population. This potential adverse effect was not discussed in the BA but it should be evaluated in the BO, especially given the likelihood for a series of dry years that may help create depensatory mortality.

The BA projected that juvenile Chinook Salmon survival through the Delta under PA conditions would increase by about 80% in higher-flow years, ranging from 0.24 in critically dry years to 0.43 in wet years (BA 5-114). Survival during the PA was projected to be 7% less than that in the NAA during dry years and 2% less during wet years. In the mainstem Sacramento River (where survival tends to be higher), survival during the PA was projected at 8% less than that in the NAA during dry years and 4% less during wet years. In all water years, juvenile Winter-run Chinook Salmon survival was projected to be less during the PA compared with the NAA.

Greater adverse project effects during dry compared with wet water years is an important finding. Juvenile Chinook Salmon abundance entering the Delta is likely much lower during dry compared with wet years (e.g., Israel et al. 2015), and the PA is projected to kill a higher proportion of fish compared with the NAA, especially during dry years. Therefore, the PA appears to have a larger adverse effect during dry years when other factors are also contributing to low survival and abundance of fish entering the Delta. This relationship could have a destabilizing effect on the population depending on the magnitude of the effect.

The Panel recommends evaluation of the compounding effect of the PA and dry years, and the potential for depensatory mortality, using a series of continuous dry years. Drought often occurs for a number of consecutive years, as the recent CA experience confirms, and climate change is likely to produce more frequent drought conditions (Dettinger and Cayan 2014, Romero-Lankao et al. 2014).

2.2.4 Effects at the North Delta Diversions

The Panel found the assumptions and rules about the vulnerability of Winter-run Chinook Salmon to be somewhat unqualified, and requiring more explicit distinction of life history diversity in the BO. It is particularly uncertain whether the ocean-type life history stage of this stock is appropriately addressed in designing the operational rules for NDD, rigorous consideration of northern Delta habitat impacts, or indicators and triggers for NDD impacts.

Whereas the size distributions and seasonal occurrence of Winter-run Chinook Salmon outmigrants is documented to be predominantly as small ("parr") juveniles that enter the northern Delta with early pulsed Sacramento River discharge, the median of the emigration often follows later in December to January in wet and above-normal years (del Rosario et al*.* 2013). These ocean-type juvenile salmon rear for extensive periods in tidal wetland and peripheral aquatic habitats of the Delta before emigrating to the Bay and ocean (Brandes and McLain 2000, Williams 2006), such that >50% of the cumulative catch emigrating from the Delta (i.e., at Chipps Island) may be up to 3-4 months from the time they entered the Delta (i.e., at Knights Landing), a significant portion thereof spent rearing in the Yolo Bypass in wet years (del Rosario et al. 2013).

The Panel recognizes considerable uncertainty about whether the operational rules for the NDD considered this often protracted demography of the Winter-run Sacramento Chinook migration to the Delta, or about the potential effects of major diversion on their rearing habitats within the Delta. We suggest that avoidance or minimization of deleterious effects to juvenile migrant and rearing Winter-run Chinook Salmon should be based predominantly on detailed real-time monitoring rather than statistical or categorical relationships between flow and fish abundance, preferably within an AM framework that includes active AM.

2.2.4.1 Fish Screen Effects

The BA (Chapter 5 and Appendix 5D) describes some of the characteristics of the northern Delta fish screens, but it does not mention whether or not the screens are designed to meet all of the criteria for salmonids as described by NMFS (2011). The brief analysis examines potential impingement of Salmon assuming an approach velocity of 0.2 ft s^{-1} (i.e., the NOAA criterion), but NMFS (2011) describes a number of additional design criteria needed to protect salmonids. ***The Panel recommends that all fish screen criteria described by NMFS (2011) should be explicitly addressed in the BO.***

Sweeping velocity is discussed in the BA but there are no estimates of sweeping velocity along the river banks now and after construction of the very long fish screens. NOAA criteria recommend sweeping velocities of at least 0.8 ft s^{-1} and sweeping velocity must not decrease along the length of the screen. Will these criteria be met by the PA?

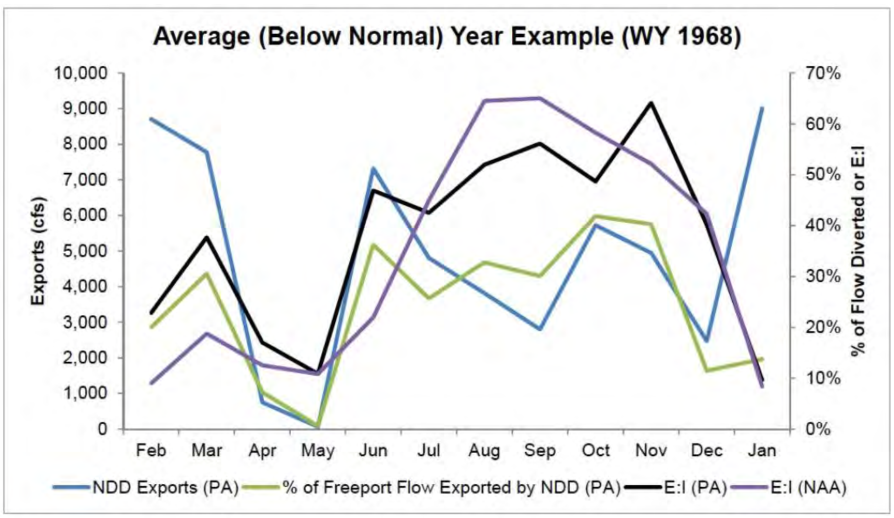
The BA concludes that the effects of NDD on impingement of juvenile salmonids is uncertain and states that this uncertainty would be addressed with monitoring and studies that examine impingement and passage time along the intakes.

2.2.4.2 Predation Effects

The BA provides a reasonable conclusion regarding predation at the northern Delta water intakes: *"*Overall, there is potential for predation of juvenile salmonids along the NDD, which would constitute an adverse effect.*"* (BA 5-84).The BA analysis cites two studies for predation impacts, the field study at Glenn Colusa and a bioenergetic approach. Ultimately, the potential effect is highly uncertain because the predation will depend on local conditions and the responses of the ESA fishes and predators to those conditions. The effect of the NDD facilities and operation on predation at this location will depend on whether the intake structure and operation alter predator abundance at the intakes and whether juvenile fishes aggregate along the screens. Some aggregation of prey fishes is likely since water is drawn into the screens and most fishes are excluded. The BA proposes to reduce predator density at the screens. An experimental approach should be conducted under AM, starting with estimates of predatory fishes at the fish screen locations and experimental control sites prior to construction of the screens. This should be followed with sampling after construction to determine whether predator abundance has increased relative to control sites. Predator diet should also be examined.

2.2.5 Water Diversion Effects on Salmonid Critical Habitat

The proposed seasonal reduction in water discharge though the Delta provides an index for the degree to which critical habitat for ESA-listed salmonids in the Delta will be altered by the PA. Figure 1 shows the percentage of total Sacramento River discharge that is expected to be removed from the northern Delta during an average "below normal" water year. In November, approximately 40% of the Sacramento River water is expected to be diverted by the PA. In November, moderate numbers of adult Winter-run Chinook Salmon, juvenile Winter-run and Spring-run Chinook Salmon, and small numbers of adult steelhead are likely to be present (BA 5, Table 5.4-1). The water removal rate is expected to decline to approximately 10% in December and January when abundance of juvenile Winter- and Spring-run Chinook Salmon increases. However, water removal increases to 20%-30% of the total river discharge in February and March when abundances of adult and juvenile Winter- and Spring-run Chinook Salmon and juvenile steelhead are expected to be relatively high (e.g., Williams 2006, del Rosario et al. 2013). The percentage of river water diverted each month varies considerably with the type of water year (see Appendix 2).



Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: E:I = exports to inflow ratio; the inflow (I) term for the PA is the Sacramento River downstream of the NDD; NDD exports are not included in the export (E) term for the PA.

Figure 7. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1968.

Figure 1. Reproduction of Figure 7, Appendix 2. Estimated monthly diversion of Sacramento River water at the North Delta Diversions (NDD; blue line) as a percentage of total river discharge just upstream from the intakes (green line) during an average "below normal" water year. See Appendix 2 for additional analyses by water year type.

The quality and quantity of habitats available for Chinook Salmon and steelhead in the Delta depend on inflows from the Sacramento River (del Rosario et al. 2013). Increased flows often provide more rearing habitat and more migratory habitat, suggesting the northern Delta water diversion has the potential to significantly alter habitat availability, and potentially quality, in some months depending on water year. As mentioned previously, salmon fry and parr migrants utilize shallow estuarine habitats more than yearling smolts, which tend to be farther offshore in the current. The effects of water diversion on habitat of salmon fry and parr migrants is complicated by the interactions between river flow, tide stage, salinity, and the locations of existing preferred habitats along the migratory corridor. The interplay among these complex interactions was not assessed in the BA.

The Habitat Suitability section of the BA (BA 5.4.3.1.2.2.1) briefly attempts to examine the effects of water diversion at the northern Delta intakes on water depth characteristics at artificial wetland and riparian benches, although not natural tidal wetlands. This simple approach does not account for observed preferred habitats along the migration corridor and other characteristics noted above. Nevertheless, the BA reported 19% to 29% lower riparian index during the PA compared with the NAA. Inundation of manufactured wetland benches did not differ between the two scenarios because the wetland benches were designed to be covered by water in nearly all water years, suggesting that the wetland depth index was not sensitive to flow conditions and was not a reasonable tool for evaluating project effects. Furthermore, the bench habitats represent only a small fraction of habitat that may be used by juvenile salmon as they rear and move downstream. ***The Panel recommends additional effort to evaluate PA effects on critical salmonid habitats, including natural and restoring tidal wetlands predictably under the large-scale influence of the NDD operations.***

2.2.6 Effects on Salmonid Diversity

McElhany et al. (2000) highlight the importance of maintaining population diversity when evaluating viability, but salmonid diversity is not fully evaluated in the BA. Diversity in the types of salmonid life history patterns (fry, parr, smolt migrants) is discussed above. Here we discuss diversity associated with migration timing. Migration timing is linked to life history types.

Juvenile Winter- and Spring-run Chinook Salmon and steelhead smolts are present in the Delta for up to ten months per year, although residence time is much less for individual fish. According to Table 5.4-1 (BA 5), juveniles from one or more of these three species are present in the Delta for all months except August. Diversity is represented in part by the broad period of juvenile outmigration that helps these species adapt to variable conditions in the ocean that can differentially affect salmonids depending on when they enter the ocean (Johnson 2015). In other words, the tail ends of the migratory periods of each species are important to species viability even though the abundance of the juveniles at the extreme ends of the migration periods is small. ***To further evaluate PA effects on diversity, the Panel recommends evaluating water removal effects (up to ~40% of Sacramento River flow depending on month and water year) during tail end migration periods when juvenile salmonid abundance is low, in addition to when most juveniles are present in the Delta.***

2.2.7 Effects on Species that Interact with ESA-listed species.

NOAA Fisheries embraces ecosystem-based management (http://ecosystems.noaa.gov/), therefore the analytical approach to the BO should consider interactions between the ESA-listed species and other species that may be affected by the PA. Predation is likely a key source of mortality for ESA-listed fishes in the Delta. For example, non-native Striped Bass, a popular sport fish, is a significant predator on juvenile Chinook Salmon in the Delta (Lindley and Mohr 2003) and reduced flow may increase predation on salmon (Cavallo et al. 2013). Lindley and Mohr (2003) reported that entrainment at the southern Delta water diversion facilities and ecosystem changes have reduced the carrying capacity for subyearling Striped Bass, and have contributed to their decline from the 1960s to 1996. However, this trend could be altered if the PA does indeed reduce entrainment at the southern Delta facilities. ***Therefore, the Panel recommends evaluating the extent to which the PA may alter the abundance of Striped Bass and other predators that consume ESA-listed species.***

The BA states that Killer Whales (“Orca”) would likely depend more on the relatively abundant hatchery Fall-run Chinook Salmon than the wild Fall-run or the ESA-listed Winter- and Wpring-run Chinook Salmon. According to the BA, approximately 20% to 60% of the hatchery Chinook Salmon have been released below the Delta where project effects would likely be minimal. Wild Fall-run Chinook Salmon reportedly represent only ~10% of all Fall-run Chinook Salmon harvested in the ocean fishery, indicating the wild component (which will be influenced by the project) is a small proportion of the total Fall-run Chinook Salmon.

Nevertheless, PA effects on wild Fall-run Chinook Salmon, an ESA candidate species, should be considered because some may be consumed by Killer Whales. This analysis should examine how the PA differentially affects fry migrants and parr migrants compared with smolt migrants, given that large smolt migrants have been the subject of most investigations. Fry migrants and parr migrants are known to represent a significant portion of wild Fall-run Chinook Salmon (Miller et al. 2010, Sturrock et al. 2015), and it is likely that they may be more vulnerable to water removal in the northern Delta compared with smolt migrants. Timing of juvenile migration through the Delta and habitat requirements are likely to be different than smolts, indicating that the PA may have a different effect on fry and parr migrants compared with smolt migrants***. When evaluating the effects of the PA on Killer Whales, the Panel recommends evaluation of PA effects on wild fry, parr and smolt migrants, given that Fall-run Chinook Salmon are likely an important prey of Killer Whales.***

2.2.8 Applying the Viable Salmonid Population (VSP) Framework in the BO

The Viable Salmonid Population (VSP) framework (McElhany et al. 2000) and the manuscript by Lindley et al. (2007) are excellent documents to guide the analytical approach for salmonids. The Analytical Approach for the BO (AABO) also identifies the 2014 NMFS recovery plan for listed Central Valley Chinook Salmon and steelhead as an example of best scientific and commercially available data. VSP criteria include population abundance, productivity, diversity, and population spatial structure.

Although the AABO highlights the use of these approaches for evaluating the viability of salmonid populations, it does not describe the significant limitations of available data needed to apply these approaches when evaluating project effects. For example, a VSP approach should consider how the project might affect diversity and the spatial structure of the Evolutionarily Significant Units (ESU) and Distinct Population Segments (DPS). There are five populations of Spring-run Chinook Salmon, one Winter-run Chinook Salmon population, and four populations of steelhead remaining in the Central Valley. Each of the Chinook Salmon populations likely has multiple juvenile life history strategies. For example, based on otolith analysis of adult salmon, Sacramento Fall-run Chinook (non-listed) were shown to produce considerable proportions of fry migrants and sub-yearling parr migrants in addition to yearling smolts (Miller et al. 2010, Sturrock et al. 2015). Although Winter- and Spring-run Chinook Salmon may produce fewer fry and parr migrants compared with Fall-run Chinook, research on life history types of Winter and Spring-run Chinook is ongoing and will help identify the contributions of these life history types (R. Johnson, NOAA Fisheries, personal communication). Williams (2006) summarizes genetic analyses that differentiate Chinook Salmon ESUs by size. ***The Panel recommends that the AABO describe how it will evaluate project effects on diversity and spatial structure.***

Evaluation of project effects on individual populations and life history types is difficult and this will lead to high uncertainty in the effects analysis. A key question is, to what degree will the PA affect fry and parr emigrants compared with large smolt emigrants (the life history type primarily evaluated in the BA)? The salmon survival models used in the BA primarily rely on acoustic tagging of large (>140 mm) hatchery Late fall-run Chinook and apply these findings to the evaluation of Winter- and Spring-run Chinook Salmon, which include juveniles that are much smaller than these tagged smolts, and to steelhead smolts. Sub-yearling fry and parr are known to rear in the estuary for longer periods of time than smolts. Seasonal use of the estuary also varies with species and life history type, and water removal by the project will vary with season. It is likely that smaller salmonids, which reside in the estuary for longer periods of time, are more vulnerable to reduced flows and related mortality factors (i.e., predators) than larger smolts (e.g., Cavallo et al. 2013), suggesting different effects on each life stage. The effect of reduced flows on residence time of each life history type and their migration route through the Delta is a key unknown because studies have focused on large hatchery smolts and because fish entering the interior Delta have greater mortality (e.g., Perry et al. 2013, Steel et al. 2013, Buchanan et al. 2013).

In short, the data are limited and the uncertainty is high, for applying VSP criteria to ESA-listed salmonids in the Delta. As we also note elsewhere, in such situations McElhany et al. (2000) recommend use of the precautionary principle and AM. ***The Panel recommends that approaches for using precaution and AM be described in the AABO.***

2.2.9 Increased Uncertainty When Using Surrogate Species

When discussing the availability of data, the draft AABO (p. 8) states *"Various sets of data and modeling efforts are useful to consider when evaluating the transition rates between life stages and consequences on population growth as a result of variations in those rates. These data are not available for all species considered in this opinion; however, data from surrogate species may be available for inference."* The AABO does not identify specific surrogate species or how it will determine the suitability of surrogate species for assessing incidental take, but it does reference the final rule describing the use of surrogates in Incidental Take Statements (80 FR 26832, May 11, 2015).

The use of surrogate species introduces additional uncertainty in the assessment of project effects on the ESA-listed species. Studies on the use of surrogate species have recognized this enhanced uncertainty and have emphasized the need to validate the use of surrogate species (e.g., Murphy et al. 2011). We anticipate that the draft BO will provide appropriate justification for the use of surrogate species.

The use of one life stage as a surrogate for other life stages having few data also requires greater discussion and justification. For example, most data for estimating survival of juvenile salmonids through the Delta involve large hatchery yearling Late fall-run smolts (>140 mm). These fish are not likely representative of smaller wild salmon smolts, and other emigrating life stages such as sub-yearling parr migrants and fry migrants that use estuarine habitats differently and for longer periods of time than large hatchery smolts (e.g., Williams 2006).

2.3 Effects on Delta Smelt

The BA for Delta Smelt assessed individual- and population-level impacts in a hierarchical structure that included assessments for each life stage (eggs/embryos, larvae/young juveniles, juveniles, migrating adults, spawning adults) in relation to the PA's construction and operation. The list of BA assessments was comprehensive and included the effects of impingement/entrainment, predation, turbidity, loss of suspended sediment/spawning substrate, contaminants, underwater noise, fish stranding, direct physical injury (from falling riprap, impingement on sheetpiles, entrainment by dredges, or from being struck by propellers), mitigation of harmful *Microcystis* (cyanobacteria) blooms, loss of phytoplankton within exported water, vegetation control, dredging, repair activities, habitat change, gate operations, loss of habitat at the construction site and barge landing areas, and cumulative changes.

The BA did not employ existing population/life-cycle models for the Delta Smelt (Maunder and Deriso 2011, Rose et al. 2013a,b) due to lack of information for properly parameterizing the models (M. Greenwood, April 5, 2016 public meeting). Moreover, the decision to not use these models is supported by Reed et al. (2014, p. 34), who stated "Mechanistic modeling exercises (e.g., Rose et al. 2013a) may help improve understanding of cause-effect mechanisms and help guide future research and monitoring; however, they are rarely sufficient to exclude the need for large-scale experimentation to separate confounding factors, and are not currently suitable for use as management tools."

During the course of the hierarchical assessment of the above-listed potential impacts, the BA generated estimates of uncertainty or otherwise communicated awareness of considerable uncertainties that were associated with individual assessments. Upon reviewing these assessments, the Panel independently noted uncertainties that were associated with potentially beneficial impacts (positive impacts), potentially negative impacts, and relatively neutral impacts. In most cases, the BA recognized and acknowledged the same uncertainties as the Panel did. We discuss the most notable types of uncertainty in the subsequent sections, which are followed by a comparison of the approaches taken by the BA and the conceptual model for Delta Smelt (MAST 2015), and then provide observations on AM of Delta Smelt, including a list of concepts for new data collections that could reduce uncertainty or improve the conceptual model for Delta Smelt.

2.3.1 Uncertainties Associated with Positive Impacts on Delta Smelt

There were some assessments that could not fully capture potentially positive aspects of the PA due to uncertainty. Some of these shortcomings involved computational issues, such as noting that assessments of impacts at the Head of Old River (HOR) gate did not include real-time gate operations that could be actively managed to reduce negative impacts. Others involved larger issues such as entrainment, food-web interactions, and the control of toxic *Microcystis* blooms. Reduced predation at the southern Delta diversions (SDD) is another potentially positive outcome of the PA. Effects of the PA on predation risks are inherently difficult to predict, and are discussed separately along with other issues that relate to potential changes in the Bay Delta's food web.

The BA used similar approaches to assess entrainment at both the NDD and SDD, employing data and relationships that were specific to each diversion location. Accordingly, the BA noted that adult Delta Smelt entrainment risk at the SDD could not be directly modeled due to lack of relevant data for abundance and turbidity. Thus, the BA obtained alternative entrainment estimates from a regression model (USFWS 2008) as predicted from modeled Old and Middle Rivers (OMR) flow that was derived using CalSim-II. These predictions suggested a reduction in adult entrainment at the SDD under the PA with the high uncertainty of the estimates acknowledged by the BA's authors (this regression model had r^2 = 0.36, exemplifying the "weak" models discussed in Section 2.5.2). The BA also noted the prospect of an overall increase in the Delta Smelt spawning-stock biomass as a beneficial result of reduced adult entrainment at the SDD under the PA. This potentially positive impact on the spawning stock appears reasonable but remains uncertain.

Various other mathematical approaches were applied to the prediction of entrainment risks for other life stages. In general, the entrainment modeling was afforded a great deal of effort with appropriate rigor applied when possible. Some of these efforts yielded inherently uncertain results due to limitations of the models used (e.g., poor regression fits/wide confidence limits around predictions, and the use of the DSM2 particle-tracking model without including real-time withdrawal management); as mentioned, these uncertainties were acknowledged by the BA's authors. Under many scenarios (month-year type combinations), estimates of larval entrainment were reduced under the PA, although there were also many scenarios where larval entrainment at the SDD was similar between the PA and the NAA. It should be noted that these modeling exercises were conducted in the absence of actual larval entrainment histories; most SDD entrainment involves larvae, which have not been monitored at the SDD (Kimmerer 2008). The general conclusion for entrainment at the SDD was positive, indicating salvage and population losses would decrease under the PA except during drier years, when northern Delta diversions would be small. Figure 6.1-9 in the BA compares estimates of entrainment reduction among year types, including graphical depictions of uncertainty.

The BA also considered the loss of phytoplankton within the exported water at the NDD, recognizing that the phytoplankton within Delta inflows contributes to the foundation of the Delta's aquatic food web. The BA estimated mean phytoplankton biomass diversions at the NDD would range 0-12% (minimum 5^{th} to maximum 95^{th} monthly percentile) and would rarely exceed a relatively low value of 5% of the Delta's standing stock of phytoplankton during any given month. However, the BA points out that the southern Delta is generally more productive than the northern Delta, and if southern Delta pumping becomes reduced under the PA, then phytoplankton production south of the Delta could be retained within the Delta as a whole, possibly yielding a net benefit to Delta secondary productivity, including productivity of Delta Smelt (BA 6-133). A more quantitative assessment of this apparent net benefit would be difficult, as it would be impeded by the limited quality and quantity of data related to phytoplankton biomass and productivity near the SDD (M. Greenwood, April 5, 2016 public meeting). While there is considerable uncertainty in this conclusion, the position of the BA on this issue appears to be reasonable.

The BA suggests that the distribution of pumping between the NDD and SDD can be manipulated to reduce water-residence times in areas of the Delta where toxic *Microcystis* blooms form (BA 6 -172). This is a suggestion for ameliorating a current problem but there is no evidence that it will actually be successful.

2.3.2 Uncertainties about Negative and Neutral Impacts on Delta Smelt

Life-stage-specific impacts of construction and maintenance of the NDD, HOR gate, barge landing sites, and new Clifton Court Forebay facilities (construction, maintenance dredging, mechanical and electrical repairs, riprap replacement, vegetation control, etc.) were largely based on the extent of spatio-temporal exclusion between Delta Smelt distributions and these various PA activities. In other words, substantial impacts were not expected to occur whenever particular life stages, which have seasonally specific geographic distributions, were expected to be distributed far enough away from PA activities. Initially, this approach appears to be sound, yet it is flawed by logical circularity. In effect, the approach first assumes that the historical status quo represents the future condition—despite the imminence of substantial future change - and then uses this position to maintain that the future change will result in the historical status quo. Future change is potentially large, as the PA could result in >35% maximum diversions of Sacramento River flows during all except critically dry years (BA 6-69). The BA does not recognize the uncertainty in its assumption that future Delta Smelt distributions will be the same as those in the past. It should be noted, however, that the BA's claim that few adult Delta Smelt would be expected near construction sites (i.e., during the time period of construction) is reasonable because it applies to a time period that precedes the PA's export of water from the Sacramento River. That is, it is not subject to the above-mentioned flaw in the spatio-temporal exclusion approach.

The assessment of impacts of water-facility operations included both modeling and spatio-temporal exclusion considerations of life-stage-specific, individual- and population-level assessments for impingement and entrainment at the NDD. Delta Smelt >90 days old (>20-21 mm) were not believed to have strong, future screen-impingement risks at the NDD because they have historically occurred downstream of the three diversion points. The BA acknowledges that any individual juvenile or adult fish that might occur near the NDD diversion points could be more vulnerable to impingement if they were to swim near the shoreline to avoid strong currents in the channel, thus causing them to swim closer to the diversion screens. The BA's evaluation of tidally assisted upstream movement by adults ("tidal surfing") identified this process as being limited to areas downstream of the NDD (i.e., limited by the upstream extent of sufficient tidal transport) and so the BA indicated most individuals would occur downstream of the diversion areas, resulting in a low population-level impact. However, future sea-level increases, combined with reduced river flows under the PA, may confound this aspect of the assessment by increasing the upstream influence of the tides (although concomitant changes to the Delta ecosystem would present a host of other challenges to ecosystem management by the time sea-level rise caused this to become a concern).

While it is understood that critical habitat effects are an element of adverse modification, it is also understood that fish responses to habitat changes may have large uncertainties. Uncertainties associated with future environmental conditions—even those involving relatively simple, abiotic conditions such as turbidity—are acknowledged in the BA. The BA's assessment of habitat impacts started with two abiotic habitat factors, salinity and turbidity, which had been combined by Feyrer et al. (2011) into an abiotic habitat index that can be modeled as a response to X2. The BA for Delta Smelt considered this model (details on BA 6.A-33) but also noted two concerns raised by an NRC review panel (NRC 2010), specifically that the Delta Smelt population response to X2 is statistically weak in both an empirical sense (i.e., in regard to data relationships) and due to the compounded uncertainty caused by linking two statistical models together. These observations undermine the rigor of the abiotic modeling exercise, as acknowledged by the BA's authors.

Another potentially negative impact that has great uncertainty involves turbidity. Delta Smelt abundance tends to be highest at turbidity levels in the range of 1-50 NTU. Turbidity in the Delta is influenced by river-borne loadings of suspended organic and inorganic particles, by local (within-Delta) production of living and nonliving organic particles, and by the transport and re-suspension of these materials by river flows, tides, winds, and three-dimensional density discontinuities within the water column. Given this complexity, there is no comprehensive turbidity model for the Delta. The BA notes that turbidity is difficult to forecast at the SDD, and therefore so is the Delta Smelt's generally positive response to turbidity.

A closely related concern—one that makes the preceding paragraph part of the negative uncertainty discussion— is the Grossman et al. (2013) finding that "Sediment concentrations in the Sacramento River have decreased by half from 1957-2001 and total suspended solids have decreased 50% from 1975-1995 (Schoellhamer et al. 2013)." The PA is expected to result in an additional 10% reduction in the Sacramento River suspended sediment load, which is substantial given the Delta Smelt's widely accepted relationship with turbidity (Feyrer et al. 2007, Sommer and Mejia 2013). Primarily sand-sized particles will be retained at the NDD facilities, but particles of this size are not important contributors to turbidity, and so plans to re-introduce sediments retained at the NDD back into the Delta (BA 6 -172) are not relevant to restoration of lost turbidity. Instead, the finer sediments (those finer than sand) will be removed while in suspension within the exported water, but may possibly settle out of suspension as velocities decrease upon the diverted water's entry into the Clifton Court Forebay. Re-introduction of sand back into the Delta may, however, be relevant to preserving spawning habitat, which is believed to be shallow, sandy, freshwater habitats (BA 6 -171).

BA assessments of population-level effects associated with the operation of Delta water-distribution systems (Delta Cross Channel, Suisun Marsh facilities, North Bay Aqueduct, other facilities) indicate that impacts should be similar or would not differ between the PA and NAA. It would first appear that impacts from continued operation of these systems would be largely secondary to impacts from the dual-conveyance facilities, yet the Suisun Marsh facilities are closely proximal to the area of highest abundance for sub-adult Delta Smelt, as indicated by the Fall Midwater Trawl Survey (Bever et al. 2016). This area of abundance extends from Suisun Slough through Grizzly Bay, Honker Bay and eastward into the area near the confluence of the Sacramento and San Joaquin Rivers, including Montezuma Slough. Any assumptions that Delta Smelt distributions will remain unchanged in this area under the PA should be avoided, and the effects of the Suisun Marsh water-distribution system on Delta Smelt need to be carefully monitored.

2.3.3 Uncertainties about Predation and Other Food-web Relationships Involving Delta Smelt.

The issue of relative predation risk is one of the most difficult challenges to the assessment, as indicated in the report by Grossman et al. (2013), who noted “stress caused by harsh environmental conditions or toxicants will render fish more susceptible to all sources of mortality including predation, disease or physiological stress.” This observation was echoed in the Interagency Ecological Program (IEP) Management Analysis and Synthesis Team (MAST) conceptual model (MAST 2015) as “prey may be more susceptible to predation if they are weakened by disease, contaminants, poor water quality, or starvation.” Thus, while predators are sometimes conspicuously attracted to elevated prey concentrations (e.g., near the SDD), diffuse predation mortality can also add up to large total mortality losses when factored across larger expanses of habitat, and such losses may be rooted in indirect habitat effects. In other words, predation may be the immediate cause of mortality for individuals that had already been weakened by other environmental conditions or disease. In fish, it is generally accepted that fast growth equates to lowered mortality risk and greater lifetime reproductive potential.

While it is a good idea to reduce Delta Smelt aggregations in areas where there is intense predation pressure, it should also be borne in mind that predation is not likely to be the single cause of long-term declining trends. The MAST conceptual model for Delta Smelt (MAST 2015) recognizes this, stating “Since predation is a natural part of functional aquatic ecosystems, predators are likely not responsible for long-term declines in populations of prey fishes, such as Delta Smelt, without some additional sources of stress that disrupt the predator-prey relationship (Nobriga et al. 2013).”

Prey relationships are also central to survival. The BA for Delta Smelt appears to under-emphasize this importance stating (6A-32): “The abiotic habitat index is based on the probability of presence of Delta Smelt given certain water clarity and salinity and does not explicitly account for other abiotic (e.g., water velocity, depth) and biotic (e.g., food density) factors that may interact with water clarity and salinity to influence the probability of occurrence. However, Delta outflow and its effects on X2 are habitat elements that the projects can directly influence, whereas the other habitat features are not.” By implying that the PA would not have an effect on food density, the BA’s position becomes misleading. The assumption that the abundance and distribution of estuarine prey organisms will not respond to altered freshwater inflows is not supported (e.g., Flannery et al. 2002, Peebles 2005, Peterson 2003, and references cited therein). Even if X2 is kept the same, interaction between river flows and Delta geomorphology/hydraulics will be different between the PA and NAA, and an associated change in the distribution and abundance of prey should be anticipated rather than dismissed.

In a demonstration of the practical utility of their conceptual model, the MAST group asked why 2011 was a good year for Delta Smelt, and was able to infer good food availability during 2011 (an isolated wet year) as a contributor to the success of all life stages (MAST 2015). The authors also identified the lack of sufficient spatio-temporal data on prey abundance as a major information gap in understanding Delta Smelt abundance trends.

Declining turbidity is one well-documented, long-term trend in the Bay Delta estuary that is likely to have affected prey distribution and abundance. Turbidity has declined markedly at a decadal scale (Schoellhamer et al. 2013), and as a result more light can reach the bottom and submerged plants. Improvements to the light environment, such as this, have been associated with abrupt community change in favor of benthic organisms over planktonic/pelagic ones (Burghart et al. 2013 and references cited therein). In reference to Delta Smelt, MAST (2015) observed "The large proportion of benthic amphipods, cumaceans, and some cladocerans (*Camptocercus* spp.) in the diet is a notable change from Delta Smelt diet in the 1970s. Delta Smelt diets historically did include amphipods, notably *Corophium* spp. (Moyle et al. 1992), yet it was a small fraction of a mostly pelagic based diet. The considerable use of benthic invertebrates for food in recent years is believed to be in large part due to food limitation associated with the long-term decline and changes in composition of the pelagic food web (Slater and Baxter 2014)." The decadal-scale decline in copepods, which are important planktonic prey for multiple life stages of Delta Smelt, is described by Winder and Jassby (2011). Food limitation is now recognized as a principal stressor on Delta Smelt, as discussed by Sommer and Meija (2013). A more comprehensive description of these food-web alterations over time is provided by Durand (2015).

The Delta Smelt is positioned toward the bottom of the food web, where variations in biomass pathways (benthic vs. planktonic/pelagic) often have their greatest effect. There are exceptions to this trend, however. Threadfin Shad, for example, are positioned at a relatively low position within the food web, yet they are capable of regularly switching between planktonic and benthic feeding (Haskell 1959). Predators such as Striped Bass that are positioned higher in the food web often integrate secondary production (prey) from whichever biomass pathway happens to be productive at the time, and as a result tend to be less vulnerable to changes in the relative dominance of one biomass pathway over another (Vander Zanden and Vadeboncoeur 2002, Rooney et al. 2006).

The nature of the Sacramento-San Joaquin estuary's changing aquatic food web has been the subject of considerable debate and discussion, which has resulted in a number of publications related to the decline of the Delta Smelt and other pelagic organisms since 2002 (Sommer et al. 2007). There are differing opinions on the cause of these declines, which translates into yet another form of uncertainty in the assessment of the PA's impacts.

2.3.4 Differences between the BA and the MAST conceptual model for Delta Smelt

Questions regarding whether the best available science was used in preparing the BA invite comparison between the approach taken by resource managers and the approach taken by researchers who use conceptual models to organize their studies. The most fundamental difference between the BA and the MAST (2015) conceptual model is that the BA, out of necessity, is dependent on defendable statistical relationships, models, computations, and direct interpretations of survey data in order to evaluate potential impacts. On the other hand, conceptual models may be largely based on similar types of information, but are allowed to extend beyond the limitations of defendability in order to continually organize the growing repository of synthesized concepts and inferred conclusions that are obtained from the literature and from discussions with other scientists. Conceptual models are more likely to use a weight-of-evidence approach that might be harder to defend (in a legal sense) than a straightforward statistical relationship might be, for example. Both approaches readily recognize where their respective uncertainties lie.

Of the two approaches, the conceptual model is much more process-based and explanatory, and is specifically geared towards facilitation of hypothesis development and testing. In their review of a draft version of the MAST conceptual model, Reed et al. (2012) recommended "The conceptual model in written and schematic form should continue to emphasize processes and their interactions over simple correlations, should ensure Delta Smelt vital rates remain central to thinking, and should be designed for routine use by scientists as an organizational tool and for testing hypotheses associated with the AMP [adaptive management plan].” The emphasis on “vital rates” refers to growth, reproductive, and mortality rates, which determine the likelihood and magnitude of the present generation’s contribution to future generations (i.e., what biologists call “fitness”). Relating habitat effects to fitness completes the argument for relevance within a scientific sense, if not a legal one (i.e., it addresses scientists’ question “why is the relationship you are studying important?”) In practice, various metrics that represent individual health or condition, such as instantaneous growth rate, size-at-age, or the extent of fat stores, can be used as proxies for vital rates that are difficult to measure directly. Again, this is based on the idea that a healthy, fast-growing fish is more likely to have reduced mortality risk and increased lifetime reproductive potential than an unhealthy, slow-growing one. The BA is thus more likely to value abundance-correlated habitat variables as potential statistical predictors of Delta Smelt abundance, and the conceptual model is more likely to value these variables as representatives of habitat processes that affect vital rates. In the latter case, the conceptual model serves as an organized platform from which hypotheses can be developed and tested with the purpose of identifying the habitat processes that most strongly influence vital rates.

Fish habitat includes both stationary habitat (marshes, mudflats, channels, etc.) and dynamic habitat (changing distributions of currents, water quality, predators, prey, competing species, etc.) that are constantly interacting with each other to influence fish vital rates. The fittest fish will be those that occupy habitats where growth is fast and mortality risk is low, but because feeding needs and predation risks typically change as fish grow larger, it is common for fish to occupy different habitats during different life stages or for fish to migrate seasonally. Fish such as Delta Smelt may also respond quickly to short-term (dynamic) changes in habitat quality. In recognition that some processes within the myriad stationary-dynamic habitat interactions are more direct in influencing vital rates than others, the MAST (2015) conceptual model states “The interplay between stationary and dynamic habitat components also helps explain the distribution and movement of Delta Smelt across its range, which cannot be understood —or managed— based on geography alone.”

Conceptual models are intentionally flexible and are allowed to change as new information is obtained and assimilated. Since publication of the MAST (2015) conceptual model, Bever et al. (2016) have identified slow current speed as a third abiotic habitat factor that is positively associated with Delta Smelt abundance. While current speed may not be as predictively powerful as salinity and turbidity, the Delta

Smelt's positive association with slow current speeds is consistent with the Sommer and Maija (2013) position that the availability of zooplankton prey may be limiting Delta Smelt abundance, and that longer hydrodynamic residence times reduce washout and dilution of the zooplankton prey. They state "In general, phytoplankton and zooplankton levels are higher in small channels that are surrounded by dense emergent vegetation in Suisun Marsh (Rob Schroeter, U.C. Davis, unpublished data). This may be more a function of longer water residence time in these low-order channels..." In general, much of the area identified as having the highest abundance of sub-adult Delta Smelt is away from the estuary's primary conveying channel (i.e., high abundance is in the area from Suisun Slough through Grizzly Bay and Honker Bay, plus Montezuma Slough, Bever et al. 2016, Figs. 4 and 12). During low-flow periods, areas near the Sacramento-San Joaquin confluence may also have longer residence times. Sommer and Maija (2013) also suspected that prey export from adjacent marshes subsidizes Delta Smelt prey availability. The BA did not consider zooplankton retention effects, but if the viewpoints of Sommer and Maija (2013) are considered to be part of the still-evolving conceptual model, then zooplankton production and retention is a concern that should be carefully evaluated. When considered from this perspective alone, the PA could have a positive, negative, or neutral effect on Delta Smelt abundance.

For these reasons, the Panel recommends that the abiotic habitat effects of the PA be explicitly considered within the context of the new Bever et al. (2016) findings, while recognizing that this exercise cannot include turbidity due to lack of a turbidity model for the PA simulation (i.e., the abiotic station index of Bever et al. 2016 should be modified to include salinity and current speed, but not turbidity). We also recommend that the water-distribution system within Suisun Marsh be qualitatively assessed for its potential influence on the salinity, current speed, and turbidity within the high-abundance area for Delta Smelt, as described above and as identified in Figure 2. The Panel is referring to the latter assessment as "qualitative" in recognition of the difficulty of mathematically scaling the fine-scale water-management actions within Suisun Marsh to larger spatial and temporal effects within the high-abundance area.

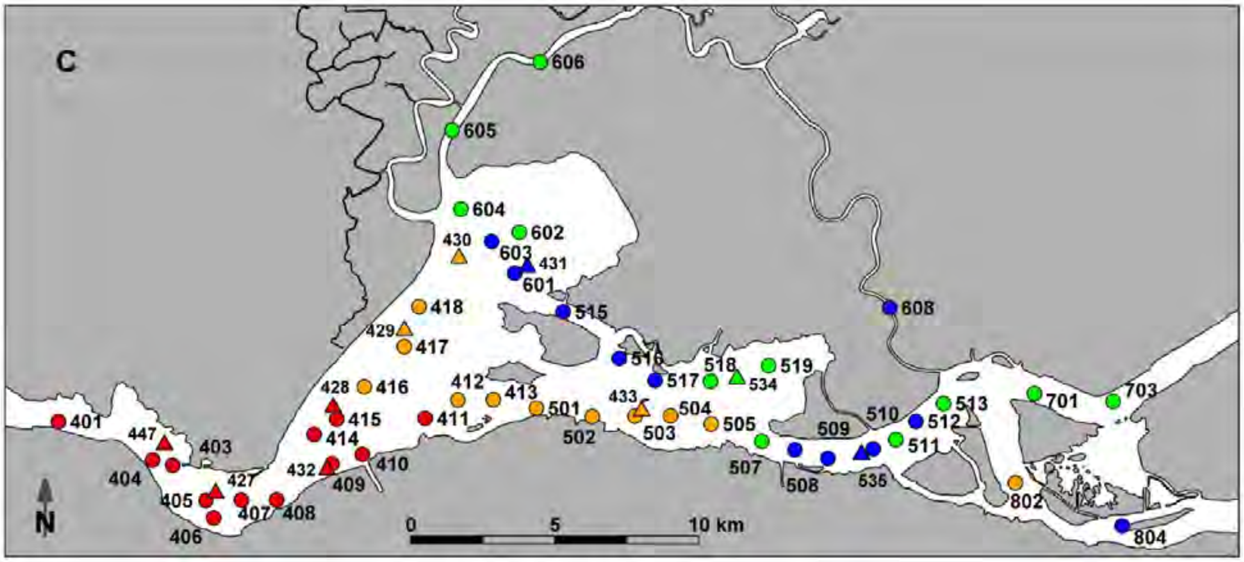


Figure 2. Reproduction of Figure 4C from Bever et al. (2016), indicating station indices for Delta Smelt catch from the Fall Midwater Trawl Survey. Relative Delta Smelt abundance is color-coded among stations in the highest abundance quartile (green), second highest quartile (blue), third highest quartile (yellow), and lowest quartile (red)—the highest historical abundances (1967-2012) were at stations coded green and blue.

2.3.5 Observations on Delta Smelt Adaptive Management (AM)

First, it should be recognized that the group of people with the most comprehensive insight into Delta Smelt biology is the Management, Analysis, and Synthesis Team (MAST) group of the IEP. As a team, they know more about Delta Smelt than the present Panel members do, and they are highly capable of forging ahead and setting new standards for best available science. In order for AM of Delta Smelt to be effective, the MAST team needs to be allowed to remain engaged and focused on the AM problem, and they must have long-term resources available that are adequate for answering key questions. The MAST (2015) conceptual model is not only an exceptional document; it is a convincing demonstration of the high level of coordination, cooperation, and thoroughness that the MAST team is capable of achieving. In the Panel's opinion, a project as important as WaterFix deserves the best ecological support possible and California is fortunate to have the MAST group available to provide this service.

Second, the use of any historical data needs to be explicitly qualified regarding its potential limitations. A number of investigations have analyzed the entire periods of record for monitoring time series (e.g., Miller et al. 2012). It is very ambitious to explain trends that are responses to decades of development in the Delta, its watershed, and San Francisco Bay. While de-convolving all of the various continuous, stepped, punctuated, stochastic, and cumulative influences on the Delta's ecosystem would be ideal (e.g., Nobriga and Rosenfield 2016), there has been a clear limit on model precision at this lengthy historical scale, and this is what led Reed et al. (2014) to state "the rate of learning about the efficacy of alternate flow policies in the Delta will likely be very slow," and more specifically, that existing monitoring programs and associated models are not sufficient for use in passive, flow-based AM implementation for Delta Smelt. New types of information are needed, and efforts to collect this new information need to be carefully designed in order for the AM process to be efficient and effective. This process has already started, and the rate of learning has been increasing dramatically in recent years. A well-directed, methodical momentum needs to be maintained into the future. An example of a promising approach was taken by MAST (2015), who demonstrated a hypothesis-based investigation of 2011, which was an isolated, successful year for Delta Smelt. Notably, they intentionally restricted their investigation to passive variations among four recent years, which eliminated the confounding effects of the long-term changes to the Delta ecosystem. This approach, along with active AM experiments when feasible, is likely to continue to be productive. The MAST group envisions eventual combination of conceptual models with mathematical models to provide a substantial improvement on the guidance for AM of projects such as WaterFix.

Third, a very large number of future studies have been proposed at various times, but these need to be placed into an organized, hypothesis-driven structure (i.e., as provided by the Delta Smelt conceptual model) in order for these studies to be most effective. Lists of proposed studies occur in BDCP documents, in the MAST (2015, Table 10) conceptual model, and in the BA (Table 6.A-11, which was taken from the Collaborative Adaptive Management Team Fall Outflow Workplan). Combinations of studies will likely work best to fill information gaps in the Delta Smelt conceptual model. During the April 2016, Panel meeting in Sacramento, many specific studies were mentioned by presenters, guests, or the Panel members themselves. Some of these are redundant to the above lists, but are repeated here as a matter of record, with no particular emphasis or priority implied by the Panel:

- Underwater cameras for nonlethal monitoring (SmeltCam, Feyrer et al. 2013)
- DIDSON (acoustic video) for nonlethal monitoring in turbid waters
- Ecogeochemical forensics (stable isotopes, otolith microchemistry; making the most of incidentally collected Delta Smelt specimens)

- Turbidity studies
- BACI-design predator-prey studies at the NDD
- Environmental DNA (eDNA) for qualitative tracking of Delta Smelt habitat use, especially to help pinpoint spawning locations
- More diet studies of Delta Smelt and Delta Smelt predators
- Characterizing otolith-based growth rate/ microchemistry/stable-isotope differences between survivors (older individuals) and the original population (younger individuals) of the same cohort
- Direct measurement of vital rates as habitat quality metrics
- Studies of variation in size-specific fecundity (similar to what is also mentioned by MAST 2015)

In addition, the MAST (2015) suggests that concurrent zooplankton sampling should be "a routine part of the four major surveys monitoring Delta Smelt." Although some zooplankton sampling has been ongoing since 2005, the MAST (2015) authors noted a number of aspects that could be improved. Finally, Grossman et al. (2013) suggested a "more comprehensive food web modeling approach could be used to assess the role of predation on populations."

2.4 Effects on Longfin Smelt

Diverse opinions and considerable speculation characterize our understanding sources of mortality to Longfin Smelt. One direct source, entrainment in the southern Delta export facilities, and multiple indirect effects related to Delta outflow, food availability and spawning habitat, have been postulated as mortality factors and inhibitions to Longfin Smelt conservation and recovery. Perhaps a root cause of uncertainty is that a population-level context for Longfin Smelt abundance appears to be unreliable and take estimates seem best expressed as a proportion of an uncertain population. This is a precarious foundation for assessment of NDD impacts in preparing the BO.

The draft Analytical Approach for Longfin Smelt (AALS) suggests that entrainment at the export facilities has been relatively low during most water year types. However, this suggestion is uncertain because Longfin Smelt entrainment occurs during the same period as Delta Smelt and salmon, and because fish <20 mm in length are not enumerated. Alternatively, some studies have argued that entrainment (or proxies thereof) is not a driver of population dynamics (MacNally et al*.* 2010, Thomson et al*.* 2010, Maunder et al*.* 2015).

Both the draft AALS and the proposed approach for Section 7 permit application utilize the Particle Tracking Model (PTM) capability to predict potential entrainment. This corresponds to Grimaldo et al. (2009) findings that adult Longfin Smelt salvage at the southern Delta export facilities was significantly negatively related to mean Old and Middle River flows in December–February. However, a number of concerns have been expressed about the DSM2-PTM methodology based on the frequency, location, and unresolved fate of particles from the 45 day PTM analysis (CDFW 11/3/2015 draft take analysis) as well as other model issues (See Section 2.4.1).

Other potential limiting factors on Longfin Smelt abundance relate to winter-spring outflow from the Delta where the Fall Midwater Trawl abundance index suggests that increased Delta outflow promotes conditions that increase survival of larvae and small juveniles during winter and spring, producing increased abundance during fall of the first year of life (Rosenfield and Baxter 2007). Several mechanisms are postulated including greater residence time in suitable feeding and rearing habitats with greater stratification (Kimmerer 2002, Kimmerer et al*.* 2009) and the increased availability of suitable spawning habitat (Grimaldo et al*.* 2014) in western reaches of the Delta such as adjoining Suisun Marsh. None of these hypotheses have been validated and some are confounded by other systematic changes such as the effects of non-indigenous clams on primary and secondary production. Alternative analyses have also suggested that Delta outflow effects may subsequently be tempered by density-dependent survival in the juvenile life stage in marine or mesohaline waters outside the Delta, which implies that small effects of slightly lower Delta outflow under the PA may not accumulate over time (Norbriga and Rosenfield 2016).

While there are intrepid efforts through monitoring, analyses and research to resolve the unknown aspects of the Longfin Smelt population and its limiting factors, the uncertainties remain daunting. This level of multifaceted uncertainty suggests to the Panel that the BA's conclusions of "very little difference in terms of predicted Longfin Smelt relative abundance between NAA and PA" in the Delta outflow relationship, or that "larval Longfin Smelt entrainment under PA would be less than under NAA" must remain speculative until smelt population dynamics is better understood. Given the persistent uncertainties about the risk and vulnerability of Longfin Smelt to the PA, the Panel reinforces the BA's emphasis on real-time management and monitoring to minimize entrainment effects under the PA. In the interim, efforts to improve acknowledged inadequacies in monitoring design and research to fill the major gaps in Longfin Smelt life history need to be concerted.

2.4.1 Particle Tracking Model (PTM) issues for Longfin Smelt

The AALS had some very specific questions related to the DSM2 particle tracking modeling. A summary of those issues is as follows (Draft AALS, pg. 4):

> In comments provided on the 11/3/2015 draft take analysis, DFW had concerns regarding the frequency, location, and unresolved fate of particles from the 45 day PTM analysis. Regional density differences were taken into account, but not temporal (across survey) differences. Taking means of means reduces variability across water year types. Ideally CDFW desires bi-weekly injections, injection locations, number of particles injected, a greater temporal period for particle transport (i.e., 90 days), and additional flux locations to better illustrate the fate of unresolved particles (i.e., particles that do not reach Chipps Island or the CVP/SWP southern Delta export facilities) (CDFW notes that there is evidence (spring of 2012) that reduced southern Delta export pumping and low outflows in the hatching/larval period are capable of translating to increased juvenile salvage. Essentially, larvae may have been unable to exit the central and southern Delta because of low flows, and subsequently grew large enough to be counted in salvage (only fish 20 mm and larger are measured)). For this reason, CDFW suggests further exploration of the fate of unresolved particles from the PTM.

Before any more PTM modeling is done for this application, the results of this analysis need to be reviewed by hydrodynamic modelers to determine whether the particles are being stranded in the simulations due to model representations. Because the DSM2 model is a one-dimensional model, the open water regions of Franks Tract and Mildred Island are each represented as a continuously stirred tank reactor (CSTR). The DSM2 model has been calibrated such that the input/output from the CSTR can represent salinity intrusion into the Delta system. The use of the CSTR was not intended to represent the actual circulation patterns in these open water regions. Therefore, if particles are getting "stuck" in the CSTRs, this is likely a limitation of the model representation of circulation in these regions. All the CDFW suggestions on page 4 (draft AALS) to improve the PTM results assume that the underlying transport physics are well represented. Unfortunately, this is likely not the case.

2.5 Estimating and Interpreting Quantitative Uncertainties

2.5.1 Quantitative Uncertainties in the BA

The BA compares the projected effects, on fish, of future scenarios for the NAA and the PA. The Panel believes that the BA strategy for making these comparisons does not adequately represent their quantitative uncertainties. We describe three main concerns by using the model predictions for the Longfin Smelt abundance index (BA, Appendix 4.A, Section 4.A.1) as an example. However, our concerns also apply to similar statistical models used throughout Ch. 4-6 of the BA.

All BA projections are subject to two general sources of uncertainty. The first source is that values of the Delta's environmental variables (flow, X2, temperature, etc.) are unknown for future years. The BA defines 82-year scenarios for NAA and PA that specify probable future values of these environmental variables. These future values are then used as inputs to fish response models. The resulting response-model predictions are then summarized over the 82-period, using boxplots of yearly point predictions grouped by water-year type (for example, Figure 4.A-1). The BA also presents exceedance plots showing the NAA versus PA distributions of point predictions over the full 82-year period (for example, Figure 4.A-2). The Panel believes that these plot formats do a good job of displaying the first source of uncertainty.

However, these boxplot and exceedance plot formats do not represent the second general source of uncertainty, namely, the uncertainty of any prediction made by a fish response model for a given set of environmental predictor values. The Panel's first concern is that the boxplot and exceedance plot formats may be misinterpreted as representing the overall uncertainty of future fish responses to NAA and PA, which more realistically should include both the environmental and the model-prediction uncertainties. Below, we suggest how these plot formats might be restructured to include both sources of uncertainty. ***If both sources cannot be included, then we recommend that the boxplot and exceedance plot figure legends state that the plots exclude model uncertainty.***

2.5.1.1. Constructing confidence intervals

The BA does address the model prediction uncertainty of each fish response model, in all cases where those uncertainties can be estimated. The Panel approves of these efforts. For Figures 4.A-1 and 4.A-2, the fish response model is a simple linear regression, whose model-prediction uncertainty can be quantified using a confidence interval (CI) around each point prediction. The width of that CI is a function of the standard errors of the estimated regression coefficients, plus the square root of the model's mean-squared error (MSE), which measures the scatter of the model-fitting data around the estimated regression line (Neter et al. 1983). In Figure 4.A-7, such CIs are plotted as envelopes surrounding the projected 82-year time series of NAA and PA fish responses. This figure format has the advantage of displaying both the environmental and model-prediction sources of uncertainty.

However, the Panel's second concern is that the CIs in Figure 4.A-7 are too narrow, because they do not accurately represent the full uncertainty of regression model predictions. Our greatest concern here, and with other similar examples, is that the CIs describe only the uncertainty of the mean model response, that is, of the location of the regression line. Instead, the CIs should also include the MSE to represent the uncertainty of an individual prediction; they should be "prediction intervals" (Neter et al. 1983). Unfortunately, the regression model for Figures 4.A-1, 4.A-2 and 4.A-7 was obtained from a source (Kimmerer 2009) that did not report the MSE, which is needed to construct prediction intervals.

The Panel recommends that the BO authors obtain the full set of regression statistics for all regressions used in PA and NAA projections, so that true prediction intervals can be constructed for all figures like Figure 4.A-7 of the BA. Failing that, the legends on such figures should probably state that the plotted CI's are too narrow by an unknown amount, because they are not true prediction intervals.

Returning to the Panel's first concern, it should be possible to modify the boxplot format of Figure 4.A-1 to include both environmental uncertainty and model prediction uncertainty. One could replace each box with the mean, across all years in a year type, of the point predictions, and then bracket those means by approximate CIs that are based on both sources of uncertainty. We sketch three ideas for constructing such CIs:

1) Make the predictions using Monte Carlo simulation, with a random residual error (mean=0, variance = MSE) added to the regression model's prediction on each trial in each year.

2) From Figure 4.A-7, extract the largest upper confidence bound and the smallest lower confidence bound, among all years in a year type. Use these as the upper and lower bounds of the CI on all predictions for that year type. This might require a Bonferroni adjustment to control the family-wise confidence level for the multiple prediction intervals, across a year type, that this approach would encompass (Neter et al. 1983).

3) Insert estimates into the law of total variance ("Eve's law"): Var(Y) = E[Var(Y|X)]+Var(E[Y|X]). In this expression, Var(Y) is the estimation variance of the response predictions (Y) in a year type, which will include both uncertainty sources, and X is one year in a year type. The first term on the right-hand side can be simply approximated by the MSE, which is the same for all predictions. A more complicated and accurate alternative would be to calculate the mean, overall years in the year type, of the full model prediction variance for each year. This first term then quantifies model prediction uncertainty. The second term on the right-hand side is the variance of the point predictions, over the years in the year type. This second term quantifies environmental uncertainty. Once Var(Y) has been estimated, construct a symmetric 95% CI around the mean of the point predictions for the year type, using a half-width of 1.96*sqrt(Var(Y)).

2.5.1.2 Interpreting model predictions and confidence intervals

During the Panel's public meeting with agency representatives, a representative asked what purpose would be served by showing wider, albeit more realistic, CIs in Figure 4.A-7, and in similar figures elsewhere. Although he did not elaborate, his reasoning may have been as follows: The CIs for PA and NAA already show nearly 100% overlap in Figure 4.A-7 and similar figures elsewhere, and the same very high overlap would also be seen with wider, more-realistic CIs. Thus, it would seem that, even though they might become wider, the more-realistic CIs would still imply that the "true", real-world effects of PA and NAA on fish are predicted to be very similar.

However, the Panel's third concern is that the CIs in time series plots such as Figure 4.A-7 are not being interpreted rigorously. This misinterpretation becomes more serious for realistically wider CIs. To rigorously interpret the CIs, we recommend redrawing Figures 4.A-7 to 4.A-9, while omitting the solid lines showing the point (mean) predictions for PA and NAA. Those solid lines have little relevance, because all that we know, with 95% confidence, is that the "true" (real-world) PA value for any year will lie *somewhere* within the PA confidence bounds, and that the true NAA value for that year will lie *somewhere* within the NAA bounds. Thus, it is possible that true yearly values for PA lie near the bottom boundary of the CI for PA, while true NAA values lie near the top boundary of the CI for NAA. If more-realistic CIs are even wider than those in Fig. 4.A-7, then such large differences between the true PA and NAA values may be biologically significant, even though such differences lie entirely within the overlapping CIs for PA and NAA. In other words, if a fish response model makes very similar point predictions for PA and NAA, but that model has high prediction uncertainty, then we have little confidence that the real-world outcomes for PA and NAA will also be similar.

The Panel recommends that time series plots such as Figure 4.A-7 omit the solid lines depicting the point predictions from the fish response model, because the point predictions are unlikely to be the actual future outcomes.

Finally, we note a more subtle consequence of using weak regression models, such as the regression model with $r^2 = 0.36$ that was used to predict Longfin Smelt entrainment (Sec. 2.3.2). If a regression model has high uncertainty (low r^2), then its coefficients tend to be small in magnitude; in the extreme case of their statistical non-significance, the coefficients cannot be distinguished from having zero magnitude. And small regression coefficients imply that model predictions are not very sensitive to changes in the predictor variables. Thus, weak regression models will generally predict similar fish responses to the PA and NAA scenarios, even if those scenarios assume distinctly different values for flow, X2, temperature, and other environmental driving variables. In other words, the small differences between the point predictions for PA and NAA, which are evident in many plots like Figures 4.A-1, 4.A-2 and 4.A-7, may be largely due to the use of highly uncertain fish response models.

2.5.2 Confronting Uncertainty in the Analytical Approach for the BO (AABO)

The Panel's understanding is that the final BO will draw heavily on the methods and results of the BA. Thus, if the BA frequently underrepresents the uncertainties of its model projections, the Panel is concerned that the BO developers may view uncertainty as a somewhat minor issue, and may also accept the BA models' point predictions as highly likely outcomes. The Panel sees evidence of this in the draft AABO, which mentions "uncertainty" only three times, two of which relate only to uncertain future climate. In particular, the conceptual model for determining a jeopardy opinion (Figure 1, AABO) makes no mention of uncertainty. We note that treating uncertainty as a minor issue is inconsistent with McElhany et al. (2000), whose guidelines for Viable Population Size, Critical Population Size and other VSP components all contain at least one guideline that specifically targets uncertainty.

The draft AABO may be trying to address uncertainty, albeit indirectly, with its intention to assess the "weight of evidence" for the effects of each action component (Table 2-1, AABO). However, although "weight of evidence" is an attractive concept, it is difficult to quantify in any objective way. ***The Panel recommends that the AABO describe how weights of evidence will be determined.***

The Panel also believes that the AABO needs to address uncertainty more directly when formulating its decision-making sequence for determination of jeopardy (AABO Table 2-2). At present, the decision sequence assumes that accurate True/False decisions can be made about the "likelihoods" of stressor occurrences, species exposures, species responses, and so forth. For the True/False decisions to be objective, such likelihoods should be quantified whenever possible. However, likelihood estimates will be highly uncertain in many cases. For example, due to model-prediction uncertainty, suppose that a likelihood (probability) is estimated to be 0.6 (likely), but the CI on that estimate ranges from 0.35 (unlikely) to 0.85 (likely). How would such a result be translated into a True/False decision about the likelihood? ***The Panel recommends that the AABO specify how decisions will be made when likelihood estimates, and projected changes in likelihood, are highly uncertain.***

2.6. Adaptive Management (AM)

According to Section 7 of the ESA, the USFWS and NMFS (the Agencies) must include in the BO a determination of whether or not the PA will lead to Jeopardy or Adverse Modification of Critical Habitat. The Panel suggests that such a determination must be based on (1) an accurate acknowledgement of the high degree of uncertainty regarding the effects of the PA; and (2) because of the legal obligation to err on the side of the species in cases where there is high uncertainty and insufficient data, a critical examination of the extent to which the PA includes adequate provisions for responding to new information about its effects on the species and critical habitat in ways that will prevent jeopardy to the species and/or adverse modification of habitat.

Put differently, there are potentially three ways the Agencies can deal with the lack of certainty and data inherent in assessing the effects of the PA. The first two are clearly stated in the Section 7 Consultation Handbook. Where significant data gaps exist there are two options: (1) if the action agency concurs, extend the due date of the BO until sufficient information is developed for a more complete analysis; or (2) develop the BO with the available information giving the benefit of the doubt to the species, which could result in a jeopardy opinion preventing the PA from going forward. A third possible way to err on the side of the species in situations where uncertainty is high would be to go forward with the project (no jeopardy with Reasonable and Prudent Measures (RPMs), or Jeopardy with Reasonable and Prudent Alternatives (RPAs)) with a firm commitment and explicit plans to modify management as needed to avoid Jeopardy or Adverse Modification as new information becomes available, e.g. through adaptive management (AM) and, where AM is not practical or feasible, structured decision making and/or scenario planning (see Allen et al. 2011 and the special issue of *Journal of Environmental Management* in which it appears for a comprehensive overview of these different approaches to natural resource management decision making).

AM is an approach to natural resource management aimed at reducing uncertainty, building knowledge and improving management outcomes over time. It goes beyond a trial and error approach in that it involves careful articulation of goals, identification of alternative management objectives, hypotheses of causation and developing procedures for the collection of data followed by evaluation and reiteration (Allen et al. 2011).

AM is a form of structured decision making (SDM), which is an organized and transparent approach to making decisions by identifying and evaluating alternatives and justifying complex decisions (Allen et al. 2011). AM is more robust than SDM, however, because, when done correctly, it adds to the process iteration and theoretically results in higher order learning.

A distinction is often made between “active” and “passive” AM based on the way uncertainty is recognized and treated. In active AM, managers attempt to reduce uncertainty by deliberately probing for information to evaluate testable hypotheses about the effects of interventions, while in passive AM, there is a lack of explicit experimentation and learning is a “useful but unintended byproduct of decision making” (Williams 2011). While both are useful for achieving management objectives in different contexts, they differ in the degree to which the objectives that guide decision making emphasize the reduction of uncertainty.

AM scholars generally agree that active AM is preferable, but realistically only feasible where both uncertainty and controllability are high, i.e., where the system can be manipulated to allow for structured experimentation. When uncertainty is high and controllability is low, developing and analyzing scenarios through “scenario planning” is generally considered more appropriate (Allen and Gunderson 2011, Peterson et al. 2013).

Scenario planning refers to a framework for developing more resilient conservation policies when faced with high uncertainty and high uncontrollability. Peterson et al. (2013) characterize a scenario in this context as “an account of a plausible future”:

> “Scenario planning consists of using a few contrasting scenarios to explore the uncertainty surrounding the future consequences of a decision. Ideally, scenarios should be constructed by a diverse group of people for a single, stated purpose. Scenario planning can incorporate a variety of quantitative and qualitative information in the decision-making process. Often, consideration of this diverse information in a systemic way leads to better decisions. Furthermore, the participation of a diverse group of people in a systemic process of collecting, discussing, and analyzing scenarios builds shared understanding “(Peterson et al. 2013).

The Panel recommends that the BO includes a critical analysis and evaluation of the approach to AM proposed in the PA for two main reasons. First, best available science suggests that, where feasible, AM is the best way to deal with uncertainty and assess and respond to the effects of management actions so as to be able to address unexpected outcomes and the need for mid-course corrections, and to continue to learn and fill data gaps. This is the approach recommended in McElhany et al. (2000), and in numerous past reviews of the CVP/SWP, and precursors of the current PA.

Second, it is in the Agencies' best interest to work out the details of the AM program in the BO to avoid possible legal challenges. An adaptive management approach is legally mandated by the Delta Plan and it is generally expected by courts reviewing ESA decisions. Fischman and Ruhl (2015) investigated U.S. Federal Courts opinions published through January 1, 2015 to understand how AM has been judged in the courts and they identified three shortcomings in AM implementation that recur in judicial cases overturning agency decisions: (1) failure to establish objectives or failure to describe monitoring protocols for a plan or project; (2) failure to define decision thresholds in monitoring; and (3) failure to identify specific actions that will be triggered when thresholds are crossed.

These ideas have already been explored by courts in the context of the Bay Delta system. In a series of decisions regarding ESA compliance in the operation of the CVP between 2006 and 2011, Judge Wanger looked at how agencies may rely on AM to ensure that water operations will not "jeopardize the continued existence" of any listed species. He compared the conservation approaches of the FWS in regard to the Delta Smelt with NMFS approach in regard to the anadromous fishes. While both agencies employed AM, Judge Wanger upheld the NMFS approach and remanded the FWS plan. While the NMFS AM protocol contained definite, substantive criteria (e.g., temperature thresholds) that triggered revision of the water system operations to avoid jeopardy, the FWS approach failed to provide enforceable, precise criteria to serve as thresholds. The Judge also overturned the FWS adoption of "a procedurally elaborate" AM protocol identifying danger thresholds for the Delta Smelt because it failed to specify what alternative actions would be taken if the threshold was crossed, saying only that it would convene a working group to "consider" a range of operational changes in the water system. In contrast, the NMFS approach specified specific enforceable requirements that would be imposed if the system crossed thresholds for the anadromous fish (Fischman and Ruhl 2015).

Therefore, to ensure that the BO is in alignment with the best available science and is legally defensible, a management program that includes active AM, where feasible, along with passive AM, should be an integral part of the PA and should include explicit plans for ongoing monitoring of the status of the species and the direct and indirect effects of (1) the design of fish facilities (the footprint of the PA installation), (2) the operations (whether the PA is jeopardizing species or adversely modifying habitat), and (3) restoration and mitigation activities (to determine how they are affecting the species and whether the PA is working to move toward recovery).

Based on the BA, it is clear that the action agency and applicant intend to employ an AM approach to the design and operation of the proposed facilities to prevent jeopardy and adverse modification throughout the life of the project and to the restoration/mitigation aspects of the PA to ensure that recovery is progressing. Chapter 3 of the BA has numerous references to AM and in each case the reader is referred to Section 3.4.7, Collaborative Science and Adaptive Management Program, for details. However, Section 3.4.7 simply states that the AM program "will be used to consider and address scientific uncertainty regarding the Delta ecosystem and to inform implementation of the operational criteria in the near term for existing BiOps … as well as in the future for the new BiOp and 2081(b) for this PA." (BA 3-72). What is unclear is exactly how AM will be structured, how it will be funded, and how it will be carried out. Directing explicit attention to the adequacy of AM plans in the forthcoming BO will be important because the Panel is in agreement that the treatment of AM in the BA is lacking in important details.

Since there is currently no mention of AM or even monitoring in the AABO, the inadequacy of the PA's plans for AM is likely to be overlooked unless the AABO is revised***. Therefore the Panel recommends that the Agencies articulate an explicit plan in the AABO for evaluating the adequacy of the plans for AM, based on best available knowledge regarding effective AM design and implementation.***

The next subsections describe features of a strengthened AM plan.

2.6.1. AM structure

The BA says AM for the PA "will build on CSAMP and CAMT". More details are needed in writing the BO. Will there be a new Delta AM team? What will be the criteria for selection to the team? Will there be independent review of the AM program? And how will the AM program be funded?

2.6.2 AM Process

The BO should provide more details about how AM will be carried out to reduce the chances of jeopardy or adverse modification related to (1) the design of facilities, (2) operations, and (3) restoration/mitigation. AM should also be used to flesh out conceptual models of species' life cycles that currently are incomplete or are missing information. The approach to assessing future effects should include explicit commitment to taking advantage of surprise events to learn (floods, droughts, levee failure events, alternative operations such as the False River emergency barrier installation in 2015). In addition, baseline monitoring of water quality, water circulation (flow, velocity), fish population attributes (both of listed species and predator communities) at the NDD inlet locations should begin in 2016 so that the effects of the PA and the effectiveness of adaptive management approaches can be measured when the PA comes online.

In the context of the PA, an active AM approach would seek to learn more about and be responsive to both direct and indirect effects of the PA and would include:

- Clear objectives for each species
- Description of monitoring protocols
- Indicators and triggers for various anticipated impacts
- Establishment of decision thresholds based on monitoring data
- Specification of actions that will be triggered when thresholds are crossed.

The BA continually refers to Section 3.4.7 (Collaborative Science and Adaptive Management Program), and AM generally, but is lacking in details about monitoring plans and triggers. For example, Sections 3.1.5 and 3.3.3 of the BA describe the real-time decision process, aimed at responding to the potential for adverse conditions as they arise, but there is no information to judge how effective this process would be under the PA. The BA does not attempt to consider the effects of real time management, instead deferring such assessment to the future, saying that *"the operating criteria will be periodically evaluated and possibly modified through the adaptive management process"* (BA 3-97). We recommend that the real-time operational decision making process be linked more explicitly to a formal AM program.

As stated earlier in this report, the BO should describe the management guidelines and actions for reservoirs on the Sacramento and American Rivers that are linked to conditions in the Delta such that flows released from the reservoirs would be altered in response to the PA. If these actions involve real-time management of the reservoirs, what are the conditions in the Delta that would cause change in water released from the reservoirs?

In addition, baseline monitoring of water quality, water circulation (flow, velocity), fish population attributes (both of listed species and predator communities) at the NDD inlet locations should begin in 2016 so that the effects of the PA and the effectiveness of adaptive management approaches can be measured when the PA comes online.

2.6.3 Adaptive Management Challenges

*C*ompliance with the ESA through AM is difficult. The ESA assumes a “linear process of examination...a single, well-defined ‘agency action,’” which is counter to the assumption of complexity, non-linearity, and uncertainty of AM. Laws and regulations associated with the ESA focus on preservation and minimization of human impact and persistence of certain individual species. They enforce a front-end approach where the underlying assumption is that people can predict outcomes of a certain action before that action has taken place. Trying to reconcile the two paradigms is difficult.

The Panel acknowledges the challenges associated with implementing active AM in the Bay Delta context. Numerous independent scientific review panels and other reports have commented on this over the years. The Panel also recognizes that the BO will not be able to pre-plan AM triggers for every decision; and that some potentially harmful effects will be easier to respond to than others. For example, unanticipated impacts related to flows may be more difficult to plan for and respond to than non-flow related impacts.

Finally, in the draft BO the Agencies should consider which aspects of the PA demand active AM to reduce the risk of jeopardy or adverse modification, and which aspects should be managed with other structured decision making approaches (Allen et al. 2011). As stated above, according to the best available science related to decision-making in complex adaptive systems, in cases where there is high uncertainty, low controllability, and high risk (e.g., where the remaining listed species are few in number), an experimental approach may not be feasible or appropriate (Allen and Gunderson 2011). In those cases, structured decision making involving scenario planning may be more appropriate than AM. The Agencies should commit to a process of determining when and in relation to which aspects of the PA AM is appropriate, and where it is not feasible or where the stakes are simply too high for an experimental approach. These determinations and their rationales should be clearly stated in the BO.

3. List of Panel Recommendations

The following table lists the Panel's recommendations, indicating their location (section and page number) in this report. Recommendations are numbered by their order of occurrence in the report, and the numbers do not represent their importance or priority for action. In the table, the Analytical Approach to the BO is designated "AABO".

Number	Recommendation	Section	Page
1	That the evaluation of the influence of climate change on the PA operations should be longer than 2030.	2.1.4	21
2	Evaluate the compounding effect of the PA and dry years, and the potential for depensatory mortality, using a series of continuous dry years.	2.2.3	25
3	That all fish screen criteria described by NMFS (2011) should be explicitly addressed in the BO.	2.2.4.1	27
4	Additional effort to evaluate PA effects on critical salmonid habitats, including natural and restoring tidal wetlands predictably under the large-scale influence of the NDD operations.	2.2.5	29
5	Evaluate water removal effects (up to ~40% of Sacramento River flow depending on month and water year) during tail end migration periods when juvenile salmonid abundance is low, in addition to when most juveniles are present in the Delta.	2.2.6	30
6	Evaluate the extent to which the PA may alter the abundance of Striped Bass and other predators that consume ESA-listed species.	2.2.7	30
7	Evaluate the PA effects on wild fry, parr and smolt migrants, given that Fall-run Chinook Salmon are likely an important prey of Killer Whales.	2.2.7	31
8	That the AABO describe how it will evaluate project effects on diversity and spatial structure.	2.2.8	32
9	That approaches for using precaution and adaptive management be described in the AABO.	2.2.8	32
10	That the abiotic habitat effects of the PA be explicitly considered within the context of the new Bever et al. (2016) findings, while recognizing that this exercise cannot include turbidity due to lack of a turbidity model for the PA simulation	2.3.4	43

	(i.e., the abiotic station index of Bever et al. 2016 should be modified to include salinity and current speed, but not turbidity). We also recommend that the water-distribution system within Suisun Marsh be qualitatively assessed for its potential influence on the salinity, current speed, and turbidity within the high-abundance area for Delta Smelt, as described above and as identified in Figure 2.		
11	That boxplot and exceedance plot figure legends state that the plots exclude model uncertainty, unless that uncertainty can be incorporated.	2.5.1	49
12	That the BO authors obtain the full set of regression statistics for all regressions used in PA and NAA projections, so that true prediction intervals can be constructed for all figures like Figure 4.A-7 of the BA. Failing that, the legends on such figures should probably state that the plotted CI's are too narrow by an unknown amount, because they are not true prediction intervals.	2.5.1.1	50
13	That time series plots such as Figure 4.A-7 omit the solid lines depicting the point predictions from the fish response model, because the point predictions are unlikely to be the actual future outcomes.	2.5.1.2	52
14	That the AABO describe how weights of evidence will be determined.	2.5.2	53
15	That the AABO specify how decisions will be made when likelihood estimates, and projected changes in likelihood, are highly uncertain.	2.5.2	53
16	That the BO includes a critical analysis and evaluation of the approach to adaptive management (AM) proposed in the PA.	2.6	55
17	That the Agencies articulate an explicit plan in the AABO for evaluating the adequacy of the plans for AM, based on best available knowledge regarding effective AM design and implementation.	2.6	57

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Appendix 1 – Materials for CA WaterFix Aquatic Science Peer Review – Phase I

For Review:

1. NMFS Biological Opinion Draft Analytical Approach
    a. Draft analytical approach
    b. South Delta Conceptual Model

2. 2016 CWF Biological Assessment (BA) Sections for Review
    a. Chapter 6 (Delta Smelt Effects Analyses only)
    - Chapter 6: Effects Analysis for Delta Smelt
    - Appendix 5.A, CalSim II Modeling and Results
    - Appendix 5.B, DSM2 Modeling and Results
    - Appendix 5.G, Projects to Be Included in Cumulative Effects Analysis for the Conveyance Section 7 Biological Assessment
    - Appendix 6.A. Quantitative Methods for Biological Assessment of Delta Smelt

    b. Chapter 5 (Salmonids and Sturgeon Effects Analysis)

    Note: All methods sections listed can be found in Appendix 5.D Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley steelhead, Green Sturgeon, and Killer Whale

    - Section 5.4.1.3.1.1.1 North Delta Exports: For overall species response to this component of the proposed action Methods: Section 5.D.1.1.1 North Delta Exports (for near-field effects only; other effects are in Sections 5.D.1.2 Indirect Mortality Within the Delta (Through-Delta Survival) and 5.D.1.3 Habitat Suitability)

    - Section 5.4.1.3.1.1.1 North Delta Exports and 5.4.1.3.1.1.1.3 Predation: For effects of intakes on predation and travel time

Methods: 5.4.1.3.1.1.1.2 Impingement, Screen Contact, and Screen Passage Time (assuming "travel time" = screen passage time)

There is no analysis of predation in Appendix 5.D

- Section 5.4.1.3.1.2.1 Indirect Mortality Within the Delta: For characterization of effects that are in-Delta yet beyond the immediate vicinity of the north Delta intakes

Methods: Section 5.D.1.2 Indirect Mortality within the Delta (Through-Delta Survival)

- Section 5.4.1.3.1.2.1.3. Through-Delta Survival: For consideration of effects on population of performance criteria of minimum 95% survival rate through north Delta intake reach

Methods: Section 5.D.1.2.2 Delta Passage Model, Section 5.D.1.2.3 Analysis Based on Newman (2003), Section 5.D.1.2.4 Analysis Based on Perry (2010), and Section 5.D.3 Life Cycle Models

- Section 5.4.1.3.1.2.2.1.1 Bench Inundation: For effects of habitat loss in north Delta due to operations of north Delta intakes

Methods: Section 5.D.1.3.1 Bench Inundation

- Section 5.4.2.1.3.1.1 Spawning, Egg Incubation, and Alevins: For effects of operations in upstream areas during summer and fall months, especially given inability of modeling to capture real-time management

Methods: Section 5.D.2.1 Water Temperature Methods and Section 5.D.2.2 Spawning Flow Methods

3. Longfin Smelt Analytical Framework and Effects Analysis

   a. Draft Analytical Approach
   b. 2081 Take Analysis
   c. Longfin Smelt Quantitative Analyses

d. PTM results

Background information:

Biological Assessment

1. 2016 CWF Biological Assessment

    a. **DSM2 Grid Version 2.0**

Federal Policies and Guidance

2. USFWS Section 7 Analytical Framework, p.138-139
3. Endangered Species Act Section 7 Consultation Handbook
4. 2008 USFWS Biological Opinion on the Long-Term Operational Criteria and Plan (OCAP) for coordination of the Central Valley Project and State Water Project
5. Designated Delta Smelt Critical Habitat Map
6. Designated Delta Smelt Critical Habitat
7. NMFS Aquatic Species Critical Habitat
8. Warranted But Precluded 12-Month Finding to Uplist Delta Smelt to Endangered Status

Research

9. Lindley et al. 2007
10. McElhaney et al. 2000
11. **2015 Final MAST report** "An updated conceptual model for Delta Smelt: our evolving understanding of an estuarine fish."
12. Final Report on Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem
13. Effects Analysis State Water Project Effects on Longfin Smelt, California Department of Fish and Game, 2009.
14. Nobriga, M. L., and J. A. Rosenfield. 2016. Population dynamics of Longfin Smelt in the San Francisco Estuary II: disaggregating forces driving long-term decline of an estuarine forage fish. Transactions American Fisheries Society 145(1):44-58

15. **FINAL REPORT:** A Synthesis of Delta Smelt Growth and Life-History Studies, Prepared for the California Department of Fish and Wildlife by: James A. Hobbs, Department of Wildlife, Fish and Conservation Biology University of California-Davis, December 2015.

Reviews

16. Independent Review Panel Report: BDCP Effects Analysis Review, Phase 3 - March, 2014
17. Report of the 2015 Independent Review Panel on the Long-term Operations Biological Opinions (LOBO) Annual Review (December 16, 2015)
18. Delta Smelt 5-Year Review

Supplemental Materials Requested by the Panel:

- **DWR Delta Simulation Model Grid Version 2.0**
- **2016 CWF Biological Assessment Appendix 5.B Figure 5.B 2-3**
- **2016 CWF Biological Assessment Appendix 5.B Figure 5.B.2-6**
- **Sobeck 2016**
- **20mm Longfin Smelt monitoring methods**
- **Fish Facilities Study Work Plan**
- **2016 CWF Biological Assessment Section 3.4.8**

Additional Materials Provided at the Review:

- **Mount et al., 2013**
- **Vogel et al., 2008**

Presentations:

- **Project Overview –BG Heiland (DWR)**
- **Endangered Species Act Overview: Section 7 Process and Biological Opinion –Jane Affonso (USFWS), Erin Strange (NOAA)**

- A Brief Overview of the California Endangered Species Act and Incidental Take Permitting –Shannon Little (CDFW)
- Status Update ESA Section 7 Consultation for California WaterFix –Kim Turner (USFWS)
- NMFS Biological Opinion Draft Analytical Approach for Salmonids and Sturgeon -- Cathy Marcinkevage (NOAA)
- Salmonids and Sturgeon Effects Analysis –Rick Wilder/Marin Greenwood (ICF)
- Delta Smelt Effects Analyses –Marin Greenwood (ICF)
- Longfin Smelt Analytical Framework and Effects Analysis –Marin Greenwood (ICF)
- Independent Science Panel Initial Recommendations

Public Comment:

- 2016 California WaterFIx Aquatic Science Peer Reivew –Doug Obegi, Natural Resources Defense Council
- Major Modeling Issues for the WaterFix Biological Assessment –Deirdre Des Jardins, California Water Research
- 2016 California WaterFix Aquatic Science Peer Review –State Water Contractors

Appendix 2. Memo from M. Greenwood on modeled Sacramento R. flows.
See attached document, ICF_Hydrograph.pdf.

Panel note on Appendix 2:

In Appendix 2, there is subtle change noted in the figure notes that state the Sacramento Inflow is defined at a location south of the NDD withdrawal facilities rather than at its traditional location at Freeport. This change gives the impression that the NDD withdrawal is at a location above the Delta. However, the inlet locations are south of Freeport, in the legal domain of the Delta.

This concept is important for the CA Department of Water Resources' Dayflow program (http://www.water.ca.gov/dayflow/). The definition of the Sacramento inflow location in the Dayflow program, which is used to calculate Delta Outflow and OMR should not be changed, in order for comparisons of pre- and post-project to be done without confusion. In addition, this provides clarity in reporting the total export from the Delta from both the Sacramento and San Joaquin rivers. Once the NDD facility is operational, an additional term, NDD, the amount exported from the NDD facility, must be added to the Dayflow suite of calculations. The addition of the NDD term will be very straightforward to include since this program is simply a water mass balance calculation.

Memorandum

Date:	April 18, 2016
To:	Independent Review Panel, 2016 California WaterFix Aquatic Science Peer Review
From:	Marin Greenwood, ICF
Subject:	**Request for graphical representation of the effects on Sacramento flow of the rules for water diversion and the amount of water that will be diverted from the North Delta (Specific panel request #1)**

Introduction

This memorandum addresses the following specific request for information and materials:

1. *Request for graphical representation of the effects on Sacramento flow of the rules for water diversion & the amount of water that will be diverted from the North Delta.*
    a. *The long tables in Ch. 3 are too complicated to easily grasp.*
    b. *Request for hydro period graphs that simply capture the differences in relative water diversion from the Sacramento by the dual conveyance facility*
        i. *For a dry, average, wet, and extremely dry water year, provide the amount (cfs) of water that will be diverted each month. This should be presented in a series of graphs with month on the x-axis. A range in the diversion should be presented to reflect the various decisions that affect water diversion.*
        ii. *On the same hydrograph, show the diversion as a percentage of total water available in the Sacramento River at the diversion site*
    c. *For the same scenarios as the diversion at the dual conveyance facility, provide hydrographs for the Sacramento River below the diversion site, such as at Rio Vista or in the Cache Slough complex*
    d. *If reasonable, for the same scenarios above, show the position of X2?*

The memorandum includes information regarding the bypass flows as proposed and modeled, in addition to the above specific hydro period requests.

Bypass Flow Criteria

The Independent Science Panel found the tables explaining North Delta Diversion (NDD) bypass flow criteria (i.e., Tables 3.3-1 and 3.3-2 in the working draft Biological Assessment) challenging to interpret. As an example graphical representation of these criteria, Figure 1 illustrates the potential diversions that would be possible based on the bypass flow criteria during December-April, which is a period of particular management importance for outmigrating juvenile salmonids (e.g., Winter-Run Chinook Salmon). Note that other regulatory constraints affect the actual bypass flows (e.g., downstream water quality requirements), so that the actual percentage of flow diverted does not necessarily correspond to the amount allowable from the bypass flow criteria alone. This is illustrated in Figure 2 below. The regulatory criteria often controlling Delta operations are contained in the State Water Resources Control Board's (SWRCB) 2006 Water Quality Control Plan (WQCP) for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary , commonly referred to as D-1641 for the SWRCB's Water Right Decision 1641 from which the objectives were derived.[1] Among these criteria, which are intended to benefit a variety of in-Delta user groups, are flow and operational criteria intended to provide reasonable protection of fish and wildlife beneficial uses. It is important to note that the California WaterFix proposes to adhere to these objectives, as described in Chapter 3 of the working draft BA. Select important flow-based criteria from the WQCP are shown in Table 1. These provide important context for the specific hydro period graphs included in response to the Independent Science Panel's request.

Requested Hydro Period Graphs

The Independent Science Panel's request for representative hydro period graphs is addressed below based on CalSim-II modeling outputs of the proposed California WaterFix action scenario (proposed action, or PA) and, for context, the no action alternative (NAA). As described in the presentation to the panel, caution should be applied when examining individual years from CalSim-II outputs, for the purpose of the model is to provide longer term, planning-level comparisons (e.g., averages by water year types). In addition to the material requested by the panel, it is important to provide context for overall operational changes under WaterFix by also considering the role of south Delta exports. This is shown below in additional plots.

The selected example years were chosen by examining the mean water year (February-January, per the CalSim-II modeling) Sacramento River at Freeport flow. The following years were selected:

- Extremely dry year: the critically dry year of 1924 (mean Freeport flow = 9,345 cfs) (Figures 3 and 4)

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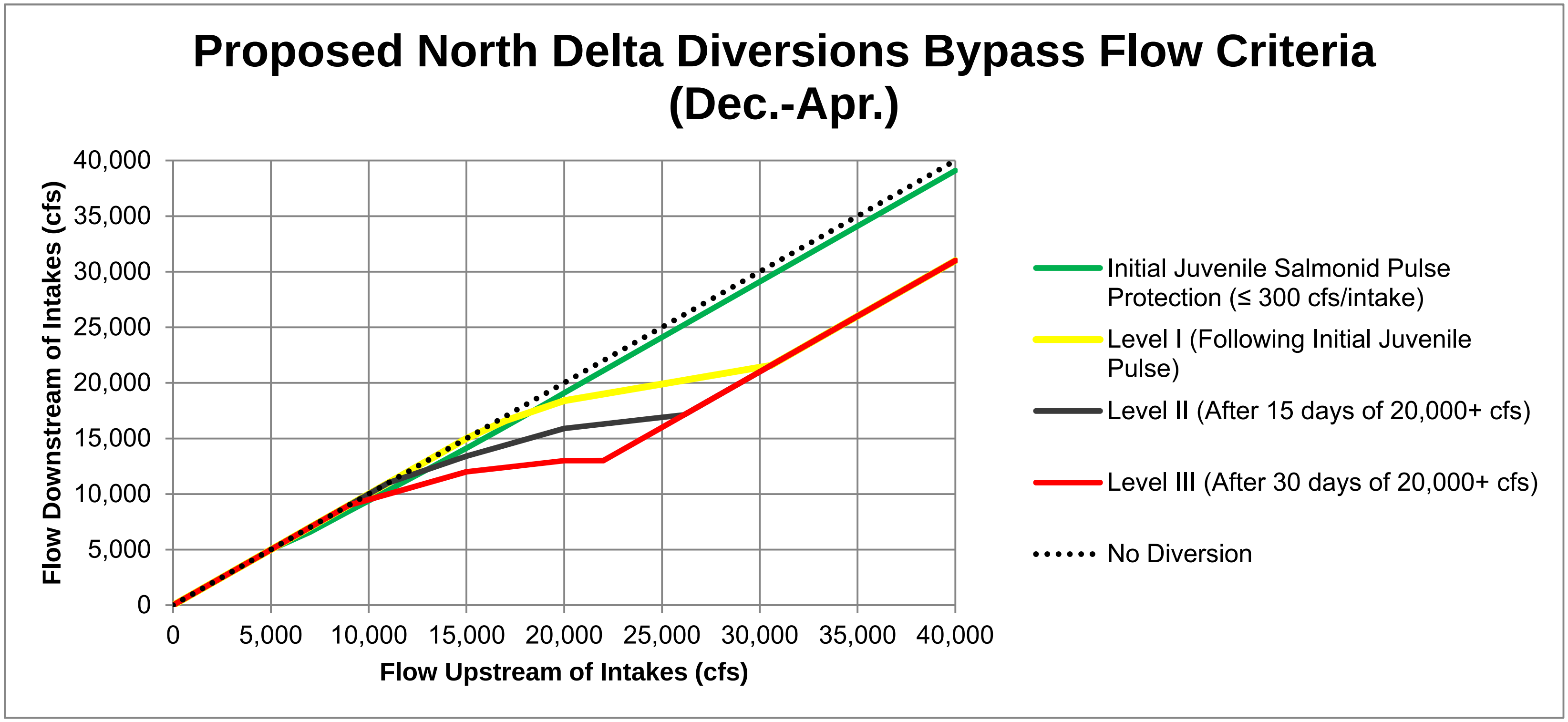
[1] State Water Resources Control Board. 2006. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. December 13. Division of Water Rights, State Water Resources Control Board, Sacramento, CA. Available: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/wq_control_plans/2006wqcp/index.shtml

- Dry year: 1989 (mean Freeport flow = 16,003 cfs) (Figures 5 and 6)
- Average year: the below normal year of 1968 (mean Freeport flow = 21,927 cfs) (Figures 7 and 8) and the above normal year of 1980 (mean Freeport flow = 21,768 cfs) (Figures 9 and 10)
- Wet year: 1996 (mean Freeport flow = 36,368 cfs) (Figures 11 and 12)

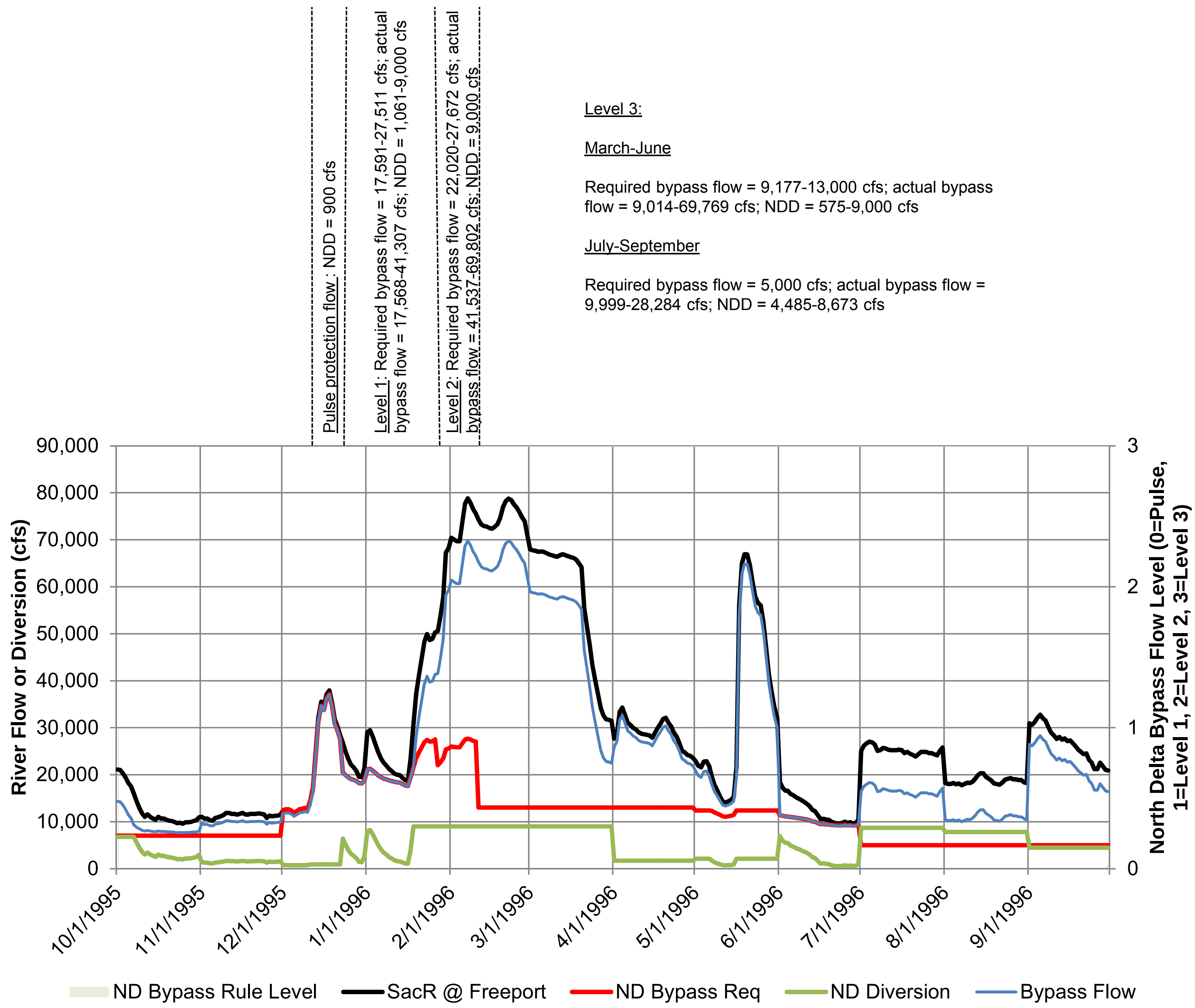
Each example year has two plots below, per the panel request and also to provide the important context for the effects of dual conveyance operations. The first plot includes the mean monthly water flow exported by the NDD, in addition to the percentage of Sacramento River flow upstream of the NDD (at Freeport) that this flow represents. The first plot's export flow axis is scaled to 10,000 cfs in order to allow the different years to be easily compared, in relation to the maximum possible 9,000-cfs diversion. Also included on the first plot is the export to inflow (E:I) ratio, which is a measure of water exported divided by water inflowing to the Delta. This ratio is included to recognize that with implementation of dual conveyance, a certain amount of export pumping would be shifted from the south Delta to the north Delta, so that south Delta exports under the PA would appreciably less than under the NAA. As noted on the first plot, the inflow (I) term for the PA is the Sacramento River downstream of the NDD (i.e., accounting for the water exported by the NDD); NDD exports are not included in the export (E) term for the PA (Figures 3,5,7,9,11).

The second plot for each example year includes the mean monthly flow in the Sacramento River at Rio Vista (for PA, as requested) and X2, the position of the 2-ppt near-bottom isohaline, with X2 shown for both the PA and NAA scenarios in order to emphasize that X2 is dependent on both south and north Delta exports. SWRCB WQCP outflow-based objectives occur year-round for the reasonable protection of fish and wildlife beneficial uses (Table 1); these are met under the PA and NAA (Figures 4, 6,8,10, 12).



Source: Adapted from Greenwood and Chilmakuri (2014: http://www.eposters.net/pdfs/habitat-restoration-and-water-diversion-effects-of-the-proposed-bay-delta-conservation-plan-on-the.pdf)

Figure 1. Proposed North Delta Diversions Bypass Flow Criteria (December-April example).

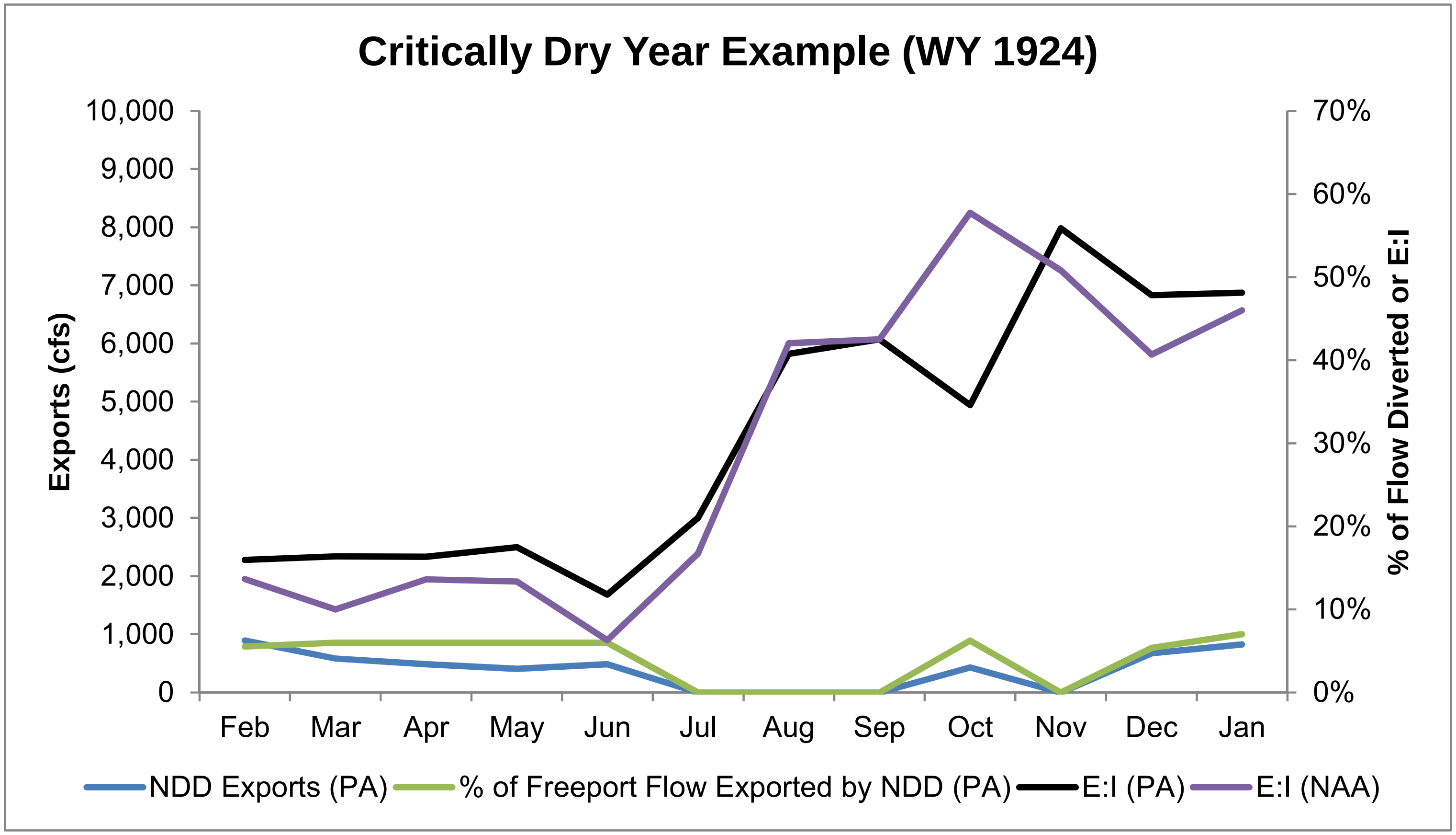


Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: the grey shading indicates the bypass rule (0=pulse/low level pumping, 1=level I, 2=level II, and 3=level III). 'SacR @ Freeport' = flow upstream of the NDD. 'ND Bypass Req' = the required bypass flow based on the criteria/rules (see Tables 3.3-1 and 3.3-2 in the working draft Biological Assessment). 'ND Diversion' is the water exports by the NDD. 'Bypass Flow' is the flow that was modeled to have been bypassed (i.e., occurred just downstream of) the NDD.

Figure 2. Example Year Daily Patterns and Operation of the North Delta Diversions

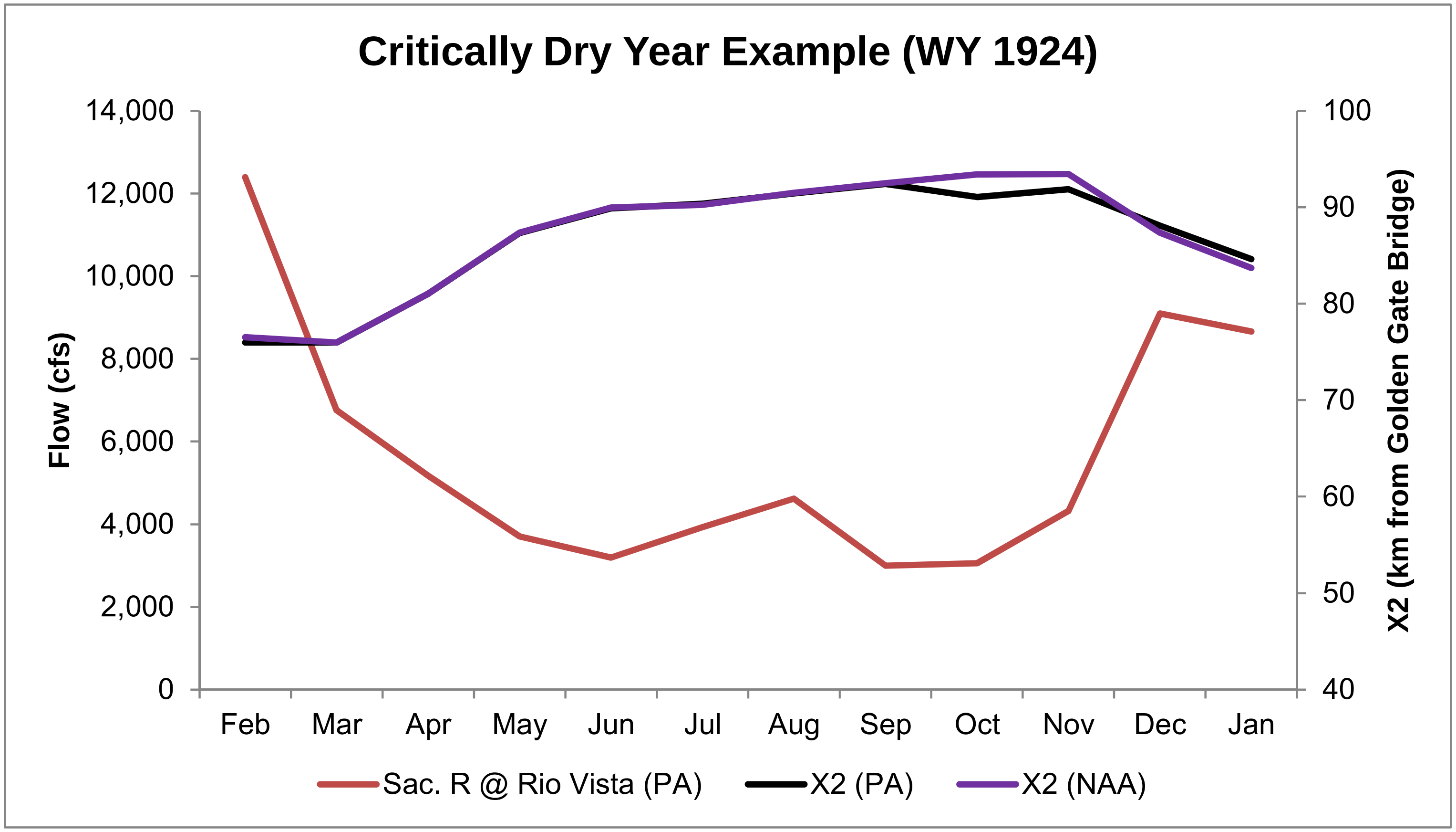
Table 1. Selected Flow-Related Water Quality Objectives for Fish and Wildlife Beneficial from the SWRCB (2006) Bay-Delta Water Quality Control Plan.

Objective	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SWP/CVP Export Limits				1,500 cfs								
Export/Inflow (E:I) Ratio	0.65	0.35					0.65					
Min. Delta Outflow	4,500-6,000 cfs						3,000-8,000 cfs					
Habitat Protection Outflow		7,100-29,200 cfs										
Rio Vista Flows									3,000-4,500 cfs			



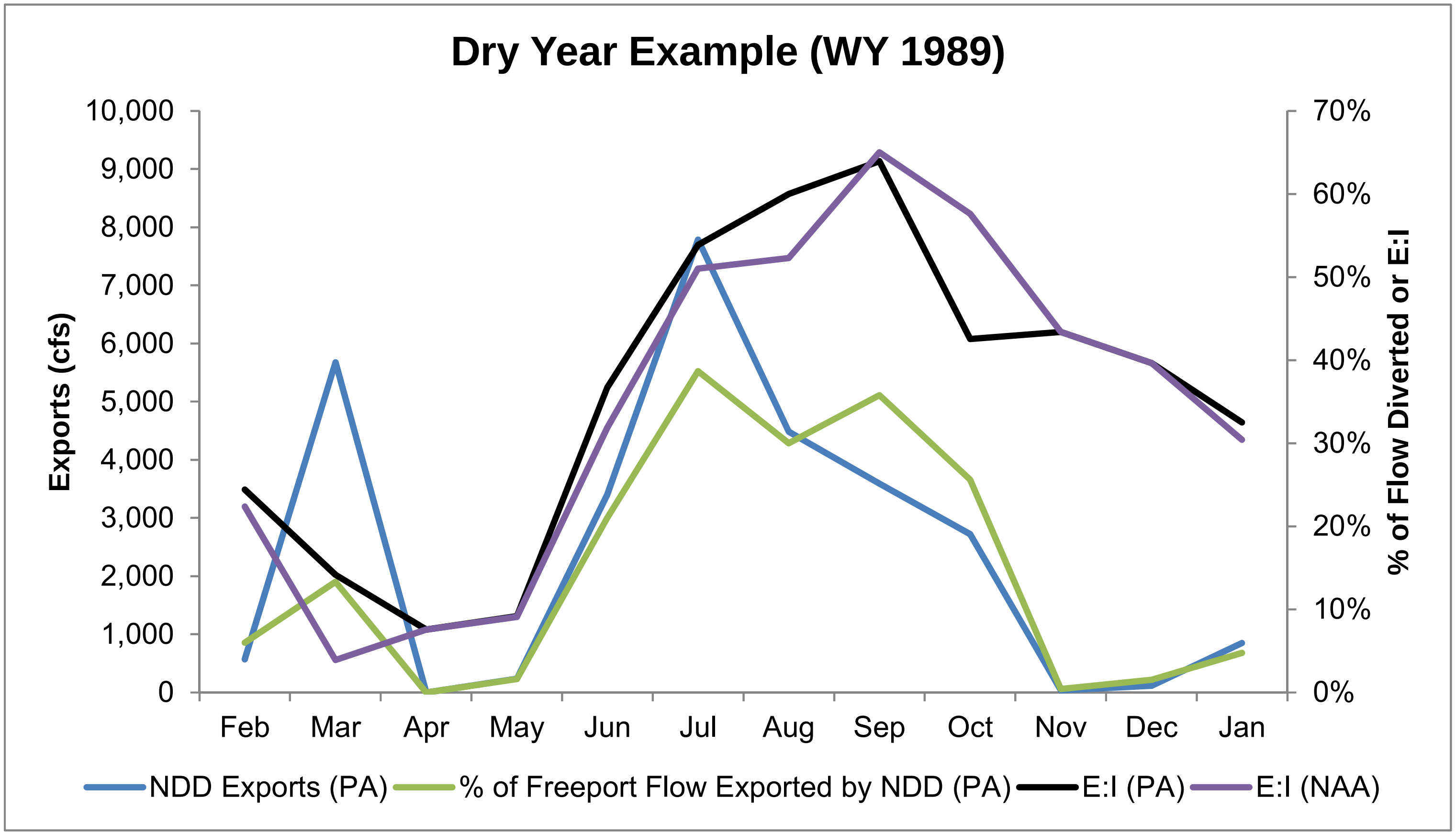
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: E:I = exports to inflow ratio; the inflow (I) term for the PA is the Sacramento River downstream of the NDD; NDD exports are not included in the export (E) term for the PA.

Figure 3. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1924.



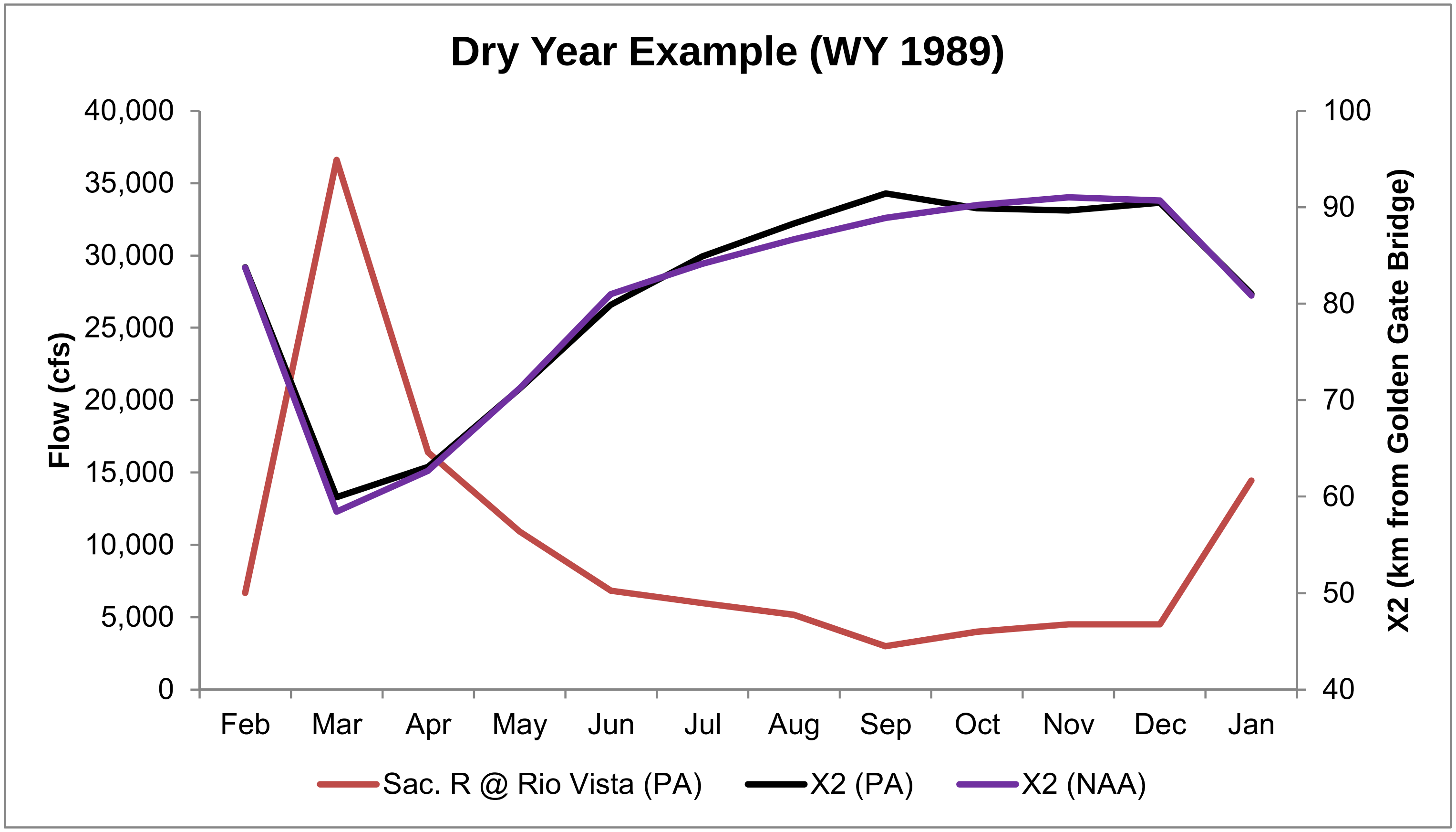
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment.

Figure 4. Modeled Mean Monthly Sacramento River Flow at Rio Vista and X2, Water Year 1924.



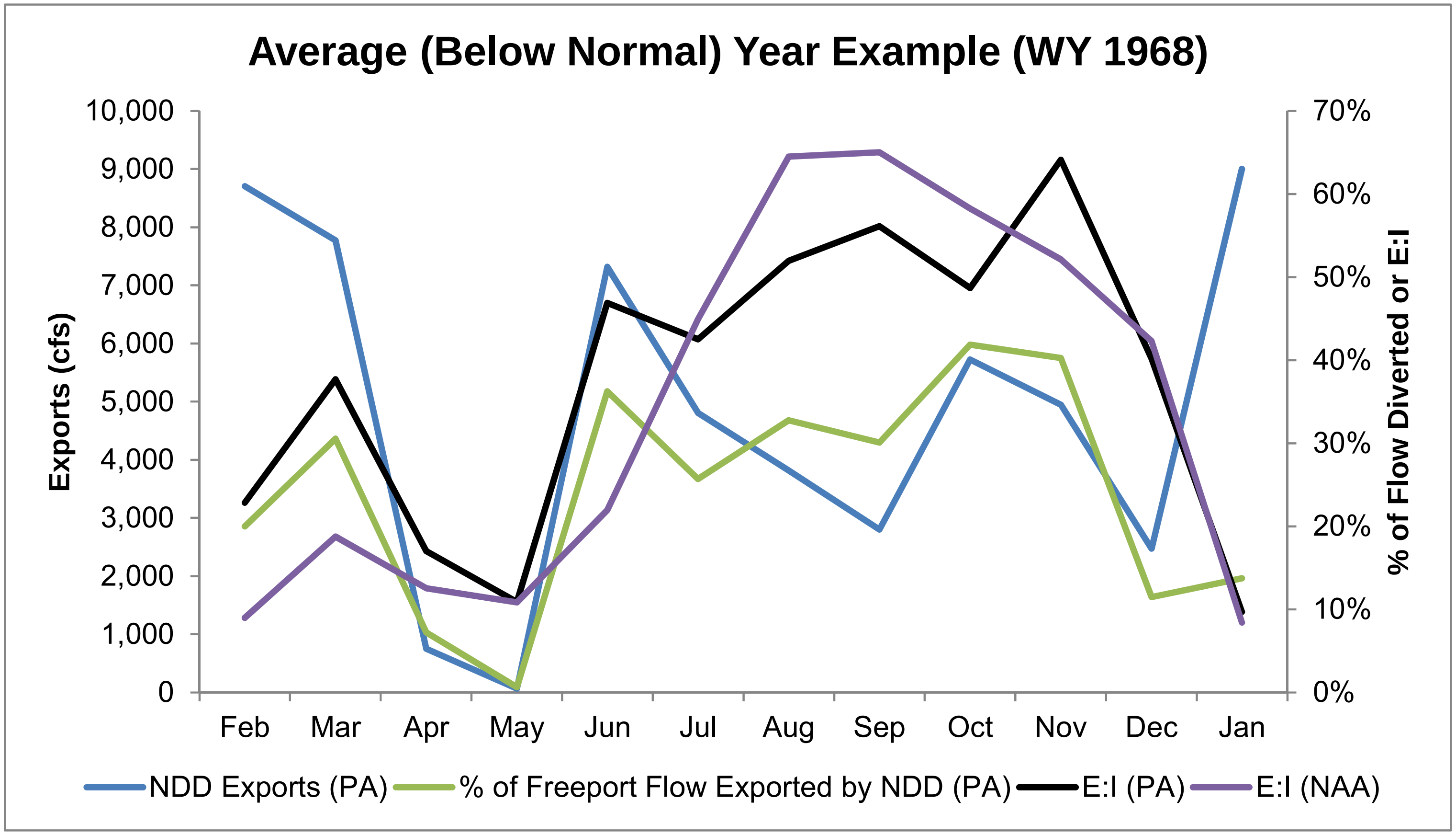
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: E:I = exports to inflow ratio; the inflow (I) term for the PA is the Sacramento River downstream of the NDD; NDD exports are not included in the export (E) term for the PA.

Figure 5. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1989.



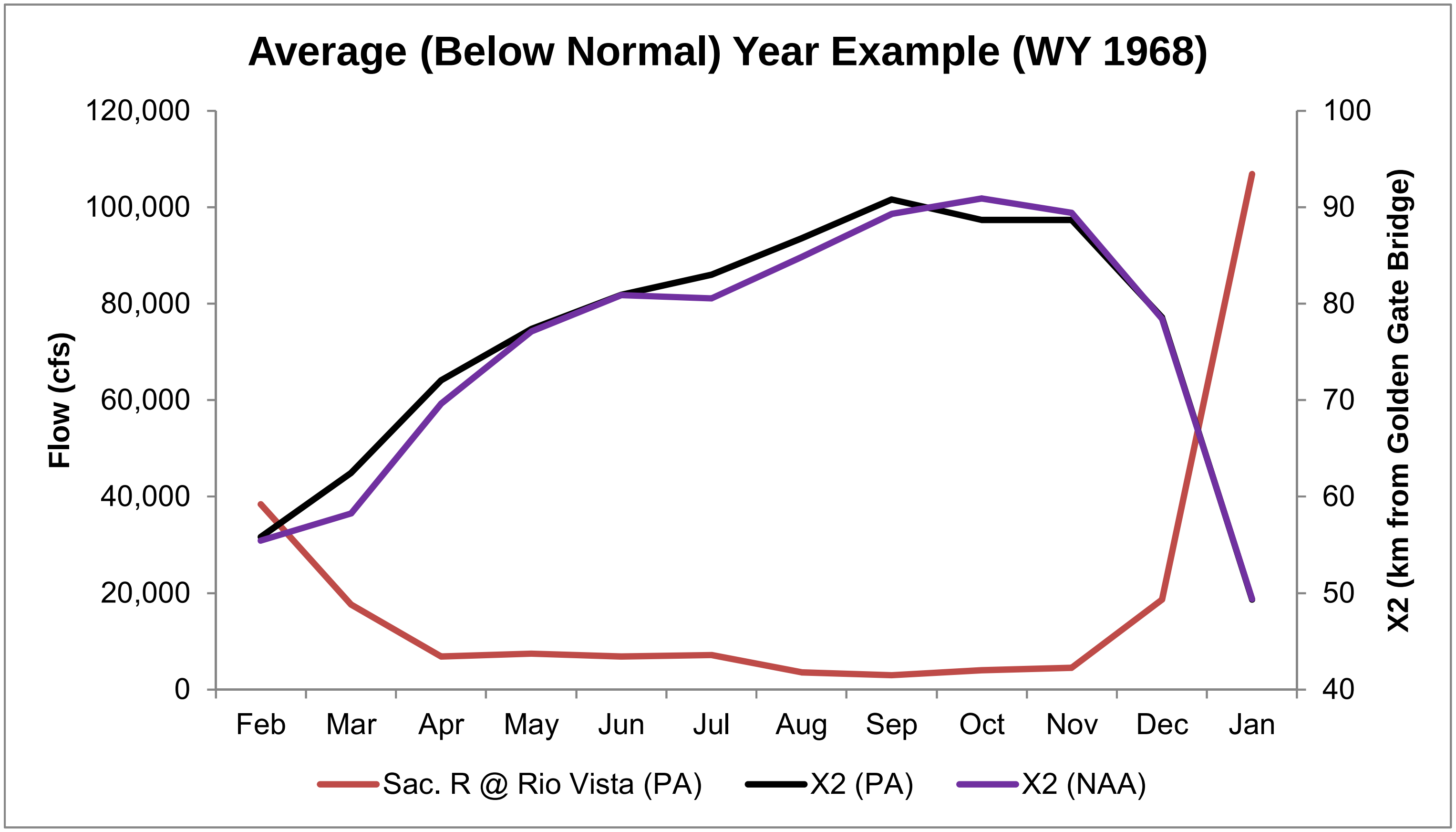
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment.

Figure 6. Modeled Mean Monthly Sacramento River Flow at Rio Vista and X2, Water Year 1989.



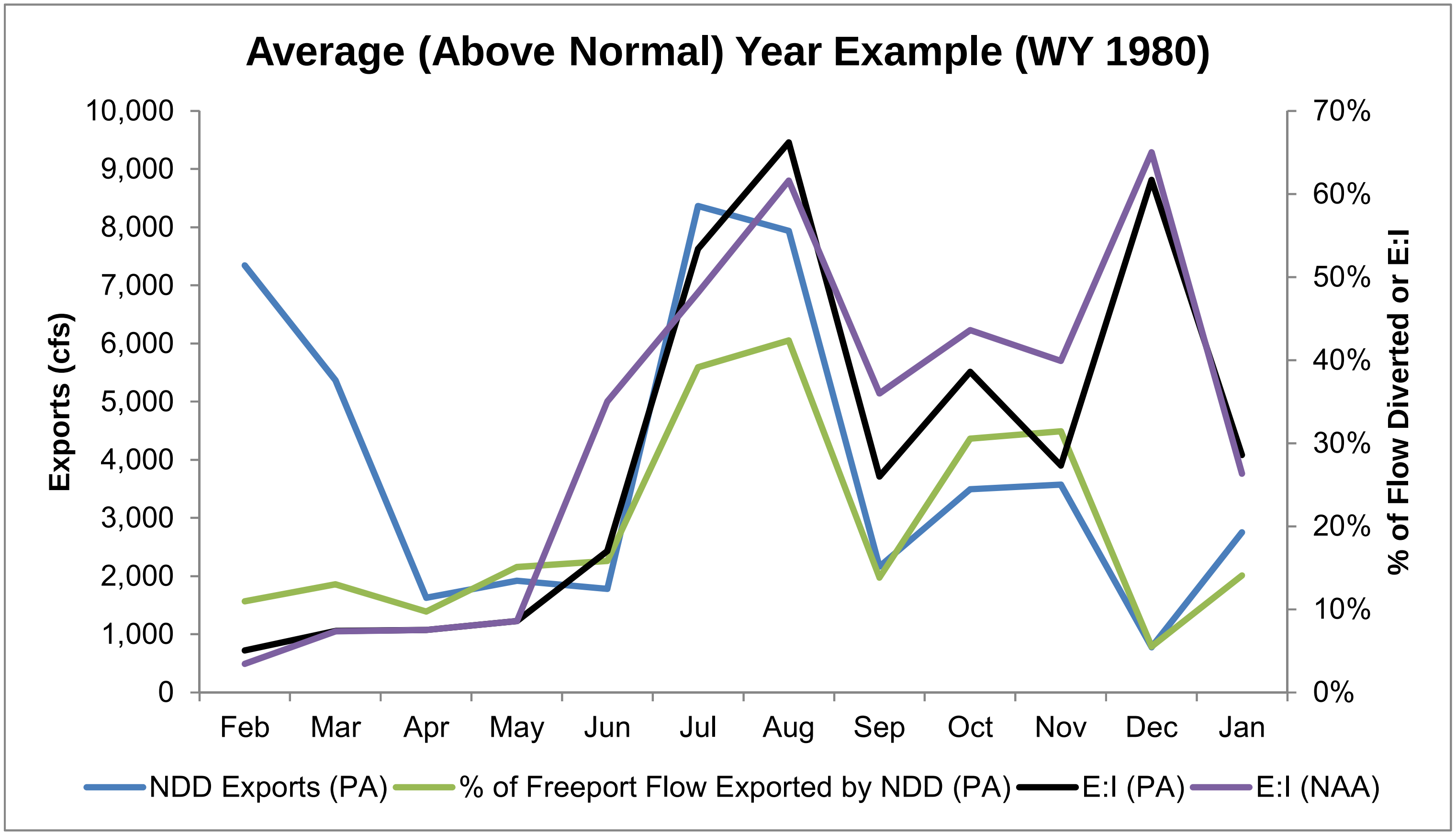
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: E:I = exports to inflow ratio; the inflow (I) term for the PA is the Sacramento River downstream of the NDD; NDD exports are not included in the export (E) term for the PA.

Figure 7. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1968.



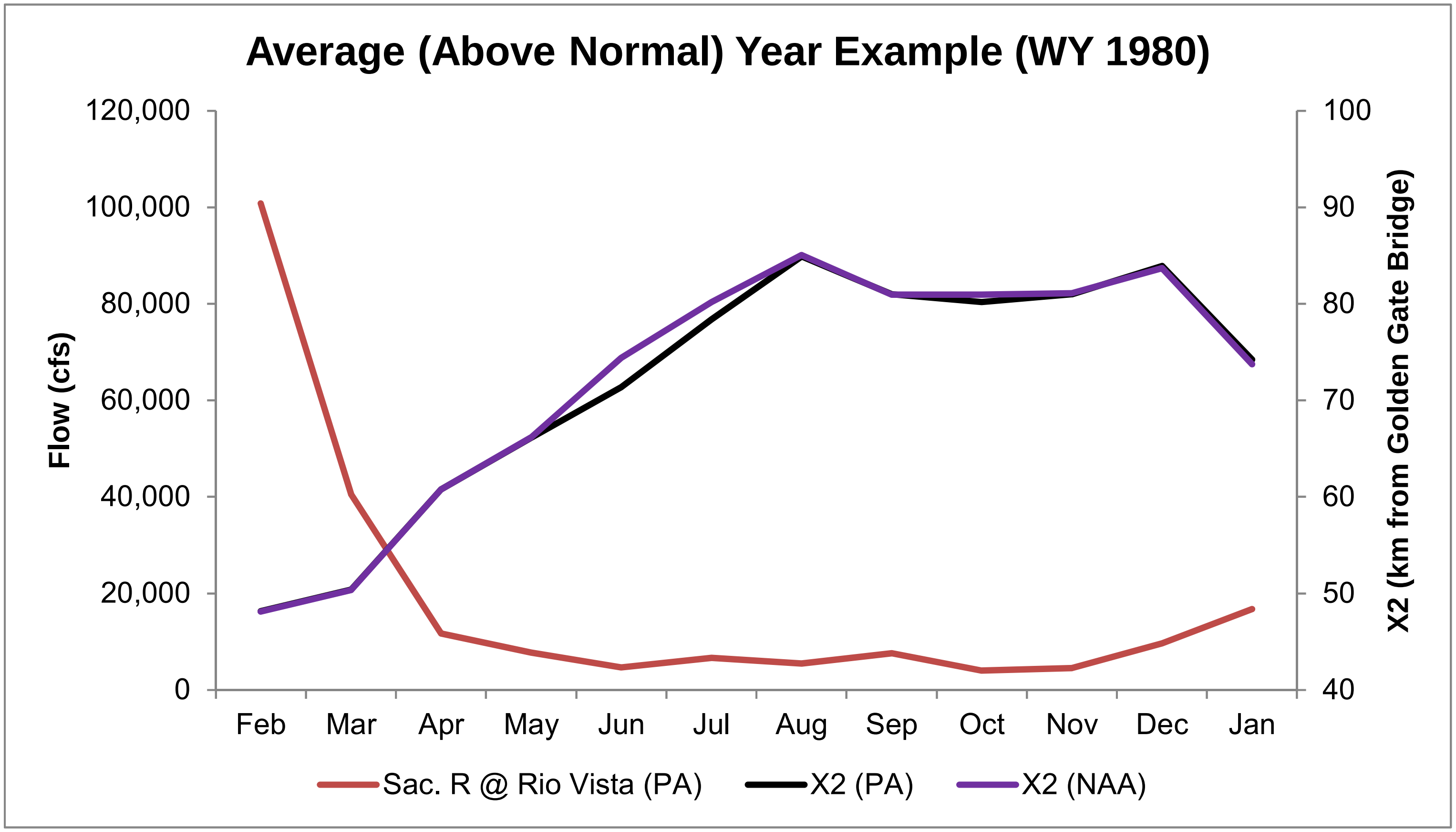
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment.

Figure 8. Modeled Mean Monthly Sacramento River Flow at Rio Vista and X2, Water Year 1968.



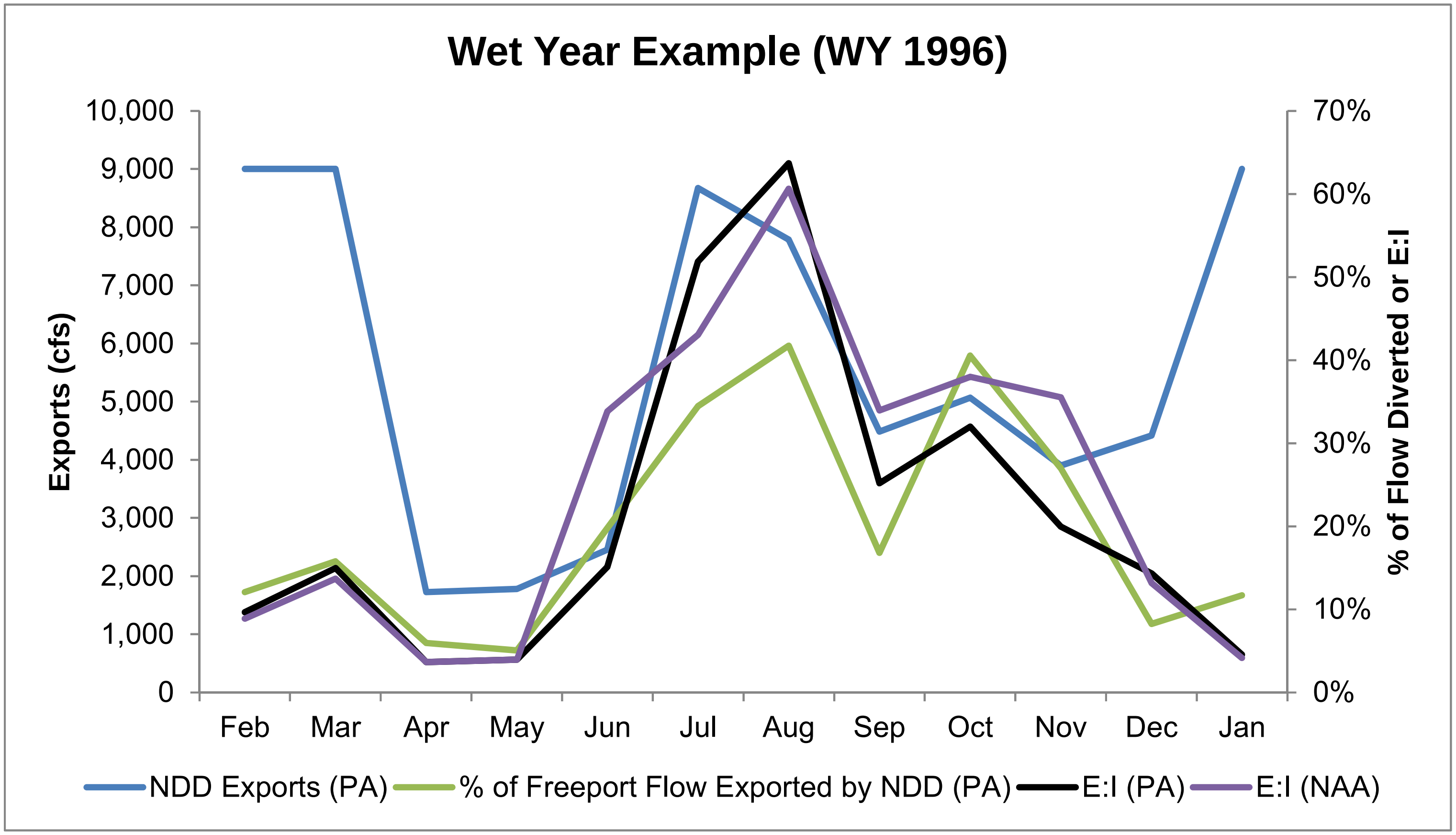
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: E:I = exports to inflow ratio; the inflow (I) term for the PA is the Sacramento River downstream of the NDD; NDD exports are not included in the export (E) term for the PA.

Figure 9. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1980.



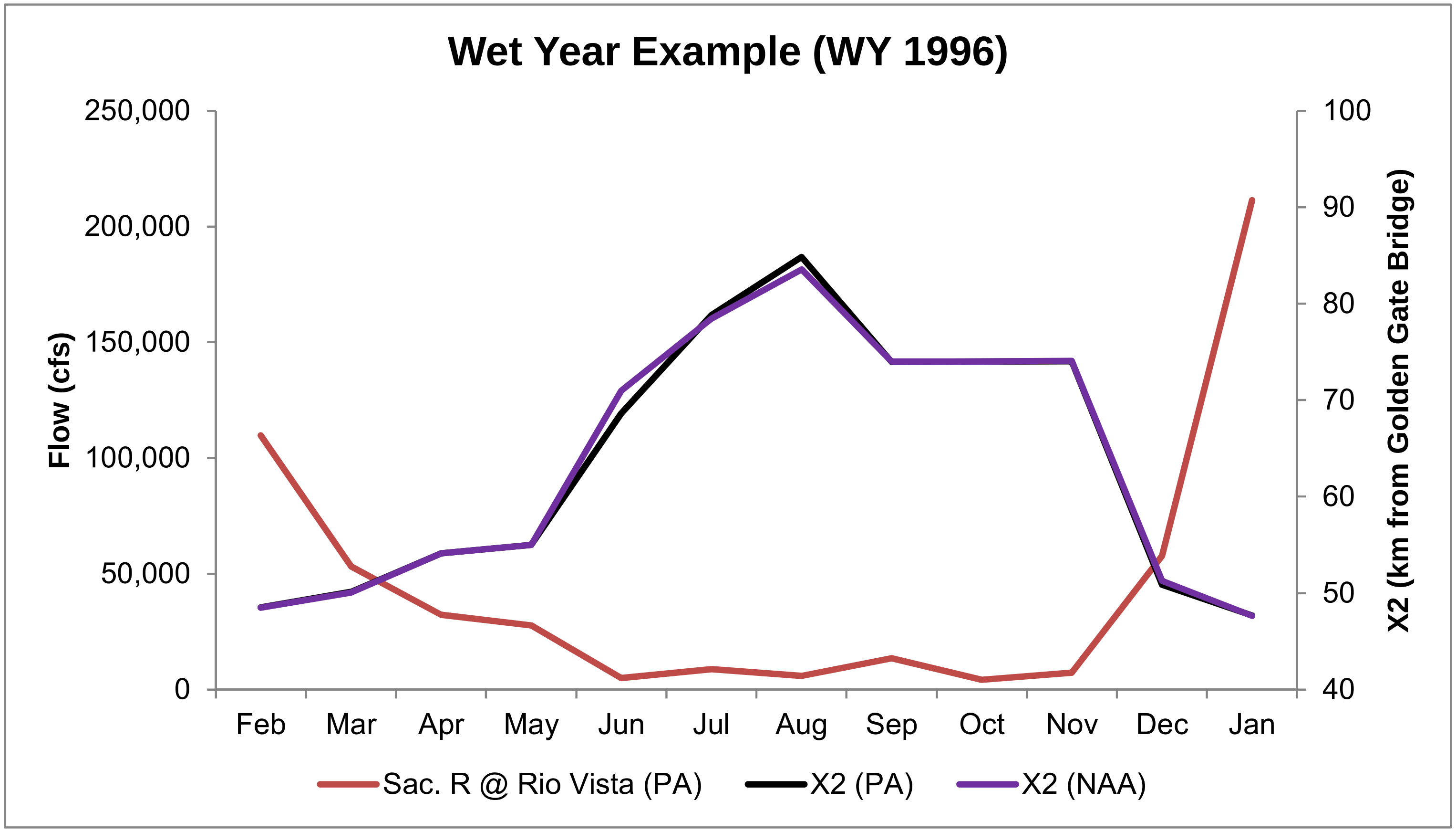
Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment.

Figure 10. Modeled Mean Monthly Sacramento River Flow at Rio Vista and X2, Water Year 1980.



Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment. Note: E:I = exports to inflow ratio; the inflow (I) term for the PA is the Sacramento River downstream of the NDD; NDD exports are not included in the export (E) term for the PA.

Figure 11. Modeled Mean Monthly Exports by the North Delta Diversions and Percentage of Sacramento River at Freeport Flows Represented by these Exports, Water Year 1996.



Source: Created by ICF from CalSim-II modeling undertaken for the working draft Biological Assessment.

Figure 12. Modeled Mean Monthly Sacramento River Flow at Rio Vista and X2, Water Year 1996.

STATEMENT OF SERVICE

CALIFORNIA WATERFIX PETITION HEARING
Department of Water Resources and U.S. Bureau of Reclamation (Petitioners)

I hereby certify that I have this day submitted to the State Water Resources Control Board and caused a true and correct copy of the following document(s):

PROTESTANT SAVE THE CALIFORNIA DELTA ALLIANCE'S RENEWED MOTION TO AMEND PROTEST

DECLARATION OF MICHAEL A. BRODSKY IN SUPPORT OF PROTESTANT SAVE THE CALIFORNIA DELTA ALLIANCE'S RENEWED MOTION TO AMEND PROTEST

to be served **by Electronic Mail** (email) upon the parties listed in Table 1 of the **Current Service List** for the California WaterFix Petition Hearing, dated July 11, 2016, posted by the State Water Resources Control Board at
http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/service_list.shtml

I certify that the foregoing is true and correct and that this document was executed on July 19, 2016.

Signature: ______________________
Name: Michael A. Brodsky
Title: Attorney

Party/Affiliation:
Save the California Delta Alliance, et al.

Address:
Law Offices of Michael A. Brodsky
201 Esplanade, Upper Suite
Capitola, CA 95010

STATEMENT OF SERVICE

CALIFORNIA WATERFIX PETITION HEARING
Department of Water Resources and U.S. Bureau of Reclamation (Petitioners)

I hereby certify that I have this day submitted to the State Water Resources Control Board and caused a true and correct copy of the following document(s):

CORRECTED DECLARATION OF MICHAEL A. BRODSKY IN SUPPORT OF PROTESTANT SAVE THE CALIFORNIA DELTA ALLIANCE'S RENEWED MOTION TO AMEND PROTEST

to be served **by Electronic Mail** (email) upon the parties listed in Table 1 of the **Current Service List** for the California WaterFix Petition Hearing, dated July 15, 2016, posted by the State Water Resources Control Board at
http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/service_list.shtml

I certify that the foregoing is true and correct and that this document was executed on July 25, 2016.

Signature: ____________________
Name: Michael A. Brodsky
Title: Attorney

Party/Affiliation:
Save the California Delta Alliance, et al.

Address:
Law Offices of Michael A. Brodsky
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