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Biological Assessment for the California WaterFix

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July 2016

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July 2016

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ABBREVIATIONS AND ACRONYMS

°C	Celsius
°F	Fahrenheit
7DADM	seven day average daily maximum
af	acre feet
AFRP	Anadromous Fish Restoration Program
AMMs	avoidance and minimization measures
ARG	American River Group
A-weighted decibel	dBA
B2IT	b2 interagency team
BA	Biological Assessment
BAFF	bioacoustic fish fence
Banks PP	Banks Pumping Plant
Bay-Delta Plan	WQCP for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
BDCP	Bay Delta Conservation Plan
Biological Review	Biological Review for Endangered Species Act Compliance of the WY 2015 Updated Drought Contingency Plan for July–November Project Description
BiOp	biological opinion
BMPs	best management practices
CALFED	CALFED Bay-Delta Program
CAMT	Collaborative Adaptive Management Team
CCF	Clifton Court Forebay
CCFPP	Clifton Court Forebay Pump Plant
CCPP	CCF pumping plant
CCV	California Central Valley
CCWD	Contra Costa Water District
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
cfs	cubic feet per second
CIDH	cast-in-drilled-hole
CNDDB	California Natural Diversity Database
COA	Coordinated Operation Agreement
CPT	cone penetration testing
CSAMP	Cooperative Science and Adaptive Management Program
CV	Central Valley
CVP	Central Valley Project
CVPA	Central Valley Project Act
CVPIA	Central Valley Project Improvement Act
cy	cubic yards
D-1641	State Water Resources Control Board Decision-1641
dB	decibels
DCC	Delta Cross Channel

DCT	Delta Condition Team
DDT	dichlorodiphenyltrichloroethane
DEIS	draft environmental impact statement
Delta	Sacramento–San Joaquin Delta
DHCCP	Delta Habitat Conservation and Conveyance Program
DOP	CPV and SWP Drought Operations Plan and Operational Forecast for April 1, 2014 through November 15, 2014
DOSS	Delta Operations for Salmon and Sturgeon
DOT	Washington Department of Transportation
DPM	Delta Passage Model
DPS	distinct population segment
DWR	California Department of Water Resources
E/I	export/inflow
EIS	environmental impact statement
ENSO	El Niño Southern Oscillation
EOS	end-of-September
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESA of 1972, as the amended	Section 7 of the Endangered Species Act
ESRP	Endangered Species Recovery Program
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FERC DEIR PA	Facilities Relicensing Draft Environmental Impact Report Proposed Project Alternative
FFGS	Floating Fish Guidance Structure
FFTT	Fish Facilities Technical Team’s
FL	fork length
FR	Federal Register
FRFH	Feather River Fish Hatchery
ft/s	foot per second
GCID	Glenn Colusa Irrigation District’s
general excavation	General Excavation for the NCCF and SCCF
GIS	Geographical Information System
H to V	horizontal to vertical
HCP	habitat conservation plan
HCP/NCCP	East Contra Costa County Habitat Conservation Plan/Natural Communities Conservation Plan
HFC	High Flow Channel
HMMP	Hazardous Material Management Plan
HOR	Head of Old River
HORB	Head of Old River Barrier
I-	Interstates
I 205	Interstate 205
I 580	Interstate 580

IEP	Interagency Ecological Program
IES	Illuminating Engineering Society
IF	Intermediate Forebay
Interior	U.S. Department of the Interior’s
IOS	Interactive Object-Oriented Salmon Simulation
IRP footnote	Independent Review Panel
ITP	Incidental Take Permit
Jones PP	C.W. ‘Bill’ Jones Pumping Plant
LFC	Low Flow Channel
LOO footnote	Long-term Operations Opinions
LSNFH	Livingston Stone National Fish Hatchery
LSZ	low-salinity zone
M&I	municipal and industrial
mg/L	milligrams per liter
MIDS	Morrow Island Distribution System
MOA	Memorandum of Agreement
mph	miles per hour
NAA	No Action Alternative
NBA	North Bay Aqueduct
NCCF	North Clifton Court Forebay
NDOI	Net Delta Outflow Index
NEPA	National Environmental Policy Act
new CCF embankment	New Clifton Court Forebay Embankment
new CCF spillway and stilling basin	New Spillway and Stilling Basin
new forebay structures	New Forebay Structures
NMFS	National Marine Fisheries Service
NPB	Nonphysical Fish Barrier
NWR	National Wildlife Refuge
NWS	National Weather Service
OBAN	Oncorhynchus Bayesian Analysis
OMR	Old and Middle River
ORV	off-road vehicles
PA	proposed action
PBDEs	polybrominated diphenyl ethers
PBFs	physical and biological features
PCBs	polychlorinated biphenyls
PCEs	primary constituent elements
PDO	Pacific Decadal Oscillation
PG&E	Pacific Gas and Electric Company
PGS	Pittsburg Generating Station
Plan	Water Quality Control Plan
POD	Pelagic Organism Decline
Project Description	Updated Project Description for July-November 2015 Drought Response Actions to Support Endangered Species Act Consultations

Reclamation	United States Department of Interior, Bureau of Reclamation
RM	river mile
RMS	root mean square
RPA	reasonable and prudent alternative
RRDS	Roaring River Distribution System
RTDOT	Real Time Drought Operations Management Team
RTM	reusable tunnel material
RTO	Real-Time Operational
SA	Settlement Agreement
SCCF	South CCF
SCT	Section 7 Consultation Team
Secretary	Secretary of the Interior
SEL	sound exposure level
SFCWA	State and Federal Contractors Water Agency
Skinner	John E. Skinner Delta Fish Protective Facility
SMSCG	Suisun Marsh Salinity Control Gates
SMUD	Sacramento Municipal Utility District
south CCF	South Clifton Court Forebay
SPCCP	Spill Prevention, Containment, and Countermeasure Plan
SPL	sound pressure level
SPT	standard penetration test
SR	State Route
SRTTG	Sacramento River Temperature Task Group
SRWTP	Sacramento Regional Wastewater Treatment Plan
State Water Board	State Water Resources Control Board
SWG	Smelt Working Group
SWP	State Water Project
SWPPP	Stormwater Pollution Prevention Plan
SWRCB	State Water Resources Control Board
TBM	tunnel boring machine
TBP	Temporary Barriers Project
TCAs	Temperature Control Actions
Temperature Management Plan	Revised Sacramento River Water Temperature Management Plan June 2015
TFCF	Tracy Fish Collection Facility
Tracy PP	Tracy Pumping Plant
TUCP	Temporary Urgency Change Petition
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
Western	Western Area Power Administration
WOMT	Water Operations Management Team
WQCP	Water Quality Control Plan
WSE	water surface elevation
WUA	weighted usable area

X2	an indicator of habitat suitability for many San Francisco Estuary organisms and is associated with variance in abundance of diverse components of the ecosystem
YCI	Year-Class Index

1 Introduction

The California Department of Water Resources (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 (HOR) gate; operate existing State Water Project (SWP) Delta facilities in coordination with the new facilities; maintain the newly- constructed and existing facilities; implement and uphold new and existing conservation measures; and implement and assist in an ongoing monitoring and adaptive management program. Proposed operations, as described in Chapter 3, Section 3.3, *Operations and Maintenance of New and Existing Facilities*, will begin only after construction of the proposed new facilities is complete.

The U.S. Department of Interior, Bureau of Reclamation (Reclamation), as the lead agency for the Endangered Species Act section 7 consultation, proposes to coordinate Central Valley Project (CVP) operations with DWR, the applicant, using the new and existing facilities. The U.S. Army Corps of Engineers (USACE) proposes to issue permits to DWR pursuant to Rivers and Harbors Act Section 10, Clean Water Act Section 404, and 33 United States Code (U.S.C.) 408.

DWR's operation of the proposed facilities, referred to as "California WaterFix," would modify operation of SWP, which is operated in coordination with the CVP. Reclamation is responsible for operation and maintenance of the CVP, and DWR is responsible for the operation and maintenance of the SWP. The proposed new facilities would operate in coordination with the existing Delta facilities, including the Clifton Court Forebay (CCF), located in San Joaquin County, California. The three proposed intakes, comprising the new proposed north Delta diversions, would be located on the east bank of the Sacramento River near Clarksburg, in Sacramento County, California, and connected to the CCF by two underground tunnels and a new pumping plant, which would be sited at the CCF. The proposed new facilities would provide water for intake at the Banks Pumping Station and the South Bay Pumping Plant, which are existing SWP facilities that draw water from the CCF for distribution through existing SWP facilities.

DWR is the entity undertaking all construction-related activities including those related to the intakes, the associated tunnels, and their associated structures. The in-water construction activities associated with the intakes, tunnels, and associated structures, as well as the change in SWP Delta operations, requires a combination of Rivers and Harbors Act Section 10, Clean Water Act Section 404, and 33 U.S.C. 408 approvals from USACE. DWR and/or its designees will operate and maintain the facilities, and Reclamation will adjust operation of the CVP to utilize the dual conveyance.

As required by the by Section 7 of the Endangered Species Act and its implementing regulations (50 CFR 402.02), this Biological Assessment (BA) is being prepared to provide the basis for consultation with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) to determine whether the proposed action (PA) is likely to: (1) adversely affect listed species or designated critical habitat; (2) jeopardize the continued existence of species that are proposed for listing; or (3) adversely modify designated critical habitat.

Through informal consultation (see 50 CFR 402.02, 402.13), this document has been developed by DWR and Reclamation in close collaboration with NMFS and USFWS, as detailed in Chapter 2 *Consultation History*. This collaboration has determined the scope of the PA, the species addressed, the analyses used to assess effects on those species, and changes to the PA to ensure that effects are minimized and, to the extent possible, beneficial. This collaboration has helped to produce a PA that minimizes potential effects on listed species and that supports the analyses needed to enable NMFS and USFWS to develop their biological opinion. Names and contact information for responsible parties are presented in Table 1-1.

Table 1-1. Responsible Parties, Respective Role, and Contact Information

Agency	Role	Contact Information
Bureau of Reclamation	Lead Federal Agency and Action Agency for Coordinated Operation of the CVP/ and SWP (“Operation”)	Brooke Miller-Levy, California WaterFix Program Manager, Bureau of Reclamation, 801 I Street, Suite 140, Sacramento, CA 95814-2536 (916) 414-2402
California Department of Water Resources	Applicant	Cindy Messer, Assistant Chief Deputy Director, Department of Water Resources, 1416 Ninth Street, Sacramento, CA 95814 916-651-6736
U.S. Army Corps of Engineers	Action Agency for Construction	Zachary Simmons or Meegan Nagy, Operations & Readiness Branch, 1325 J Street (CESPK-CO-OR), Sacramento, CA 95814-2922 916-557-7257

1.1 Relationship to Existing Biological Opinions

This BA is being submitted with a request for initiation of formal consultation that is expected to result in a biological opinion that will apply to, among other things, construction of new facilities described in Chapter 3, *Description of the Proposed Action*, of this BA. The CVP/SWP will continue to operate pursuant to the 2008 USFWS and 2009 NMFS Biological Opinions (National Marine Fisheries Service 2009, 2011; U.S. Fish and Wildlife Service 2008) until the new facilities are constructed. Once the new facilities are operational, the new biological opinion will replace and supersede the 2008 USFWS and 2009 NMFS Biological Opinions for operations of the CVP and SWP described in Chapter 3 of this BA, which includes both new operational provisions and operational provisions that will remain in effect unmodified. As such, once the new facilities are operational, CVP and SWP operations not described in Chapter 3 of this Biological Assessment will continue to operate pursuant to the 2008 USFWS and 2009 NMFS Biological Opinions.

As discussed in Chapter 2, *Consultation History*, and in Section 3.1.4, *Delta Operations Regulatory Setting*, there are currently numerous regulatory constraints in place that apply to the PA. Many of the existing regulatory constraints are in place as a result of the 2008 and 2009 Biological Opinions (BiOps; National Marine Fisheries Service 2009, 2011; U.S. Fish and Wildlife Service 2008) and a California Incidental Take Permit (California Department of Fish and Game [CDFG] 2009); these have been incorporated into the PA unless otherwise noted, although several components will continue to be evaluated through the current and future Collaborative Science and Adaptive Management Program (Section 3.4.7). Table 3.1-1 identifies the proposed new facilities, identifies the existing regulatory constraints that apply to CVP/SWP facilities and operations in the Delta region, and notes which requirements are (or are not) incorporated in the PA.

1.2 Inclusion of Upstream Operations

The PA is described in Chapter 3, and does not include any upstream operational changes. A number of physical and biological models were used to assess the general long-term operational effects of the PA, with the primary model being CALSIM II, a monthly model, on which other monthly and daily flow and temperature models rely for input. These models represent the best scientific and commercial data available to estimate and analyze the potential system-wide environmental effects of the PA related to water operations. However, the modeled results cannot represent exactly how the project would necessarily operate, because they cannot take into account the various annual, seasonal, and real-time conditions that occur as part of the operational management of the CVP and SWP. These operations occur in response to uncontrollable and unpredictable conditions that can vary significantly, and often at a time step much shorter than the basis for the operations model.

The increased flexibility provided by the dual conveyance system and changes in operational criteria for facilities within the Delta may allow for changes in upstream operations to occur, but such changes would remain consistent with the existing operating criteria governing operations on the tributary systems. For example, upstream operations may change in response to climate change and sea level rise as shown in the modeling of the No Action Alternative (NAA) for the BDCP Draft EIR/EIS (California Department of Water Resources, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service 2013), even though the operating criteria for those conditions remain unchanged. Appendix 5A presents a detailed description of the CALSIM II modeling assumptions and results.

The PA does not propose any changes to upstream operational criteria, and the CALSIM model assumes that the currently applicable criteria, including those set forth in the NMFS BiOp (National Marine Fisheries Service 2009, 2011), remain intact. As is the case today, the PA and the rest of the CVP and SWP will be operated to meet authorized purposes, including flood control, navigation, water supply, and fish and wildlife purposes, in a manner that comports with applicable legal and contractual obligations. The modeled results show that the CVP could be operated slightly differently under the PA, but these differences in results do not thoroughly reflect the ability to manage the upstream operations in a way that addresses environmental variables and meets the applicable flow and temperature criteria. Rather, results are intended to be a reasonable representation of long-term operational trends of the CVP and SWP, providing the ability to compare and contrast the effect of current and assumed future operational conditions. The effects of these differences in results are thoroughly evaluated in this BA (Chapter 5, Section 5.4.2). The existing processes used to manage upstream operations and meet the current applicable criteria (which are not proposed to change) will continue. As such, there are no proposed new actions related to upstream operations.

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. To determine if an action is interrelated to or interdependent with a proposed action, the Fish & Wildlife Service Endangered Species Consultation Handbook

(FWS Handbook) directs that the agency "should ask whether another activity in question would occur 'but for' the proposed action under consultation" (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998, 4-27). 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.

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, consistent with the directive from FWS Handbook, upstream actions are not interrelated to or interdependent with the PA.

1.3 Species Considered

Pursuant to the interagency consultation requirements of Section 7 of the Endangered Species Act (ESA) of 1972, as amended (the "Act"), this BA has been prepared to assess the effects of the PA on species listed or designated critical habitat under the ESA. Determination of which listed species should be included in this BA was based on review of Geographical Information System (GIS) distributional maps and water operations modeling, field visits, literature reviews, and discussions with federal and State agencies. Species lists were generated on May 20, 2015, by the USFWS' Bay-Delta Fish and Wildlife Office and on May 22, 2015, by the USFWS' Sacramento Fish and Wildlife Office. On July 24, 2015, NMFS confirmed the list of species under NMFS jurisdiction in an email. These lists are attached as Appendix 1.A and Appendix 1.B. The species addressed in this document have been derived from the species lists provided by USFWS and NMFS. Species considered for inclusion in this BA include all species on the USFWS and NMFS species lists and additional species with potential to occur in the action area (Table 1-2 and Table 1-3).

1.3.1 Species Addressed in This Biological Assessment

Table 1-3 identifies the listed species that may be affected by the PA, status of designated critical habitat in the action area, listing status (threatened or endangered), and which Federal agency (USFWS or NMFS) retains jurisdiction and responsibility under Section 7 of the Act. Throughout this document, the term "listed species" is used to refer to the species listed in Table 1-2 or to its critical habitat, and is not intended to include any other species listed under the ESA.

1.3.2 Species Considered but Not Addressed Further

In addition to the species listed in Table 1-2, a number of species and their critical habitat were considered for inclusion because initial review indicated they could occur in the action area; however, based on analysis of the PA, Reclamation and DWR have determined that the PA will not affect (*no effect*) these listed species or designated critical habitat (Table 1-3). A rationale for that determination is provided in Table 1-3.

Table 1-2. Listed Species Addressed in This BA

Common Name	Scientific Name	Jurisdiction	Status	Status of Critical Habitat
Chinook salmon, Sacramento River winter-run ESU	*Oncorhynchus tshawytscha*	NMFS	Endangered	Designated critical habitat in action area
Chinook salmon, Central Valley spring-run ESU	*Oncorhynchus tshawytscha*	NMFS	Threatened	Designated critical habitat in action area
Steelhead, California Central Valley DPS	*Oncorhynchus mykiss*	NMFS	Threatened	Designated critical habitat in action area
Green sturgeon, southern DPS	*Acipenser medirostris*	NMFS	Threatened	Designated critical habitat in action area
Killer whale, Southern Resident DPS	*Orcinus orca*	NMFS	Endangered	Designated critical habitat in action area
Delta Smelt	*Hypomesus transpacificus*	USFWS	Threatened	Designated critical habitat in action area
Salt marsh harvest mouse[a]	*Reithrodontomys raviventris*	USFWS	Endangered	Critical habitat not designated.
Riparian brush rabbit	*Sylvilagus bachmani riparius*	USFWS	Endangered	Not designated
San Joaquin kit fox	*Vulpes macrotis mutica*	USFWS	Endangered	Not designated
California clapper rail[a]	*Rallus longirostris obsoletus*	USFWS	Endangered	Not designated
California least tern	*Sternula antillarum browni*	USFWS	Endangered	Not designated
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	USFWS	Threatened	Designated critical habitat not in action area
Giant garter snake	*Thamnophis gigas*	USFWS	Threatened	Not designated
California red-legged frog	*Rana draytonii*	USFWS	Threatened	Designated critical habitat in action area
California tiger salamander	*Ambystoma californiense*	USFWS	Threatened	Designated critical habitat not in action area
Vernal pool fairy shrimp	*Branchinecta lynchi*	USFWS	Threatened	Designated critical habitat in action area
Vernal pool tadpole shrimp	*Lepidurus packardi*	USFWS	Endangered	Designated critical habitat not in action area
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	USFWS	Threatened	Designated critical habitat not in action area
Least Bell's vireo	*Vireo bellii pusillus*	USFWS	Endangered	Designated critical habitat not in action area
Soft bird's beak[a]	*Cordylanthus mollis* ssp. *mollis*	USFWS	Endangered	Designated critical habitat in action area
Suisun thistle[a]	*Cirsium hydrophilium*	USFWS	Endangered	Designated critical habitat in action area

DPS = distinct population segment

ESU = evolutionarily significant unit

[a] Species occurs in Suisun Marsh, and is addressed in Appendix 6.C, *Suisun Marsh Species,* rather than the main body of this Biological Assessment.

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Table 1-3. Species Considered but Not Addressed Further because of "No Effect" Determinations

Common Name	Scientific Name	Jurisdiction	ESA Status	Potential for Effect	Potential to Affect Critical Habitat
Steelhead, Central California Coast DPS	*Oncorhynchus mykiss*	NMFS	Threatened	The species' range does not overlap the action area.	Designated critical habitat not in action area
Coho salmon, Southern Oregon/Northern California Coast ESU	*Orncorhynchus kisutch*	NMFS	Threatened	The species' range does not overlap the action area.	Designated critical habitat not in action area
Lange's metalmark butterfly	*Apodemia mormo langei*	USFWS	Endangered	The species' range does not overlap the action area.	Designated critical habitat not in action area
Conservancy fairy shrimp	*Branchinecta conservatio*	USFWS	Endangered	Occurrences have not been detected in the area to be affected by the conveyance facility, transmission lines, or geotechnical activity. The vernal pools to be affected by these activities were surveyed consistent with USFWS protocol, and Conservancy fairy shrimp was not detected. Moreover, the vernal pools to be affected are not large turbid pools that are characteristic of Conservancy fairy shrimp habitat. Restoration projects will avoid any areas that potentially support Conservancy fairy shrimp.	Designated critical habitat not in action area
Longhorn fairy shrimp	*Branchinecta longiantenna*	USFWS	Endangered	Occurrences have not been detected in the area to be affected by the conveyance facility, transmission lines, or geotechnical activity. The vernal pools to be affected by these activities were surveyed consistent with USFWS protocol, and longhorn fairy shrimp was not detected. Restoration projects will avoid any areas that potentially support longhorn fairy shrimp.	Designated critical habitat not in action area.
Delta green ground beetle	*Elaphrus viridis*	USFWS	Threatened	There are no proposed activities in the area where this species is known to occur. Tidal restoration could occur along Lindsay Slough within the range of the species but would be required to avoid Delta green ground beetle habitat.	Designated critical habitat not in action area
San Bruno elfin butterfly	*Callophrys mossii bayensis*	USFWS	Endangered	The species' range does not overlap the action area.	Proposed critical habitat not in action area
Callippe silverspot butterfly	*Speyeria callippe*	USFWS	Endangered	Documented occurrences are outside the legal Delta in the hills west of Interstate 680 (LSA and ESP 2009); therefore, there is no potential for take or effects on this species.	Critical habitat not designated
Alameda whipsnake	*Masticophis lateralis euryxanthus*	USFWS	Threatened	The occurrences, critical habitat, and recovery unit for Mt. Diablo – Black Hills population are approximately 8 miles west of the boundary of the PA, primarily west and north of Los Vaqueros Reservoir. No suitable habitat would be affected by the PA. Although some grassland protection could occur west of the Delta to mitigate effects on other species, the grasslands would not provide suitable habitat for Alameda whipsnake. Accordingly, the PA would not affect this species.	Designated critical habitat not in action area
Western snowy plover	*Charadrius alexandrinus nivosus*	USFWS	Threatened	The species' range does not overlap the action area; there are only three nesting records for the species in Yolo County since 1945—the Yolo Bypass, Davis Sewage Ponds, and Woodland Sugar Ponds; no other recent records exist for the Delta or Sacramento Valley.	Critical habitat not designated
Riparian woodrat	*Neotoma fuscipes riparia*	USFWS	Endangered	There is one reported occurrence near Vernalis from 1935 (California Department of Fish and Wildlife 2013). Two extant populations occur, one documented at Caswell Memorial State Park and the other unconfirmed near Vernalis. There is no modeled habitat in the area to be affected by the PA.	Critical habitat not designated
Large-flowered fiddleneck	*Amsinckia grandiflora*	USFWS	Endangered	Species does not occur in the action area.	Critical habitat not designated
Succulent (fleshy) owl's clover	*Castilleja campestris* ssp. *Succulenta*	USFWS	Threatened	Species does not occur in the action area.	Designated critical habitat not in action area

Common Name	Scientific Name	Jurisdiction	ESA Status	Potential for Effect	Potential to Affect Critical Habitat
Tiburon paintbrush	*Castilleja affinis* subsp. *neglecta*	USFWS	Endangered	Species does not occur in the action area.	Critical habitat not designated
Palmate-bracted bird's-beak	*Chloropyron palmatum*	USFWS	Endangered	There are no recorded occurrences in the action area.	Critical habitat not designated
Contra Costa wallflower	*Erysimum capitatum* var. *angustatum*	USFWS	Endangered	There are no recorded occurrences in the action area.	Designated critical habitat not in action area
Santa Cruz tarplant	*Holocarpha macradenia*	USFWS	Threatened	Species does not occur in the action area	Critical habitat not designated
Contra Costa goldfields	*Lasthenia conjugens*	USFWS	Endangered	There are no recorded occurrences in the action area.	Designated critical habitat not in action area
Colusa grass	*Neostapfia colusana*	USFWS	Threatened	There are no recorded occurrences in the action area.	Designated critical habitat not in action area
Antioch Dunes evening-primrose	*Oenothera deltoides* subsp. *howellii*	USFWS	Endangered	There are no recorded occurrences in the action area.	Designated critical habitat not in action area
Slender Orcutt grass	*Orcuttia tenuis*	USFWS	Threatened	Occurrences and critical habitat are located east of the action area.	Designated critical habitat in action area
Sacramento Orcutt grass	*Orcuttia viscida*	USFWS	Endangered	Occurrences and critical habitat are located east of the action area.	Designated critical habitat not in action area
Keck's checkerbloom	*Sidalcea keckii*	USFWS	Endangered	Species does not occur in the action area.	Critical habitat not designated
Showy rancheria clover	*Trifolium amoenum*	USFWS	Endangered	There are no recorded occurrences in the action area.	Critical habitat not designated
Solano grass	*Tuctoria mucronata*	USFWS	Endangered	There are no recorded occurrences in the action area.	Designated critical habitat not in action area

1.4 References

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U.S. Fish and Wildlife Service. 2008. *Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP)*. Biological opinion. December. Sacramento, CA. Available: http://www.fws.gov/sacramento/delta_update.htm.

2 Consultation History

2.1 Consultation History

The Federal Reclamation Central Valley Project (CVP) and California State Water Project (SWP) are two major inter-basin water storage and delivery systems that divert and re-direct water from the southern portion of the Sacramento–San Joaquin Delta (Delta), and have a complex history of consultation under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.) (Act). Aspects of this consultation history dealing with the management of CVP/SWP facilities located in the Delta are summarized chronologically in Table-2-1. A biological opinion (BiOp) covering the effects of CVP/SWP facilities located in the Delta on listed fish species has been in place continuously since February 14, 1992, but numerous formal and informal consultations have occurred over the years as new species of fish, plants, and wildlife have been listed, new critical habitat has been designated, project operation has changed in response to regulatory requirements, and legal challenges have occurred. Today, CVP/SWP facilities located in the Delta are managed consistent with the 2009 National Marine Fisheries Service (NMFS) and 2008 U.S. Fish and Wildlife Service (USFWS) BiOps. For a detailed history of consultation from 1992–2009 please see the 2009 NMFS[1] and 2008 USFWS[2] BiOps.

One part of this long and complex consultation history has been for a proposed north Delta diversion facility (i.e., for a dual-water conveyance system), which as now presented in Chapter 3, the Proposed Action (PA) of this biological assessment (BA), has been under various stages of development since January 2006, first as part of a conservation strategy in the Bay-Delta Conservation Plan (BDCP), and now as a stand-alone project referred to as "California WaterFix." Accordingly, this BA has been prepared by the U.S. Bureau of Reclamation (Reclamation) to initiate an interagency consultation consistent with ESA Section 7. Reclamation is the lead Federal agency for this consultation, and has been designated by the U.S. Army Corps of Engineers to act in their behalf for the purposes of this consultation, as specified in a letter of April 2, 2015 (SPK-2008-00861; Jewell 2015). The past 8 years has been spent in nearly continuous engagement among multiple agencies, including the Bureau of Reclamation (Reclamation), the California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), NMFS, and USFWS (among others) for the "co-equal goals" of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem; this HCP/NCCP process has included numerous productive discussions and the publication of many reports and other documents that address both technical and policy issues. Most of the record of this HCP/NCCP development process is publicly available in the form of documents that have been archived on a DWR-administered website at

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[1] The June 4, 2009, NMFS *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project* can be found at: http://www.westcoast.fisheries.noaa.gov/central_valley/water_operations/ocap.html. All references to this document are intended to include the amendments issued on April 7, 2011, which can be found at: http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/Operations,%20Criteria%20and%20Plan/040711_ocap_opinion_2011_amendments.pdf.

[2] The December 15, 2008, USFWS *Biological Opinion on Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP)* can be found at: http://www.fws.gov/sfbaydelta/cvp-swp/cvp-swp.cfm.

www.baydeltaconservationplan.com. In December 2013, the draft BDCP was released along with a draft environmental impact statement (DEIS) intended to comply with the Federal requirements under section 10 of the ESA as a habitat conservation plan (HCP), and the associated Federal environmental analysis (NEPA) requirements. The project described in the draft BDCP and DEIS also was intended to comply with applicable state regulations.[3] In coordination with Reclamation, DWR, as the applicant, has since added three NEPA alternatives to the range considered to meet the purpose and need of the PA and DWR and Reclamation have identified the PA in this biological assessment as the preferred alternative. Reclamation and DWR, therefore, have now chosen to pursue ESA compliance for operations in the Delta under the Section 7 process (with Reclamation as the Federal action agency), as represented by this biological assessment (BA) and its associated consultation. A Supplemental Draft EIS[4] was issued on July 9, 2015, updating the 2013 Draft EIS. The new NEPA alternatives in the Supplemental Draft EIS contain fewer conservation measures and changes in tunnel alignment and diversion operations than the previously analyzed alternatives. With the additional alternatives, DWR and Reclamation propose the use of Section 7 consultation to comply with the ESA. DWR considers these additional alternatives within the range of alternatives that meet the purpose and need as described in the EIS and has subsequently identified the PA as the NEPA preferred alternative. Reclamation and DWR, therefore, have now chosen to pursue ESA compliance for operations in the Delta under the Section 7 process (with Reclamation as the Federal action agency), as represented by this BA and its associated consultation.

From March 2015 through November 2015, NMFS, USFWS, CDFW, DWR, and Reclamation participated in collaborative meetings to develop appropriate technical approaches to the evaluation of this PA. These included the following:

- Weekly Section 7 Consultation Team meetings.
- Weekly ESA Technical Team meetings.
- Weekly Terrestrial Technical Team meetings.
- Weekly Aquatics Technical Team meetings.
- Various workshops to discuss specific topics, such as the inclusion of climate change, application of specific modeling tools, modeling assumptions, and other technical topics.

In September, 2014, planning efforts for the ESA Section 7 compliance component of the Bay Delta Conservation Plan (BDCP), a Section 10 permit application, commenced with the formation of the Section 7 Consultation Team (SCT). Attendees included representatives from Reclamation, DWR, USFWS, NMFS, and DFW. The purpose of the SCT was to coordinate the use of the BDCP Section 10 document for purposes of completing the Section 7 consultation. Meetings were held bimonthly through December. In February 2015, Reclamation and DWR decided to pursue a Section 7 consultation in lieu of the Section 10 permit. At that time, the SCT

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[3] The BDCP was also intended to comply with the California Natural Community Conservation Planning Act and therefore, the EIS was prepared as a joint document with the environmental impact report (EIR) in compliance with the California Environmental Quality Act (CEQA).

[4] Prepared jointly with DWR's CEQA document, a Partially Recirculated Draft EIR

began meeting weekly and was focused on the development of a new document to support Section 7 consultation. Additionally, technical teams were formed with the same membership as the SCT to allow USFWS and NMFS to provide technical assistance in the development of the BA. Technical teams met regularly to discuss the proposed action, analytical approaches, organization of the BA, and other topics pertinent to the development of the BA. The SCT and technical teams continued to meet regularly through the development of the Final BA. In addition, Principal meetings were held throughout the development of the BA to discuss the Section 7 consultation as well as other topics pertinent to the proposed action.

Additionally, beginning in April 2015, the U.S. Army Corps of Engineers (USACE) and U.S. Environmental Protection Agency (EPA) also participated in technical discussions pertaining to relevant components of the consultation through the weekly ESA technical team meetings.

Table-2-1. Chronology of ESA Consultation for Coordinated CVP/SWP Operations.

Date	Action
July, 2006	Several state and private parties enter into a memorandum of agreement (MOA) that sets out the financial commitments of the parties to carry out actions to satisfy existing regulatory requirements related to operation of the CVP/SWP and develop a conservation plan for the Delta that would support new regulatory authorizations under state and Federal endangered species laws for current and future activities related to the CVP/SWP. This plan comes to be called the Bay-Delta Conservation Plan (BDCP). DWR unites the MOA parties into a BDCP Steering Committee, which commences regular meetings that continue until November 18, 2010.
December 15, 2008	USFWS issues a BiOp for the *Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP)* (USFWS 2008), portions of which address operation and management of CVP/SWP facilities in the Delta. Reclamation provisionally accepts and then implements the BiOp including the Reasonable and Prudent Alternative (RPA).
June 4, 2009	NMFS issues a BiOp for the *Long-Term Operations of the Central Valley Project and State Water Project* (NMFS 2009), portions of which address operation and management of CVP/SWP facilities in the Delta. Reclamation provisionally accepts the BiOp, including RPA, on June 4, 2009, and then implements.
September, 2010	USFWS issues a BiOp, analyzing the effects of the geotechnical studies for the BDCP and preliminary engineering studies for the Delta Habitat Conservation and Conveyance Program.
December, 2010	The BDCP steering committee is dissolved and DWR continues the BDCP planning process as the principal applicant for the BDCP, which is intended to serve as an HCP for the purposes of ESA compliance and as a natural community conservation plan for the purposes of NCCPA compliance. The BDCP at this stage includes, in a preliminary form, the proposed new facilities and water operations subsequently incorporated into the PA for the California WaterFix. DWR and its contractors meet regularly with Reclamation, CDFW, NMFS, and USFWS staff members to discuss issues related to development of the HCP and Natural Community Conservation Plan (NCCP); these meetings continue until release of the draft BDCP in December 2013.
January 7, 2011	FWS issues BiOp on DWR’s 2011 Georgiana Slough Non-Physical Barrier Study.
February 22, 2011	NMFS issues BiOp on DWR’s 2011 Georgiana Slough Non-Physical Barrier Study.
April 7, 2011	NMFS issues amendments to the RPA of its 2009 BiOp (NMFS 2009). Subsequent references in this biological assessment to NMFS’s 2009 CVP/SWP BiOp should be interpreted to include reference to these 2011 amendments, as applicable.

Date	Action
May 4, 2011	The District Court issues a final judgment amending its December 14, 2010, decision in the Delta Smelt Consolidated Cases and orders USFWS to complete a final revised BiOp by December 1, 2013.
September 20, 2011	In the Consolidated Salmonid Cases (a group of six related cases brought against NMFS by various water management entities), the District Court remands portions of the 2009 NMFS BiOp to NMFS for further consideration.
December 12, 2011	Following on its September 2011 remand decision, the District Court orders NMFS to complete a draft BiOp by October 1, 2014, and a final BiOp by February 1, 2016.
December 14, 2011	USFWS issues a draft BiOp on the effects of coordinated CVP/SWP operations on Delta Smelt.
December, 2012	The Departments of the Interior and Commerce and DWR file a joint motion in the District Court for a 3-year extension of the current court-ordered deadlines. The request included delaying completion of the USFWS and NMFS BiOps and the associated NEPA process for 3 years in favor of implementing a Collaborative Science and Adaptive Management Program (CSAMP), which is largely targeted at key Delta actions included in the RPA identified in the BiOps, and as a test run for adaptive management activities included in the BDCP.
April 9, 2013	The District Court grants a staged extension, extending all deadlines related to the remanded BiOps and the NEPA process by 1 year, with the potential for two additional 1-year extensions if satisfactory progress is demonstrated to the court. This extended the deadline for the final USFWS revised BiOp to December 1, 2014, and the final NMFS revised BiOp to February 1, 2017.
October 18, 2013	DWR issues a biological assessment for the 2014 Georgiana Slough Floating Fish Guidance Structure Study.
December 13, 2013	DWR issues draft BDCP, files an application for an incidental take permit under Section 10 of the Act, and together with Reclamation, NMFS, and USFWS, issues a Draft Environmental Impact Report (EIR)/EIS, evaluating the BDCP and 12 other alternatives. Public comment period on the plan and EIR/EIS extends through July 29, 2014.
February 11, 2014	USFWS issues a BiOp on DWR’s 2014 Georgiana Slough Floating Fish Guidance System Project.
February 18, 2014	NMFS issues a BiOp on DWRs 2014 Georgiana Slough Floating Fish Guidance Structure Project.
February 21, 2014	USFWS issues a programmatic BiOp on DWR’s 2013–2017 Temporary Barriers Project, which supersedes USFWS’s previous BiOps and amendments for the Temporary Barriers Project.
March 5, 2014	The District Court extends all deadlines an additional year. This revises the deadline for the final USFWS revised BiOp to December 1, 2015, and the final NMFS revised BiOp to February 1, 2018.
March 13, 2014	The United States Court of Appeals for the Ninth Circuit (Appellate Court) issues an opinion on the Smelt Consolidated Cases, reversing the District Court remand of the 2008 USFWS BiOp.
September 16, 2014	The Appellate Court issues a mandate on the Delta Smelt Consolidated Cases that the judgment of the court, entered March 13, 2014, was in effect.
October 1, 2014	The District Court issues an amended judgment on the Delta Smelt Consolidated Cases, reaffirming the November 13, 2009, judgment that Reclamation’s adoption of the December 15, 2008, USFWS BiOp violated NEPA, remanding Reclamation’s December 2008 Provisional Acceptance of the USFWS BiOp and requiring that Reclamation comply with its obligations under NEPA and issue a finding of no significant impact or record of decision (ROD) by no later than December 1, 2015.

Date	Action
January 9, 2015	Reclamation reinitiates consultation with USFWS on the 2008 FWS OCAP Biological Opinion and Conveyance of Revised Incidental Take for the 2015 Water Year.
February, 2015	Reclamation and DWR decide to pursue an ESA Section 7 compliance pathway for permitting of water facilities formerly proposed under BDCP.
April 2, 2015	U.S. Army Corps of Engineers, Sacramento District, designates Reclamation as lead Federal agency for the ESA Section 7 consultation on the California WaterFix.
October 1, 2015	Reclamation delivers a draft California WaterFix biological assessment to NMFS and USFWS for review.
October 30, 2015	Reclamation delivers additional components of the draft California WaterFix biological assessment to NMFS and USFWS for review.
November 2015	NMFS and FWS provide comments on the draft California WaterFix biological assessment to Reclamation in the context of a series of meetings and emails.

2.2 References

Jewell, Michael S. 2015. Letter from Michael S. Jewell, Chief, Regulatory Division, U.S. Army Corps of Engineers, Sacramento District, to Michelle Banonis, U.S. Bureau of Reclamation, Sacramento, CA. Dated April 2, 2015. Identification number SPK-2008-00861.

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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 U.S. Fish and Wildlife Service (USFWS) and 2009 National Marine Fisheries Service (NMFS) Biological Opinions (BiOps) 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	

Topic	Action	Description	Source	Comments
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)	Existing real-time decision making process is incorporated into the PA as described in Section 3.1.5. In addition to this process a separate real-time operations coordination team will be convened in an advisory capacity, as described in Section 3.3.3.
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.
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.

Topic	Action	Description	Source	Comments
Flow	Jones Pumping Plant	Permitted diversion capacity of 4,600 cfs	Reclamation (2008) USFWS (2008) NMFS (2009)	To be operated per flow criteria. Permitted diversion capacity does not allow for more water to be exported in conjunction with the operation of NDD than is permitted by the SWRCB.
Flow	Banks Pumping Plant	Diversion rates at Clifton Court intake are 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 all aspects of this action including salvage based triggers, and replace this RPA action. See Table 3.3-1 and Section 3.3.2.
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.
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.

Topic	Action	Description	Source	Comments
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 without any 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.
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.

Topic	Action	Description	Source	Comments
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.
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.

Topic	Action	Description	Source	Comments
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)	In progress.
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.
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.

Topic	Action	Description	Source	Comments
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
IEP = Interagency Ecological Program
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 entails construction and operation of facilities 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 also entails operation of the existing and proposed new CVP/SWP Delta facilities in a manner that minimizes or avoids adverse effects on listed species, and that protects and enhances 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.

The Proposed Action includes ongoing compliance with D-1641 (the current Bay-Delta Water Quality Control Plan), ongoing compliance with the Fall X2 RPA (FWS 2008), and a new spring outflow criterion that ensures the same spring outflow exceedance frequencies that would have occurred absent the PA. Reclamation has reinitiated consultation with FWS and NMFS on the Coordinated Long-Term Operation of the CVP and SWP (LTO). This more broadly-scoped consultation will update system-wide operating criteria for the LTO consistent with the requirements of section 7 and will be coordinated with the update of the water quality control plan.

Presentation of the PA in this biological assessment does not amount to a project approval by DWR or Reclamation. DWR must complete CEQA review, as well as compliance with several other federal and state environmental laws and regulations, before it can construct, operate or use any new facilities associated with the PA. Reclamation must complete NEPA review prior to implementing any federal actions associated with the PA. In conducting its CEQA review, and completing other environmental compliance processes, DWR may be required to modify, add, or remove elements of the PA consistent with the requirement to adopt mitigation measures and/or alternative in order to address specific environmental impacts. Consistent with the directives of CEQA, DWR may determine, at the completion of the CEQA process, to deny approval of the PA or specific elements of the PA based on any significant environmental impact that cannot be mitigated. Prior to the conclusion of formal consultation, the BA will be supplemented if substantive changes are made to the PA relevant to the analysis of listed species or designated critical habitat.

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 C.W. "Bill" Jones Pumping Plant (Jones 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 SWRCB Decision 1641 (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 (1995 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 that impose multiple operations responsibilities on CVP/SWP in the Delta to meet the flow objectives in the 1995 WQCP. With D-1641 (issued December 29, 1999) and its subsequent revision (Revised D-1641, dated March 15, 2000), the SWRCB implements the objectives set forth in the 1995 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 subsequently 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 1995 WQCP. 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 1995 WQCP.

The SWRCB adopted a revised WQCP on December 13, 2006. There were no changes to the Beneficial Uses from the 1995 WQCP to the 2006 WQCP, nor were any new water quality objectives adopted in the 2006 WQCP. 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 2006 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 WQCP. Phase 2 will involve comprehensive changes to the 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.

3.1.4.5 Annual/Seasonal Temperature Management Upstream of the Delta

Reclamation is required to control water temperature in the Sacramento River pursuant to State Water Board Order WR 90-5. Furthermore, per the Reasonable and Prudent Alternative (RPA) (Action Suite I.2) in the NMFS 2009 BiOp, Reclamation is required to develop and implement an annual Temperature Management Plan by May 15 each year to manage the cold water supply within Shasta Reservoir and make cold water releases from Shasta Reservoir, and Trinity Reservoir through the Spring Creek Tunnel, to provide suitable temperatures for listed species, and, when feasible, fall-run Chinook salmon, which is an important commercial fishery and a prey base for listed Southern Resident Distinct Population Segment (DPS) killer whale. Reclamation shall manage operations to achieve certain daily average water temperatures in the Sacramento River between Keswick Dam and Bend Bridge. In addition, Reclamation is required to provide the draft February forecast and initial allocations, as well as a projection of temperature management operations for the summer months to NMFS for review and evaluation under RPA Action I.2.3.

Since December 2013, state and Federal agencies that supply water, regulate water quality, and protect fish and wildlife have worked closely to manage these resources despite persistent drought conditions. As an example, in 2015 and 2016, Reclamation and NMFS adjusted the February operations forecast modeling, temperature compliance criteria, and Keswick release schedule in efforts to minimize further temperature effects. However, recent drought operations under the 2009 NMFS BiOp RPA have resulted in approximately 5.6% and 4.2% egg-to-fry survival to Red Bluff in 2014 and 2015, respectively[1]. In consideration of recent concerns with the level of protection provided by the NMFS 2009 BiOp RPA based on the very low egg-to-fry survival to Red Bluff, and new information regarding temperature tolerance during early life stages over the past few years, NMFS will work with Reclamation and other state and Federal agencies to adjust the RPA Action Suite 1.2. The adjustment will be made pursuant to the 2009 NMFS BiOp Section 11.2.1.2. *Research and Adaptive Management*, which states "After completion of the annual review, NMFS may initiate a process to amend specific measures in this RPA to reflect new information, provided that the amendment is consistent with the Opinion's underlying analysis and conclusions and does not limit the effectiveness of the RPA in avoiding jeopardy to listed species or adverse modification of critical habitat." This process is anticipated to conclude in late 2016 and may include refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. The adjusted RPA Action Suite I.2 will apply to Reclamation's Shasta operations when the adjustment process is completed as described above.

3.1.5 Real-Time Operations Upstream of the Delta

The goal for real-time decision making is to assist fishery management by minimizing potential 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 through 2030.

The PA does not propose changing any of the existing real-time operational 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.

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

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

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[1] NMFS' March 18, 2016, response to the Bureau of Reclamation's February forecast.

3.1.5.1 Ongoing Processes to support Real-Time Decision Making

Real-time changes to CVP/SWP operations that help avoid and minimize adverse effects to 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 fish and wildlife agency (consisting of USFWS, NMFS, and the California Department of Fish and Wildlife [CDFW]) determinations, Reclamation, DWR, and the fish and wildlife agencies have developed and refined (U.S. Bureau of Reclamation 2008; National Marine Fisheries Service 2009; U.S. Fish and Wildlife Service 2008) 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. All of 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, operational 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 fish and wildlife 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 fish and wildlife 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 addition, certain actions may require input from the SWRCB to assess consistency with WQCP requirements or other water rights permit terms. 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.The management team is comprised of management staff from Reclamation, DWR, and the fish and wildlife agencies. The 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.

All of 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.

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

CURRENT REAL TIME OPERATIONS DECISION-MAKING[2]			
Working Group	**Description**	**Agency Lead**	**Meeting**
Water Operations Management Team (WOMT)	Existing technical work teams report weekly updates and recommendations to the WOMT, which is then used to advise USFWS, NMFS and CDFW in order to make final determinations for listed aquatic species conservation needs and water operations.	DWR	Weekly (Tuesday at 1:00PM) October–June
Water Operations Technical Work Teams			
Smelt Working Group (SWG)	A technical advisory team that provides recommendations on SWP and CVP operations to USFWS, CDFW, and WOMT pursuant to the USFWS RPA on Delta Smelt and CDFW ITP on Longfin Smelt.	FWS	Weekly (Monday at 10:00AM) December–June
Delta Operations for Salmonids and Sturgeon (DOSS)	A technical advisory team that provides recommendations on SWP and CVP operations to NMFS and WOMT pursuant to the NMFS RPA on anadromous salmonids and green sturgeon.	NMFS	Weekly (Tuesday at 9:00AM) October–June
CALFED Operations Group	Representatives from fish agencies and stakeholder groups make recommendations to SWP and CVP operations with the requirements of the SWRCB's Decision 95-6, the NMFS & USFWS biological opinions and CVPIA.	DWR	Monthly
Central Valley Project Improvement Act B2 Interagency Team (B2IT)	Discusses implementation of section 3406 (b)(2) of the CVPIA, which defines the dedication of CVP water supply for environmental purposes. It communicates with WOMT to ensure coordination with the other operational programs or resource-related aspects of project operations, including flow and temperature issues.	FWS	Weekly (Thursdays at 9:30AM)
Data Assessment Team (DAT)	Coordinates and disseminates information and data among Project and Fisheries agencies and stakeholders that are related to water project operations, hydrology, and fish surveys in the Delta.	DWR	Weekly
Delta Conditions Team (DCT)	Coordinates with scientists and engineers from the state and federal agencies, water contractors, and environmental groups to review the real-time operations and Delta conditions, including data from new turbidity monitoring stations and new analytical tools. The members of the DCT provides their individual information to the SWG and/or DOSS, which can then be used to provide recommendations to WOMT.	FWS	Weekly (Friday at 9:30AM)
Sacramento River Temperature Task Group (SRTTG)	Meets initially in the spring to discuss biological, hydrologic, and operational information, objectives, and alternative operations plans to recommend a temperature control point. Once the SRTTG has recommended an operation plan for temperature control, Reclamation	USBR	Monthly (April–October)

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[2] National Marine Fisheries Service 2009; U.S. Fish and Wildlife Service 2008

	submits to the SWRCB an operations plan for temperature control, generally on or before June 1st each year.		
American River Group (ARG)	Although open to the public, the ARG meetings generally include representatives from several agencies and organizations with on-going concerns and interests regarding management of the Lower American River. The ARG convenes monthly or more frequently if needed, with the purpose of providing fishery updates and reports for Reclamation to help manage Folsom Reservoir for fish resources in the Lower American River.	USBR	Monthly
Clear Creek Technical Working Group (CCTWG)	Group that identifies, prioritizes, and guides restoration opportunities on lower Clear Creek with an emphasis on anadromous fish.	USBR	Quarterly
Stanislaus Operation Group (SOG)	Action III.1.1 calls for Reclamation to create a Stanislaus Operations Group to provide a forum for real-time operational flexibility and implementation of the alternative actions defined in the RPA. This group provides direction and oversight to ensure that the East Side Division RPA actions are implemented, monitored for effectiveness and evaluated. Reclamation, in coordination with SOG, shall submit an annual summary of the status of these actions.	USBR	Monthly
Stanislaus River Forum (SRF)	New group formed to allow for stakeholder input immediately prior to the SOG discussions. Not part of the existing NMFS BiOp.	USBR	Monthly (Right before SOG)
NMFS BiOp Annual Review Group	Reclamation and NMFS will host a workshop to review the prior water years' operations and to determine whether any measures prescribed in the 2009 NMFS Biological Opinion RPA should be altered in light of information learned from prior years' operations or research.	NMFS	Annually (No later than 11/30)
5 Agency Meeting (BO RPA Implementation)	To assure close coordination and oversee the efforts of IMT on the implementation of the biological opinions governing SWP and CVP.	DWR	Monthly
Implementation Management Team (IMT)	Responsible for ensuring the regulatory compliance and implementation of the biological opinions (i.e. RPA actions).	NMFS	Monthly
Interagency Fish Passage Steering Committee (IFPSC)	To charter, and support through funding agreements, an interagency steering committee to provide oversight and technical, management, and policy direction for the Fish Passage Program.	USBR	Periodically

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

3.1.5.2.1 Water Operations 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. Existing working groups/technical work teams report weekly updates and recommendations to the WOMT, which are then used to advise USFWS, NMFS and CDFW in order to make final determinations for listed aquatic species conservation needs and water operations.

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, Smelt Working Group, Delta Conditions Team, Delta Operations for Salmonids and Sturgeon Workgroup, and American River Group. Each of these teams is described in more detail below. A more detailed list is provided in Table 3.1-2 above.

3.1.5.2.2.1 The Sacramento River Temperature Task Group

The Sacramento River Temperature Task Group (SRTTG) is a multiagency group formed by Reclamation 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 temperature management plan to SWRCB and NMFS, generally on or before June 1 each year.

After implementation of the operations plan, the SRTTG may report out on the results of studies and monitoring, or temperature model runs. The group holds meetings as needed, typically monthly through the summer and into fall, to recommend 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, U.S. Environmental Protection Agency (USEPA), Reclamation, and NMFS. 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, SWG has also developed recommendations for CDFW to minimize adverse effects on longfin smelt.

The SWG compiles 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 WOMT, 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 historically occurred.

3.1.5.2.2.3 Delta Operations for 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 on salmonids and green sturgeon. The purpose of DOSS is to review CVP and SWP operations in the Delta and the collected data from the different ongoing monitoring programs.

3.1.5.2.2.4 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 DOSS workgroup. Individual members of the DCT may provide, in accordance with a process provided by the WOMT, their information to the SWG or DOSS for their consideration in developing recommendations to the Project Agencies for actions to protect listed fish 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 recommendations 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).

3.1.6 Take Authorization Requested

The PA includes several activities that are expected to result in incidental take of federally listed species. In compliance with Section 7 of the ESA, take authorization is being requested for activities in which take is anticipated. However, some activities that may result in incidental take are not able to be authorized at this time because of lack of specific detail for effects to federally listed species. In these cases, separate incidental take authorization may be required via reinitiation of the CWF consultation, separate Section 7 consultation, or scientific collection permits.

The following timeline of actions indicates which of the actions under the PA include a request for take authorization. For clarity on the relationship of these actions to the existing biological opinions, the timeline also includes some components of operations pursuant to the USFWS (2008) and NMFS (2009) biological opinions for the operations of the CVP and SWP.

3.1.6.1 Construction Phase

The construction phase begins when the NEPA record of decision is issued and ends when operations of the NDDs commence. During the construction phase, take authorization is requested for the following activities.

- All activities described in Section 3.2.1 *Geotechnical Exploration*.
- All activities described in Section 3.2.2 *North Delta Diversions*.
- All activities described in Section 3.2.3 *Tunneled Conveyance*.
- All activities described in Section 3.2.4 *Intermediate Forebay*.
- All activities described in Section 3.2.5 *Clifton Court Forebay*.
- All activities described in Section 3.2.6 *Connections to Banks and Jones Pumping Plants.*
- All activities described in Section 3.2.7 *Power Supply and Grid Connections.*
- All activities described in Section 3.2.8 *Head of Old River Gate.*
- All activities described in Section 3.2.9 *Temporary Access and Work Areas.*

During the construction phase, take authorization is not requested for the following activities.

- CVP/SWP operations, which will continue pursuant to the USFWS (2008) and NMFS (2009) biological opinions.
- Construction of the Georgiana Slough non-physical barrier described in Section 3.4.3.1.1.1 *Nonphysical Fish Barrier at Georgiana Slough.*
- Construction of mitigation for impacts to listed species, described in Section 3.4.3 *Restoration for Fish Species* and Section 3.4.5 *Terrestrial Species Conservation*. Once these mitigation sites have been selected, following procedures described in the cited sections, separate Section 7 consultations are expected for construction at each mitigation site.
- Mitigation site compliance monitoring effects on listed species other than valley elderberry longhorn beetle and California red-legged frog. Such monitoring will need scientific collection permits.

3.1.6.2 Operations Phase

The operations phase begins when operations of the NDDs commence. During the operations phase, take authorization is requested for the following activities.

- Operations of the NDDs as described in Section 3.3.2.1 *Operational Criteria for North Delta CVP/SWP Export Facilities.*
- Continued operations of south Delta CVP/SWP export facilities (i.e., operations currently covered under the USFWS (2008) and NMFS (2009) biological opinions for the operations of the CVP and SWP) as described in Section 3.3.2.2 *Operational Criteria for South Delta CVP/SWP Export Facilities.*
- Operations of the HOR gate as described in Section 3.3.2.3 *Operational Criteria for the Head of Old River Gate.*
- Operations of the Delta Cross Channel gates as described in Section 3.3.2.4 *Operational Criteria for the Delta Cross Channel Gates.*
- Operations of the Suisun Marsh facilities as described in Section 3.3.2.5 *Operational Criteria for the Suisun Marsh Facilities.*
- Operations of the North bay Aqueduct intake as described in Section 3.3.2.6 *Operational Criteria for the North Bay Aqueduct Intake.*
- Operations of the Georgiana Slough non-physical barrier as described in Section 3.4.3.1.1.1 *Nonphysical Fish Barrier at Georgiana Slough.*
- Giant garter snake habitat maintenance as described in Section 3.3.6.4 *Clifton Court Forebay and Pumping Plant* and Section 3.3.6.6 *Power Supply and Grid Connections.*

During the operations phase, take authorization is not requested for the following activities.

- All activities described in Section 3.4.3.1.1.1 *Nonphysical Fish Barrier at Georgiana Slough.* Installation and operations of this barrier are expected to be covered under a separate Section 7 consultation.
- In-water maintenance activities described in Section 3.3.6.1 *North Delta Diversions.* It is not possible, prior to final design of the facilities, to define how these activities would be performed or how often they would be needed. These activities will be addressed via consultation reinitiation or via a separate Section 7 consultation.
- In-water maintenance activities described in Section 3.3.6.4 *Clifton Court Forebay and Pumping Plant.* It is not possible, prior to final design of the facilities, to define how these activities would be performed or how often they would be needed. These activities will be addressed via consultation reinitiation or via a separate Section 7 consultation.

- In-water maintenance activities described in Section 3.3.6.5 *Connections to Banks and Jones Pumping Plants.* It is not possible, prior to final design of the facilities, to define how these activities would be performed or how often they would be needed. These activities will be addressed via consultation reinitiation or via a separate Section 7 consultation.

- In-water maintenance activities described in Section 3.3.6.7 *Head of Old River Gate.* It is not possible, prior to final design of the facilities, to define how these activities would be performed or how often they would be needed. These activities will be addressed via consultation reinitiation or via a separate Section 7 consultation.

- Fish monitoring and studies described in Section 3.4.7 *Monitoring and Research Program.* These studies are subject to design through a collaborative process engaging the fish and wildlife agencies. The need for take authorization and any necessary Section 7 consultation will occur through that process.

- Mitigation site compliance monitoring effects on listed species other than valley elderberry longhorn beetle and California red-legged frog. Such monitoring will need scientific collection permits.

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.

As part of the water right change in point of diversion process with the California State Water Resources Control Board, DWR and Reclamation are working to address the concerns of protesting legal users of water throughout the watersheds involved in either the CVP or SWP. To date, only one settlement, with Contra Costa Water District (CCWD), is complete. The CCWD settlement requires the inclusion of mitigation measures for water quality effects associated with the PA. The mitigation measures include sequenced implementation mechanisms, related to the construction, operation, and maintenance of additional facilities to transfer water to existing CCWD facilities. Because the detail and related effects of those facilities are currently being defined, the adverse effects to listed species and to critical habitat are not evaluated in this BA. When actions associated with implementation of the agreement are sufficiently defined to provide for analysis of potential adverse effects to listed species and critical habitat, a supplement to this BA will be provided to the Services.

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]; 3.C *Conceptual Engineering Report, Volume 2*; and 3.D *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 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 general avoidance and minimization measures detailed in Appendix 3.F *General Avoidance and Minimization Measures* (AMMs)[4]. 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 species-specific AMM, proposed work may occur at the following times of day (see Table 3.2-1 for definitions of each term).

- Clearing: Between dawn and sunset.

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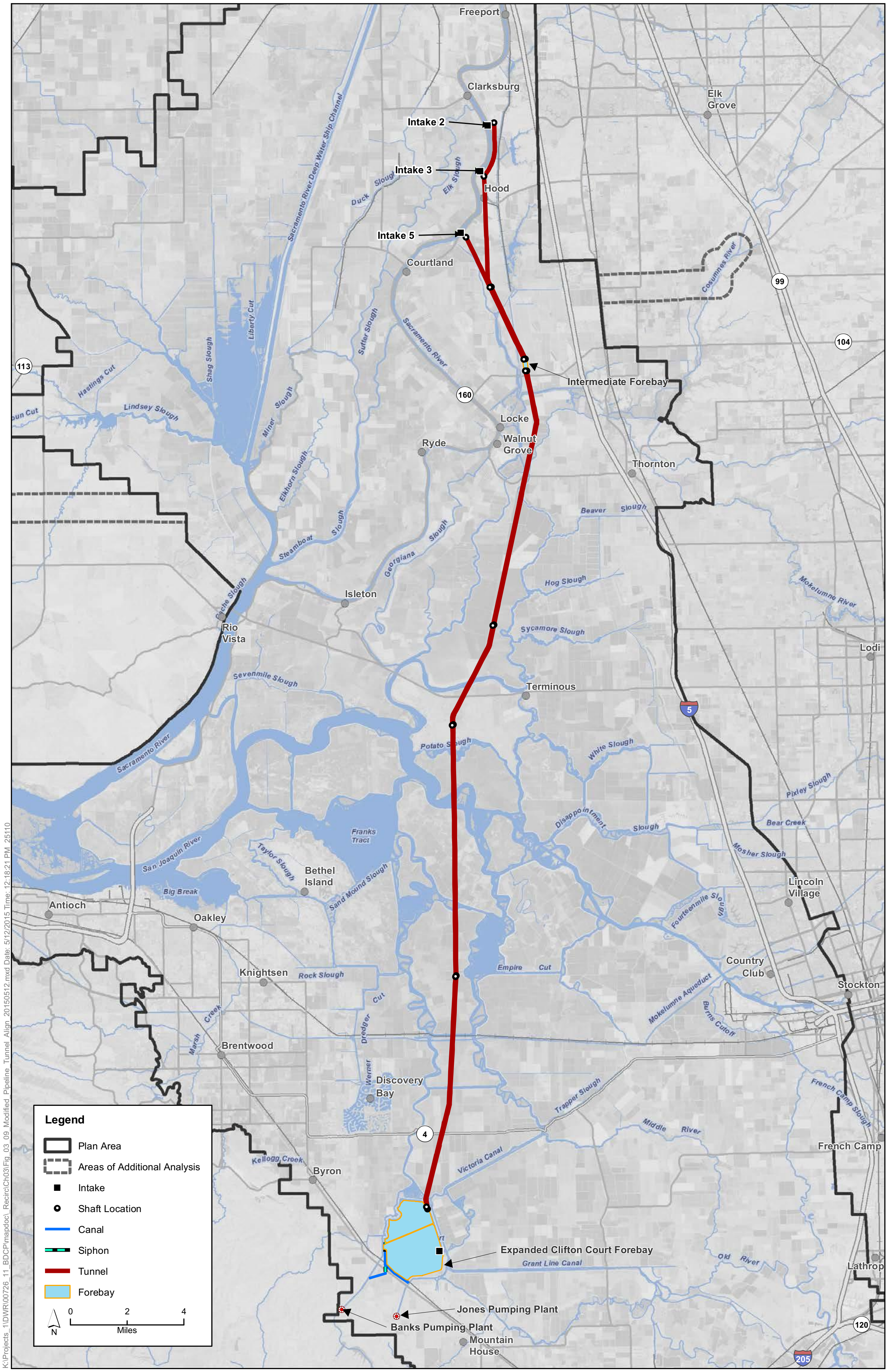
[3] Note that Appendix 3.B *Conceptual Engineering Report, Volume 1* and Appendix 3.C *Conceptual Engineering Report, Volume 2* were prepared to support engineering conceptual design as of July 1, 2015. During the preparation of this biological assessment, certain design changes were made in order to further minimize potential effects on listed species. Thus the PA described in this biological assessment differs in some particulars from the description in the appendices. Where such inconsistencies occur, the biological assessment constitutes an accurate description and represents DWR's and Reclamation's intent to perform the PA as here described.

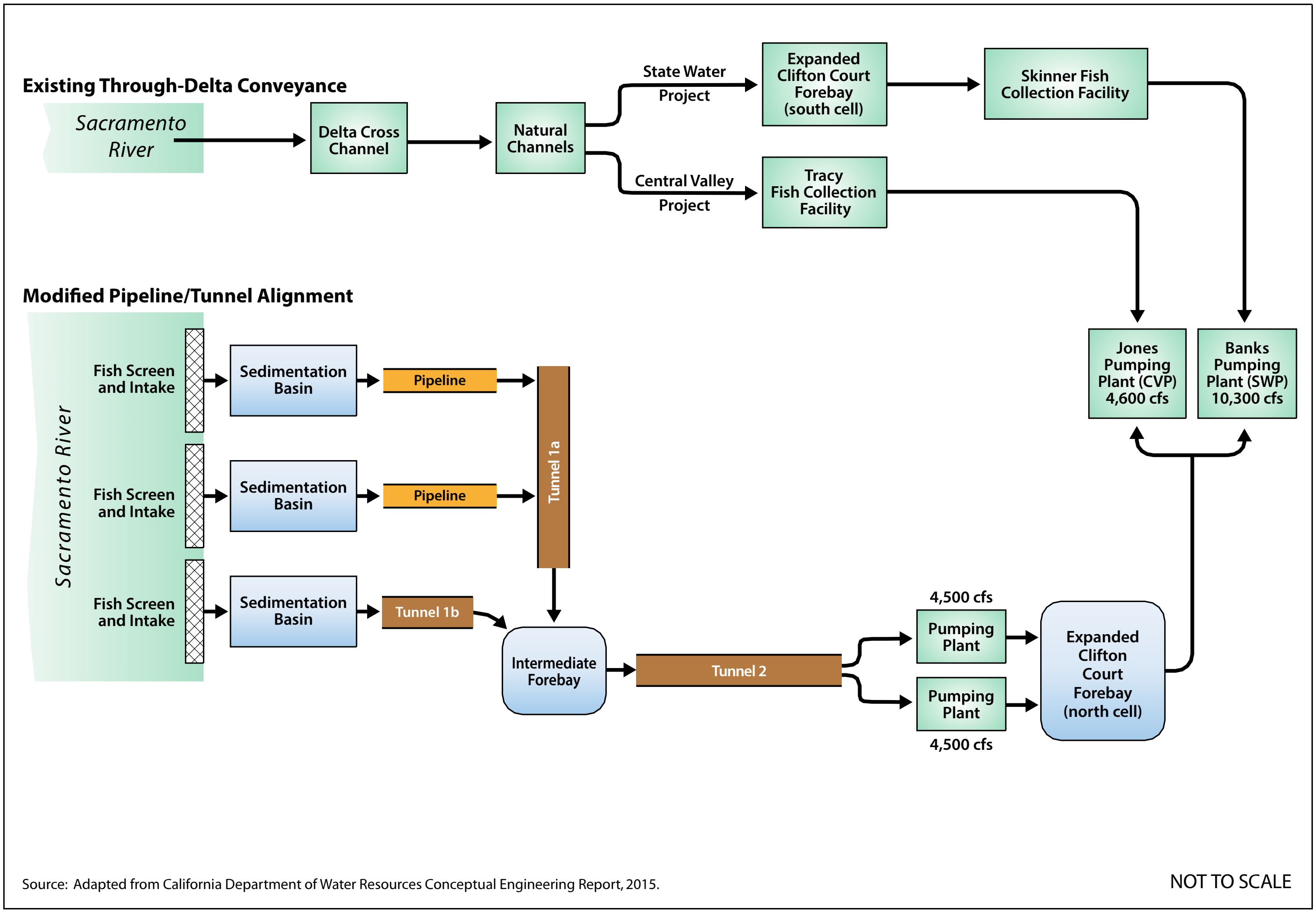
[4] The AMMs presented in this section are also the subject of concurrent environmental review processes required for approval of the PA and, therefore, may be subject to further revision. Prior to the conclusion of formal consultation, the BA will be supplemented if substantive changes are made to the AMMs relevant to the analysis of listed species or designated critical habitat.



K:\Projects_1\DWR\00726_11_BDCP\mapdoc_Recirc\Ch03\Fig_03_09_Modified_Pipeline_Tunnel_Align_20150512.mxd Date: 5/12/2015 Time: 12:18:21 PM 25110

Sources: Plan Area, ICF 2012; Option Features (Rev 5a), DHCCP DWR 2015

Figure 3.2-1 Proposed Action Overview



Source: Adapted from California Department of Water Resources Conceptual Engineering Report, 2015.

BDCP EIR/EIS (2/26/15) TM

Figure 3.2-2 Conveyance Schematic

- Site work: At any time of the day or night.
- Ground improvement: At any time of the day or night.
- Borrow fill: At any time of the day or night.
- Fill to flood height: At any time of the day or night.
- Dispose spoils: At any time of the day or night.
- Dewatering: At any time of the day or night.
- Dredging and Riprap Placement: Between dawn and sunset when performed adjacent to or in water bodies. At any time of the day or night when performed in dry areas or in a previously-cleared area.
- Barge operations: At any time of the day or night.
- Landscaping: Between dawn and sunset.
- Pile Driving: Between dawn and sunset.

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.

Several activities required for conveyance construction (e.g., dredging, pile driving, barge operations, geotechnical exploration, etc.) will result in disturbance and redistribution of sediments at and below the surface. There is a potential for some of these sediments to contain existing contaminants, and the disturbance associated with these activities could increase the risk of exposure to contaminants for listed species. Detailed sediment and contaminant characterizations of the specific areas expected to be subject to sediment disturbance are limited and do not provide enough information to support a thorough analysis of effects at this time. Examples of such studies include the maintenance dredging of Discovery Bay and the maintenance dredging of federal navigational channels in San Francisco Bay.

The former study (Central Valley Water Board 2003) considered a site near Clifton Court forebay where sediments are predominantly silt- and clay-sized, with less than 33% sand. Such sediments may be taken as representative of potential contaminants in the Clifton Court Forebay area. Contaminants detected in sediment testing included arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, zinc, tributyltin, polycyclic aromatic hydrocarbons, and organochlorine pesticides. Arsenic levels averaged 7.4 mg/kg, which is below average Sacramento-San Joaquin Delta background concentrations. All other constituents were at concentrations significantly below Human Residential and Human Industrial screening values.

The latter study (USACE and San Francisco Water Board 2014) considered a variety of federally maintained navigation channels. Although the channels are located downstream of the

Sacramento-San Joaquin Rivers confluence, the evaluated materials had predominately been transported downstream from those rivers, and at several of the tested sites primarily consisted of fine sand; thus study results are expected to be representative of contaminants likely to be found in the NDD area, where preliminary geotechnical results indicate surficial sediments that are predominately sand-sized. Sediment from the San Francisco Ship Channel was found to be 93% to 99% sand, and the analysis concluded "The total organic carbon levels in composite samples (total of two composites) ranged from 0.11 percent to 0.35 percent for samples collected in 2010. This is considered to be low, and in the highly suitable range for beneficial reuse. Throughout the years that MSC has been tested for maintenance dredging purposes, the sediment has been determined to be suitable for unconfined aquatic placement at the San Francisco Bar Channel Disposal Site (SF-8) or the Ocean Beach Demonstration Site." Testing at the Suisun Bay Channel and New York Slough found sediments to be 94% to 99% sand and concluded "Historically, the sediment has been deemed suitable for in-Bay placement at SF-9 and Suisun Bay placement site (SF-16). In 2009, confirmatory chemistry tests were run, in addition to the usual grain-size testing; these tests showed that no potential contaminant exceeded acceptable limits." Other sites yielded similar results, but are not reported here because their primary sediment source was not the Sacramento and San Joaquin rivers.

Based on these previous studies, the preliminary contaminant risk to listed species is low due to low contaminant levels in both clay/silt and sand samples, with particularly low concentrations likely in the predominately sand-sized sediments at the NDDs where exposure risk is greatest. Therefore, analysis of all actions in this PA that result in potential turbidity effects and sediment disturbance assumes a level of risk to the species from exposure to contaminants that is equivalent to the findings of the first-level sediment assessment for an initial evaluation of effects to listed fish species and their aquatic habitat. The PA also includes AMMs that are intended to specifically address the identified preliminary contaminant risk(s).

As described in Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material,* to better define potential effects to listed species or aquatic habitat, and to streamline the collection and incorporation of newer information (i.e., monitoring data or site-specific baseline information), the following protocol will be followed. The action agency will work with State and Federal resource agencies with authorization and jurisdiction to identify the timeline for information gathering in relation to initiation of the specific action, but it is anticipated to be at least several months prior to the initiation of the action. At that time, DWR and Reclamation will follow the protocol below.

- DWR will ensure the preparation and implementation of a pre-dredge sampling and analysis plan (SAP). The SAP will be developed and submitted by the contractor(s) as part of the water plan required per standard DWR contract specifications (Section 01570). Prior to initiating any dredging activity, the SAP will evaluate the presence of contaminants that may affect water quality from the following discharge routes.
    - Instream discharges during dredging.
    - Direct exposure to contaminants in the material through ingestion, inhalation, or dermal exposure.

  - Effluent (return flow) discharge from an upland disposal site.
  - Leachate from upland dredge material disposal that may affect groundwater or surface water.

- Concentrations of the identified chemical constituents in the core samples will be screened through appropriate contaminant screening tables to ensure compliance with applicable agency guidelines.

- Results of the sediment analyses and the quality guidelines screening will determine the risk associated with the disturbance of the sediment horizons by identifying specific pathways of exposure to adverse effects.

- Results of the testing will be provided to all relevant State and Federal agencies for their use in monitoring or regulating the activities under consideration.

- If the results of the chemical analyses of the sediment samples indicate that one or more chemical constituents are present at concentrations exceeding screening criteria, then additional alternative protocols to further minimize or eliminate the release of sediments into the surrounding water column must be implemented.

- The applicant must provide to CDFW, NMFS and USFWS a plan to reduce or eliminate the release of contaminated sediment prior to the start of any actions that will disturb the sediments in the proposed construction area. Plans using a shrouded hydraulic cutterhead, or an environmentally sealed clamshell bucket may be acceptable provided that adequate supporting information is provided with the proposed plan. Plans should also include descriptions of the methods employed to treat, transport, and dispose of the contaminated sediment, as well as any resulting decant waters.

This approach incorporates the potential for take authorization to be revised at the time that effects of the action are determined to be “reasonably certain to occur” and the description of activities, existing conditions, and risk to species can be more specifically described with updated, site-specific information.

This type of approach is consistent with approaches to ESA compliance for other large-scale, long-term, repeated actions that do not have adequate site-specific and current information to support the analysis of effect of a specific future action at the time of consultation.

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 impacts are presented.

Temporary impacts include impacts associated with new facility construction, but not ongoing or future facility operations. The following criteria determine whether a construction impact is temporary or permanent for the purposes of assessing effects on listed species.

- For all wildlife species and Delta Smelt, impacts lasting more than 1 year (365 days) are considered permanent.

- For all salmonid species and green sturgeon, impacts lasting more than 2 years are considered permanent.

Temporary impacts are not compensated for by habitat restoration; however, affected sites are restored to preconstruction conditions.

Note that Appendix 3.A does not include facilities for which the location is unknown. These unknown locations fall into three types: geotechnical exploration sites, safe haven work areas, and barge landings. Section 3.2.1 *Geotechnical Exploration* describes geotechnical exploration sites; Section 3.2.3 *Tunneled Conveyance* describes safe haven work areas; and Section 3.2.10.9 *Barge Landing Construction and 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.

Appendix 3.B[3] *Conceptual Engineering Report, Volume 1,* provides 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[3] *Conceptual Engineering Report, Volume 2,* provides detailed drawings of conveyance facilities.

Appendix 3.D *Construction Schedule for the Proposed Action*, contains 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 (Storm Water 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 proposed in-water work windows[5] 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.

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

Number	Title	Summary
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.
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.

A great deal of refinement has occurred during the PA development process, 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.

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 1,380 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 on 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 ranging from a few hours to 12 work days, depending on exploration type and target depth. Exploration locations that involve only CPT testing and/or soil test pits will typically be active for less than 1 day (normally a crew would do two such locations per day). There will be approximately 415 sites that involve only CPT testing. The remaining exploration locations (approximately 965) involve soil borings and will be active for multiple days, with the duration of activity dependent upon the depth of the borings. The deepest borings (i.e., 300 feet) will be located at shaft locations, and will require up to 12 work days. There will be approximately 50 such locations. The remaining 365 borings will be to depths of up to 200 feet and will be located along the majority of the tunnel alignment and at other facility construction sites (i.e., the intakes, Intermediate Forebay, and facilities near Clifton Court Forebay); work at these sites will require approximately 5 work days each. After each site is explored, bored 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. Piezometers will be installed at some sites, and at these locations, technicians may periodically revisit the sites to collect data. Aquifer pump tests will also be performed at some sites; however, pump test activities are not expected to exceed 10 days at these sites.

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. An additional 25 to 35 of these locations will be at the major water undercrossings along the tunnel alignment and 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 between 100 and 200 feet below the mud line (i.e., river bottom).

DWR will conduct overwater drilling only during the in-water work window[5] 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 550 land-based and 43 overwater 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 830 land-based and 94 overwater 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	550	880
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 6 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 6 days per week. Work will be performed within proposed in-water work windows[5]. 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 3 years of implementation. See Appendix 3.D *Construction Schedule for the Proposed Action* for further information on the 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 and 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 analyses 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 NMFS, CDFW, and 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[3] *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[3] *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, 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 Structure along Sacramento River Bank (feet)	Area of Intake Construction Site (acres)	Area of Tidal Perennial Habitat (acres)	
				Temporary In-Water Work	Permanent (Intake + Wing Wall Transitions)
Intake 2	41.1	1,969	190	4.9	2.6
Intake 3	39.4	1,497	152	3.3	1.8
Intake 5	36.8	1,901	144	5.0	2.3
Total	**--**	**5,367**	**486**	**13.2**	**6.6**

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 the Intermediate Forebay; 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 on fish, therefore 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. 2007), and therefore 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[6]. 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 inch 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 refugia areas (further discussed below).

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[6] 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).

Table 3.2-6. Fish Screen Dimensions

Intake	Screen Height	Screen Width	Number of Screens	Total Length of Screens[1]
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

Notes

[1] Fish screen length is shorter than structure length shown in Table 3.2-5 because structure length includes concrete approach sections and refugia.

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 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 by the fish agencies (i.e., USFWS, NMFS, and CDFW). The review and final design process will incorporate lessons from the Fish Facilities Technical Team (2011) work, the current NMFS (2011) guidance for fish screens, and recent relevant projects, as applicable. 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 NDD construction is presented in Appendix 3.D *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.

Each intake has its own construction duration with Intakes 2, 3, and 5 each projected to take approximately 4 to 5 years. 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 cover 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 Landing Construction and Operations*). Before site work commences, the contractor will implement erosion and sediment controls in accordance with the Storm Water Pollution Prevention Plan (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*.

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,* respectively, 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. Levee widening is done by placing low permeability levee fill material on the land-side of the levee. The material is compacted in lifts and keyed into the existing levee and ground. The levee will be widened by about 250 feet at each intake site. 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.

SR 160 will be impacted by construction activities at each of the three intake sites. During the levee widening, the highway will be permanently relocated from its current alignment along the top of the river levee to a new alignment established on top of the widened levee aligned approximately 220 feet farther inland from the river. The location of the new permanent SR 160 alignment is shown in Appendix 3.C *Conceptual Engineering Report, Volume 2,* Drawings 13, 14, 15 and 16.

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 river width varies from 475 feet at Intake 3 to 615 feet at Intake 5, so this represents 1.6% to 7.4% of the channel width.

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 permanent, 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*, with fish rescue occurring at that time, in accordance with a fish rescue plan that has been previously approved by CDFW, NMFS, and USFWS. Preparation and requirements for fish rescue plans are described in Appendix 3.F *General Avoidance and Minimization Measures*, *AMM8 Fish Rescue and Salvage Plan.* Following dewatering, areas within the cofferdam will be 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 after intake construction is complete 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 3.2-7 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 3.2-7 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 3.2-7 assumes that all piles will be driven using impact pile driving, but the design intent is to use impact pile driving only for placement of the intake structure foundation piles. All other piles will be started using vibratory pile driving and driving will be completed using impact pile driving. Based on experience during construction of the Freeport diversion facility, it is expected that approximately 70% of the length of each pile can be placed using vibratory pile driving, 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 3.2-7. 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 – Intakes 2, 3, and 5	In-water	Sheet pile	2,500	4	60	210	12,600
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. 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. In-water pile driving will be subject to abatement (e.g., use of a bubble curtain), 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*.

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[7], 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).

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

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[7] 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.

(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*). TBMs also have the potential to generate subsurface effects due to the sound produced by TBM excavation, which can be detected by sensitive receptors such as green sturgeon.

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 3.2-8 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[8], tunneling will be 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 electrically-powered conveyor will carry excavated material from the TBM back to the launch shaft, where a vertical conveyor will carry the material to the surface for disposal (Section 3.2.10.6 *Dispose Spoils*). A narrow-guage railway may be installed in the tunnel with a diesel locomotive, or rubber wheeled diesel engine trucks may be used to carry workers, tunnel lining segments, and other materials from the launch shaft to the TBM.

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[8] 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 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.

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 *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 Landing Construction and 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 3.2-8. 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

3.2.3.2 Schedule

Appendix 3.D *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.

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 such as ground freezing. 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 3.2-9 shows the number of safe haven interventions expected to be associated with each tunnel, based upon current understanding of site conditions.

Table 3.2-9. 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*

The principal dates for construction of the IF are shown in Table 3.2-10.

Table 3.2-10. 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	7/1/2026	7/11/2031	61 months
Earthworks	7/1/2026	12/25/2029	42 months
Inlet & outlet ground improvements	12/28/2028	10/12/2030	23 months
Inlet & outlet site work	9/27/2029	4/12/2030	8 months
Operate concrete batch plant; inlet & outlet concrete work	3/27/2030	4/11/2031	13 months
Inlet & outlet gates, mechanical & electrical work	12/25/2030	7/11/2031	7 months

[a] Dates given in this table assume a Record of Decision date of 1/1/2018 and a construction end date of 7/11/2031.

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 will have a surface footprint of 243 acres, all of which is permanent impact (under current conditions, the area is a vineyard). 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. In order to accomplish this dual function, the existing forebay will be divided into two halves, North CCF (NCCF) and South CCF (SCCF). The NCCF will received screened water from the new river intakes, while the SCCF will continue to receive flows from the existing Old River intake gate on CCF. The NCCF will be designed to accommodate hydraulic surges and transitions related to short-term (typically less than 24 hours) differences in the rate of water delivery to NCCF and the rate of export by the CVP/SWP pumps. The NCCF will also be the site for a pump station, the operations of which form the primary control and constraints on the rate of water diversion through the river intakes (although that rate is also subject to control at the river intakes). Collective operations of these facilities will be coordinated through an operations center sited at the NCCF pump station. The SCCF will continue to operate as under current conditions. To minimize environmental impacts, the proposed size of the CCF and its appurtenant facilities have been optimized 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[3] *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 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 Appendix 3.D *Construction Schedule for the Proposed Action*; 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 modifications to the current CCF to create a North and South 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 begin 47 months after project start (scheduled to occur in January; the start year depends upon the date of project authorization and the time needed to prepare contract specifications and issue contracts) and will proceed continuously for 61 months.

- The CCPP will be constructed at the northeast corner of the CCF complex and includes the shafts used to launch the TBMs. Construction will start at the CCPP will begin 36 months after project start and will proceed continuously for 100 months.

- CCF work will occur throughout the site, and will be continuously active from 84 months after project start until 147 months after project start. Apart from startup activities (access improvement, mobilization, etc.), embankment and canal work will continue from 90 months to 130 months after project start. Work on control structures and spillways will occur from 108 months to 144 months after project start.

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).

3.2.5.1.3 Clifton Court Forebay Technical Team

Modifications to CCF constitute one of the most complex aspects of the PA. Recognizing that design of these modifications is still in an early stage, DWR, Reclamation, NMFS, CDFW, and USFWS have determined that ongoing collaborative efforts will be needed to ensure that the final design and construction procedures for CCF minimize effects on listed species. Accordingly, representatives from each of these agencies will participate in a Clifton Court Forebay Technical Team (CCFTT). The CCFTT will convene upon initiation of formal consultation for the PA and will meet periodically until DWR completes final design for the proposed CCF modifications (a time period expected to be at least two years). The CCFTT will be charged with the following duties:

- Based on construction information presented by DWR, review and make recommendations regarding phasing of CCF construction for the benefit of listed and unlisted fish or for water quality. In considering any options for phasing, the CCFTT will consider preliminary costs and constructability.

- Based on construction information presented by DWR, review and make recommendations regarding appropriate techniques for dewatering, fish rescue, and fish exclusion during in-water work. Dewatering and fish rescue will be needed for all cofferdam work at CCF, and fish exclusion will be needed for dredging. In considering these techniques, the CCFTT will consider preliminary costs and constructability.

- Develop performance criteria and study programs to evaluate critical issues in CCF operations. One such issue is changes to predation patterns in the SCCF, which may have significantly deeper water depths, different residence times, and more exposure of mineral substrates, compared to the current CCF. Other operational issues may also be identified by the CCFTT.

- Identify and describe near-term research/monitoring needs, if any, to reduce key uncertainties prior to construction.

- Prepare draft and final reports summarizing CCFTT recommendations. The final report must be provided no less than 8 months prior to DWR's completion of final design, so that recommendations can be incorporated into those construction contract documents.

CCFTT recommendations will be reviewed by the five agencies for consideration. Adopted recommendations will be incorporated to CCF final design. DWR will abide by monitoring provisions and other measures sufficient to demonstrate implementation of these recommendations.

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[3] *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 Landing Construction and 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[3] *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 portion of the CCPP fill pad adjoined by water (Appendix 3.C[3] *Conceptual Engineering Report, Volume 2,* Drawings 75 and 83; however note that, as detailed below, the design has been modified to dewater NCCF prior to CCPP construction; thus no sheet pile cofferdam will be placed in the portions of the CCPP fill pad adjoining the NCCF). 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 number, 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”). Sheet piles will be driven starting with a vibratory hammer, then switching to an impact hammer if refusal is encountered before target depths. 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 include the following:

- Phase 1 – SCCF expansion (eastern and western parts of expansion area shown in Appendix 3.C, *Conceptual Engineering Report, Volume 2,* Drawings 54 and 82)
- Phase 2 – Dredge to design depth within the portion of CCF located south of the proposed embankment separating NCCF and SCCF
- Phase 3 – Remove embankment separating the existing CCF from the expansion area
- Phase 4 – Construct embankment separating NCCF and SCCF, with subsequent dewatering, fish rescue, and excavation to design depth within NCCF
- Phase 5 – Construct West and East Side Embankments located south of the proposed embankment separating the NCCF and SCCF
- Phase 6 – Construct NCCF East Side Embankment
- Phase 7 – Construct NCCF West Side Embankment
- Phase 8 – Construct NCCF North Side Embankment

3.2.5.2.2.1 Embankments

All construction except Phases 2 and 3 (dredging and embankment removal; discussed in the following section) will consist of embankment construction. In all phases, this will follow the same general approach:

- All Phases: Clear and grub 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.
- All Phases: Temporary or permanent relocation or installation of electrical transmission lines as needed.
- Phases 1, 4 and 5: Drive sheet piles to enclose the construction area with a cofferdam. Piles will be driven from a barge, or from land where possible. Sheet pile driving within the existing CCF or adjacent to the existing waterways, Old River and Italian Slough, will occur within fish-bearing waters. In these areas, implement fish rescue and salvage plans as required per Appendix 3.F, *General Avoidance and Minimization Measures*, *AMM8 Fish Rescue and Salvage Plan*. In Phase 1, where a portion of the new SCCF embankment adjoins the existing Jones PP approach canal, pile driving will occur in non-fish-bearing waters. See Section 3.2.10.11, *Pile Driving,* for further discussion of how pile driving will be performed. Then, dewater area enclosed by cofferdam. See Section 3.2.10.7, *Dewatering,* for further discussion of how dewatering will be performed.

- Phases 6, 7 and 8: Because the NCCF will be dewatered prior to construction of these embankments, no pile driving or cofferdam construction will be necessary.

- Phases 1 and 4 to 8: Dewater and excavate 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 Spoils*.

- Phases 1 and 4 to 8: Possibly, install a slurry cutoff wall. The need for such walls will be determined following detailed geotechnical investigations.

- Phases 1 and 4 to 8: Construct 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

- Phases 1, 2 and 5 to 8: Trimming or removal of sheet piles if needed (Phases 6 to 8 will not have sheet piles) and placing riprap or other appropriate slope protection materials on water-side of slopes using excavators, loaders and trucks as required.

3.2.5.2.2.2 Phased Construction at Clifton Court Forebay

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

- Phase 1 – Drive sheet piles on southwest side of CCF by outflow channel and southeast side of forebay by inflow gates 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. Modify existing SCCF intake concurrently with embankment construction. Relocate or raise electrical transmission towers within the construction area concurrently with embankment construction.

- Phase 2 – Dredge the portion of CCF located south of the proposed embankment dividing NCCF from SCCF. The area 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 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*. Silt curtains will be placed in a west-east orientation so as to not impede water flow from inlet to outlet in the portions of the forebay not being dredged at any given time, and will enclose an area of approximately 200 acres. Portions of the forebay deeper than -10.0 feet (principally, the scour holes near the CCF inlet and outlet) will not be dredged and silt curtains will be placed so as to avoid exposing these areas to dredging-related water quality effects. Four or five such 200-acre cells will be dredged sequentially to complete dredging in the affected area. Dredging will be performed only during the in-water work window[5]; three successive work windows will be needed to complete the dredging. 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.

- Phase 3 – Drive sheet piles to connect the two sets of sheet piles installed on the south side of CCF during Phase 1. 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*. 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 2.

- Phase 4 – Drive sheet piles for partitioning forebay. Dewater NCCF, which is now blocked off by partition sheet piles. In the dewatered area, excavate to a bottom elevation of -8.0 ft. Construct partition embankment fill as described above.

- Phase 5 – Construct embankment on east side of NCCF, following procedure described above. Construct spillway (described below) concurrently with embankment construction.

- Phase 6 – Construct embankment on west side of NCCF, following procedure described above.

- Phase 7 – Construct embankment on north side of NCCF, following procedure described above; note that much of the north side work will have already been completed during pad construction for the CCPP. Construct spillway (described below) concurrently with embankment construction.

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 Jones PP draws water from the Old River and West Canal via an approach canal that originates at the Tracy Fish Collection Facility, near the southeast corner of the CCF. The Banks PP 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. 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*, 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[3] *Conceptual Engineering Report, Volume 2*, Sheet 82):

- Old 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, Sheets 88 and 89. Note that the design in Appendix 3.C has been revised to site the control structure shown just upstream of the Skinner Fish Facility. The control structure will instead be sited downstream of the facility. As such, 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[3] *Conceptual Engineering Report, Volume 2*, Sheets 95 and 96). Design and construction of the structure are further detailed in Appendix 3.B[3] *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.

3.2.8.1.1 HOR Gate Technical Team

Recognizing that design of these HOR gate is still in an early stage, DWR, Reclamation, NMFS, CDFW, and USFWS have determined that ongoing collaborative efforts will be needed to ensure that the final design and construction procedures for the HOR gate minimize effects on listed species. Accordingly, representatives from each of these agencies will participate in an HOR Gate Technical Team (HGTT). The HGTT will convene upon initiation of formal consultation for the PA and will meet periodically until DWR completes final design for the HOR gate (a time period expected to be at least two years). The HGTT will be charged with the following duties:

- Based on construction information presented by DWR, review and make recommendations regarding provisions for fish passage at the HOR gate. In considering such provisions, the HGTT will consider preliminary costs and constructability.
- Based on construction information presented by DWR, review and make recommendations regarding appropriate techniques for dewatering, fish rescue, and fish exclusion during in-water work. These measures will likely be needed for all cofferdam work at the HOR gate. In considering these techniques, the HGTT will consider preliminary costs and constructability.
- Identify and describe near-term research/monitoring needs, if any, to reduce key uncertainties prior to construction.
- Prepare draft and final reports summarizing HGTT recommendations. The final report must be provided no less than 8 months prior to DWR's completion of final design, so that recommendations can be incorporated into construction contract documents.

HGTT recommendations will be reviewed by the five agencies for consideration. Adopted recommendations will be incorporated to HOR gate final design specifications prior to construction contract issuance. DWR will abide by monitoring provisions and other measures sufficient to demonstrate implementation of these recommendations.

3.2.8.2 Construction

Appendix 3.D *Construction Schedule for the Proposed Action* presents the schedule for HOR gate 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 the following.

- *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 will last approximately 15 days, will be performed during the in-water work window[5], 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 proposed in-water work windows[5] 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 cofferdams will require approximately 550 sheet piles (275 per season). 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 an estimated 210 strikes per pile over a period of approximately 18 days per season. 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 (50 per season) 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 an estimated 1,050 strikes per pile over a period of approximately 3 days per season. 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 18 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 Landing Construction and 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 3.2-8). 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*). Ground improvement constitutes a permanent impact; improved ground will remain in place for the duration of the PA and thereafter. 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 Appendix 3.F *General Avoidance and Minimization Measures, AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*. 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 Appendix 3.F *General Avoidance and Minimization Measures, AMM6 Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*. 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 3.2-11 provides a summary of how spoils would be stored, and Table 3.2-12 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 3.2-11. 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 3.2-12. 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. Current conceptual design for the plan suggests that it will incorporate placement of sediment during low flow periods at a seasonally inundated location along the mainstem river, such as a bench constructed for the purpose. The sediment would then be remobilized and carried downstream following inundation during seasonal high flows (generally, the winter and spring months). The sediment reintroduction would be designed for consistency with Basin Plan objectives for turbidity, viz., “"For Delta waters, the general objectives for turbidity apply subject to the following: except for periods of storm runoff, the turbidity of Delta waters shall not exceed 50 NTUs in the waters of the Central Delta and 150 NTUs in other Delta waters. Exceptions to the Delta specific objectives will be considered when a dredging operation can cause an increase in turbidity. In this case, an allowable zone of dilution within which turbidity in excess of limits can be tolerated will be defined for the operation and prescribed in a discharge permit" (Central Valley Water Board 1998, p. III-9.00).

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 the proposed in-water work windows[5]; and other measures intended to minimize risk to listed species.

Riprap placement would also comply with relevant NPDES and SWRCB requirements; and with the proposed in-water work windows[5].

3.2.10.9 Barge Landing Construction and 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. Appendix 3.D *Construction Schedule for the Proposed Action* presents the schedule for barge landing construction. Locations of the barge landings are shown in 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 landings may also be needed to serve safe haven access sites, if they are sited in areas where existing surface roads will not be adequate to transport the equipment needed for shaft construction. Barge landings 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. The effects analysis has determined a potential acreage for these impacts that is large enough to encompass the contingency of potential barge dock construction at all of these locations. Further points characterizing the barge landings 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; precast tunnel segnent liner sections, etc.; post-construction underwater debris removal; and other activities.

- Barges will be required to use existing barge landings 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 landing sites will be approximately 33 acres.

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

- Barge landings are assumed not to require dredging for construction or maintenance. No such dredging is proposed and take authorization for it is not requested.

- Each dock will be supported by 24-inch steel piles placed approximately every 20 ft under the dock, for a total of up to 51 piles[9]. An additional 56 piles will be required to construct the connecting bridge. See Section 3.2.10.11 *Pile Driving* and Appendix 3.E *Pile Driving Assumptions for the Proposed Action* for details on piling and pile driving associated with barge landing construction.

- 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. All piling will either be removed, or cut at the mudline.

- Approximately 11,800 barge trips are projected to carry tunnel segment liners from ports (locations not yet determined, but likely in the Sacramento area) to barge landings via the Sacramento River, averaging approximately 4 round-trips per day for up to 5.5 years. Because barges may also be used for other purposes, such as transportation of bulk materials, a total of 15,000 barge trips are projected as a conservative assumption (i.e., a greater number of trips is not expected to occur). This is a small increase relative to

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[9] 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.

> existing marine traffic in the area. Barges used will be commercial vessels propelled by tugboats. Barge sizes have not been determined. Commercial barge operators on the Sacramento River are required to operate in compliance with navigational guidelines.

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).
    - Potential for suspension of contaminated sediments.

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[10]. 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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[10] 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*. For all sheetpile cofferdams proposed at the Delta intakes, CCF, and HOR gate, it is assumed that approximately 70% of the length of each pile can be placed using vibratory pile driving, with impact driving used to finalize pile placement. 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 3.2-13 shows the approximate channel widths, 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 3.2-13. Pile Driving Sites and Durations

Facility or Structure	Average Width of Water Body (feet)	Year of Construction	Duration of Pile Driving (days)[1]
Intake 2 Cofferdam	700	Year 8	42
Intake 2 Foundation	700	Year 9	19
Intake 3 Cofferdam	500	Year 7	42
Intake 3 Foundation	500	Year 8	14
Intake 5 Cofferdam	600	Year 5	42
Intake 5 Foundation	600	Year 6	19
Barge Landings	265–1,030	Year 1 and 2	2
CCF Cofferdams	10,500	Year 9 and 10	337
CCFN Siphon Inlet	10,500	Year 9	72
CCFN Siphon Outlet	10,500	Year 7	72
HOR gate Cofferdams	150	Year 7	18
HOR gate Foundation	150	Year 7	4

Notes

[1] Indicates number of days required for one pile driver. Work may be completed more quickly if multiple pile driving rigs operate concurrently.

3.3 Operations and Maintenance of New and Existing Facilities

This section of Chapter 3 discusses proposed operations and maintenance of the PA, which includes new and existing 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.

As previously stated, DWR has entered into a settlement agreement with CCWD, the effects of which are not evaluated in this BA. When operational and maintenance actions associated with implementation of the agreement are sufficiently defined to provide for analysis of potential adverse effects to listed species and critical habitat, a supplement to this BA will be provided to the Services.

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)[11] 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.

The USFWS (2008) and NMFS (2009) BiOps for CVP/SWP operations will continue to apply for CVP/SWP activities not covered in this BA. For Shasta operations, the NMFS (2009) RPA adjustment (Action Suite 1.2) for seasonal temperature management that will likely be completed in late 2016 will apply. The proposed CWF operating criteria are not intended to change Shasta operations; thus, the NMFS (2009) RPA adjustment (Action suite 1.2) for seasonal temperature management will control if there are any unforeseen conflicts in Shasta operations between the proposed CWF operating criteria and the adjusted RPA. To summarize the proposed action includes modified or new operational criteria for the following facilities:

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[11] 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 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
- 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 3.4.6 *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 when the proposed north Delta diversion intakes are operational. The proposed operational criteria were developed in coordination with NMFS, USFWS, and DFW to minimize project effects on listed species. Further descriptions, including the intent of the specific criteria for each facility are described below. Two new criteria, not associated with any facility, include a minimum flow at Rio Vista and a spring outflow criteria. The purpose of the Rio Vista minimum flow is to ensure a minimum flow in the Sacramento River in January through August, where there currently is no minimum flow requirement under D-1641. The purpose of the spring outflow criteria is to maintain spring outflows consistent with the current Biological Opinions (FWS 2008; NMFS 2009), as described above. 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. Even though this BA attempts to describe the temporal scale at which some of the operational criteria will be implemented (e.g. north Delta bypass flow requirements and OMR requirements), a detailed operations plan will be developed by Reclamation and DWR in coordination with DFW, NMFS and USFWS prior to the new facilities becoming operational, which will detail 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 II Modeling

Parameter	Criteria	Summary of CALSIM II Modeling Assumptions[a]
New Criteria Included in the Proposed Action		
North Delta bypass flows[12]	- Bypass Flow Criteria (specifies bypass flow required to remain downstream of the North Delta intakes): o October, November: Minimum flow of 7,000 cfs required in river after diverting at the North Delta intakes. o December through June: see below o July, August, September: Minimum flow of 5,000 cfs required in river after diverting at the North Delta intakes. - Initial Pulse Protection: o 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. o Low level pumping maintained through the initial pulse period. o Sacramento River pulse is determined based on the criteria specified in Table 3.3-2, and real-time monitoring of juvenile fish movement. o If the initial pulse begins and ends before Dec 1, post-pulse criteria for the month of May go	- Initial Pulse Protection: o 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. o 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.

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[12] Sacramento River flow upstream of the intakes to be measured flow at Freeport. Bypass flow is the Sacramento River flow quantified downstream of the Intake # 5. Sub-daily north Delta intakes' diversion operations will maintain fish screen approach and sweeping velocity criteria.

Parameter	Criteria	Summary of CALSIM II Modeling Assumptions[a]
	into effect 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): o 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, 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[13], no OMR flow[14] 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[15], and no more negative than an average of −2,000 cfs when the delta smelt USFWS (2008) BiOp action 1	- 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

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[13] San Joaquin River based OMR action triggered when the leading edge of the pulse releases are measured at Vernalis..

[14] OMR measured through the currently proposed index-method (Hutton 2008) with a 14-day averaging period consistent with the current operations (USBR 2014).

[15] December 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. Reclamation and DWR will require lead time of no less than 3 days to change operations in response to the pulse.

Parameter	Criteria	Summary of CALSIM II Modeling Assumptions[a]
	triggers. No OMR flow restriction prior to the Sacramento River pulse or delta smelt action 1 triggers. • January, February[16]: 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[17]: 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[18]: 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 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[19]. • OMR criteria under 2008 USFWS and 2009 NMFS BiOps or the above, whichever results in	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.

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[16] 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.

[17] Water year type as described in the above footnote.

[18] When OMR target is based on Vernalis flow, will be a function of 5-day average measured flow.

[19] The PA operations include a preference for south Delta pumping in July through September months to provide limited flushing flows to manage water quality in the south Delta.

Parameter	Criteria	Summary of CALSIM II Modeling Assumptions[a]
	more positive, or less negative OMR flows, will be applicable[20].	
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.

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[20] Change in CVP/SWP pumping from the south Delta will occur to comply with OMR targets will be achieved to the extent exports can control the flow. The OMR targets would not be achieved through releases from CVP/SWP reservoirs. The combined CVP/SWP export rates from the proposed north Delta intakes and the existing south Delta intakes will not be required to drop below 1,500 cfs to provide water supply for health and safety needs, critical refuge supplies, and obligation to senior water rights holders.

Parameter	Criteria	Summary of CALSIM II 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).[21] 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).	• 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.
Rio Vista minimum flow standard[22]	• 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[23]		
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.

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[21] 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.

[22] 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

[23] All the CALSIM II modeling assumptions are described in Appendix 5.A, *CALSIM Methods and Results*.

Parameter	Criteria	Summary of CALSIM II Modeling Assumptions[a]
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)
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 define the criteria for modeling purposes and provide the real-time operational criteria levels as operations move between and among the levels. 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 Diversions*.
<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

Assumptions

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

Assumptions

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

5. Delta Outflow

Delta Outflow

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 under Early Long-Term Q5 climate projections, without San Joaquin River Restoration Flows for this BA.

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 3.4.6 *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 Table 3.3-1 and Table 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 manage water quality 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.[24]

- 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 30th:** The HOR gate will be closed to coincide with and protect the D-1641 upstream pulse flow releases and adult salmonid migration as specified in Table 3.3-1. Priority management in these two months is for protecting flow for upstream migrating adult salmonids accessing the San Joaquin River tributaries for spawning.
- **January:** The initial operating criterion will be to close the gate when juvenile salmonids are first detected in monitoring. Gate shall remain closed while fish are present, but

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[24] 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.

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.

- **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.
- To reduce downstream flood risks based on current conditions, HOR gate will remain open if San Joaquin River flow at Vernalis is greater than 10,000 cfs (threshold may be revised to align with any future flood protection actions).

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, 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 (*i.e*., daily and weekly) adjustments to be made to water operations, within the range of criteria described in Section 3.3.1, *Implementation*, and Section 3.3.2, *Operational Criteria*. RTO will be implemented to maximize water supply for CVP/SWP, subject to providing the necessary protections for listed species, through the existing decision-making process and related technical work teams identified in Section 3.1.5.2 *Groups Involved in Real-Time Decision Making and Information Sharing*[25].

To complement the RTO process, the Action Agencies (DWR and Reclamation) can convene a separate real time operations coordination team (RTOCT) 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 RTOCT effort will assist DWR and Reclamation in fulfilling their responsibility to inform the SWP and CVP participants regarding available information and real-time decisions. This coordination effort may 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 Action Agencies and fish and wildlife agency representatives will confer with the SWP and CVP contractor representatives regarding ideas, options and additional funding to enhance the

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[25] The decision-making process and technical work teams identified here are provisional and may be subject to further revision, either through future coordination or as developed through the Collaborative Science and Adaptive Management Program described in Section 3.4.6.

information available for decisions on RTO. The SWP and CVP contractor representatives will confer with other SWP and CVP contractors regarding RTOTC coordination and decisions. This RTOCT is intended to supplement the existing process and teams. This may result in recommendations being made through the DCT. Decision-making will still happen as it currently does under the USFWS (2008) and NMFS (2009) BiOps, as outlined in Appendix 1: Project Description to the NMFS 2009 BiOp where it states (p.28):

"The process to identify actions for protection of listed species varies to some degree among species but follows this general outline: A Fisheries or Operations Technical Team compiles and assesses current information regarding species, such as stages of reproductive development, geographic distribution, relative abundance, physical habitat conditions, then provides a recommendation to the agency with statutory obligation to enforce protection of the species in question. The agency's staff and management will review the recommendation and use it as a basis for developing, in cooperation with Reclamation and DWR, a modification of water operations that will minimize adverse effects to listed species by the Projects. If the Project Agencies do not agree with the action, then the fishery agency with the statutory authority will make a final decision on an action that they deem necessary to protect the species. In the event it is not possible to refine the proposed action in order that it does not violate section 7(a)(2) of the ESA, the Project and fisheries agencies will reinitiate consultation.

The outcomes of protective actions that are implemented will be monitored and documented, and this information will inform future recommended actions."

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 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. Any modifications to- the criteria and/or ranges set out in the operating criteria shall occur through the adaptive management Program, and the effects of any such modifications shall be analyzed by Reclamation and DWR, in consultation with NMFS and USFWS, to determine if Reclamation and DWR should reinitiate consultation prior to implementation. Nothing in this section shall limit the Services ability to make adjustments pursuant to existing BiOps or limit their existing authorities to exercise discretion pursuant to existing regulations and procedures.

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.

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 3.4.6). Based on the outcome of the studies listed in Section 3.4.6, 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[26].

The following operational framework serves as an example based on the recommended NDD RTO process (Marcinkevage and Kundargi 2016). A 5-agency technical team co-chaired by NMFS and CDFW will develop the RTO process 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.

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[26] 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.

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[27].
- Upon initiation of fish pulse, operations must reduce to low-level pumping.
- Pumping may not exceed low-level pumping for the 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[27].
- 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 pumping protection as the first pulse if the first pulse occurred before December [1][28]. 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[29] 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[30].
- Upon initiation of a migration event, operations must revert back to Level 1 (if not already there) for migration protection.

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[27] Triggers will be developed from data provided by monitoring stations.

[28] 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.

[29] X_a – Specific durations and triggers will be developed from data provided by monitoring stations.

[30] X_m – Specific durations and triggers will be developed from data provided by monitoring stations.

- Migration protection operations must be maintained at Level 1 until the combined catch at all Sacramento stations is below X_a^{29} 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.

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:** The HOR gate will be closed to coincide with and protect the D-1641 upstream pulse flow releases and adult salmonid migration as specified in Table 3.3-1. Priority management in these two months is for protecting flow for upstream migrating adult salmonids accessing the San Joaquin River tributaries for spawning.

- **January:** The initial operating criterion will be to close the gate when juvenile salmonids are first detected in monitoring. Gate shall remain closed while fish are present, 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.

- **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.

- To reduce downstream flood risks based on current conditions, HOR gate will remain open if San Joaquin River flow at Vernalis is greater than 10,000 cfs (threshold may be revised to align with any future flood protection actions).

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 PP, about five miles north of Tracy, consists of six available pumps. The Jones PP is located at the end of an earth-lined intake channel about 2.5 miles in length. At the entrance to 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 more than 20 km away from the pumping plants, in the west Delta near the Sacramento/San Joaquin confluence. Currently those sites include the Emmaton and Delta Base release sites for the CVP, and the Curtis Landing and Horseshoe Bend release sites for the SWP.

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 (TFCF) 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 prevent fish with a body width greater than 2 inches from passing between them and redirect them toward one of four bypass entrances along the louver arrays. Smaller fish, that can pass through the louvers, may be behaviorally redirected by the louver structure. The louvers perform best at flows low enough to allow fish to behaviorally redirect before they contact the structure.

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, 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. This discussion is provided for informational purposes only; the PA does not seek incidental take authorization for facilities maintenance (see Section 3.1.6 *Take Authorization Requested*). Accordingly Reclamation will conduct a separate Section 7 consultation addressing facilities maintenance, if and when such a consultation is necessary.

3.3.6.1 North Delta Diversions

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[5]. 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[5].

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[5].

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 the proposed in-water work windows[5]. 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 proposed in-water work windows; 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 3.4.5, *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 3.4.3 *Summary of Restoration for Fish Species,* and Section 3.4.5, *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*.

This biological assessment does not request take authorization for construction and maintenance of habitat restoration sites; such authorization will be sought, as needed, during the siting, design, and permitting work for each restoration site (see Section 3.1.6 *Take Authorization Requested*). The approximate location of the restoration sites is described for each species below. For each species, a technical team consisting of representatives from Reclamation, NMFS, USFWS, DWR and CDFW will be established to develop siting, design, and performance criteria for the needed habitat restoration. This group will work collaboratively to select the most biologically appropriate and cost-effective restoration site(s), design the restoration plan, set performance criteria, and develop the restoration unit management plan for the site(s).

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 Summary 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. In consequence, this biological assessment does not seek take coverage for the performance of habitat restoration; rather, restoration sites will be subject to site-specific ESA Section 7 consultation prior to performance of restoration. The following descriptions of restoration actions offsetting effects to listed fish species, however, describes in general terms how and where restoration will be sited and constructed.

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. The conservation measures provide for the restoration of suitable habitat for Delta Smelt, Chinook salmon, steelhead, and green sturgeon.

The PA will occur, and its effects will 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 will 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*.

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 will only be affected during construction activities; although all Delta Smelt habitat impacts are considered permanent because they are typically an annual fish.) Although there will be dredging and other construction-related disturbances in the Clifton Court Forebay, it is not considered critical habitat for any of the species, and the AMMs associated with construction will minimize effects.

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

Resource	Location of Impact	Maximum Direct Impacts		Mitigation Ratio	Total Compensation, Restoration by Impact Area	Total Compensation, Restoration	Potential Location of Proposed Restoration
		Total Impacts					
		Permanent	Temporary				
Chinook salmon and CCV steelhead							
Channel margin habitat (linear miles)	North Delta Diversions	Construction: 1.02; operations: 0.42	0 (occur within same footprint as permanent impacts)	3:1	4.3	4.3 miles	Sacramento River, Steamboat and Sutter Sloughs, or other areas agreed to by NMFS and CDFW[1]
Tidal perennial habitat (acres)	North Delta Diversions	6.6	20.1	3:1	80.1	154.8 acres	Sherman Island, North Delta, South Delta, or other areas agreed to by NMFS and CDFW, commiserate to area of specific effect
	Head of Old River[2]	2.9	0	3:1	7.5		
	Barge Landings	22.4	0	3:1	67.2		
Green sturgeon							
Tidal perennial habitat (acres)	North Delta Diversions	6.6	20.1	3:1	80.1	154.8 acres	Sherman Island, North Delta, or other areas agreed to by NMFS and CDFW
	Head of Old River[2]	2.9	0	3:1	7.5		
	Barge Landings	22.4	0	3:1	67.2		
Delta smelt							
Shallow water habitat (acres)	North Delta Diversions (intake + wing wall transitions + 1,000 feet downstream suspended sediment effect)	5.6	All impacts are considered permanent to delta smelt because of the species' predominantly one-year life cycle	5:1[3]	28	273 acres (of which 108 acres must be sandy beach spawning habitat, and 74.7 acres must be tidal perennial habitat)	Sherman Island, Cache Slough, North Delta or other areas agreed to by USFWS and CDFW
Shallow water critical habitat (acres)	Critical habitat near North Delta Diversions[4]	245 (of which 36 is sandy beach spawning habitat)		Overall 1:1, with 3:1 for sandy beach spawning habitat	245 (of which 108 acres must be sandy beach spawning habitat)		
Tidal perennial habitat (acres)	Head of Old River[2]	2.9		3:1	7.5		
	Barge Landings	22.4		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] The 5:1 mitigation ratio assumes in-water work in June; should work not occur in June, the ratio will be 3:1. This may vary by intake.

[4] The mitigation is for potential reduced access to shallow water critical habitat because of the higher shoreline velocities expected from the NDD.

[5] The 245 acres estimate is based on 250 total acres from downstream end of intake 5 to I Street bridge, Sacramento, minus the footprint of the three intakes + wing wall transitions and associated in-water work during construction (3.7 acres) + acreage 1000 feet downstream of intakes 2 and 3 (1.3 acres) because of suspended sediment; these acreages are already accounted for with the direct impact from the NDD.

3.4.3.1 Chinook Salmon and CCV Steelhead

3.4.3.1.1 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. Furthermore, in-water activities associated with the proposed action will, as described in Section 3.2 *Conveyance Facility Construction*, comply with the proposed in-water work windows.[5] In addition, the following species-specific avoidance and minimization measure will be implemented to minimize the potential for adverse effects on Chinook salmon and CCV steelhead.

3.4.3.1.1.1 Nonphysical Fish Barrier 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). 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 in entrainment and that an approach be implemented if a NMFS-approved solution is identified by the process outlined in NMFS (2009a). Like other CVP/SWP operations, operation of any implemented engineering solution will be governed by the 2009 NMFS and 2008 USFWS biological opinions until this proposed action is operational; at that time, the operations of any barrier will be governed by the biological opinion(s) issued for this biological assessment. This AMM does not directly offset the effect of the operation of the NDD (that is, it does not reduce the extent of harm to fish that pass the NDD). However, it is expected to provide a higher probability of survival for fish that pass the NDD and encounter the Sacramento River-Georgiana Slough junction since the reduced Sacramento River flows that result from the operation of the NDD could increase the potential for entrainment into Georgiana Slough.

Since 2011, DWR has been testing various engineering solutions in the Sacramento River at Georgiana Slough. Two types of structures have been tested at this location and are considered options for this AMM. The first is a true nonphysical barrier that functions by inducing behavioral aversion to a noxious stimulus, e.g., visual or auditory deterrents (Noatch and Suski 2012). In 2011 and 2012 DWR tested a 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. The second type of structure, a floating fish guidance structure (FFGS), was tested in 2014. Though not a true nonphysical barrier because the structure contains physical screens, the structure induces behavioral aversion while essentially all the flow maintains its direction.

Because the design of the barrier associated with the PA has not yet been determined, construction of the barrier is not included in the PA and will instead be a separate Section 7 consultation, as required by NMFS (2009a) RPA IV.1.3, completed prior to the initiation of NDD operations (e.g., a Corps permit for installation and removal of the barrier will provide a future Federal nexus requiring consultation). At that time, the results of the investigations of various engineering solutions as required by the NMFS BiOp (2009a, 2011) are expected to be adequate to develop a proposal for barrier design, seasonal installation and removal, and detailed, design-specific protocols for operation. These design and operation specifics will be detailed in a biological assessment supporting what is expected to be a formal consultation.

In 2011 and 2012, DWR began to study the effectiveness of a BAFF at the Georgiana Slough–Sacramento River junction in preventing outmigrating juvenile Chinook salmon from entering Georgiana Slough (California Department of Water Resources 2012b; Perry et al. 2014). This type of nonphysical barrier has shown promising results in field studies at other locations such as a field experiment on Atlantic salmon (*Salmo salar*) smolts in the River Frome, UK (Welton et al. 2002). For the studies at the Georgiana Slough junction, approximately 1,500 acoustically tagged juvenile late fall–run Chinook salmon produced at the Coleman National Fish Hatchery (and, in 2012, approximately 300 steelhead) 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 percentage of salmon smolts passing the junction that were entrained into Georgiana Slough was reduced from 22.1% (barrier off) to 7.4% (barrier on) due to implementation of the barrier (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. During the 2012 study period, the percentage of salmon smolts passing the junction that were entrained into Georgiana Slough was reduced from 24.2% (barrier off) to 11.8% (barrier on) due to implementation of the barrier, with a similar reduction for steelhead (26.4% to 11.6%) (California Department of Water Resources 2015). This lower rate may be because of the notably lower river flow conditions in 2012 compared to 2011 (California Department of Water Resources 2015).

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; by inducing a behavioral aversion to barrier stimuli, the BAFF increases the likelihood that fish remain on the Sacramento River side of the critical streakline. With this understanding, in 2014 DWR began a study of 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 it 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). This technology is considered as a potential design for this AMM because the large majority of flow does not change its destination; as with the BAFF, the structure's purpose is to keep fish on the Sacramento River side of the critical streakline. The results from the study of the FFGS are not yet available.

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 (California Department of Water Resources 2012b) and spring-run Chinook salmon and young-of-the-year fall-run Chinook salmon.

Given the uncertainty of the structure design, the nascent science behind the effectiveness of any design at this location, and the lack of availability of FFGS results, the PA assumes that the operation of this AMM will provide a similar reduction in entrainment as was observed during the low flow conditions of 2012.

3.4.3.1.2 Restoration Actions

The PA includes restoration of 154.8 acres of tidal perennial habitat suitable for Chinook salmon and steelhead and 4.3 miles of channel margin habitat to offset permanent and temporary losses of migration and rearing habitat.

3.4.3.1.2.1 Tidal Perennial Habitat Restoration

The PA includes 154.8 acres of tidal perennial habitat restoration to offset effects on salmonid rearing and migration habitat, as shown in Table 3.4-1.

Tidal perennial habitat restoration site selection and design will occur in coordination with CDFW, USFWS and NMFS. Restoration will primarily occur through breaching or setback of levees, thereby restoring tidal fluctuation to land parcels currently isolated behind those levees. Factors to be considered when evaluating sites for potential location and design of tidal perennial habitat restoration include 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).

Shallow subtidal areas in large portions of the Delta support extensive beds of nonnative submerged aquatic vegetation (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). Tidal perennial habitat restoration 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 is proposed in association with tidal habitat, which will provide more heterogeneity and support pelagic habitat adjacent to emergent wetland. Additionally, bench habitats will be incorporated into site selection and design to provide added specific benefits to salmonids, such as shallow-water foraging and refuge habitat. Tidal perennial habitat restoration will be sited in consultation with NMFS, USFWS, and CDFW, within areas of the Delta appropriate for offsetting effects of the PA.

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 create 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 perennial habitat is presented in Figure 3.4-1.

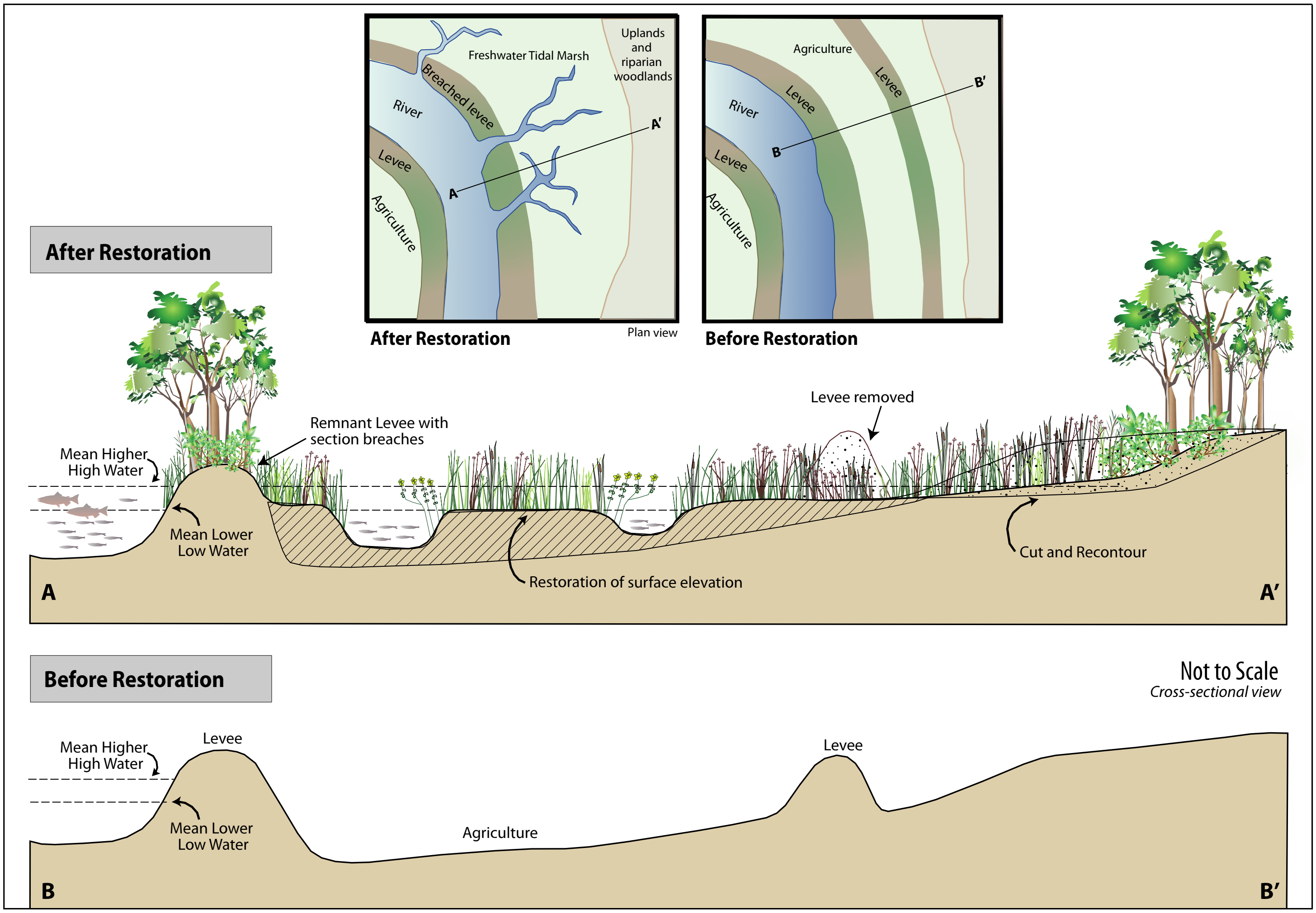
A technical team consisting of representatives from Reclamation, NMFS, USFWS, DWR and CDFW will be established to develop siting, design, and performance criteria for tidal perennial habitat restoration. This group will work collaboratively to select the most biologically appropriate and cost-effective restoration site(s), design the restoration plan, set performance criteria, and develop the restoration unit management plan for the site(s).

Completion of construction at each site will precede the corresponding impacts associated with conveyance facility construction. 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 CDFW, USFWS and NMFS by Reclamation.

General AMMs described in Appendix 3.F *General Avoidance and Minimization Measures* will be implemented during tidal restoration construction. General AMMs applicable to tidal restoration work include AMMs 1 to 10, AMM14, AMM15, and AMM17.

Construction of tidal perennial habitat restoration could affect salmonids 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 will be temporary and will be offset by the long-term benefits of the restored habitat (any sites so contaminated as to produce contrary results will be deemed unsuitable for restoration).

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



Graphics/... BDCP Other Chapters/SAIC Nov 2010 (created: 11/09/10) (Rev. 11-9-2012 TM)

Figure 3.4-1 Conceptual Design for Restored Tidal Perennial Habitat

levee materials from within and adjacent to tidal and other aquatic habitats. Levee breaching will entail in-water work using construction equipment such as bulldozers and backhoes; any in-water work will be performed during an in-water work window to be approved by CDFW, NMFS and USFWS. Removed levee materials will be placed on the remaining levee sections, placed within the restoration area, or hauled to a disposal area previously approved by CDFW, NMFS and USFWS. 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 material 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.

3.4.3.1.2.2 Channel Margin Habitat Restoration

The PA includes 4.3 linear miles of channel margin restoration to offset effects on salmonid rearing and migration habitat caused by the reduction in frequency of inundation of existing restored benches and habitat loss due to the NDD. The proposed compensation is based on GIS analysis of the permanent and temporary footprint for the NDD, and a review of the magnitude of change for the select benches in the analysis. GIS 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 as well as the temporary areas of effect. The construction-related portion reflects the footprint of the combined three NDD (5,367 linear feet, or 1.02 miles), including their association wing wall transitions. The operations-related portion reflects potentially less frequent inundation of riparian benches because of NDD water diversions. The total linear extent of riparian bench effects (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.

Channel margin restoration will 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 currently 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 will 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. This conservation measure is intended to increase habitat diversity and complexity, provide long-term nutrient storage and substrate for aquatic macroinvertebrates, moderate flow disturbances, increase retention of leaf litter, and provide refuge for fish during high flows. 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.

A technical team consisting of representatives from Reclamation, NMFS, USFWS, DWR and CDFW will be established to develop siting, design, and performance criteria for channel margin restoration. This group will work collaboratively to select the most biologically appropriate and cost-effective restoration site(s), design the restoration plan, set performance criteria, and develop the restoration unit management plan for the site(s).

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. Completion of construction at each site will precede the corresponding 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 CDFW, USFWS and NMFS by Reclamation.

General AMMs described in Appendix 3.F, *General Avoidance and Minimization Measures* will be implemented, and an in-water work windows subject to approval by CDFW, USFWS and NMFS will be observed, during implementation of channel margin enhancement. General AMMs applicable to channel margin enhancement 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.

3.4.3.1.3 South Delta Habitat Restoration

The PA includes construction in the central and south Delta of the HOR gate and several barge landings. This construction will convert areas that are considered aquatic habitat for salmon into physical structures that commonly attract predatory fish and may reduce habitat complexity for native fishes. The affected habitat largely consists of rip-rap, and effects on this habitat will be offset by the restoration shown, for each listed species, in Table 3.4-1. Mitigation proposed as part of the PA includes restoration actions that will offset ,at a 3:1 ratio, any habitat impacts that may occur due to HOR gate and barge landing construction. The PA restoration actions will adhere to the following principles, which assure that the proposed habitat restoration benefits salmonids.

- Habitat restoration and mitigation efforts will target migration routes commonly used by San Joaquin River basin salmonids to the extent possible. Highest priority for restoration site selection will apply to sites near the south Delta construction sites. Sites upstream of the head of Old River will also be considered if those locations provide greater benefit.

- The restoration will focus on creating benefits for salmonids through improved habitat function. Some combination of channel margin and tidal perennial habitat, cited and designed in coordination with NMFS and CDFW, will be targeted to achieve these benefits, consistent with restoring south Delta historical habitat function and processes (see Whipple et al. 2012). Habitat functions most beneficial to salmonids and native species will therefore be the focus on the restoration mitigation efforts. Examples include restoration of floodplain habitat, riparian habitat with appropriate vegetation to deliver organic inputs and terrestrial invertebrates to the adjacent riverine system, refugia from predators or elevated velocities resulting from high flows, and seasonal flooding during winter and spring even in drier water year types.

- As part of the restoration of tidal perennial and/or channel margin habitat restoration, features may include small-scale levee setbacks or benches that provide seasonally inundated terraces during high runoff events. Restoration plans will consider areas where this functionality can be restored or created. An Engineer Technical Letter variance will need to be obtained from the Corps of Engineers, and may limit the areas that can be restored.

- Restoration areas will promote benefits for native species and deterrents to non-native species. For instance, seasonal flooding and draining with varying inundation periods are a natural deterrent to colonization of invasive plants and species. Vegetation on the created terraces or floodplains will be monitored for invasive plant species. Control of invasive plants will be performed in a manner to be determined in consultation with the resource agencies to avoid infestations.

3.4.3.2 Green Sturgeon

3.4.3.2.1 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*.

3.4.3.2.2 Tidal Perennial Habitat Restoration Actions

Based on the current estimate of effects, the PA includes restoration of 154.8 acres of tidal perennial habitat suitable for green sturgeon, with a focus on intertidal and subtidal areas for foraging (Israel and Klimley 2008). The general approach to tidal perennial habitat restoration will parallel that described in Section 3.4.3.1.2.1 *Tidal Perennial Habitat Restoration*. As with tidal habitat restoration benefitting Chinook salmon and steelhead, a technical team consisting of representatives from Reclamation, NMFS, USFWS, DWR and CDFW will be established to develop siting, design, and performance criteria for tidal perennial habitat restoration. This group will work collaboratively to select the most biologically appropriate and cost-effective restoration site(s), design the restoration plan, set performance criteria, and develop the restoration unit management plan for the site(s). To the extent practicable, tidal perennial habitat restoration benefitting green sturgeon will be colocated with tidal perennial habitat restoration benefitting Chinook salmon and steelhead.

Tidal perennial habitat will be sited in areas suitable for creation of intertidal and subtidal habitat, which will provide important foraging habitat for green sturgeon (Israel and Klimley 2008). On the basis of the observed areas occupied by acoustically tagged juvenile green sturgeon (Klimley et al. 2015), it is expected that areas prioritized for salmonid restoration will also provide suitable function for green sturgeon if including elevations to yield intertidal and subtidal habitat.

3.4.3.3 Southern Resident Killer Whale

3.4.3.3.1 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.

3.4.3.3.2 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.

3.4.3.4 Delta Smelt

3.4.3.4.1 Avoidance and Minimization Measures

AMMs that will be implemented to avoid or minimize effects on Delta Smelt are detailed in Appendix 3.F, *General Avoidance and Minimization Measures*, and are summarized in Table 3.2-2. General AMMs specifically applicable to Delta Smelt include AMMs 1 to 7, AMM8, AMM9, AMM14, AMM15, and AMM17. Furthermore, in-water activities associated with the proposed action will, as described in Section 3.2 *Conveyance Facility Construction*, comply with the proposed in-water work windows[5].

3.4.3.4.2 Conservation Measures

The following conservation measure is proposed for Delta Smelt: Restoration of nearly 348 acres of habitat suitable for Delta Smelt, of which nearly 103 acres is intended to offset construction impacts on Delta Smelt and their habitat, and 245 acres are intended to offset potential impaired Delta Smelt access to shallow water critical habitat in the vicinity of the NDDs (Table 3.4-1). Restoration will be performed at a site in the vicinity of Sherman Island, Cache Slough, or the north Delta to be approved by USFWS.The proposed habitat restoration, shown in Table 3.4-1, will offset effects on Delta Smelt spawning, rearing, and migration habitat. Of this total, the PA proposes to mitigate 245 acres of shallow water habitat for impacts related to the potential changes in access to shallow water critical habitat upstream of the proposed NDD. GIS was used to calculate that the total shallow water critical habitat located above the NDD (including both banks of the Sacramento River) is 250 acres. In addition to potential use of this habitat during the early part of the life cycle, Delta Smelt may also use this critical habitat during spawning, which is believed to occur in sandy beach areas. Of the 250 acres of designated shallow water critical habitat located above the NDD, examination of aerial photographs combined with GIS analysis suggests that 36 acres are sandy beach area and therefore potentially suitable for spawning. The effects analysis hypothesizes that this potential spawning area may become inaccessible to Delta Smelt because of the presence of the NDD (see Chapter 6). Monitoring of Delta Smelt use of this area will occur to evaluate whether this effect is occurring, and the consultation will be reinitiated if it is found that Delta Smelt continue to use the area. The 245 acres of proposed restoration represents a 1:1 mitigation ratio for the entire area of shallow water critical habitat, minus the approximately 5 acres of habitat related to construction of the NDD that would be mitigated at a 5:1 ratio. Of the 245 acres included in the overall 1:1 mitigation ratio, sandy beach habitat will be mitigated at a 3:1 ratio, and therefore will comprise 108 acres of the total 245 acres related to the presence of the NDD.

Habitat restoration site selection and design will occur in coordination with USFWS and NMFS. Restoration will primarily occur through breaching or setback of levees, thereby restoring tidal fluctuation to land parcels currently isolated behind those levees. Factors to be considered when evaluating sites for potential location and design of habitat restoration include 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. These factors are similar to those considered in terms of crediting restoration sites in the Delta:

- Improved rearing habitat: High order, marsh-adjacent channels; energetic; turbid, cool, low salinity water over a diverse landscape for capturing prey and decreased predation; accessible to Delta Smelt for direct use.
- Improved spawning habitat: Sandy beaches with appropriate water velocities and depths to maintain the habitat and is accessible to Delta Smelt for direct use. Must have appropriate water quality conditions for Delta Smelt.

Geographic priority will be given to sites in the vicinity of Sherman Island, Cache Slough, and the North Delta. Tidal perennial habitat restoration will replace loss of such habitat at barge landings and the HOR gate, whereas shallow water habitat restoration will replace loss of such habitat in the north Delta as a result of NDD construction and operations.

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). Shallow water and tidal perennial habitat restoration 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 is proposed in association with tidal habitat, which will provide more heterogeneity and support pelagic habitat adjacent to emergent wetland. Tidal perennial habitat restoration will be sited in the vicinity of Sherman Island, Cache Slough, or at other sites in the north Delta.

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 create 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 perennial habitat is presented in Figure 3.4-1.

A technical team consisting of representatives from Reclamation, NMFS, USFWS, DWR and CDFW will be established to develop siting, design, and performance criteria for tidal perennial habitat restoration. This group will work collaboratively to select the most biologically appropriate and cost-effective restoration site(s), design the restoration plan, set performance criteria, and develop the restoration unit management plan for the site(s).

Completion of construction at each site will precede the corresponding impacts associated with conveyance facility construction. 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 CDFW, USFWS and NMFS by Reclamation.

General AMMs described in Appendix 3.F *General Avoidance and Minimization Measures* will be implemented during tidal restoration construction. General AMMs applicable to tidal restoration work include AMMs 1 to 10, AMM14, AMM15, and AMM17.

Construction of shallow water and tidal perennial habitat restoration could affect Delta Smelt 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 will be temporary and will be offset by the long-term benefits of the restored habitat (any sites so contaminated as to produce contrary results will be deemed unsuitable for restoration).

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 will entail in-water work using construction equipment such as bulldozers and backhoes; any in-water work will be performed during an in-water work window to be approved by CDFW, NMFS and USFWS. Removed levee materials will be placed on the remaining levee sections, placed within the restoration area, or hauled to a disposal area previously approved by CDFW, NMFS and USFWS. 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 material 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.

3.4.4 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 3.4.5 *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 *Summary 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 3.4.5, *Terrestrial Species Conservation*.

Table 3.4-2. Summary of Maximum Direct Impact, Proposed Compensation, and Potential Location of Restoration and Protection for Federally Listed Species of Wildlife[31]

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 Disturbance[32] (Acres)	Protection	Restoration	Total Compensation, Protection	Total Compensation, Restoration	
San Joaquin kit fox	2,956	47	11	3:1	-	141	0	Byron Hills Region, East Contra Costa County, or FWS-approved conservation bank
Western yellow-billed cuckoo	11,224	32	0	0	2:1	0	64	USFWS approved location
Giant garter snake								
Aquatic habitat	26,328	205	0	2:1 to 3:1		410 to 615		Northeast and Central Delta
Upland habitat	62,619	570	7	2:1 to 3:1		1,140 to 1,710		
California red-legged frog								
Aquatic habitat	118	1[i]	1	3:1		3		Byron Hills Region, East Contra Costa County or FWS approved conservation bank
Upland cover and dispersal habitat	3,498	51[33]	17	3:1	-	153	0	
California tiger salamander	12,724	50[34]	8	3:1	-	150	0	Byron Hills Region, East Contra Costa County or FWS approved conservation bank
Valley elderberry longhorn beetle								
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,

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[31] Maximum direct impacts presented here do not include effects from restoration/mitigation because take associated with restoration/mitigation will not be authorized under the biological opinion.

[32] Temporary disturbance will be mitigated by returning disturbed areas to pre-project conditions. This disturbance mostly includes overland travel and temporary work areas in grasslands and agricultural lands.

[33] Includes 47 acres within the construction footprint and 4 acres of upland habitat potentially subject to vibrations adjacent to construction

[34] Includes 47 acres within the construction footprint and 3 acres of upland habitat potentially subject to vibrations adjacent to construction.

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 Disturbance[32] (Acres)	Protection	Restoration	Total Compensation, Protection	Total Compensation, Restoration	
								prioritizing Altamont Hills Recovery Area, or conservation bank.
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, or conservation bank
Least Bell's vireo	11,224	32	0	0	2:1	0	64	USFWS approved location

[a] Giant garter snake upland habitat will be created or protected in association with the protected and restored aquatic habitat.

[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.

3.4.5 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*.

3.4.5.1 Riparian Brush Rabbit

3.4.5.1.1 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.6.7, *Head of Old River Gate Habitat Assessment*, there is no suitable habitat within the project footprint.

3.4.5.1.2 Avoidance and Minimization Measures

3.4.5.1.2.1 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 suitable habitat.

- Establish a 1,400-foot buffer between any lighting and pile driving and 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} at the nearest residential land uses.

- Limit pile driving to daytime hours (7:00 a.m. to 6:00 p.m.).

3.4.5.1.2.2 Geotechnical Exploration

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

3.4.5.1.2.3 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.

3.4.5.1.2.4 Restoration Activities

Restoration activities for the PA will not occur within riparian brush rabbit suitable riparian habitat, or within 100 feet of such habitat.

3.4.5.2 San Joaquin Kit Fox

3.4.5.2.1 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 as grasslands in the area depicted in Figure 6.3-1 and 6.3-2. San Joaquin kit fox preconstruction surveys will be required for activities occurring on, or within 200 feet[35] of, suitable habitat. A USFWS-approved biologist will conduct these pre-construction surveys.

3.4.5.2.2 Avoidance and Minimization Measures

AMMs are described below first for activities with fixed locations including the Clifton Court Forebay canal. 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*.

3.4.5.2.2.1 Activities with Fixed Locations

Construction of the Clifton Court Forebay canal 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 have been sited, construction associated with these activities will follow the avoidance and minimization measures described below.

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[35] 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).

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).

3.4.5.2.2.1.1 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.

3.4.5.2.2.1.2 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.

3.4.5.2.2.1.3 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).

3.4.5.2.2.1.4 Clifton Court Forebay Operations and Maintenance

Following completion of Clifton Court Forebay modifications, the area to be operated and maintained within suitable kit fox habitat will be fenced with chain link fencing that prevents entry of San Joaquin kit fox. The fencing will be inspected annually to ensure there are no holes or gaps in the fencing that would allow kit foxes to enter.

3.4.5.2.2.2 Activities with Flexible Locations

3.4.5.2.2.2.1 Geotechnical Exploration

- Geotechnical work in and within 200 feet of San Joaquin kit fox habitat will be limited to daytime hours.

- 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.

3.4.5.2.2.2.2 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 3.4.5.2.2.1.1, *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 3.4.5.2.1.1, *Activities with Fixed Locations,* will be followed. These measures will be applied to both transmission line construction and long-term maintenance.

3.4.5.2.2.2.3 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 3.4.5.2.2.1.1, *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 3.4.5.2.1.1, *Activities with Fixed Locations,* will be followed during construction and management of the vernal pool habitat.

3.4.5.2.3 Compensation for Effects

DWR will protect San Joaquin kit fox habitat at a ratio of 3:1 (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. 47 acres of suitable San Joaquin kit fox habitat will be affected and therefore 141 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	47	3:1	141

3.4.5.2.4 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. Alternatively, credits may be purchased at a FWS-approved conservation bank.

3.4.5.2.5 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.

3.4.5.3 California Least Tern

3.4.5.3.1 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.

3.4.5.3.2 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*.

Safe havens, RTM, and transmission lines will fully avoid California least tern foraging habitat. Transmission lines may cross waterways, but must avoid disturbance of open water habitat.

3.4.5.4 Western Yellow-Billed Cuckoo

3.4.5.4.1 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.

3.4.5.4.2 Avoidance and Minimization Measures

3.4.5.4.2.1 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 when cuckoos are not present.

- If an activity is to occur within 1,200 feet of western yellow-billed cuckoo habitat (or within 2,000 feet if pile driving will occur) during the period of from June 15 through September 1[36], the following measures will be implemented to avoid noise effects on migrating western yellow-billed cuckoos.

    - Prior to the construction, a noise expert will create a noise contour map showing the 60 dBA noise contour specific to the type and location of construction to occur in the area.

    - During the period between June 15 and September 1, a USFWS-approved biologist will survey any suitable migratory habitat for yellow-billed cuckoos within the 60 dBA noise contour on a daily basis during a two-week period prior to construction. While construction is occurring within this work window, the USFWS-approved biologist will conduct daily surveys in any suitable habitat where construction related noise levels could exceed 60 dBA (A-weighted decibel) L_{eq} (1 hour). If a yellow-billed cuckoo is found, sound will be limited to 60dBA in the habitat being used until the USFWS-approved biologist has confirmed that the bird has left the area.

- 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.

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[36] Based on occurrence data, this is the period within which yellow-billed cuckoos have been observed in the legal Delta.

- 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*.

3.4.5.4.2.2 Activities with Flexible Locations

3.4.5.4.2.2.1 Geotechnical Exploration

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

3.4.5.4.2.2.2 Safe Haven Work Areas

During the siting phase of safe haven construction, a USFWS approved biologist will work with the engineers to avoid loss or degradation of suitable western yellow-billed cuckoo migratory habitat. This includes ensuring that safe haven work areas are not sited in western yellow-billed cuckoo habitat. This also includes ensuring noise from safe haven work areas do not exceed 60 dBA at nearby western yellow-billed cuckoo migratory habitat.

3.4.5.4.2.2.3 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.

3.4.5.4.2.2.4 Safe Havens

Safe haven sites will avoid western yellow-billed cuckoo migratory habitat. All work associated with safe haven sites will be conducted during daylight hours, and will not require any lighting.

3.4.5.4.2.2.5 Restoration/Mitigation 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. (Furthermore, the biological opinion for the PA will not authorize take resulting from restoration/mitigation actions.

3.4.5.4.3 Compensation to Offset Impacts

DWR will offset the loss of 32 acres of western yellow-billed cuckoo migratory habitat through the creation or restoration at a 2:1 ratio, for a total of 64 acres of migratory 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.

3.4.5.5 Giant Garter Snake

3.4.5.5.1 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. When each site is available for surveys, a giant garter snake expert, approved by USFWS and CDFW, will then delineate giant garter snake habitat at each project site, based on the definition of suitable habitat, including both aquatic and upland habitat.

2. 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 3.4.5.5.3, *Compensation for Effects*.

3. 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.

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

5. When avoidance is not possible, the measures discussed below in Section 3.4.5.5.2, *Avoidance and Minimization Measures,* are required.

3.4.5.5.2 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*).

3.4.5.5.2.1 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.

- Initiate construction and clear suitable habitat in the summer months, between May 1 and October 1, and avoid giant garter snake habitat during periods of brumation (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.* Once a construction site has been cleared and exclusionary fencing is in place, work within the cleared area can occur between October 1 and May 1.

- 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, as well at 50 feet outside the work site exclusion fencing in suitable habitat.

- 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.

- Once habitat is deemed giant garter snake-free, exclusion fencing will be constructed around the construction site so not snakes may re-enter prior to or during construction.

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.

3.4.5.5.2.2 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 upland habitat, as delineated by a USFWS approved biologist and based on the suitable habitat definition in Section 4.A.9.6, will be avoided. The following avoidance and minimization measures will be used to minimize unavoidable effects on the giant garter snake upland habitat.

- Geotechnical activity in giant garter snake upland habitat will be confined to the giant garter snake's active period (May 1 through October 1).

- Movement of heavy equipment will be confined to existing roads as much as possible, and will avoid suitable upland giant garter snake habitat .

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

Safe Haven Work Areas

Safe haven work areas will avoid giant garter snake aquatic and upland habitat.

Power Lines and Grid Connections

Giant garter snake avoidance and minimization measures for transmission lines will be the same as described in Section 3.4.5.5.2.1, *Activities with Fixed Locations*. These power lines and grid connections will be designed to avoid giant garter snake aquatic habitat.

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 3.4.5.5.2.1, *Activities with Fixed Locations*.

3.4.5.5.3 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). An estimated 775 acres of giant garter snake habitat will be affected, therefore 2,325 acres of giant garter snake 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 1,550 acres of mitigation. A combination of in-kind and high-priority mitigation may be used.
- Giant garter snake upland mitigation will be placed and protected adjacent to aquatic habitat protected for giant garter snake. 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).

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

- Characteristics of restored and protected habitat may change from the above descriptors if new information and best available science indicate greater benefits as agreed upon by USFWS.

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 Total	**205**	**3:1 or 2:1[1]**		**615 or 410**	
Upland Total	**570**			**1,710 or 1,140**	
TOTAL	**775**			**2,325 or 1,550**	

[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.

3.4.5.5.4 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, or corridors between these areas, 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 with a design that provides equal or greater habitat value for the species as agreed upon by USFWS.

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 at high-priority mitigation sites. In-kind mitigation sites will be managed in a manner that maintains or exceeds the quality of habitat impacted by project activities. 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.

3.4.5.6 California Red-Legged Frog

3.4.5.6.1 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.

3.4.5.6.2 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.

3.4.5.6.2.1 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.

- 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. Once the initial ground disturbance has occurred, the area has been cleared, and exclusionary fencing is in place, work within the disturbed area can occur outside the construction window.

- 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.

- No initial clearing activities will occur during rain events or within 24-hours following a rain event, prior to clearing a site and installing exclusionary fencing. An approved biologist will check the exclusion fencing daily to ensure it is intact, and if there are any breaches in the fencing, the approved biologist will survey the work area of Calfornia red-legged frogs. If the species is found, the approved biologist will relocate the frog consistent with an approved relocation plan.

- 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.

- If work must be conducted at night, all lighting will be directed away and shielded from California red-legged frog habitat outside the construction area to minimize light spillover to the greatest extent possible. If light spillover into adjacent California red-legged frog habitat occurs, a USFWS-approved biologist will be present during night work to survey for burrows and emerging California red-legged frogs in areas illuminated by construction lighting. If California red-legged frog is found above-ground the USFWS-approved biologist has the authority to terminate the project activities until the light is directed away from the burrows, the California red-legged frog moves out of the illuminated area, or the California red-legged frog is relocated out of the illuminated area by the USFWS-approved biologist.

- 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.

3.4.5.6.2.2 Activities with Flexible Locations

3.4.5.6.2.2.1 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 California red-legged frog suitable habitat 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.

3.4.5.6.2.2.2 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 3.4.5.6.2.1, *Activities with Fixed Locations,* will be followed.

3.4.5.6.2.2.3 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.

3.4.5.6.3 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, 51 acres of upland habitat will be affected (including 47 acres within the construction footprint and four acres adjacent to the construction footprint, potentially subject to vibrations) and 153acres 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	51	3:1	153
Aquatic	1	3:1	3
Total	**52**	–	**156**

3.4.5.6.4 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.

3.4.5.6.5 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.

3.4.5.7 California Tiger Salamander

3.4.5.7.1 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. Once a construction area has been cleared, it will no longer be considered suitable habitat.

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.

3.4.5.7.2 Avoidance and Minimization Measures

3.4.5.7.2.1 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.

3.4.5.7.2.2 Activities with Fixed Locations

The following measures will be implemented for activities with known locations. No aquatic habitat for California tiger salamander will be affected.

Site Preparation-

- 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 suitable habitat for the species (defined above). 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.

- 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.

- 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. Prior to initiating surveys, water trucks will spray the work area to influence emergence. Watering will occur at dusk, trucks will make a single pass, and the USFWS-approved biologist(s) will survey the watered area for one hour following the spraying. If California tiger salamander are found, they will be relocated consistent with the Relocation Plan described above. Also see *Species Observation and Handling Protocol*, below.

Initial Clearance/Ground Disturbance

- Except for limited vegetation clearing necessary to minimize effects to nesting birds, initial suitable habitat clearance and disturbance will be confined to the dry season, generally May through October 15. All initial clearing 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). Clearing activities within California tiger salamander habitat will cease 24 hours prior to a 40% or greater forecast of rain from the closest National Weather Service (NWS) weather station. Clearing may continue 24 hours after the rain ceases, if no precipitation is in the 24-hour forecast. If clearing must continue when rain is forecast (greater than 40% chance of rain), a USFWS-approved biologist will survey the worksite before clearing begins each day rain is forecast. If rain exceeds 0.5 inches during a 24-hour period, clearing 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. Once the ground has been cleared and perimeter fencing is in place, these restrictions do not apply.

During Construction

- 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.

- 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. 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.

- To the extent possible, 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 within 300 feet of California tiger salamander habitat. 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.

- If work must be conducted at night within 300 feet of California tiger salamander habitat, all lighting will be directed away and shielded from California tiger salamander habitat outside the construction area to minimize light spillover to the greatest extent possible. If light spillover into adjacent California tiger salamander habitat occurs, a USFWS-approved biologist will be present during night work to survey for burrows and emerging California tiger salamanders in areas illuminated by construction lighting. If California tiger salamander is found above-ground the USFWS-approved biologist has the authority to terminate the project activities until the light is directed away from the burrows, the California tiger salamander moves out of the illuminated area, or the California tiger salamander is relocated out of the illuminated area by the USFWS-approved biologist.

- 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.

- **Species Observation and Handling Protocol**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.

3.4.5.7.2.3 Activities with Flexible Locations

3.4.5.7.2.3.1 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 within California tiger salamander suitable habitat will avoid impacts to areas 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.

- Geotechnical exploration activities will cease no less than 30 minutes before sunset and will not begin again until no less than 30 minutes after sunrise within 300 feet of California tiger salamander habitat.

3.4.5.7.2.3.2 Safe Havens

Safe havens will avoid suitable California tiger salamander habitat.

3.4.5.7.2.3.3 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 3.4.5.7.2.1, *Activities with Fixed Locations,* will be followed, with the following exception.

- Transmission line construction activities will cease no less than 30 minutes before sunset and will not begin again until no less than 30 minutes after sunrise within 300 feet of California tiger salamander habitat.

3.4.5.7.2.3.4 Restoration

3.4.5.7.2.3.4.1 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 3.4.5.7.2.1, *Activities with Fixed Locations,* will be followed.

3.4.5.7.2.3.4.2 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 physical or biological features (PBFs)[37] 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 PBFs. With the application of the AMM, adverse modification to PBFs of California tiger salamander critical habitat will be avoided.

3.4.5.7.3 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 50 acres of habitat will be affected (47 acres within the construction footprint and 3 acres adjacent to construction, potentially subject to vibrations); therefore, 150 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	50	3:1	150
Total	**50**	**-**	**150**

3.4.5.7.4 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:

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[37] The designations of critical habitat for listed species have generally used the term primary constituent elements (PCEs). NMFS and USFWS' recently issued a final rule amending the regulations for designating critical habitat (81 FR 7414; February 11, 2016), which replaced the term PCEs with physical or biological features (PBFs). In addition, NMFS and USFWS' recently issued a final rule revising the regulatory definition of "destruction or adverse modification" of critical habitat (81 FR 7214; February 11, 2016), which refers to PBFs, not PCEs. The shift in terminology does not change the approach used in conducting an analysis of the effects of the proposed action on critical habitat, which is the same regardless of whether the original designation identified PCEs or PBFs. In this biological assessment, we use the term PBFs to include PCEs, as appropriate for the specific critical habitat.

- 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.

3.4.5.7.5 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[38].

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[38] 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.

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 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.

3.4.5.8 Valley Elderberry Longhorn Beetle

3.4.5.8.1 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*).

3.4.5.8.2 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.

3.4.5.8.2.1 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 3.4.4, *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.

3.4.5.8.2.2 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.

3.4.5.8.2.2.1 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 3.4.5.8.2.1, *Activities with Fixed Locations.*

3.4.5.8.2.2.2 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 3.4.5.8.2.1, *Activities with Fixed Locations.*

3.4.5.8.2.2.3 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 3.4.5.8.2.1, *Activities with Fixed Locations.*

3.4.5.8.2.2.4 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 3.4.5.8.2.1, *Activities with Fixed Locations*.

3.4.5.8.3 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 3.4.5.8.4, *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.

3.4.5.8.4 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.

3.4.5.8.4.1 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.

3.4.5.8.5 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.

3.4.5.8.5.1 Levee Maintenance

All levee maintenance that involves ground-disturbing activities will implement relevant measures described above under Section 3.4.5.8.2, *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).

3.4.5.8.5.2 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.

3.4.5.8.5.3 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.

3.4.5.8.5.4 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.

3.4.5.8.5.5 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.

3.4.5.8.5.6 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.

3.4.5.9 Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

3.4.5.9.1 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.

3.4.5.9.2 Avoidance and Minimization Measures

3.4.5.9.2.1 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.

3.4.5.9.2.2 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.

3.4.5.9.3 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.

3.4.5.9.4 Siting Criteria for Compensation for Effects

3.4.5.9.4.1 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.)

3.4.5.9.4.2 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.

3.4.5.9.4.3 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.

3.4.5.9.5 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.

3.4.5.9.5.1 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.

3.4.5.9.5.2 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.

3.4.5.10 Least Bell's Vireo

3.4.5.10.1 Habitat Definition

AMMs for least Bell's vireo 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.15.6, *Suitable Habitat Definition*. The model for least habitat is described in Appendix 4.A, Section 4.A.15.7, *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 least Bell's vireo.

3.4.5.10.2 Avoidance and Minimization Measures

3.4.5.10.2.1 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 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.

- Prior to construction, all suitable least Bell's vireo 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 least Bell's vireos in the area where vegetation will be removed, vegetation removal will be done when the birds are not present.

- If an activity is to occur within 1,200 feet of least Bell's vireo habitat (or within 2,000 feet if pile driving will occur) during the breeding period for least Bell's vireos, the following measures will be implemented to avoid noise effects on least Bell's vireo.

  - Prior to the construction, a noise expert will create a noise contour map showing the 60 dBA noise contour specific to the type and location of construction to occur in the area.
  - During the breeding period for least Bell's vireo, a USFWS-approved biologist will survey any suitable habitat for least Bell's vireo within the 60 dBA noise contour on a daily basis during a two-week period prior to construction. While construction is occurring within this work window, the USFWS-approved biologist will conduct daily surveys in any suitable habitat where construction related noise levels could exceed 60 dBA (A-weighted decibel) L_{eq} (1 hour). If a least Bell's vireo is found, sound will be limited to 60dBA in the habitat being used until the USFWS-approved biologist has confirmed that the bird has left the area.

- 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 least Bell's vireo 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 least Bell's vireo 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*.

3.4.5.10.2.2 Activities with Flexible Locations

3.4.5.10.2.2.1 Geotechnical Exploration

During geotechnical activities, a USFWS approved biologist will be onsite to avoid the loss or degradation of suitable least Bell's vireo habitat by exploration activities.

3.4.5.10.2.2.2 Safe Haven Work Areas

During the siting phase of safe haven construction, a USFWS approved biologist will work with the engineers to avoid loss or degradation of suitable least Bell's vireo habitat. This includes ensuring that safe haven work areas are not sited in least Bell's vireo habitat. This also includes ensuring noise from safe haven work areas do not exceed 60 dBA at nearby least Bell's vireo habitat.

3.4.5.10.2.2.3 Power Supply and Grid Connections

The final transmission line alignment will be designed to minimize removal of least Bell's vireo habitat by removing no more than three acres of this habitat. To minimize the chance of least Bell's vireo 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.

3.4.5.10.2.2.4 Safe Havens

Safe haven sites will avoid least Bell's vireo habitat. All work associated with safe haven sites will be conducted during daylight hours, and will not require any lighting.

3.4.5.10.2.2.5 Restoration/Mitigation Activities

A USFWS biologist will work with the restoration siting and design team to avoid the permanent loss of suitable least Bell's vireo habitat. (Furthermore, the biological opinion for the PA will not authorize take resulting from restoration/mitigation actions.

3.4.5.10.3 Compensation to Offset Impacts

DWR will offset the loss of 32 acres of least Bell's vireo habitat through the creation or restoration at a 2:1 ratio, for a total of 64 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 Collaborative Science and Adaptive Management Program

Considerable scientific uncertainty exists regarding the Delta ecosystem, including the needs of the species, the effects of CVP/SWP operations and the related operational criteria for the PA. 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. It is expected that this program will be based on the draft framework described in Appendix 3.H *Adaptive Management Framework for the California Water Fix (CWF) and 2008/2009 Biological Opinions on the combined operations of the Central Valley Project (CVP) and State Water Project (SWP)*. The draft adaptive management framework describes concepts to develop an adaptive management program for the CWF joint ESA Biological Opinion and 2081(b) Incidental Take Permit, and the CVP/SWP 2008/2009 BiOps and CESA authorizations.

3.4.7 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 (i.e., NDD, HOR gate, CCF), including the MMRP that will be required under CEQA approvals and any additional monitoring required to assess effectiveness of AMMs and inform any necessary revision.

- 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 and assess effects of the proposed NDD, HOR gate and modified CCF.

- Monitoring and studies related to operation of the proposed new facilities that must occur after operation of the new facilities has commenced (e.g., to support real-time operation of HOR gate), including those necessary to monitor the condition of both the species and the habitat conditions that may be influenced by the new facilities (e.g., upstream temperatures, potential for redd dewatering, Delta rearing conditions, water quality, etc.).

- Monitoring and studies related to evaluation of the effectiveness of proposed facilities (e.g., non-physical barrier at Georgiana Slough), habitat restoration and other mitigation measures 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 is expected to also be initiated through the adaptive management framework described in Appendix 3.H *Adaptive Management Framework for the California Water Fix (CWF) and 2008/2009 Biological Opinions on the combined operations of the Central Valley Project (CVP) and State Water Project (SWP)*. Implementation of such monitoring actions would only occur if take authorization for the action were approved by the jurisdictional fish and wildlife agencies.

3.4.7.1 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. Monitoring programs required under the existing NMFS (2009) BiOp includes the following items, called for under RPA Action 11.2.1.3 *Monitoring and Reporting Requirements*.

1. Reclamation and DWR shall participate in the design, implementation, and funding of the comprehensive CV steelhead monitoring program on CVP- and SWP-controlled streams.

2. Reclamation and DWR shall ensure that all monitoring programs regarding the effects of CVP and SWP operations and which result in the direct take of winter-run, spring-run, CV steelhead, or Southern DPS of green sturgeon, are conducted by a person or entity that has been authorized by NMFS.

3. Reclamation and DWR shall submit weekly reports to the interagency Data Assessment Team (DAT) regarding the results of monitoring and incidental take of winter-run,

spring-run, CV steelhead, and Southern DPS of green sturgeon associated with operations of project facilities.

4. Reclamation and DWR shall provide an annual written report to NMFS describing the results of real-time monitoring of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon associated with operations of the DCC/CVP/SWP Delta pumping facilities, and other Division level operations authorized through this RPA.

5. Reclamation and DWR shall continue the real-time monitoring between October 1 and June 30 each year of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon in the lower Sacramento River, the lower San Joaquin River, and the Delta to establish presence and timing to serve as a basis for the management of Delta pumping operations consistent with actions in this RPA.

6. Reclamation and DWR shall submit weekly DAT reports and an annual written report to NMFS describing the results of real-time monitoring of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon associated with operations of Delta pumping facilities and other Division level operations authorized through this RPA.

7. Reclamation shall coordinate with NMFS, FWS, and DFW to continue implementing and funding fisheries monitoring of spring-run and CV steelhead in Clear Creek to aide in determining the benefits and effects of flow and temperature management.

8. Reclamation and DWR shall jointly fund these monitoring locations for the duration of the Opinion (through 2030) to ensure compliance with the RPA and assess the performance of the RPA actions.

    a. Upstream: Adult escapement and juvenile monitoring for spring-run, winter-run, and steelhead on the Sacramento River, American River, Feather River, Clear Creek, Mill Creek, Deer Creek and Battle Creek.

    b. Red Bluff Diversion Dam – completed.

    c. Installed and operating at Tisdale Bypass.

    d. Delta: Continuation of the following monitoring stations that are part of the IEP: Chipps Island Trawl, Sacramento Trawl, Knights Landings RST, and beach seining program. Additionally, assist in funding new studies to determine green sturgeon relative abundance and habitat use in the Delta.

    e. San Joaquin River monitoring shall include: Adult escapement and juvenile monitoring for steelhead on the Stanislaus River; Mossdale Kodiak Trawling to determine steelhead smolt passage; steelhead survival studies associated with VAMP; monitoring at HORB to determine steelhead movement in and around the barrier; predation studies in front of HORB and at the three agricultural barriers in the South Delta; and new studies to include the use of non-lethal fish guidance devices (e.g., sound, light, or air bubbles) instead of rock barriers to keep juveniles out of the area influenced by export pumping.

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[39], 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 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.

3.4.7.2 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 CDFW, 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

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[39] This program is described and data are archived at http://www.water.ca.gov/iep/activities/monitoring.cfm

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.

Furthermore, DWR commits to track impacts of the PA on habitat related issues associated with the modifications to Clifton Court Forebay and the HOR gate, and report the results to the jurisdictional fish and wildlife agencies (CDFW, NMFS, USFWS) on an annual basis. DWR will work closely with CDFW, USFWS and NMFS to ensure that these monitoring efforts support RTOs for the HOR gate; study drivers/predictors of loss, predation rates and survival; fish presence and movement around these structures and elsewhere in the south Delta; and water quality and circulation patterns in and around CCF.

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.

3.4.7.3 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. This monitoring begins with gathering baseline data to compare with post-construction monitoring and studies. While a more detailed effort has already been made regarding monitoring for the NDD, monitoring prior to operations will be required throughout the action area, including CCF, the HOR gate, and key habitat areas downstream and upstream of the new facilities. DWR will commit to working with the fish agencies to develop the specifics of that monitoring, which will be a key charge of both the Clifton Court Forebay Technical Team (Section 3.2.5.1.3 *Clifton Court Forebay Technical Team*) and HOR gate (Section 3.2.8.1.1 *HOR Gate Technical Team*).

For the NDD, specific monitoring studies will be also developed in collaboration with USFWS, CDFW, and NMFS that are focused on preconstruction conditions and on design of the diversions. These monitoring efforts prior to operations will build off the work done by the Fish Facilities Technical Team (2011), which identified monitoring associated with the north Delta intakes and their effects. The pre-construction studies identified by this group were focused on specific key questions rather than general monitoring needs 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. These studies and their projected timeframes will be revisited as the final monitoring plan is developed.

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, *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.	How do alternative north Delta intake refugia designs perform with regard to desired biological function?	Two years to perform study; 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	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.

Potential Research Action[1]	Key Uncertainty Addressed	Timeframe
fish, and to assess ways to reduce such by-catch, if necessary.		
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 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.	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.
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-	How will the new north Delta intakes affect delta and longfin smelt density	Pre-construction study will cover at least 3 years. Post-construction study will be

Potential Research Action[1]	Key Uncertainty Addressed	Timeframe
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.	and distribution in the affected reach of the Sacramento River?	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 the screen system to consistently achieve compliance with design criteria.	Approximately 6 months beginning with initial facility operations.
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	Study to be performed at varied river stages and diversion rates, during first 2 years of facility operation.

Monitoring Action(s)	Action Description[1]	Timing and Duration
	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.	
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) Interagency Ecological Program 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 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.	Start prior to construction of water diversion facilities and continue for the duration of the PA.
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.

3.4.7.4 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 four types of monitoring, performed to assess system state and effects on listed species: monitoring addressing the operation of the proposed new facilities, monitoring related to species condition and habitat that may be influenced by operations of the new facilities, monitoring to evaluate the effectiveness of the proposed facilities, and monitoring addressing the habitat protection and restoration sites.

3.4.7.4.1 Monitoring Addressing Conveyance Facilities Operations

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) also identified monitoring associated with the north Delta intakes and their post-construction effects. Some of this work was focused on specific key questions rather than general 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. For Delta Smelt, no specific monitoring plan is proposed, however, a future FWS-approved monitoring plan may be developed once operations commence.

Monitoring and studies will also be developed for the new South Delta facilities, including specifically the modified CCF and HOR gate, as part of the respective tech teams for these components of the PA. These will focus on entrainment and salvage; drivers/predictors of fish loss, predation rates and survival; fish presence and movement around these structures; and water quality and circulation patterns.

3.4.7.4.2 Monitoring Addressing Habitat Affected by Operations of the New Facilities

Overall operational monitoring will also be needed in areas upstream and downstream of the new facilities. The specific monitoring studies will be developed in collaboration with USFWS, CDFW, and NMFS and focus on entrainment into the interior delta, outflow, temperature, redd dewatering, fish presence and movement, and through-delta survival

3.4.7.4.3 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 through the adaptive management framework . 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.

Before determining whether an action was considered interrelated or interdependent, actions that are considered ongoing or reasonably foreseeable and occur wholly or in part within the action area, and that may be functionally related to the PA, were evaluated and screened. 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 are part of the PA, and their utility does not depend upon the PA, in whole or in part, and are therefore not considered interdependent and interrelated.

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, upstream actions are not interrelated to or interdependent with the PA.

Additionally, as to why upstream operations are no considered interrelated and interdependent with the PA:

- 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 and is therefore described and analyzed in this BA. 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, 2007-10, and 2013-2016. 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.

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 meet the needs of both public health standards and urban and agricultural water demand, as well as protecting the ecosystem and its inhabitants. The most notable droughts in recent history are the droughts that occurred in 1976-77, 1987-92, and 2013-2016. 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. In 1977, 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 of salmon egg and pre-emergent fry incubation. 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 current 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 Keswick 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, California Central Valley steelhead, and Southern distinct population segment of North American green sturgeon.

The biological opinions for operation of the CVP and SWP, together with changes in SWRCB Bay-Delta requirements, represent a major difference between 1987-92, 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 operation of the CVP and SWP afforded additional protections to listed fish species than 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 Processes and Tools

On January 17, 2014, Governor Brown proclaimed a State of Emergency due to severe drought conditions and directed the State Water Board, among other things, to consider modifying requirements for reservoir releases or diversion limitations that were established to implement a water quality control plan. The Proclamation stated that such modifications may be necessary to conserve cold water stored in upstream reservoirs that may be needed later in the year to protect salmon and steelhead, to maintain water supply, and to improve water quality. The Proclamation was followed by several executive orders continuing the State of Emergency and identifying and expediting actions necessary for state and local agencies and Californians to take to reduce the harmful effects of the drought, including streamlined processing of permits and increased enforcement, conservation, and coordination.

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 operations consistent with the BiOps and prepared appropriate documentation to support the permitting and consultation processes. This included preparation of a Temporary Urgency Change Petition (TUCP) for submittal to the SWRCB, and Endangered Species Act (ESA) and California Endangered Species Act (CESA) consultation letters/memorandums for exchange with USFWS, NMFS, and CDFW. 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 Real Time Drought Operations Management Team (RTDOMT) and frequent meetings of the executive leadership of these agencies. State agencies also provided enhanced monitoring in the Delta. The effectiveness of the actions under the TUCP and BiOps and results of the monitoring activities were reviewed and utilized, in light of the species responses, to inform the continued response to drought.

A variety of tools were used to plan, implement, and monitor WY 2014 and 2015 drought response actions. These included participation by technical staff, managers, and directors in various ongoing and new multi-agency teams, hydrologic and biological modeling efforts, and monitoring activities including:

a. Multi-agency communication and coordination teams, including but not limited to RTDOMT, Delta Operations for Salmon and Sturgeon (DOSS), Smelt Working Group (SWG), and the 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. Aerial redd and carcass surveys
        2. Redd dewatering surveys
        3. Fall mid water trawl
        4. Spring Kodiak trawl
        5. Rotary screw trap
        6. Delta smelt early warning survey
    ii. Water quality
        1. Sediment
        2. Turbidity plume
        3. Algae
        4. Temperature

iii. First flush events and runoff associated with precipitation events

3.7.2 Proposed Future Drought Procedures

In order to evaluate the challenges related to the 2013-2016 drought, federal and state agencies (Reclamation, DWR, USFWS, NMFS, CDFW, and SWRCB) relied heavily on on-going communication and coordination through the RTDOMT and frequent meetings of the executive leadership of these agencies. In order to better prepare for future droughts, this type of coordination and communication will need to begin as early as possible.

Therefore, on October 1st, if the prior water year was dry or critical[40], Reclamation and DWR will convene a multi-agency drought management team to include representatives from Reclamation, DWR, USFWS, NMFS, SWRCB, and CDFW and be charged with evaluating current hydrologic conditions and the potential for continued dry conditions that may necessitate the need for development of a drought contingency plan for the water year.

The drought management team will commit to convening at least every month to assess hydrologic conditions and forecast predictions and identify the potential need for development of a drought contingency plan until it is clear that drought conditions for that year will not persist. Information and recommendations from the drought management team will be reported back to the executive leadership of the agencies. These assessments would also inform what actions should be included in a drought contingency plan, depending on the updated hydrology assessment and the magnitude and duration of the preceding dry conditions. While a drought contingency plan may recommend adhering to the operations as identified in existing regulatory authorizations, in longer periods of dry conditions, the plan could also propose other drought response actions. Such a contingency plan should, at a minimum, include information pertaining to: an evaluation of current and forecasted hydrologic conditions and water supplies; recommended actions or changes needed to respond to drought (including changes to project operations, contract deliveries, and regulatory requirements) and any associated water supply or fish and wildlife impacts; identified timeframes; potential benefits; monitoring needs and measures to avoid and minimize fish and wildlife impacts; and proposed mitigation (if necessary).

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[40] For either Sacramento Valley or San Joaquin Water Year classifications

3.8 References

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4 Action Area and Environmental Baseline

4.1 Introduction

This chapter describes the action area of the proposed action (PA) as well as the environmental baseline in the action area, including an overview of environmental conditions and a description of the effects of these conditions on the species included in this biological assessment. Detailed species accounts for each species considered in this BA are provided in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*.

4.2 Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action, and not merely the immediate area involved in the action (50 CFR §402.02). For purposes of this consultation, the action area includes the entire legal Delta, Suisun Marsh, and Suisun Bay; and extends upstream within the channels of the Sacramento and American Rivers below Keswick and Nimbus Dams, respectively

Figure 4-1. For purposes of the Southern Resident distinct population segment (DPS) of killer whale only, the action area includes nearshore coastal areas in California, Oregon, and Washington (Figure 4-2).

The action area was derived considering several factors to account for all effects of the PA. First, to determine the action area for listed fish and their designated critical habitat, the CALSIM II model was used to screen for the extent of potential direct and indirect effects within the Sacramento and San Joaquin Rivers and their tributaries. Where CALSIM II results did not differ between the PA and No Action conditions, no effect was assumed within the Sacramento and San Joaquin Rivers and their tributaries because it indicates that the PA would not have an effect on operations, and therefore would not affect species in those areas. Where CALSIM II results did not differ between the PA and No Action conditions, it was assumed that the PA did not cause an effect, and that the action area did not need to include those areas. This is discussed further in the introduction to Section 5.4.2, *Upstream Hydrologic Changes*, which describes the tributaries that are part of the SWP/CVP with no difference between PA and No Action are the Trinity River, Clear Creek, the San Joaquin River, and the Stanislaus River; these areas therefore were excluded from the action area. Additionally, the Feather River system is excluded from the action area due to the existing formal consultation on water operations in that system, as detailed in Section 4.4 *Feather River Operations Consultation*. The entire legal Delta and Suisun Marsh are included in the action area for fish species because the PA may affect any waterway in the Delta or Suisun Marsh. Detailed modeling results are provided as Appendix 5.A, *CALSIM Methods and Results*. For listed species of wildlife, the entire legal Delta was assumed to account for all of the potential construction effects, including the siting of offsetting measures including habitat restoration. For the Southern Resident killer whale, all nearshore coastal waters within their range in California, Oregon, and Washington are included in the action area because this distribution is consistent with the description provided by NMFS (2009: 158-160).

Figure 4-1 California WaterFix Action Area

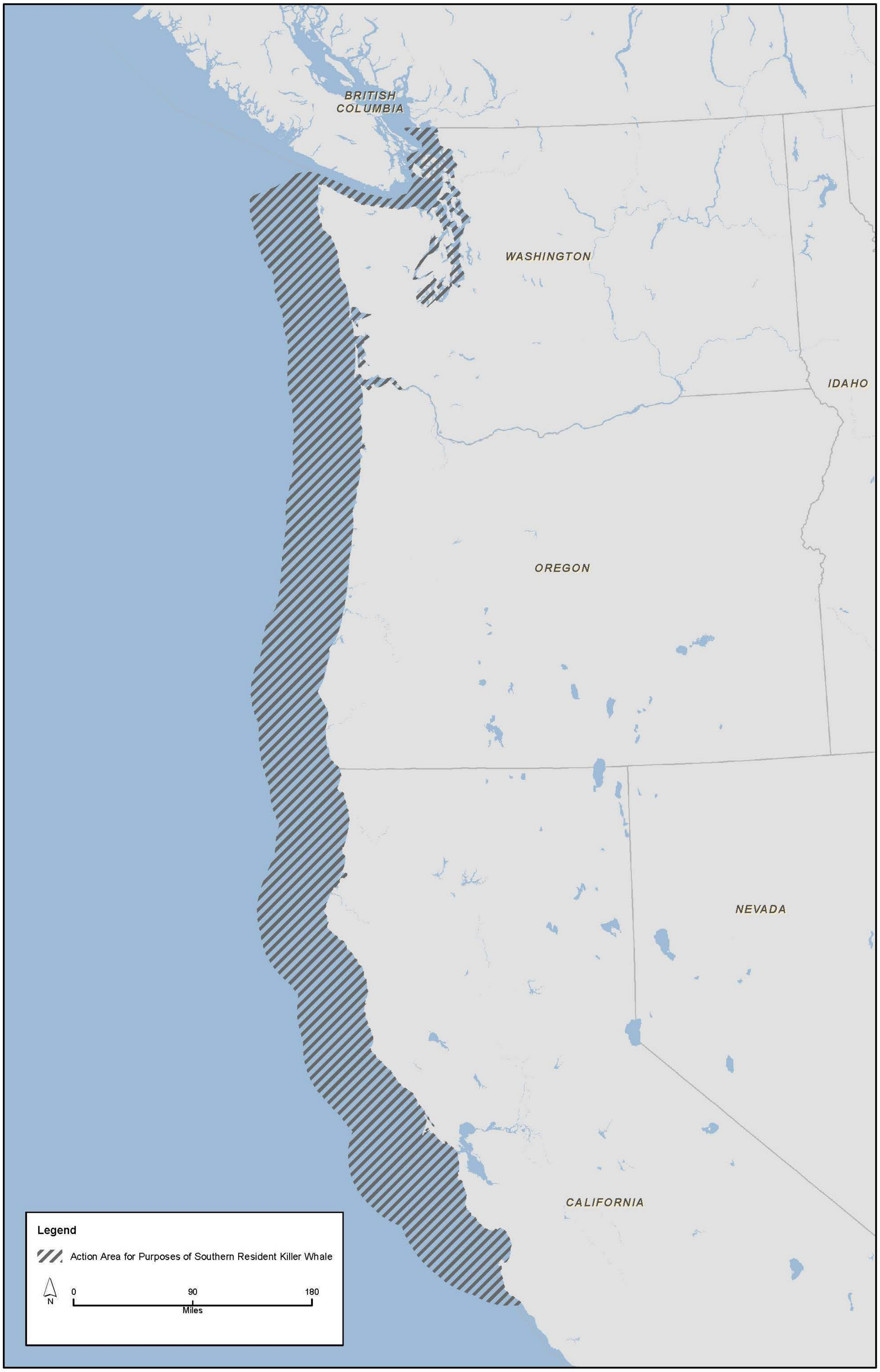


Figure 4-2. California Water Fix Action Area for Purposes of Southern Resident Killer Whale

4.3 Environmental Context

This section includes a general description of environmental conditions in the action area to provide relevant background information for the environmental baseline. The environmental baseline for each species is presented below in Section 4.5, *Status of the Species/Environmental Baseline Summary*.

4.3.1 Historical Conditions

Much of the broad scale geology of the Central Valley, Delta, and Suisun Marsh was formed before the Pleistocene epoch (more than 2 million years ago), while finer details wrought by younger geologic formations, including the recent uplift and movement of the Coast Range and the deposition of broad alluvial fans along both sides of the Central Valley, formed during the Pleistocene epoch from 2 million to 15,000 years ago (Louderback 1951; Olmsted and Davis 1961; Lydon 1968, Shlemon 1971; Atwater et al. 1979; Marchandt and Allwardt 1981; Helley and Harwood 1985; Band 1998; Unruh and Hector 1999; Graymer et al. 2002; Weissmann et al. 2005; Unruh and Hitchcock 2009). Approximately 21,000 years ago, the last glacial maximum ended and the eustatic (worldwide) sea level began to rise from the lowstand (lowest sea level bathymetric position or depth during a geologic time) of -394 feet (-120 meters) in a series of large meltwater pulses interspersed by periods of constant rising elevation. The rise continued until the Laurentide ice sheet had completely melted 6,500 years ago and the rate of sea level rise slowed dramatically (Edwards 2006; Peltier and Fairbanks 2006). During this change from glacial to interglacial period, runoff brought enormous quantities of sediment from the Sierra Nevada and Coast Range that formed alluvial fans and altered stream channels in the Central Valley (Olmsted and Davis 1961; Shlemon 1971; Marchandt and Allwardt 1981; Helley and Harwood 1985; Weissmann et al. 2005).

The modern Delta formed sometime between 10,000 and 6,000 years ago, when the rising sea level inundated a broad valley that occupied the Delta region. Despite its name, the Sacramento–San Joaquin River Delta is not simply the merging of two river deltas, but is instead an elongated and complex network of deltas and flood basins with flow sources that include Cache Creek, Putah Creek, Sacramento River, Mokelumne River, San Joaquin River, and Marsh Creek. Based on current unimpaired flow estimates, the Sacramento River is the largest source of flows and has contributed an average of 73% of historical inflows into the Delta. The eastside tributaries, including the Mokelumne River, contribute about 6%, and the San Joaquin River contributes 21% (California Department of Water Resources 2007).

Currently, during high-flow events (when water from the Sacramento River spills into the bypasses), approximately 80% of Sacramento River flow enters the Yolo Bypass, a flood control bypass west of the city of Sacramento, via the Fremont Weir (Roos 2006). Flows begin to enter Fremont Weir when Sacramento River flows at Freeport exceed 56,000 cubic feet per second (cfs). The flood stage flows can have many sources, including direct flows from tributaries such as the Feather and American Rivers, as well as flows transiting a system of passive and active weirs (James and Singer 2008; Singer et al. 2008; Singer and Aalto 2009). The Yolo Bypass also serves as a conduit for Cache Creek and Putah Creek, as their waters enter the Sacramento River via Cache Slough at the southern end of the Yolo Bypass. The San Joaquin River discharges into a broad network of sloughs and channels, and the Mokelumne River delta merges with the San

Joaquin River delta on the eastern side of the Delta. On the southwest side of the Delta, the Marsh Creek delta merges with the San Joaquin River delta.

While flooding has always been a regular occurrence along the Sacramento River (Thompson 1957, 1960, 1961, 1965), the natural geomorphic processes and hydrologic regimes were completely disrupted by the enormous increase in sediment and debris generated by hydraulic mining operations in the central Sierra Nevada from 1853 to 1884 (Gilbert 1917; Mount 1995). Large volumes of mining sediment remain in the tributaries today (James 2004a; 2004b). The portion of the estimated 1.5 billion cubic feet of sediment that poured into the Sacramento Valley filled river channels and increased flooding severity and peak flows (Gilbert 1917; Kelley 1989; Mount 1995; James 2004a; Hitchcock et al. 2005; William Lettis & Associates 2005; James 2006; Central Valley Regional Water Quality Control Board 2008; James and Singer 2008; James et al. 2009). In the 1900s, another pulse of mining sediment was discharged into the Sacramento River watershed (James 1999). While it is often assumed the mining sediment has already passed through the Delta or is stored behind dams, large amounts remain within the system (James 1999, 2004a, 2004b, 2006; James and Singer 2008; James et al. 2009). Other Central Valley streams, such as the Cosumnes River, have been affected to a lesser extent by similar mining or agriculture-derived sources of sediment (Florsheim and Mount 2003). Historically, the initial pulse of sediment made its way into the San Francisco Estuary where it filled shallow tidal bays. However, with current reduced sediment loads into the estuary, the remaining sediments in the estuary are being eroded and transported into the Pacific Ocean (Cappiella et al. 1999; Ganju and Schoellhamer 2010).

Soils in the Delta are extremely variable in texture and chemical composition. In the interior of the Delta, soils are generally a combination of peat beds in the center of islands with relatively coarse textured inorganic sediments deposited in the channels and along the margins of the islands (William Lettis & Associates 2005; Unruh and Hitchcock 2009; Deverel and Leighton 2010). Ancient dune deposits on the islands and shoreline of the western Delta near the San Joaquin River predate the peat beds (Carpenter and Cosby 1939; San Francisco Estuary Institute 2010). The soils in the Suisun Marsh area are generally peat or fine textured mineral soils in and along the islands closest to Suisun Bay, and fine textured mineral soils are found closer to the border of the marsh where it abuts the uplands. The soils of the Cache Slough area are primarily mineral soils that are either fine-textured and of local origin, or coarse-textured material that is a legacy of gold mining in the Sierra Nevada and streams leading from the Sierra Nevada. The uplands north of Suisun Marsh and west of the Sacramento River are generally alkaline clays (Mann et al. 1911; Bryan 1923; Thomasson Jr. et al. 1960; Graymer et al. 2002). The soils of the Yolo Basin are alkaline clays on the west side, a mixture of clay, sand, and peat on the bottom of the basin, and silts with sand splays on the natural levee of the Sacramento River (Anonymous 1870; Mann et al. 1911; Andrews 1972). The soils along the southwestern border of the Delta are sands to the north and alkaline clays to the south (Carpenter and Cosby 1939; Natural Resources Conservation Service 2009; San Francisco Estuary Institute 2010). Along the eastern border of the Delta, the soils are heterogeneous patches of clays, loams, and peat (Florsheim and Mount 2003; Natural Resources Conservation Service 2009).

It is estimated that prior to reclamation actions (filling, levee construction, diking, and draining), nearly 60% of the Delta was inundated by daily tides. The tidal portion of the Delta consisted of backwater areas, tidal sloughs, and a network of channels that supported highly productive freshwater tidal marsh and other wetland habitats (Whipple et al. 2012). Similar complex drainage networks, ponds, and salt panes existed in tidal brackish marshes in Suisun Marsh and along the north shore of east Contra Costa County (Brown 2004; Whipple et al. 2012; San Francisco Estuary Institute 2010). The soils in these marshes were generally peat beds that accumulated and were preserved under anoxic conditions. In contrast, soils in channels and along the higher-energy channel margins of islands tend to be composed primarily of mineral sediment (William Lettis & Associates 2005; Unruh and Hitchcock 2009).

Reclamation occurred over vast areas in the Delta, Yolo Basin, Suisun Marsh, and the south shore of Suisun Bay between the 1850s and the early 1930s, completely transforming their physical structure (Thompson 1957, 1965; Suisun Ecological Workgroup 2001; Brown 2004; Whipple et al. 2012; San Francisco Estuary Institute 2010). Levee ditches were built to drain land for agriculture, human habitation, mosquito control, and other human uses while channels were straightened, widened, and dredged to improve shipping access to the Central Valley and to improve downstream water conveyance for flood management. During this period, over 300,000 acres of tidal marshes in the Delta were diked, drained, and converted to agriculture (Atwater et at. 1979). Thus, the complex, shallow, and dendritic marshlands were replaced by simplified, deep, and barren channels. This hydrogeomorphic modification fragmented aquatic and terrestrial habitats, and decreased the value and quantity of available estuarine habitat (Herbold and Vendlinski 2012; Whipple et al. 2012).

Floodplain includes areas that are inundated by overbank flow during the winter and spring peak flows. Inundation can last for up to several months. In presettlement times, floodplain was arguably one of the most productive natural communities in the Delta, and its loss can be linked to the decline of many native Delta species. Reclamation, channel modification for flood control, and water removals for agriculture and export have resulted in a substantial reduction in floodplain areas. Floodplains provide important habitat for rearing, migrating, and adult fish; migratory waterfowl; and amphibians, reptiles, and mammals native to the Delta.

Under natural conditions, inflows from both the Sacramento and San Joaquin Rivers to the Delta were much lower from July through November compared to the December to June period (The Bay Institute 1998), and in drought periods likely led to salinity intrusions. This difference was more dramatic in the San Joaquin River. The San Joaquin River has an upper watershed consisting of impermeable granitic rock that does not support dry season groundwater discharge. In contrast, the upper watershed of the Sacramento River is composed of permeable volcanic rock. As a result, groundwater discharge from this volcanic system historically maintained a summer base flow at Red Bluff of approximately 4,000 cfs, without which the Sacramento River would have nearly dried up each fall (The Bay Institute 1998).

Water diversions in the San Joaquin Valley began earlier than those in the Sacramento Valley, and by 1870, flows of the San Joaquin River were significantly reduced (California Department of Water Resources 1931; Jackson and Patterson 1977). Sacramento River diversions, particularly late spring and summer diversions for rice irrigation, increased dramatically from 1912 to 1929. The combination of significant drought periods and increased diversion during the annual low-flow period resulted in an unprecedented salinity intrusion into the Delta in fall 1918 (California Department of Water Resources 1931; Jackson and Patterson 1977; The Bay Institute 1998; Contra Costa Water District 2010). The economic impacts of these diversion-caused saltwater intrusions ultimately led to the creation of the Central Valley Project (CVP) and the construction of dams for the storage and release of fresh water to prevent salinity intrusion (Jackson and Patterson 1977). Between the 1930s and 1960s, construction of dams and diversions on all major rivers contributing to the Delta resulted in substantial changes to Delta hydrodynamics (The Bay Institute 1998; Contra Costa Water District 2010). Four dams (Shasta, Oroville, Trinity, and Monticello) in the Sacramento Valley have individual storage capacities greater than 1 million acre-feet (af) (12 million af total); an additional four dams (New Melones, Don Pedro, New Exchequer, and Pine Flat) with storage capacities greater than 1 million af (6.5 million af total) drain into the San Joaquin Valley (California Department of Water Resources 1993).

The main effect of this upstream water development was the dampening of the seasonal high flows during the winter and spring and low flows during the fall into the Delta (Contra Costa Water District 2010). Reclamation of the Delta and upstream water development also accentuated salinity intrusions into the Delta. Current water management regulations have reduced the annual fluctuations in saltwater intrusion but have also shifted the boundary between fresh and salt water farther into the Delta (Contra Costa Water District 2010). Reclamation, dam construction, flood management, and water projects have greatly transformed the geometry and hydrology of the Delta, as well as downstream locations including Suisun Bay and Suisun Marsh (California Department of Water Resources 2013a).

4.3.2 Physical Environment

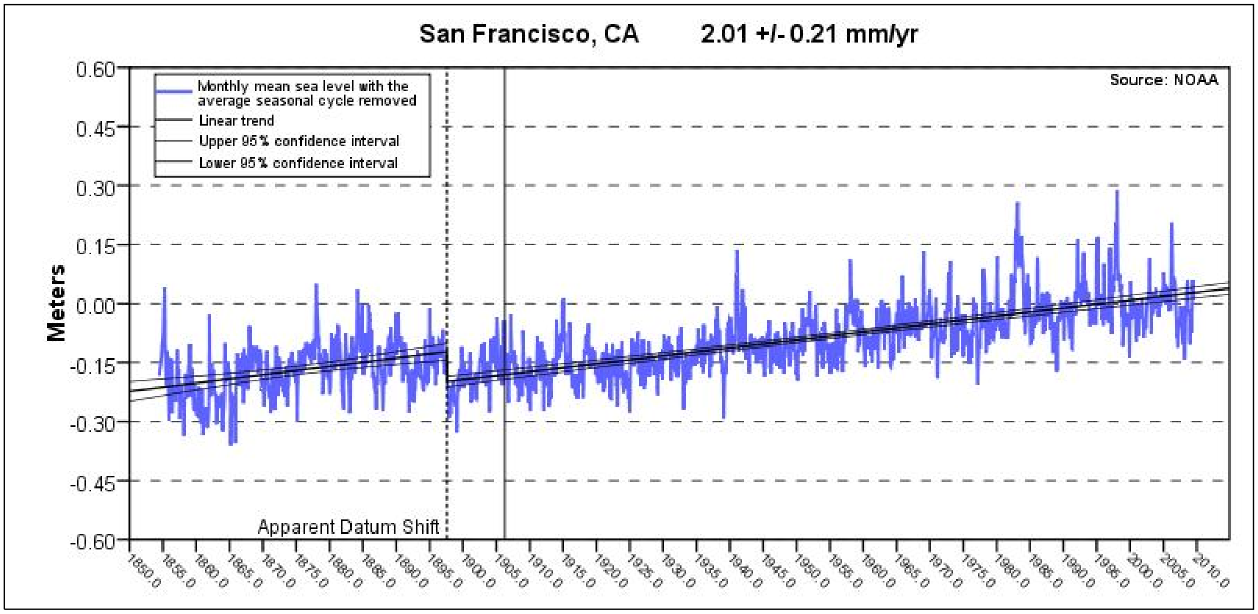
4.3.2.1 Climate Conditions

The climate in the Sacramento–San Joaquin Delta region is spatially variable, but is generally characterized as hot Mediterranean (Köppen climate classification) (Kottek et al. 2006). The general climate becomes milder from east to west due to marine influence as it is affected by winds off the Pacific Ocean.

Summers are hot with average summer highs in the upper 80 degrees Fahrenheit (°F) to lower 90°F, with little to no precipitation and low humidity. Heat waves are common in summer months, during which temperatures can reach triple digits for consecutive days. Periodically, a “Delta breeze” of cool and humid air from the ocean moves onshore and cools the Central Valley in the vicinity of the Delta by up to 7°F (3.9 degrees Celsius [°C]) (Pierce and Gaushell 2005). Winters are mild (average daily highs during November through March are in the mid-50 to mid-60°F) and wet. Approximately 80% of annual precipitation occurs from November to March. The primary origin of precipitation is the seasonal arrival of low-pressure systems from the Pacific Ocean. Very dense ground fog (tule fog) is common between periods of precipitation in the Delta from November through March.

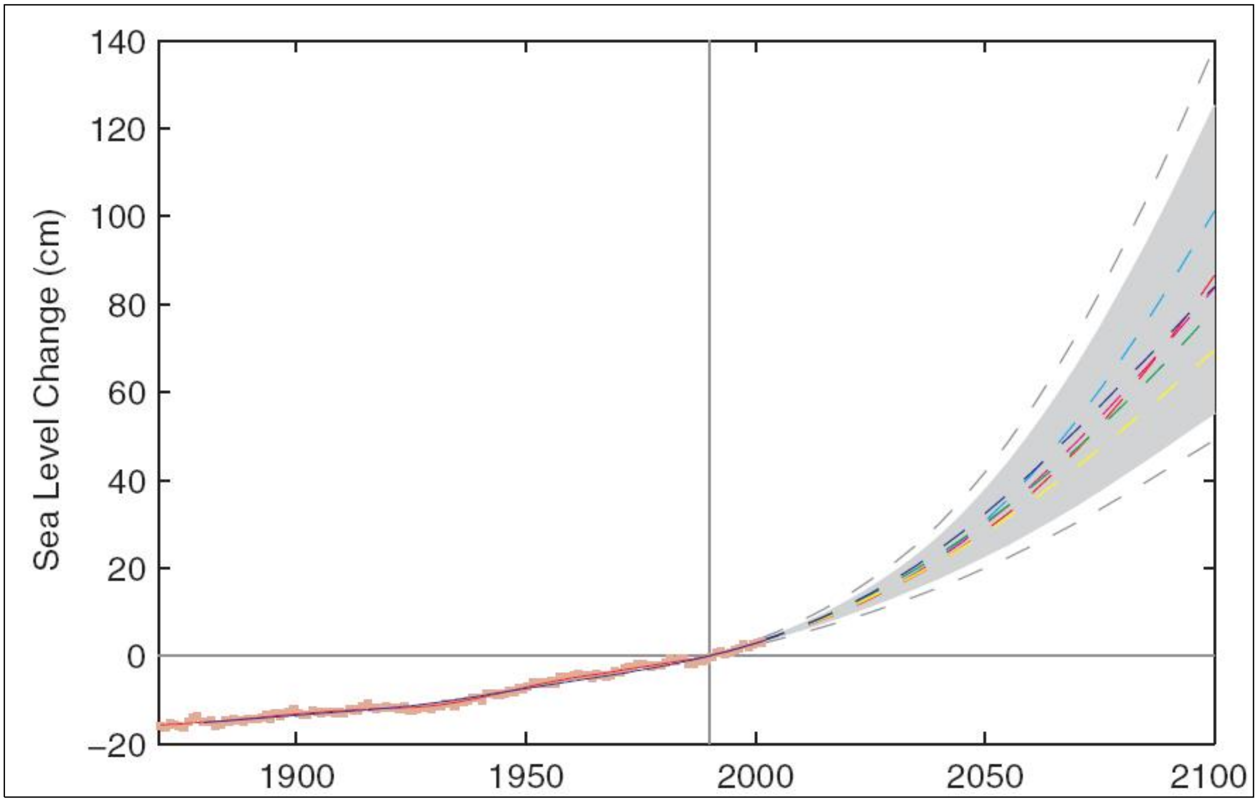
The climate of the Delta is predicted to change in complex ways. Although there is high uncertainty, temperatures in the Delta are projected to increase at an accelerating pace from 3.6 to 9°F (2 to 5°C) by the end of the century (Cayan et al. 2009). Depending upon the general-circulation model used, there are variable predictions for precipitation change, with most models simulating a slight decrease in average precipitation (Dettinger 2005; California Climate Change Center 2006). The Mediterranean seasonal precipitation experienced in the Delta is expected to continue, with most precipitation falling during the winter season and originating from North Pacific storms. Although the amount of precipitation is not expected to change dramatically over the next century, seasonal and interannual variation in precipitation will likely increase as it has over the past century (California Department of Water Resources 2006). This could lead to more intense winter flooding, greater erosion of riparian habitats, and increased sedimentation in wetland habitats (Field et al. 1999; Hayhoe et al. 2004).

Rahmstorf (2007) used a semi-empirical approach to project future sea level rise, yielding a projected sea level rise of 1.6 to 4.6 feet above 1990 levels by 2100 when applying the Third Assessment Report warming scenarios. Other recent estimates indicate global increases by 2100 of 1.6 to 3.3 feet (National Research Council 2010); 2.6 to 6.6 feet (Pfeffer et al. 2008); and 3.2 to 5.1 feet (Vermeer and Rahmstorf 2009) (Figure 4-3 and Figure 4-4).



Source: National Oceanic and Atmospheric Administration 2009

Figure 4-3. Observed Mean Sea Level Trend for the San Francisco Tide Gage near the Golden Gate



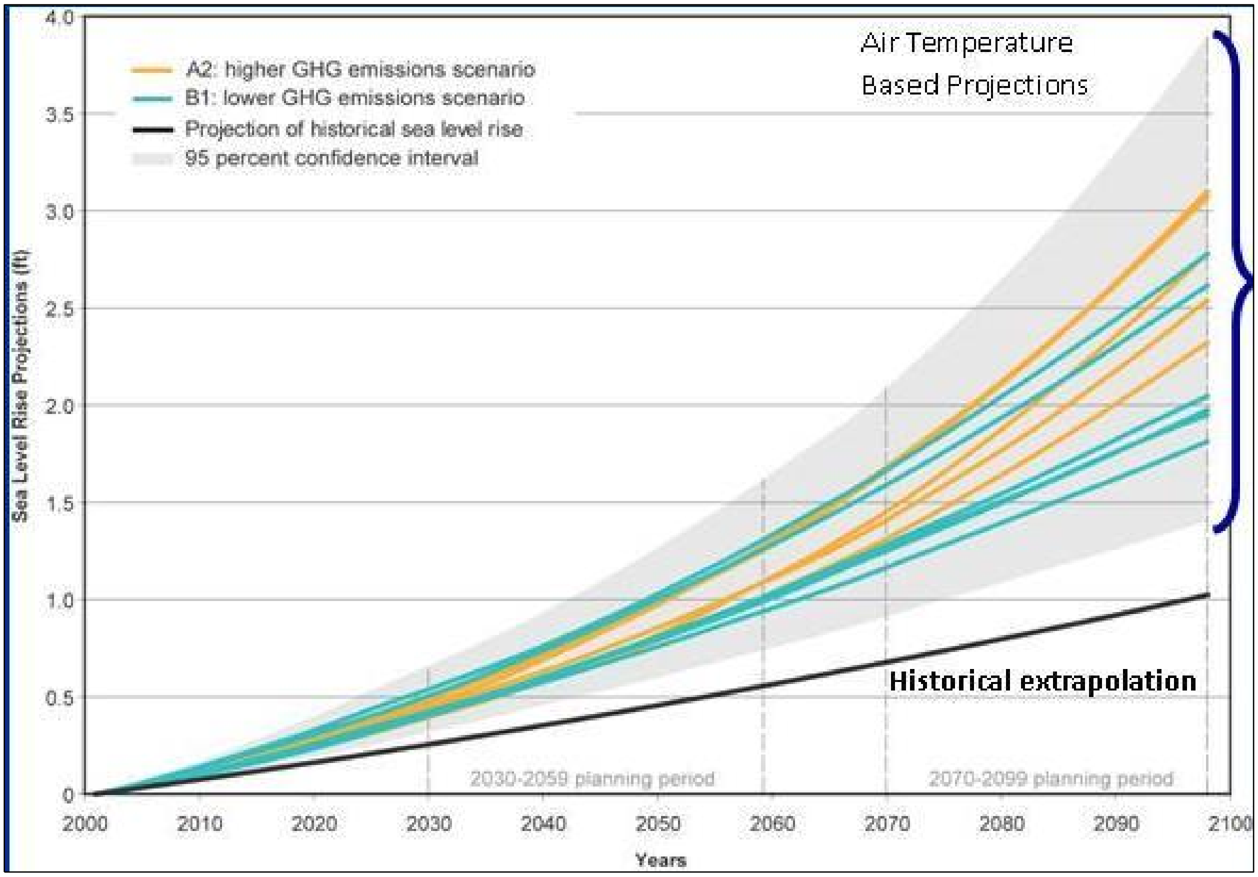
Source: Rahmstorf 2007

Figure 4-4. Past Global Mean Sea Level and Future Mean Sea Level Based on Global Mean Temperature Projections

Using the Rahmstorf (2007) method, the CALFED Bay-Delta Program (CALFED) Independent Science Board estimated ranges of sea level rise of 2.3 to 3.3 feet at midcentury and of 1.6 to 4.6 feet by the end of the century (CALFED Independent Science Board 2007). Some tidal gage and satellite data indicate that rates of sea level rise are increasing (Church and White 2006; Beckley et al. 2007). Scenarios modeled by the California Climate Action Team projected sea level rise increases along the California coast of 1.0 to 1.5 feet above 2000 levels by 2050 and 1.8 to 4.6 feet by 2100 (Cayan et al. 2009). However, if California's sea level continues to mirror global trends, increases in sea level during this century could be considerably greater. Increasing sea levels will seriously threaten the integrity of the Delta's levees and conveyance of water supplies through the Delta (Florsheim and Dettinger 2007).

For water planning purposes, the California Department of Water Resources (DWR) estimated sea level rise over the 21st century using the method of Rahmstorf (2007) and 12 climate projections selected by the California Climate Action Team (Chung et al. 2009). The historical 95% confidence interval was extrapolated to estimate the uncertainties in the future projections (Figure 4-5). Midcentury sea level rise projections ranged from 0.8 to 1.0 foot, with an uncertainty range spanning 0.5 to 1.2 feet. End-of-century projections ranged from 1.8 to 3.1 feet, with an uncertainty range of 1.0 to 3.9 feet. These estimates are slightly lower than those of Rahmstorf (2007) because DWR used a more limited ensemble of climate projections that did not include the highest projections of temperature increases (Chung et al. 2009).

Parker et al. (2011) observed that, in the Bay-Delta, other factors complicate sea level rise projections, including the Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation (ENSO) events. The PDO is characterized by cool or warm phase shifts in North Pacific sea surface temperatures that commonly persist for 20 to 30 years. Superimposed on the PDO cycles are smaller-scaled El Niño and La Niña events that persist for about a year. Climatic impacts associated with La Niña events are similar to those tied to the cool PDO phases, and climate conditions related to El Niño episodes parallel those of warm PDO phases. Parker et al. (2011) observed that rates of sea level rise slow during the negative (cool) phase and increase during the positive (warm) phase. They also noted that fluctuations in sea level rise, when combined with processes such as ENSO events, may have a greater effect on wetlands than a steady increase.



Source: Chung et al. 2009.

Figure 4-5. DWR-Generated Future Sea Level Rise Projections for the Bay Delta Using the Rahmstorf Method and Regionally Downscaled Data

Increasing sea level rise will increase saltwater intrusion into the Sacramento–San Joaquin River Delta (Delta), disrupting marsh and estuary ecosystems and reducing freshwater and terrestrial plant species habitat. Increased salinity also may increase mortality for species that are sensitive to salinity concentrations. Changes in salinity levels may place added stress on other species, reducing their ability to respond to disturbances. Increased frequency and severity of flood events combined with sea level rise can relocate species and damage or destroy species habitat. Lower ecosystem productivity from increased salinity will affect both phytoplankton-based and detritus-based foodwebs (Parker et al. 2011).

Sea level rise is predicted to be an especially significant factor in in the legal delta within the action area, where much of the land has subsided to below sea level and is protected from flooding by levees. In the Delta, sea level rise in combination with ongoing subsidence of Delta islands will increase the instability of the Delta's levee network, increasing the potential for island flooding and sudden landscape change in the Delta over the next 50 years (Mount and Twiss 2005). The current subsided island condition, combined with higher sea level, increased winter river flooding, and more intense winter storms, will significantly increase the hydraulic forces on the levees. With sea level rise exacerbating current conditions, a powerful earthquake in the region could collapse levees, leading to major seawater intrusion and flooding throughout the reclaimed lands of the Delta, altering the tidal prism, and causing substantial changes to the tidal perennial aquatic natural community (Mount and Twiss 2005; Florsheim and Dettinger 2007).

Predicted warmer temperatures will affect the rate of snow accumulation and melting in the snowpack of the Sierra Nevada. Some projections predict reductions in the Sierra Nevada spring snowpack of as much as 70 to 90% by the end of the century (California Climate Change Center 2006). Knowles and Cayan (2002) estimated that a projected warming of 3°F (1.6°C) by 2060 would cause the loss of one-third of the watershed's total April snowpack, whereas a 4°F (2.1°C) warming by 2090 would reduce April snowpack by 50%. Recent literature indicates a general decline in the April 1 snow water equivalent for the Pacific Northwest and northern Sierra locations, and increases in parts of the southern Sierra (Mote et al. 2008, Pederson et al 2011, Pierce et al. 2008). Measurements taken to track the water content of snow (snow water equivalent) since 1930 show that peak snow mass in the Sierra Nevada has been occurring earlier in the year by 0.6 day per decade (Kapnick and Hall 2009). These predicted changes in the dynamics of the snowpack will influence the timing, duration, and magnitude of inflow from the Sacramento and San Joaquin River watersheds. For example, with more precipitation falling as rain instead of snow and the snowpack melting earlier, greater peak flows will result during the rainy season and lower flows during the dry season. Knowles and Cayan (2004) predict that inflows will increase by 20% from October through February and decrease by 20% from March through September, compared to current conditions. Storm surges (tidal and wind-driven) associated with the more intense storms predicted for the future will also exacerbate Delta flooding. On April 1, 2015, DWR found no snow at the Phillips snow course during its early-April measurements. This was the first time in 75 years that no snow was found there. Readings found that the statewide snowpack held only 5% of the historical average of water content for April 1 (California Department of Water Resources 2015).

4.3.2.2 Hydrologic Conditions

The hydrology of the Delta is primarily influenced by tides, Delta inflow and outflow, diversion, and Delta Channel configuration (California Department of Water Resources 1999). Delta inflows are governed by several existing regulations including the current NMFS biological opinion (BiOp) (2009) for long-term coordinated operations of the CVP/SWP. The effects of these operations on fish are described in the species accounts included in Section 4.5, *Status of the Species/Environmental Baseline Summary*, and in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*. The Delta receives runoff from a watershed that includes more than 40% of the state's land area including the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras River tributaries.

4.3.2.2.1 River Hydrology

Multiple upstream tributaries to the Sacramento and San Joaquin Rivers influence flow into the Delta. The Feather and American Rivers and many large creeks drain directly into the Sacramento River, while the Cache and Putah Creeks drain into the Yolo Bypass, which joins the Sacramento River in the Cache Slough area. The Yuba and Bear Rivers drain into the Feather River before its confluence with the Sacramento River. The Calaveras, Stanislaus, Tuolumne, Merced, and Kings Rivers drain into the San Joaquin River upstream of the Delta. Eastside streams, particularly the Mokelumne River, also contribute inflows to the Delta. The Cosumnes River drains directly into the Mokelumne River, and both drain into the San Joaquin River after entering the Delta. In addition to the Sacramento and San Joaquin Deltas, the Mokelumne Delta in some ways can be viewed as a third important river delta.

Regardless of water year type[1], the large majority of unimpaired upstream flow into the Delta originates from the Sacramento River and its tributaries, and a lesser extent originates from the San Joaquin River and its tributaries. The Cosumnes and Mokelumne Rivers and other smaller tributaries, collectively called the eastside tributaries, contribute only a small percentage of inflows.

Numerous upstream dams and diversions greatly influence the timing and volume of water flowing into the Delta from rivers and tributaries. These values vary by water-year type and the inflows associated with the water year. For example, in the 2000 water year, an above-normal water year, 69% of water entering the Delta passed through the system as outflow, 6% was consumed within the Delta, less than 1% was diverted via the North Bay Aqueduct and by Contra Costa Water District (CCWD), and 24% was exported via CVP/SWP facilities. Additional water was withdrawn upstream of the Delta via upstream diversions and reservoirs, accounting for an additional 7,525 thousand af (California Department of Water Resources 2008). For comparison, in the 2001 water year, a dry year, approximately 51% of water entering the Delta passed through the system as outflow, 12% was consumed within the Delta, and 37% was exported via CVP/SWP facilities. Kimmerer (2002) shows that the proportion of inflow exported by the CVP/SWP decreases as inflow increases. As inflow decreases, the relationship between inflow and outflow strengthens because CVP/SWP exports can capture a larger proportion of the inflow (Kimmerer 2002a). Much of the precipitation that contributes to Delta inflow originates from the Sacramento River and its tributaries (85% median contribution), with smaller contributions from the San Joaquin River and its tributaries (11% median contribution) (Kimmerer 2002a).

The hydrograph of the Delta is highly variable both within and across years. Within years, water flow is generally greatest in winter and spring with inputs of wet season precipitation and snowpack melt from the Sierra Nevada and lowest during fall and early winter before significant rainfall. The construction of upstream dams and reservoirs for flood protection and water supply has dampened the seasonal variation in flow rates. Water is released from reservoirs year-round, and flooding is much less common than it was before dam and levee construction. As a result, the frequency of small- to moderate-sized floods has been significantly reduced since major dam

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[1] Water-year type is determined using the Water Supply Index at <http://cdec.water.ca.gov/cgi-progs/iodir/WSI.2015>

construction, although the magnitude and frequency of large floods has not been significantly altered. Additionally, because of climatic changes, there have been more large floods in the last 50 years than the 50 years before then. Across years, extended wet and dry periods (defined as periods during which unimpaired runoff was above or below average, respectively, for 3 or more years) occurred numerous times in the last 100 years, and the duration and magnitude of extended wet and dry periods have increased in the last 30 years. This includes the 6-year drought of 1987 to 1992 and the prolonged periods of wetness in the early- to mid-1980s and middle-to-late 1990s (California Department of Water Resources 2007). As of 2015, California is currently in its fourth consecutive year of below-average rainfall and very low snowpack. The wet and dry periods recorded over the last 150 years, however, are less severe and shorter than the prolonged wet and dry periods of the previous 1,000 years.

The Yolo Bypass is an important physical feature affecting river hydrology during high-flow events in the Sacramento River watershed. The bypass is a 59,280-acre engineered floodplain that conveys flood flows from the Sacramento River, Feather River, American River, Sutter Bypass, and western tributaries and drains (Harrell and Sommer 2003). The leveed bypass protects Sacramento and other nearby communities from flooding during high-water events and can convey up to 80% of flow from the Sacramento basin during flood events (Sommer et al. 2001a). Most water enters the Yolo Bypass by spilling over the Fremont and Sacramento weirs and returns to the Sacramento River in the Delta approximately 5 miles upstream of Rio Vista. The Yolo Bypass floods seasonally in approximately 60% of years (Sommer et al. 2001b).

4.3.2.2.2 Tides

The Delta, lower portion of the Yolo Bypass, and Suisun Marsh are tidally influenced by the Pacific Ocean, although tidal range and influence decrease with increasing distance from the San Francisco Bay (Kimmerer 2004). Tides are mixed semidiurnal with two highs and two lows each day (i.e., one larger magnitude high and low and one lower magnitude high and low). A typical diurnal range is 3.3 to 4.6 feet (1 to 1.4 meters) in the western Delta (Orr et al. 2003). The entire tidal cycle is superimposed upon the larger 28-day lunar cycle with more extreme highs and lows during spring tides and depressed highs and lows during the neap tides. In addition, annual tidal elevations are highest in February and August. The multiple temporal scales at which these cycles occur causes significant variation in draining and filling of the Delta, and therefore, in patterns of mixing of the waters (Kimmerer 2004). Additionally, variation in mean sea level can also be caused by changes in atmospheric pressure and winds (Department of Water Resources 2013b).

4.3.2.2.3 Water Supply Facilities and Facility Operations

Over 3,000 diversions remove water from upstream and in-Delta waterways for agricultural, municipal, and industrial uses; 722 of these are located in the mainstem San Joaquin and Sacramento Rivers and 2,209 diversions are in the Delta (Herren and Kawasaki 2001). The CVP, managed by the Bureau of Reclamation (Reclamation), and SWP, managed by DWR, use the Sacramento and San Joaquin Rivers and other Delta channels to transport water from river flows and reservoir storage to two water export facilities in the south Delta (Figure 4-6). The C. W. “Bill” Jones Pumping Plant (herein referred to as the Jones Pumping Plant) is operated by the CVP and the Harvey O. Banks Delta Pumping Plant (herein referred to as the Banks Pumping Plant) is operated by the SWP. Water from these facilities is exported for urban and agricultural water supply demands throughout the San Joaquin Valley, Southern California, the Central

Coast, and the southern and eastern San Francisco Bay Area. The long-term operations of the CVP/SWP were included in the NMFS 2009 and USFWS 2008 BiOps, including Reasonable and Prudent Alternatives (RPA) to avoid jeopardy to listed fish species and adverse modification to their habitats. The effects of these operations are described in more detail in the applicable species accounts provided in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*.

Water enters the Banks Pumping Plant via the Clifton Court Forebay. Large radial arm gates control inflows to Clifton Court Forebay during the tidal cycle to reduce approach velocities, prevent scouring of adjacent channels, and allow water to enter the Clifton Court Forebay at times other than low tide, which reduces water level fluctuation in the south Delta (U.S. Fish and Wildlife Service 2005). The Banks Pumping Plant operates to move water from Clifton Court Forebay into the 440-mile (708-kilometer) California Aqueduct. Water in the California Aqueduct travels to O'Neill Forebay, where a portion of the water is diverted to the joint-use CVP/SWP San Luis Reservoir for storage. The remaining water flows southward via the joint-use San Luis Canal, and to the South Bay Pumping Plant and South Bay Aqueduct.

The Jones Pumping Plant pumps water from Old River in the Delta into the Delta-Mendota Canal. The Jones Pumping Plant facility does not have an associated forebay. The Delta-Mendota Canal sends water southward, providing irrigation water along the way, towards the O'Neill Forebay where a portion of the water is diverted into the San Luis Reservoir. The remaining water continues in the Delta-Mendota Canal, again providing water for irrigation and refuges, as well as municipal and industrial uses, until it reaches the Mendota Pool, where water is returned to the San Joaquin River to replenish downstream flows.

The Delta Cross Channel (DCC) is operated by Reclamation. The DCC is opened to augment through-Delta flows from the Sacramento River towards the pumping facilities in the south Delta and/or to improve water quality in the central and south Delta (Figure 4-6). Two large radial gates on the Delta Cross Channel can open or close to control flows into the central Delta. When the DCC is opened, water is diverted from the Sacramento River into Snodgrass Slough and southward through the forks of the Mokelumne River. Opening the DCC increases flows, but also increases the likelihood of Sacramento Basin juvenile salmonids being entrained towards the Central Delta (Perry et al. 2012). Opening the DCC may also lead to increased straying of adult Mokelumne River Hatchery Chinook salmon, though this topic is still under investigation. During winter and spring, the DCC is often closed to keep migrating juvenile salmonids within the Sacramento River and away from the Central Delta. The DCC is also closed during flood events to reduce scour and protect downstream levees.

The Barker Slough Pumping Plant is operated by the SWP and draws water from Barker Slough into the North Bay Aqueduct (Figure 4-6). The intake is located just upstream of where Barker Slough empties into Lindsey Slough, which is approximately 10 miles (16 kilometers) from the mainstem Sacramento River. The North Bay Aqueduct is operated by DWR as part of the SWP and delivers wholesale water to the Solano County Water Agency and the Napa County Flood Control and Water Conservation District. The 27.6-mile North Bay Aqueduct extends from Barker Slough to the end of the Napa Turnout Reservoir.

The South Delta Temporary Barriers project consists of the installation of four rock barriers each spring in south Delta channels: the head of Old River, Old River at Tracy, Grant Line Canal, and

Middle River. The head of Old River barrier is also installed during the fall for dissolved oxygen reasons. The head of Old River barrier is considered a fish barrier because it is installed to keep migrating juvenile Chinook salmon in the San Joaquin River. The other three barriers are agricultural barriers, meaning they are installed to maintain water quality and water levels for agricultural uses in the south Delta. The head of Old River barrier was not installed in spring 2009 or 2010 because the U.S. Fish and Wildlife Service (USFWS) BiOp (U.S. Fish and Wildlife Service 2008) prohibited the installation of the barrier for the protection of Delta Smelt. The rock barriers are not installed in years when San Joaquin River flows are high, such as during 1998.

The CCWD diverts water from the Delta to the Contra Costa Canal and the Los Vaqueros Reservoir using four intake locations: Rock Slough, Old River, Mallard Slough, and Middle River (on Victoria Canal) (Figure 4-6). The Contra Costa Canal and its pumping plants have a capacity of 350 cfs and were built by Reclamation from 1937 to 1948 as part of the CVP. The Contra Costa Canal is owned by Reclamation but operated and maintained by CCWD. The screened Old River Pump Station (250 cfs capacity) was built in 1997 as part of the Los Vaqueros Project to improve water quality for CCWD. The Old River Pump Station connects via pipelines to a transfer pump station (200 cfs) used to pump water into Los Vaqueros Reservoir (160,000 af capacity) and from the transfer station via gravity pipeline to the Contra Costa Canal. The screened Mallard Slough Intake and Pump Station (39 cfs capacity) were constructed in the 1920s and rebuilt to make it seismically protected in 2001. It is used primarily in winter and spring during wet periods when water quality is sufficiently high. The screened Middle River Intake and Pump --Station (250 cfs capacity) were completed in 2010 to provide additional operational flexibility and improved water quality. The Middle River Intake connects to the Old River Pump Station via a pipe that crosses Victoria Island and tunnels underneath Old River. The Middle River Intake is used primarily in late summer and fall to provide better water quality than is obtainable from the other three intakes.

The effects of the operations of these Delta CVP/SWP facilities on listed species have been evaluated as part of the current BiOps for the CVP/SWP Long-term Operations (U.S. Fish and Wildlife Service 2008; National Marine Fisheries Service 2009). They form part of the baseline described in Section 4.5, *Status of the Species/Environmental Baseline Summary*, and in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*.

East Contra Costa Irrigation District provides water supplies to the city of Brentwood, portions of Antioch and Oakley, the unincorporated community of Knightsen, and surrounding unincorporated rural areas. The East Contra Costa Irrigation District operates a diversion located at Indian Slough on Old River in combination with canals and pumping stations for distribution within the service area. The primary purpose of the diversion is to provide raw water for irrigation of cultivated lands, landscape, and recreational uses (e.g., golf courses). The district has agreements with CCWD and City of Brentwood to make surplus water available for municipal use.

The City of Antioch, located in eastern Contra Costa County, supplies water through diversions directly from the San Joaquin River, raw water purchased from CCWD that is delivered through the Contra Costa Canal, and treated water delivered through CCWD's Multi-Purpose Pipeline. Antioch receives approximately 85% of its water supplies from CCWD. The majority of the water is provided for municipal and residential use, with industrial (11%) and agricultural (13%) uses in the service area.

Byron-Bethany Irrigation District provides water for agricultural, industrial, and municipal uses to portions of Alameda, Contra Costa, and San Joaquin Counties (Byron-Bethany Irrigation District 2005 The district maintains two water diversions from the Delta under a pre-1914 appropriative water right and a riparian water right on Old River. Water diversions occur from the SWP intake channel, located between the Skinner Fish Protection Facility and the Banks Pumping Plant. Two diversions serve the Byron Division and the Bethany Division. The District also operates a series of pumping stations and canals for water distribution.

East Bay Municipal Utility District's Mokelumne Aqueduct traverses the Delta, carrying water from Pardee Reservoir on the Mokelumne River to the East Bay (Figure 4-6). East Bay Municipal Utility District, in partnership with Sacramento County, constructed a major new diversion from the Sacramento River at Freeport. This new diversion, sized at 185 million gallons per day capacity, feeds into the Mokelumne Aqueduct and the Vineyard Surface Water Treatment Plant for central Sacramento County use.

There are over 2,200 water diversions in the Delta, most of which are unscreened and are used for in-Delta agriculture irrigation (Herren and Kawasaki 2001). Industrial diversions in the Delta include the Mirant Power plants at Pittsburg and Antioch. Water from these diversions cools generators producing electric power at the plants.

Suisun Bay and Suisun Marsh are important ecosystems connected to the Delta, and habitat conditions and facility operations in Suisun Bay and Marsh can affect ecosystem conditions in the Delta. A system of levees, canals, gates, and culverts in Suisun Marsh was constructed in 1979–80 and is currently operated by DWR to lower salinity in privately managed wetlands in Suisun Marsh. The Suisun Marsh Salinity Control Gates are composed primarily of a set of radial gates that extend across the entire width of Montezuma Slough. The control gates are used to reduce salinity from Collinsville through Montezuma Slough and into the eastern and central parts of Suisun Marsh, and to reduce intrusion of saltwater from downstream into the western part of Suisun Marsh. In addition to radial gates, the Suisun Marsh Salinity Control Gates consist of permanent barriers adjacent to the levee on either side of the channel, flashboards, and a boat lock. The gates have been operated historically from September to May and open and close twice a day during full operation to take advantage of tidal flows. The gates are opened during ebb tides to allow fresh water from the Sacramento River to flow into Montezuma Slough and are closed during flood tides to prevent higher-salinity water from downstream from entering Montezuma Slough. Gate operations have been curtailed in recent years to allow for salmon passage while still meeting the salinity requirements outlined within State Water Resources Control Board Decision-1641 (D-1641).

4.3.2.3 Non-Water Supply Delta Infrastructure and Uses

The Delta supports a substantial amount of infrastructure related to urban development, transportation, agriculture, recreation, energy, and other uses. Portions of six counties are included in the legal Delta: Yolo, Sacramento, Solano, Contra Costa, Alameda, and San Joaquin (California Department of Water Resources 2006).

The major land use for the Delta is agriculture, which represents approximately two-thirds of all surface area. There is increasing residential, commercial, and industrial land use in the Delta, most of which occurs around the periphery of the Delta. Major urban developments within the cities of Sacramento, West Sacramento, Stockton, Tracy, Antioch, Brentwood, and Pittsburg are in the Delta. Small towns located wholly within the Delta are Clarksburg, Hood, Walnut Grove, Isleton, Collinsville, Courtland, Locke, Ryde, Bethel Island, and Discovery Bay. Much of the development occurs in the secondary zone of the Delta.

Several interstate highways (Interstates [I-] 5, 80, 205/580, and 680) and one state highway (State Route [SR] 99) are on the periphery of the Delta, and three state highways (SR 4, SR 12, and SR 160) and multiple county roads cut across the Delta. Three major railways cross through the Delta. The Delta contains a network of electrical transmission lines (over 500 miles [805 kilometers]) and gas pipelines (over 100 lines). Natural gas extraction and storage is another important Delta use. In addition to approximately 95 public and private marinas (Lund et al. 2007), two major ports (Stockton and Sacramento) and their associated maintained ship channels are in the Delta. These ports can handle high tonnage (55,000-ton class) ships to move cargo to and from the Pacific Ocean. Much of the Delta, including 635 miles (1,022 kilometers) of boating waterways, is used for a variety of recreational purposes including water sports, fishing, hunting, and wildlife viewing (Lund et al. 2007). The effects of this infrastructure on species are described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, as applicable.

4.3.3 Reasonable and Prudent Alternative Actions under Existing Biological Opinions to Avoid Jeopardy and Adverse Modification of Critical Habitat

The coordinated long-term operations of the CVP/SWP are currently subject to the RPAs of BiOps issued by USFWS (2008) and NMFS (2009) pursuant to Section 7 of the Endangered Species Act (ESA). Each of these BiOps was issued with RPAs to avoid the likelihood of jeopardizing the continued existence of listed species or of resulting in the destruction or adverse modification of critical habitat that were the subject of consultation in each BiOp.

USFWS BiOp RPA. The USFWS BiOp concluded that the long-term operations of the CVP/SWP were likely to jeopardize the continued existence of Delta Smelt and were likely to destroy or adversely modify their designated critical habitat. Therefore, the USFWS BiOp included an RPA with five components comprising three types of actions to avoid jeopardy to Delta Smelt: require a reduction in the magnitude of reverse Old and Middle River (OMR) flows to reduce smelt entrainment; implement a "Fall X2" standard requiring that X2[2] be located at no

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[2] X2 refers to the horizontal distance from the Golden Gate up the axis of the Delta estuary to where tidally averaged near-bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs; the X2 standard was established

greater than 46 and 50 miles (74 and 81 km) from Golden Gate in September, October, and November of wet and above normal years, respectively, to improve rearing conditions for Delta Smelt; and implement 8,000 acres of tidal restoration in Suisun Marsh and/or the north Delta to provide suitable habitat for Delta Smelt. The OMR and Fall X2 actions have been implemented, and a portion of the 8,000 acres of tidal restoration is currently in the planning and development stage. The USFWS BiOp requires that this restoration be completed within 10 years (i.e., 2018) and several non-federal agencies are involved in implementation, including DWR and the State and Federal Contractors Water Agency (SFCWA).

NMFS BiOp RPA. The NMFS BiOp concluded that the long-term operations of the CVP/SWP were likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, Southern distinct population segment (DPS) of North American green sturgeon, and Southern Resident DPS of killer whale. In addition, the NMFS BiOp concluded that the long-term operations of the CVP/SWP were likely to destroy or adversely modify designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead and proposed (subsequently designated) critical habitat for the Southern DPS of North American green sturgeon. Therefore, the NMFS BiOp included an RPA consisting of a suite of actions that addressed Delta and upstream conditions throughout the CVP/SWP to avoid jeopardy of these species and the destruction or adverse modification of critical habitat for these species. Many of the in-Delta activities are included in the PA (Table 3.1-1).

Several components of the NMFS BiOP RPA have been implemented or are in the planning stages. Examples include the Delta operational changes that have been implemented since 2009 that are intended to reduce entrainment loss of Chinook salmon and steelhead; current planning efforts for the restoration of the Yolo Bypass; changes in water operations to improve temperature conditions for aquatic resources in the Sacramento, American, and Stanislaus Rivers; adjustments to the operations of the Suisun Marsh Salinity Control Gates and the Delta Cross Channel Gates; investigation into the efficacy of non-physical barriers in the Delta to improve salmonid survival; upstream habitat improvement projects; and a host of monitoring activities, studies, and investigations to better understand the ongoing effects of CVP/SWP operations.

Many of the RPA actions are implemented in areas that are expected to be unaffected by the PA but they provide benefits to the species addressed in this biological assessment; thereby improving the viability of the species. These include actions such as operational (including flow ramping rates) and physical habitat restoration activities in the Upper Sacramento River, Clear Creek, American River, and Stanislaus River and a Battle Creek restoration project. Additionally, several actions in the RPA include climate change adaptation measures that are difficult to quantify or measure, but that when implemented, should substantially improve the resilience of these species to climate change and the ongoing effects of the CVP/SWP.

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to improve shallow water estuarine habitat in the months of February through June and relates to the extent of salinity movement into the Delta (Jassby et al. 1995).

4.3.4 Mitigation Measures Included in the 2009 State Water Project Longfin Smelt Incidental Take Permit

The 2009 SWP Longfin Smelt Incidental Take Permit (ITP) was issued by the California Department of Fish and Wildlife (CDFW) on February 23, 2009, subject to DWR's compliance with and implementation of Conditions of Approval. Several conditions have the potential to affect species addressed in this BA. Conditions include minimizing entrainment at SWP Banks Pumping Plant (Conditions 5.1 and 5.2), minimizing entrainment at Morrow Island Distribution System (MIDS) (in Suisun Marsh) (Condition 6.1), improving salvage efficiencies (Conditions 6.2 and 6.3), maintaining fish screens at North Bay Aqueduct (NBA), Roaring River Distribution System (RRDS), and Sherman Island diversions (Condition 6.4), fully mitigating through the restoration of 800 acres of inter-tidal and associated sub-tidal wetland habitat in a mesohaline part of the estuary (Conditions 7.1–7.3), and monitoring and reporting (Conditions 8.1-8.5). Conditions 5.1 and 5.2 are being implemented through DWR's participation in the smelt working group. Conditions 6.1 through 6.4 are currently being planned and implemented and are in various stages of completion. Conditions 7.1 through 7.3 are being planned consistent with the planning for restoration required for the USFWS BiOp (2008) RPA described above. Additionally, the various monitoring programs required in Conditions 8.1–8.5 are being planned or implemented consistent with the settlement agreement associated with the permit.

4.3.5 Recent Drought Activities

In 2014, California experienced its third year of drought conditions. This section describes some of the key activities that have occurred. Section 4.5, *Status of the Species/Environmental Baseline Summary*, below describes the species-specific effects caused by the drought and associated activities. Water year 2012 was categorized as below normal, calendar year 2013 was the driest year in recorded history for many parts of California, and water year 2014 began on a similar dry trend (State Water Resources Control Board 2014a). In May 2013, Governor Edmund G. Brown, Jr. issued Executive Order B-21-13, which directed the State Water Board and DWR to take immediate action to address dry conditions and water delivery limitations. The Department of Water Resources and the United States Bureau of Reclamation (collectively referred to as Petitioners) filed a Temporary Urgency Change Petition (TUCP) with the State Water Resources Control Board (State Water Board), Division of Water Rights on January 29, 2014, pursuant to California Water Code section 1435[3]. The TUCP was conditionally approved by the State Board on January 29, 2014 and modified on February 7, February 28, March 18, April 9, April 11, and April 18, 2014, to extend and change the conditions. On April 29, 2014, the Petitioners submitted a request to the State Water Board to modify and renew the TUCP Order pursuant to Water Code section 1441, which allows temporary change orders to be renewed for up to 180 additional days. On May 2, 2014, the State Water Board issued an Order approving the April 29, 2014 TUCP modification and renewal pursuant to Water Code section 1438(a), which allows the State Water Board to issue a temporary change order in advance of public noticing requirements. The May 2, 2014 Order: (1) extended a change to Delta outflow

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[3] A full chronology of the TUCP and all of its modifications and associated materials (e.g., biological reviews for endangered species compliance) is provided by SWRCB at http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/tucp/index.shtml.

requirements to May and July[4]; (2) changed the Western Delta electrical conductivity requirement by moving the compliance point from Emmaton to Threemile Slough during May through August 15; and (3) changed the Sacramento River at Rio Vista flow requirement from 3,000 cubic feet per second (cfs) to 2,000 cfs during September through November 15 (State Water Resources Control Board 2014b). The State Board received eight Petitions for Reconsideration of the January 31, 2014 TUCP and subsequent modifications. The State Water Board denied these petitions; however, changes to the TUCP were made to improve planning and coordination based upon these petitions (State Water Resources Control Board 2014a).

As of 2015, California is in its fourth consecutive year of below-average rainfall and very low snowpack. Water Year 2015 is also the eighth of nine 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 May 2015, 66% of the state was experiencing an Extreme Drought and 46% was experiencing an Exceptional Drought, as recorded by the National Drought Mitigation Center, U.S. Drought Monitor. Of particular concern is the state's critically low snow pack, which provides much of California's seasonal water storage. On April 1, 2015, DWR found no snow at the Phillips snow course for the first time in 75 years of early-April measurements (California Department of Water Resources 2015). The lack of precipitation over the last several years has also contributed to low reservoir storage levels in the Sacramento watershed. Lake Shasta on the Sacramento River, Oroville Reservoir on the Feather River, and Folsom Lake on the American River were at 55%, 46%, and 57% of capacity, respectively, on May 22, 2015 (64%, 55%, and 70% of average for February, respectively). Trinity Lake (water from the Trinity system is transferred to the Sacramento River system) on the Trinity River was at 36% of capacity and 48% of the February average. The San Joaquin River Watershed in particular has experienced severely dry conditions for the past three years as indicated by rainfall and snowpack (State Water Resources Control Board 2015).

As was done in 2013, California Governor Edmund G. Brown has issued a Drought Emergency Proclamation that is effective through May 31, 2016, and which directs the State Water Board to, among other things, consider petitions, such as the TUCPs to modify requirements for reservoir releases or diversion limitations that were established to implement a water quality control plan. On January 23, 2015, the Petitioners 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 CVP/SWP for the next 180 days, with specific requests for February and March of 2015. The TUCP requested temporary modification of requirements included in State Water Board 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. The TUCP requested modifications to water right requirements to meet the Delta outflow, San Joaquin River flow, DCC closure, and export limits objectives. The Petitioners requested these temporary modifications in February and March in order to respond to unprecedented critically dry hydrological conditions as California entered its fourth straight year of below-average rainfall and snowmelt runoff. The TUCP also identified possible future modification requests for the period from April to September (State Water Resources Control Board 2015).

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[4] The order approved modification in April and July to 3,000 cfs (instead of the 4,000 cfs that would otherwise be required).

On February 3, 2015, the State Water Board issued an order approving in part the TUCP[5], subject to conditions. The State Water Board then modified the February 3, 2015 Order on March 5, 2015, and on April 6, 2015. On May 21, 2015, the Petitioners submitted a request to the State Water Board to modify and renew the TUCP Order pursuant to Water Code section 1441, which allows temporary change orders to be renewed for up to 180 additional days. A July 3, 2015 Order approved the May 21, 2015 request. On February 3, 2015, the State Water Board issued an Order that took action on the January 23, 2015 TUCP. The February Order approved temporary changes to D-1641 requirements during February and March. On March 5, 2015, State Water Board issued an Order that modified the February 3 Order in response to the January 23, 2015 TUCP. On March 24, 2015, the Petitioners requested approval of additional changes to D-1641 flow and water quality requirements through November of 2015. On April 6, 2015, the State Water Board issued an Order, which extended the changes to Delta outflow and export requirements through June, and extended the change to the DCC Gate closure requirement through May 20, 2015. On May 18, 2015 Reclamation submitted an *Updated Project Description for July-November 2015 Drought Response Actions to Support Endangered Species Act Consultations* (Project Description), *Biological Review for Endangered Species Act Compliance of the WY 2015 Updated Drought Contingency Plan for July–November Project Description* (Biological Review), *Revised Sacramento River Water* Temperature Management Plan *June 2015* (Temperature Management Plan), and an *Updated Biological Information for June 2015 Temperature Management Plan* to NMFS and on June 25, 2015 requested concurrence that the operations described are within the limits of the Incidental Take Statement of the CVP/SWP 2009 BiOp and serves as the Contingency Plan under NMFS BiOp Action I.2.3.C through November 2015. On July 1, 2015, NMFS concurred that Reclamation's May 18, 2015 Project Description (with the exception of the Shasta Operations/Keswick Release Schedule, which was superseded with the June 25, 2015 Sacramento River temperature management plan) is consistent with RPA Action I.2.3.C and meets the specified criteria for a contingency plan (National Marine Fisheries Service 2015). On May 21, 2015, the Petitioners submitted a request to the State Water Board to modify and renew the TUCP Order pursuant to Water Code section 1441. The State Water Board issued an Order acting on this request on July 3, 2015.

Reclamation filed a TUCP with the State Water Board on June 17, 2015 in order to temporarily change terms of Reclamation's permits for the New Melones Project on the Stanislaus River requiring implementation of the dissolved oxygen objective on the Stanislaus River. Specifically, the TUCP requests temporary changes to permit conditions included in State Water Board Decisions 1422 and 1641, requiring that Reclamation attain the minimum dissolved oxygen objective on the Stanislaus River below Goodwin Dam as specified in the Central Valley Regional Water Quality Control Board's Plan for the Sacramento River and San Joaquin River Basins. This petition was approved by the State Water Board, subject to conditions, on August 4, 2015. On May 22, 2015 Reclamation submitted the Project Description and Biological Review to

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[5] Specifically, during February–March, the order modified minimum monthly Delta outflows to 4,000 cfs; modified minimum monthly San Joaquin River flows at Vernalis to 500 cfs; allowed the DCC Gates to be opened consistent with triggers to protect fish species; and added export constraints to allow exports of 1,500 cfs when Delta outflows were below 7,100 cfs regardless of DCC Gate status and allowed exports up to D-1641 limits when Delta outflows were above 7,100 cfs and the DCC Gates are closed.

USFWS and on June 25, 2015 submitted supplemental information to USFWS and requested concurrence that the effects of the proposed operations in the May 22, 2015 Project Description are consistent with the range of effects analyzed in the USFWS BiOp. On June 26, 2015, USFWS accepted Reclamation's determination that the effects of operations in the Project Description were consistent with the effects analyzed in the USFWS BiOp (U.S. Fish and Wildlife Service 2015).

On July 2, 2015, CDFW confirmed that the existing October 14, 2011 consistency determinations for the USFWS BiOp and April 26, 2012 consistency determination for the NMFS BiOp remained in effect and no further authorization was necessary. Additionally, CDFW confirmed that operations under the Project Description would not affect California Endangered Species Act (CESA) coverage under the Longfin ITP, and that conditions in the Longfin ITP would not be affected (California Department of Fish and Wildlife 2015).The drought conditions over the last 4 years have had substantial impacts on fish and wildlife species and their habitats. As previously noted, Reclamation and DWR submitted biological reviews of listed fish species of concern for the TUCP, in order to review species status and assess potential effects of TUCP modifications. In 2015, these reviews included the *Smelt Supporting Information for Endangered Species Act Compliance for Temporary Urgency Change Petition Regarding Delta Water Quality* (Bureau of Reclamation 2015a) and the *Salmonid and Green Sturgeon Supporting Information for Endangered Species Act Compliance for Temporary Urgency Change Petition Regarding Delta Water Quality* (Bureau of Reclamation 2015b), which were submitted as part of the January 23, 2015, TUCP. Subsequent biological reviews were provided as part of the TUCP, and covered April through September[6] and July through November 15.[7] A summary of drought effects on each species covered in this BA is provided in Section 4.5, *Status of the Species/Environmental Baseline Summary*.

Please refer to Section 3.7, *Drought Procedures*, for a discussion of how any future drought conditions will be addressed under the PA.

4.4 Feather River Operations Consultation

As part of the SWP, DWR operates the Oroville Facilities on the Feather River under a license from the Federal Energy Regulatory Commission (FERC). As part of the FERC process for relicensing the Oroville Facilities, NMFS is consulting with FERC under ESA Section 7 regarding effects on listed species under NMFS' jurisdiction from FERC's proposed relicensing the Oroville Facilities. NMFS released a draft BiOp for FERC relicensing of the Oroville Facilities in July 2009. A final BiOp is scheduled for release in spring of 2016.

The original FERC license to operate the Oroville Facilities expired in January 2007. Since then, an annual license that renews automatically each year has been issued, authorizing DWR to continue operating to the terms of the original FERC license until the new license is issued. To prepare for the expiration of the original FERC license, DWR began working on the relicensing

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[6] See http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/2015/biorev2_aprsep.pdf.

[7] See http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/2015/tucp052115.pdf.

process in 2001. As part of the process, DWR entered into a Settlement Agreement (SA), signed in 2006, with state, federal, and local agencies; state water contractors; non-governmental organizations; a tribal government; and others to implement improvements within the FERC boundary. The FERC boundary includes all of the Oroville Facilities, including Lake Oroville, and extends downstream of Oroville Dam to include portions of the Low Flow Channel (LFC) on the lower Feather River and portions of the High Flow Channel (HFC) of the Lower Feather River downstream of the Thermalito Afterbay Outlet. In addition to the SA, a Habitat Expansion Agreement was negotiated with NMFS and others to address the effects of the Oroville Facilities on anadromous fish in the Feather River, and to provide an alternative to NMFS and USFWS exercising their authority to prescribe fish passage under Federal Power Act Section 18.

In 2010, the State Water Resources Control Board issued the Clean Water Act Section 401 Certification for FERC relicensing of the Oroville Facilities, analyzing the SA-proposed conditions. Although the new FERC license has not been issued, it is anticipated to include the SA license terms and conditions from Appendix A and the terms and conditions of the Clean Water Act Section 401 Certification. DWR will also comply with the requirements in the NMFS BiOp after it is issued to FERC and FERC relicenses the Oroville Facilities. It is anticipated that the new FERC license will be issued for a period of up to 50 years. The FERC license and its associated agreements and permits will be the primary regulatory drivers for operations at the Oroville Facilities. Operational requirements in the forthcoming license and associated permits are expected to include minimum channel flows, water temperature, and ramping rates. These requirements will need to be met, along with any other requirements imposed on the SWP through this consultation. The analysis below describes the similarities in the proposed operations in the FERC SA and the PA, and why no conflicts between these operations is expected.

The operations modeled for the No Action Alternative (NAA) and the PA in this BA are similar to the operations modeled in DWR's BA for FERC relicensing of the Oroville Facilities. The modeling assumptions for the NAA and the PA in this BA incorporated flow requirements specified in the SA (Table 4-1). Because the NMFS BiOp for FERC relicensing of the Oroville Facilities is not yet final, the draft BiOp terms and conditions were not included in the modeling assumptions. However, for purposes of understanding potential differences between what was assumed for the modeling of the NAA and the PA in this BA and what is expected to be included in the NMFS BiOp for FERC relicensing of the Oroville Facilities on the Feather River, various flow requirements were compared (Table 4-1). As shown, the majority of assumed criteria for Feather River minimum instream flow in the NAA and the PA modeling are the same as those included in the NMFS Draft BiOp for FERC Oroville Facilities relicensing. One exception is the pulse flow target flows in March, April, and May in the NMFS Draft BiOp, which were not part of the SA and were not assumed in the modeling of the NAA and the PA in this BA.

As shown, the pulse flow targets at the southern end of the FERC boundary range from 2-day pulses to 12-day pulses of 7,000 cubic feet per second (cfs) in wet and above normal water years. Based on the input from the Green Sturgeon Technical Subcommittee of the Feather River Technical Team, two additional 2-day (48-hour) pulse flows of sufficient magnitude and duration to improve passage impediments and facilitate upstream movement of adult sturgeon may be provided. There is uncertainty as to what future pulse flow specifications NMFS might include in the Final BiOp for FERC relicensing of the Oroville Facilities because of changing river bathymetric conditions. The 12-day pulse under the NMFS Draft BiOp in March requires approximately 165 TAF of flow released from Oroville Facilities. The two pulses in April and May require approximately 56 TAF and 28 TAF, respectively. Given that these short-duration pulse flows are limited to wetter conditions and relatively small in volume, their effect on the available coldwater pool in Lake Oroville for the months following the pulse is expected to be small. Should these pulse flow operations remain in the final NMFS BiOp for FERC relicensing of the Oroville Facilities, DWR will implement them in coordination with other SWP operations, including the PA described in this BA. Given the similarities between assumed Feather River operations criteria in the NAA and PA modeling for this BA, and the conditions in the NMFS Draft BiOp (Table 4-1), the PA is not expected to affect the ability to meet the conditions analyzed in the final NMFS BiOp for FERC relicensing of the Oroville Facilities.

Table 4-2 shows the availability of Temperature Control Actions (TCAs) from the FERC DEIR PA modeling. Because the Feather River flow requirements and all the water temperature objectives for the NAA in the current BA are the same as those analyzed in the FERC Oroville Facilities relicensing BA and the Oroville Facilities Relicensing Draft Environmental Impact Report Proposed Project Alternative (FERC DEIR PA) modeling, conditions under NAA would be similar to those of the FERC DEIR PA. Given that modeling for the PA would result in storage conditions in Oroville (Table 4-3) that would be similar to those of the NAA, as well as similar temperature conditions in the LFC (
Table 4-4 and Table 4-5), conditions under the PA at the two common water temperature compliance locations, the Feather River Fish Hatchery (FRFH) and Robinson Riffle, would be expected to be similar to the FERC DEIR PA.

Even if the Oroville storage conditions under the PA were lower than the conditions that were modeled in the FERC DEIR PA, the PA would utilize the TCAs described in the SA. As noted in the Table 4-2, not all the TCAs were required to meet the temperature requirements at FRFH and Robinson Riffle under FERC DEIR PA modeling; if needed, the PA can utilize the remaining TCAs. With ability to exercise various TCAs outlined in the SA, DWR is expected to have enough flexibility to meet the minimum instream flow and temperature requirements outlined in the NMFS Draft BiOp without significantly affecting the operations resulting from the PA.

In conclusion, modeling of the Oroville Facilities conducted as part of the Oroville Facilities Relicensing EIR, BA, and draft BiOp is consistent with modeling conducted for the PA in this BA. Although the TCAs taken to achieve the water temperatures could be different under the PA modeling, flows and temperatures in the Feather River LFC and FRFH are expected to be generally similar under the PA and the NMFS BiOp for relicensing of the Oroville Facilities. Therefore, no additional analysis of those operations and associated effects is included in this BA. However, the effects of the Oroville Facilities operations are considered as part of the status of the species and critical habitat as applicable.

Table 4-1. Feather River Minimum Instream Flow Requirements Included in the Oroville Facilities Settlement Agreement and California WaterFix BA PA Modeling Compared to the NMFS Draft BiOp.

	Oroville Facilities Settlement Agreement, and California WaterFix BA No Action Alternative and PA Modeling	NMFS Draft BiOp
Minimum Flow in Feather River LFC	700 cfs, except from September 9 to March 31 of each year to accommodate spawning of anadromous fish release (800 cfs).	Same
Minimum Flow in Feather River HFC	Consistent with existing license and 1983 DWR-CDFW agreement (750–1,700 cfs)	Same
Additional Pulse Flows	None	In wet and above normal water years, target flows: Mar 1–12: 7,000 cfs Apr 1–30: two 48-hour, 7,000 cfs pulse flows May 1–31: one 48-hour, 7,000 cfs pulse flow In below normal and dry water years, convene Green Sturgeon Technical Team and Feather River Technical Team to determine if pulse flows are warranted. In Mar–Apr, if directed, provide two 48-hour, 2,500 cfs pulse flows

Table 4-2. Annual Availability of Oroville Facilities Temperature Management Actions in the Oroville Facilities Relicensing DEIR PA Alternative Simulation.

Temperature Management Action	Number of Years Utilized	Remaining Years of Availability
Pumpback curtailment[1]	74	0
Remove all shutter on the Hyatt Intake[2]	2	72
Increase LFC flow to 1,500 cfs[3]	10	64
Release 1,500 cfs from the river valve[4]	3	71

Source: *Oroville Facilities Relicensing DEIR Proposed Project Simulation*.

Period of Record: 1992–1994.

[1] Pumpback curtailed for at least a portion of the year.

[2] All 13 shutters are removed from the Hyatt Intake.

[3] For Robinson Riffle water temperature objective only.

[4] For Feather River Fish Hatchery water temperature objective only; river valve is operational.

Table 4-3. End-of-Month Oroville Storage Modeling Results for the NAA and the PA

Statistic	End of Month Storage (TAF)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	2,051	2,070	19	1%	2,112	2,173	61	3%	2,712	2,706	-6	0%	2,788	2,788	0	0%	2,917	2,919	2	0%	3,035	3,049	14	0%
20%	1,779	1,915	136	8%	1,799	1,951	152	8%	2,031	2,175	144	7%	2,610	2,788	178	7%	2,788	2,788	0	0%	2,964	2,964	0	0%
30%	1,612	1,756	145	9%	1,656	1,760	104	6%	1,793	1,984	190	11%	2,287	2,356	69	3%	2,788	2,788	0	0%	2,897	2,933	37	1%
40%	1,364	1,526	161	12%	1,374	1,495	120	9%	1,583	1,720	137	9%	1,941	2,191	250	13%	2,553	2,658	105	4%	2,788	2,809	21	1%
50%	1,257	1,378	121	10%	1,249	1,355	107	9%	1,391	1,524	133	10%	1,703	1,875	172	10%	2,176	2,449	272	13%	2,646	2,777	132	5%
60%	1,165	1,248	83	7%	1,138	1,238	100	9%	1,252	1,259	7	1%	1,595	1,607	12	1%	1,892	1,976	84	4%	2,261	2,341	80	4%
70%	1,098	1,163	65	6%	1,022	1,118	96	9%	1,093	1,211	118	11%	1,298	1,342	44	3%	1,677	1,728	51	3%	2,041	2,133	92	5%
80%	999	1,059	60	6%	958	1,004	46	5%	983	1,083	100	10%	1,147	1,233	86	7%	1,432	1,473	41	3%	1,706	1,737	31	2%
90%	906	929	22	2%	890	921	31	3%	903	957	54	6%	1,007	1,076	69	7%	1,244	1,254	10	1%	1,491	1,518	27	2%
Long Term Full Simulation Period[b]	1,399	1,480	81	6%	1,390	1,470	80	6%	1,565	1,644	79	5%	1,830	1,912	81	4%	2,146	2,209	64	3%	2,387	2,435	47	2%
Water Year Types[c]																								
Wet (32%)	1,919	1,978	58	3%	1,877	1,943	66	4%	1,996	2,079	83	4%	2,185	2,297	112	5%	2,830	2,858	28	1%	2,942	2,942	0	0%
Above Normal (16%)	1,507	1,602	95	6%	1,488	1,579	91	6%	1,583	1,675	91	6%	1,773	1,858	85	5%	2,516	2,612	96	4%	2,892	2,927	36	1%
Below Normal (13%)	1,239	1,412	173	14%	1,174	1,348	174	15%	1,301	1,459	158	12%	1,712	1,851	138	8%	2,125	2,228	103	5%	2,400	2,526	126	5%
Dry (24%)	1,079	1,155	76	7%	1,145	1,210	65	6%	1,501	1,553	52	3%	1,753	1,793	40	2%	1,583	1,659	76	5%	1,939	2,012	73	4%
Critical (15%)	836	873	37	4%	835	874	38	5%	961	991	30	3%	1,362	1,389	27	2%	1,218	1,269	51	4%	1,376	1,423	46	3%

Statistic	End of Month Storage (TAF)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	3,352	3,352	0	0%	3,538	3,538	0	0%	3,538	3,538	0	0%	3,037	2,944	-92	-3%	2,758	2,639	-119	-4%	2,217	2,242	24	1%
20%	3,298	3,298	0	0%	3,538	3,538	0	0%	3,535	3,528	-8	0%	2,952	2,889	-63	-2%	2,516	2,429	-87	-3%	1,960	2,094	133	7%
30%	3,268	3,274	6	0%	3,475	3,475	0	0%	3,357	3,202	-154	-5%	2,746	2,635	-111	-4%	2,313	2,201	-112	-5%	1,824	1,848	24	1%
40%	3,208	3,215	7	0%	3,312	3,375	63	2%	3,103	2,993	-110	-4%	2,468	2,384	-84	-3%	1,979	2,048	69	3%	1,522	1,734	212	14%
50%	2,925	3,044	120	4%	3,018	3,078	60	2%	2,831	2,798	-32	-1%	2,201	2,166	-35	-2%	1,718	1,802	84	5%	1,331	1,545	213	16%
60%	2,600	2,657	57	2%	2,690	2,779	89	3%	2,448	2,430	-18	-1%	1,821	1,866	45	2%	1,508	1,514	6	0%	1,256	1,394	139	11%
70%	2,218	2,283	66	3%	2,300	2,332	32	1%	2,015	2,101	86	4%	1,448	1,610	162	11%	1,247	1,279	32	3%	1,203	1,244	41	3%
80%	1,900	1,857	-43	-2%	1,860	1,933	72	4%	1,682	1,763	81	5%	1,241	1,294	53	4%	1,130	1,225	95	8%	1,075	1,136	61	6%
90%	1,661	1,654	-6	0%	1,512	1,578	65	4%	1,306	1,359	54	4%	1,138	1,218	80	7%	986	1,102	116	12%	897	977	80	9%
Long Term Full Simulation Period[b]	2,654	2,695	41	2%	2,749	2,793	43	2%	2,602	2,593	-9	0%	2,118	2,108	-10	0%	1,817	1,815	-2	0%	1,512	1,601	89	6%
Water Year Types[c]																								
Wet (32%)	3,300	3,300	0	0%	3,486	3,488	1	0%	3,439	3,383	-56	-2%	2,958	2,876	-82	-3%	2,619	2,548	-71	-3%	2,102	2,163	61	3%
Above Normal (16%)	3,246	3,262	16	1%	3,392	3,410	18	1%	3,231	3,122	-109	-3%	2,598	2,497	-101	-4%	2,115	2,061	-54	-3%	1,657	1,738	81	5%
Below Normal (13%)	2,656	2,776	119	4%	2,716	2,832	116	4%	2,530	2,584	54	2%	1,922	1,960	38	2%	1,512	1,586	75	5%	1,307	1,503	196	15%
Dry (24%)	2,178	2,251	73	3%	2,209	2,288	78	4%	1,957	2,011	54	3%	1,476	1,544	68	5%	1,284	1,326	41	3%	1,146	1,247	102	9%
Critical (15%)	1,401	1,436	35	2%	1,388	1,423	35	3%	1,248	1,289	42	3%	1,028	1,097	68	7%	925	984	59	6%	874	912	38	4%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 4-4. Modeled Feather River Low Flow Channel near Fish Dam Monthly Temperature for the NAA and the PA

Statistic	Monthly Temperature (Deg-F)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	57.9	58.2	0.3	1%	58.9	58.9	0.0	0%	54.8	54.3	-0.5	-1%	51.4	51.5	0.1	0%	51.5	51.5	0.0	0%	53.4	53.4	0.0	0%
20%	56.0	55.6	-0.4	-1%	57.8	57.4	-0.4	-1%	54.0	53.4	-0.6	-1%	50.4	50.5	0.1	0%	50.9	51.1	0.2	0%	52.7	52.8	0.1	0%
30%	54.8	54.6	-0.2	0%	56.6	56.0	-0.6	-1%	53.1	53.0	-0.1	0%	49.8	49.9	0.1	0%	50.5	50.8	0.3	1%	51.7	51.9	0.2	0%
40%	54.1	54.0	-0.1	0%	56.0	55.2	-0.8	-1%	52.6	52.3	-0.3	-1%	49.4	49.4	0.0	0%	50.0	50.0	0.0	0%	51.4	51.3	-0.1	0%
50%	54.0	53.6	-0.4	-1%	55.4	54.8	-0.6	-1%	52.2	51.9	-0.3	-1%	49.2	49.3	0.1	0%	49.6	49.8	0.2	0%	50.8	50.8	0.0	0%
60%	53.7	53.4	-0.3	-1%	55.0	53.6	-1.4	-3%	51.6	51.5	-0.1	0%	48.8	48.8	0.0	0%	49.3	49.4	0.1	0%	50.1	50.2	0.1	0%
70%	53.3	53.2	-0.1	0%	54.2	52.8	-1.4	-3%	51.3	51.0	-0.3	-1%	48.1	48.2	0.1	0%	48.9	49.0	0.1	0%	49.6	49.7	0.1	0%
80%	53.2	53.1	-0.1	0%	52.8	52.5	-0.3	-1%	50.8	50.5	-0.3	-1%	47.5	47.7	0.2	0%	48.5	48.4	-0.1	0%	49.3	49.0	-0.3	-1%
90%	53.0	52.9	-0.1	0%	52.3	52.2	-0.1	0%	49.6	49.5	-0.1	0%	47.0	47.0	0.0	0%	47.6	47.7	0.1	0%	48.4	48.5	0.1	0%
Long Term Full Simulation Period[b]	55.0	54.8	-0.2	0%	55.6	55.0	-0.6	-1%	52.2	52.0	-0.2	0%	49.1	49.2	0.1	0%	49.6	49.7	0.1	0%	50.9	50.9	0.0	0%
Water Year Types[c]																								
Wet (32%)	53.5	53.4	0.0	0%	54.7	54.3	-0.5	-1%	52.9	52.6	-0.4	-1%	50.1	50.1	0.0	0%	48.7	48.8	0.1	0%	49.4	49.4	0.0	0%
Above Normal (16%)	53.5	53.3	-0.1	0%	54.5	54.1	-0.5	-1%	51.9	51.8	-0.2	0%	48.8	49.0	0.1	0%	45.9	45.9	0.0	0%	46.1	46.0	0.0	0%
Below Normal (13%)	54.5	54.3	-0.2	0%	55.6	54.5	-1.1	-2%	52.2	51.5	-0.7	-1%	48.2	48.3	0.1	0%	50.2	50.3	0.1	0%	51.6	51.8	0.2	0%
Dry (24%)	55.5	54.9	-0.6	-1%	55.9	55.2	-0.7	-1%	52.1	52.0	-0.1	0%	46.5	46.6	0.1	0%	49.9	50.1	0.2	0%	52.3	52.2	-0.1	0%
Critical (15%)	59.5	59.3	-0.3	0%	57.8	57.4	-0.4	-1%	51.2	51.3	0.1	0%	48.1	48.2	0.1	0%	50.3	50.4	0.1	0%	52.1	52.0	-0.1	0%

Statistic	Monthly Temperature (Deg-F)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	53.8	53.6	-0.2	0%	56.9	56.9	0.0	0%	58.8	58.7	-0.1	0%	62.7	62.4	-0.3	0%	62.7	62.9	0.2	0%	59.8	58.3	-1.5	-3%
20%	53.1	52.8	-0.3	-1%	56.5	56.6	0.1	0%	58.5	58.4	-0.1	0%	61.9	62.0	0.1	0%	62.0	62.2	0.2	0%	57.1	57.3	0.2	0%
30%	52.4	52.4	0.0	0%	56.2	56.3	0.1	0%	58.3	58.2	-0.1	0%	61.4	61.5	0.1	0%	61.5	61.5	0.0	0%	56.8	56.7	-0.1	0%
40%	52.2	52.2	0.0	0%	56.0	56.0	0.0	0%	58.2	57.9	-0.3	-1%	61.2	61.3	0.1	0%	60.8	61.0	0.2	0%	55.5	56.4	0.9	2%
50%	51.9	51.9	0.0	0%	55.9	55.9	0.0	0%	58.0	57.8	-0.2	0%	61.1	61.1	0.0	0%	60.4	60.7	0.3	0%	54.9	56.1	1.2	2%
60%	51.7	51.7	0.0	0%	55.7	55.8	0.1	0%	57.8	57.5	-0.3	-1%	61.1	61.0	-0.1	0%	60.3	60.4	0.1	0%	54.7	55.3	0.6	1%
70%	51.3	51.3	0.0	0%	55.3	55.3	0.0	0%	57.6	57.4	-0.2	0%	60.9	61.0	0.1	0%	60.1	60.2	0.1	0%	54.6	55.0	0.4	1%
80%	50.6	50.7	0.1	0%	54.9	54.9	0.0	0%	57.5	57.3	-0.2	0%	60.9	60.9	0.0	0%	59.9	60.0	0.1	0%	54.5	54.8	0.3	1%
90%	50.2	50.2	0.0	0%	54.5	54.5	0.0	0%	57.2	57.0	-0.2	0%	60.8	60.7	-0.1	0%	59.7	59.7	0.0	0%	54.3	54.6	0.3	1%
Long Term Full Simulation Period[b]	52.0	51.9	0.0	0%	55.8	55.8	0.0	0%	58.0	57.8	-0.2	0%	61.4	61.4	0.0	0%	61.0	61.0	0.0	0%	56.1	56.3	0.2	0%
Water Year Types[c]																								
Wet (32%)	50.9	51.0	0.0	0%	55.1	55.1	0.0	0%	57.8	57.5	-0.2	0%	61.3	61.2	-0.1	0%	60.5	60.6	0.2	0%	54.5	54.8	0.3	0%
Above Normal (16%)	48.0	47.9	-0.1	0%	51.9	51.9	0.0	0%	53.6	53.3	-0.4	-1%	56.2	56.2	0.0	0%	55.3	55.5	0.2	0%	50.3	50.7	0.4	1%
Below Normal (13%)	52.6	52.5	-0.1	0%	55.9	55.9	0.0	0%	58.1	57.8	-0.3	0%	61.0	61.0	0.0	0%	60.4	60.6	0.2	0%	56.0	57.0	1.0	2%
Dry (24%)	52.6	52.7	0.0	0%	56.0	56.0	0.0	0%	57.9	57.9	-0.1	0%	61.3	61.4	0.1	0%	61.5	61.3	-0.2	0%	56.8	57.0	0.2	0%
Critical (15%)	52.4	52.4	-0.1	0%	56.4	56.4	0.0	0%	58.6	58.6	0.1	0%	62.8	62.7	-0.1	0%	62.8	62.5	-0.2	0%	60.2	59.3	-0.9	-2%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

Table 4-5. Modeled Feather River Low Flow Channel at Robinson Riffle Monthly Temperature for the NAA and the PA

Statistic	Monthly Temperature (Deg-F)																							
	October				November				December				January				February				March			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	59.7	59.6	-0.1	0%	58.3	58.2	-0.1	0%	53.3	53.1	-0.2	0%	50.7	50.7	0.0	0%	52.4	52.3	-0.1	0%	54.9	54.8	-0.1	0%
20%	58.1	58.2	0.1	0%	57.1	56.8	-0.3	-1%	52.9	52.4	-0.5	-1%	50.0	49.9	-0.1	0%	51.5	51.5	0.0	0%	54.1	54.2	0.1	0%
30%	56.9	56.8	-0.1	0%	56.3	55.8	-0.5	-1%	52.1	51.9	-0.2	0%	49.5	49.7	0.2	0%	51.0	51.2	0.2	0%	53.5	53.5	0.0	0%
40%	56.6	56.6	0.0	0%	55.8	54.8	-1.0	-2%	51.7	51.3	-0.4	-1%	49.0	49.1	0.1	0%	50.7	50.7	0.0	0%	52.8	52.8	0.0	0%
50%	56.3	56.1	-0.2	0%	55.2	54.6	-0.6	-1%	51.1	51.1	0.0	0%	48.7	48.8	0.1	0%	50.3	50.5	0.2	0%	52.1	52.2	0.1	0%
60%	56.0	55.9	-0.1	0%	54.8	53.8	-1.0	-2%	50.6	50.5	-0.1	0%	48.2	48.3	0.1	0%	50.0	50.1	0.1	0%	51.9	51.8	-0.1	0%
70%	55.7	55.5	-0.2	0%	54.4	53.5	-0.9	-2%	50.4	50.2	-0.2	0%	47.8	47.8	0.0	0%	49.7	49.8	0.1	0%	51.4	51.3	-0.1	0%
80%	55.2	55.1	-0.1	0%	53.5	52.9	-0.6	-1%	50.1	49.8	-0.3	-1%	47.4	47.5	0.1	0%	49.0	49.0	0.0	0%	50.9	50.9	0.0	0%
90%	54.8	54.8	0.0	0%	52.6	52.3	-0.3	-1%	49.1	48.9	-0.2	0%	46.3	46.6	0.3	1%	48.2	48.2	0.0	0%	50.1	50.1	0.0	0%
Long Term Full Simulation Period[b]	57.0	56.8	-0.2	0%	55.4	54.9	-0.5	-1%	51.3	51.1	-0.2	0%	48.6	48.7	0.1	0%	50.3	50.3	0.1	0%	52.5	52.5	0.0	0%
Water Year Types[c]																								
Wet (32%)	55.6	55.6	0.0	0%	54.7	54.3	-0.4	-1%	51.9	51.6	-0.3	-1%	49.6	49.6	0.0	0%	49.6	49.6	0.1	0%	51.2	51.2	0.0	0%
Above Normal (16%)	55.7	55.5	-0.1	0%	54.3	53.9	-0.4	-1%	50.9	50.8	-0.1	0%	48.3	48.4	0.1	0%	46.5	46.5	0.0	0%	47.8	47.8	0.0	0%
Below Normal (13%)	56.6	56.5	-0.2	0%	55.5	54.6	-0.9	-2%	51.1	50.5	-0.6	-1%	47.7	47.8	0.1	0%	50.6	50.7	0.1	0%	53.0	53.1	0.1	0%
Dry (24%)	57.5	57.0	-0.5	-1%	55.8	55.2	-0.6	-1%	51.3	51.3	-0.1	0%	46.1	46.2	0.1	0%	50.5	50.6	0.1	0%	53.6	53.5	0.0	0%
Critical (15%)	60.7	60.5	-0.2	0%	57.3	56.9	-0.3	-1%	50.2	50.3	0.1	0%	47.8	47.8	0.1	0%	50.9	51.1	0.1	0%	53.6	53.5	0.0	0%

Statistic	Monthly Temperature (Deg-F)																							
	April				May				June				July				August				September			
	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]																								
10%	57.6	57.4	-0.2	0%	62.1	62.1	0.0	0%	66.1	65.9	-0.2	0%	69.6	69.5	-0.1	0%	68.8	68.7	-0.1	0%	63.0	62.5	-0.5	-1%
20%	56.5	56.3	-0.2	0%	61.6	61.6	0.0	0%	65.8	65.6	-0.2	0%	69.1	69.0	-0.1	0%	68.0	68.1	0.1	0%	61.6	62.0	0.4	1%
30%	56.0	56.0	0.0	0%	61.2	61.2	0.0	0%	65.4	65.2	-0.2	0%	68.7	68.8	0.1	0%	67.6	67.7	0.1	0%	61.1	61.5	0.4	1%
40%	55.5	55.6	0.1	0%	60.8	60.8	0.0	0%	65.1	64.9	-0.2	0%	68.6	68.5	-0.1	0%	67.1	67.2	0.1	0%	60.7	61.0	0.3	0%
50%	55.0	55.0	0.0	0%	60.6	60.6	0.0	0%	64.6	64.3	-0.3	0%	68.2	68.3	0.1	0%	66.6	66.9	0.3	0%	60.4	60.7	0.3	0%
60%	54.6	54.7	0.1	0%	60.3	60.4	0.1	0%	64.2	64.0	-0.2	0%	68.0	68.1	0.1	0%	66.3	66.4	0.1	0%	60.1	60.4	0.3	0%
70%	54.4	54.4	0.0	0%	60.0	60.0	0.0	0%	63.8	63.8	0.0	0%	67.8	67.7	-0.1	0%	66.1	66.1	0.0	0%	59.6	60.0	0.4	1%
80%	54.0	53.9	-0.1	0%	59.8	59.8	0.0	0%	63.4	63.3	-0.1	0%	67.3	67.4	0.1	0%	65.8	65.7	-0.1	0%	59.4	59.6	0.2	0%
90%	53.4	53.3	-0.1	0%	59.1	59.1	0.0	0%	62.8	62.9	0.1	0%	67.0	66.9	-0.1	0%	65.3	65.3	0.0	0%	58.8	59.1	0.3	1%
Long Term Full Simulation Period[b]	55.3	55.3	0.0	0%	60.7	60.7	0.0	0%	64.5	64.4	-0.1	0%	68.4	68.4	0.0	0%	66.9	66.9	0.0	0%	60.7	60.9	0.1	0%
Water Year Types[c]																								
Wet (32%)	54.0	54.0	0.0	0%	60.2	60.2	0.0	0%	64.0	63.8	-0.2	0%	68.4	68.4	0.0	0%	66.7	66.9	0.1	0%	59.8	59.9	0.2	0%
Above Normal (16%)	51.2	51.2	0.0	0%	56.4	56.5	0.0	0%	59.9	59.6	-0.2	0%	62.6	62.6	0.0	0%	60.9	61.1	0.1	0%	54.8	55.1	0.3	1%
Below Normal (13%)	56.2	56.2	0.0	0%	60.5	60.5	0.0	0%	64.9	64.7	-0.2	0%	68.3	68.3	0.0	0%	66.7	66.8	0.1	0%	60.8	61.5	0.7	1%
Dry (24%)	55.9	55.9	0.0	0%	60.9	61.0	0.0	0%	64.9	64.8	0.0	0%	68.1	68.1	0.1	0%	67.1	67.0	-0.1	0%	61.1	61.3	0.2	0%
Critical (15%)	55.9	55.8	0.0	0%	60.9	60.9	0.0	0%	64.6	64.7	0.1	0%	69.4	69.3	-0.1	0%	68.1	68.0	-0.1	0%	63.5	62.9	-0.7	-1%

a Exceedance probability is defined as the probability a given value will be exceeded in any one year.

b Based on the 82-year simulation period.

c As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999); projected to Year 2030. WYT for a given water year is applied from Feb through Jan consistent with CALSIM II.

d There are 26 wet years, 13 above normal years, 11 below normal years, 20 dry years, and 12 critical years projected for 2030 under Q5 climate scenario.

4.5 Status of the Species/Environmental Baseline Summary

Environmental baseline, as defined in 50 CFR 402.02, "includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process." This section describes the environmental baseline for each species, with additional detail provided in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, particularly with respect to threats to the species.

Table 1-3 includes a summary of listed species addressed in this BA. Some of the detailed baseline description is contained within Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, due to the large size of the action area, which in some cases encompasses the freshwater geographic range of a listed fish species.

The PA would not begin operations until after at least a decade of construction activities, as described in Chapter 3, *Description of the Proposed Action*. A number of other processes have the potential to change the environment in which the PA would operate, but either these are not reasonably certain to occur, or they have not yet been developed in sufficient detail to assess their likely effect upon listed species and their critical habitat. These include the Water Quality Control Plan (WQCP) Update currently underway by the State Water Resources Control Board (SWRCB) and the implementation of the California Water Action Plan. Changes in the environmental baseline are also likely to occur during the timeframe leading up to the PA, and during performance of the PA, in response to changes in the natural environment and include climate change and potential natural events such as earthquakes, floods, and droughts. Additionally, while considered part of the baseline for this consultation, the Long-term Operations BiOps are not fully implemented and some components of the RPAs (e.g., fish passage) may fundamentally change CVP management. It is also possible that other substantial federal actions may occur prior to implementation that could alter the environmental baseline: possible examples include consultation on system-wide CVP operations, or construction of substantial new water storage facilities in the Central Valley watershed. Potential changes in the environmental baseline that are not foreseeable but are conceivable in the context of such changes include increased flows on the Sacramento River, changes in Delta outflow criteria, warmer waters throughout the CVP and SWP, and changes in access to spawning areas above major dams. Collectively, these could result in substantial variance from the outcomes evaluated in this BA. In consideration of this possibility, the PA would operate in compliance with the operational criteria set forth in 3.3, *Operations and Maintenance of New and Existing Facilities*, or other criteria developed as part of these other processes and/or adjustments made through the Collaborative Science and Adaptive Management Program described in Section 3.4.7, *Collaborative Science and Adaptive Management Program*.

4.5.1 Chinook Salmon, Sacramento River Winter-Run ESU

The Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) evolutionarily significant unit (ESU), currently listed as endangered, was initially listed as a threatened species under emergency provisions of the ESA on August 4, 1989 (54 FR 32085), and in a final rule in 1990 (55 FR 46515; November 5, 1990). On January 4, 1994, NMFS re-classified Sacramento River winter-run Chinook salmon as an endangered species (59 FR 440). NMFS concluded that winter-run Chinook salmon in the Sacramento River warranted listing as an endangered species due to several factors, including (1) the continued decline and increased variability of run sizes since its first listing as a threatened species in 1989; (2) the expectation of weak returns in future years as the result of two small year classes (1991 and 1993); and (3) continued threats to the "take" of winter-run Chinook salmon (August 15, 2011, 76 FR 50447).

The Sacramento River winter-run Chinook salmon ESU currently consists of only one population that is confined to the upper Sacramento River, spawning downstream of Shasta and Keswick Dams in California's Central Valley. In addition, an artificial propagation program at the Livingston Stone National Fish Hatchery (LSNFH) produces winter-run Chinook salmon that are part of this ESU (June 28, 2005, 70 FR 37160). All historical spawning and rearing habitats have been blocked since the construction of Shasta Dam in 1943. Most components of the winter-run Chinook salmon life history (e.g., spawning, incubation, freshwater rearing) have been compromised by this habitat blockage. Remaining spawning and rearing areas are completely dependent on cold-water releases from Shasta Dam in order to sustain the remnant population.

NMFS designated critical habitat for Sacramento River winter-run Chinook salmon on June 16, 1993 (58 FR 33212). Critical habitat includes the Sacramento River from Keswick Dam at river mile (RM) 302 to Chipps Island, RM 0, at the westward margin of the Delta; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge. Critical habitat includes the bottom and water of these waterways, and the adjacent riparian zone (Figure 4.A.1-2 in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*).

Physical or biological features (PBFs)[8] of winter-run Chinook salmon critical habitat are discussed in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.1.2, *Critical Habitat*. Within the action area, and as described by NMFS (2009), many of the PBFs of

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[8] The designations of critical habitat for listed species have generally used the term primary constituent elements (PCEs). NMFS and USFWS' recently issued a final rule amending the regulations for designating critical habitat (81 FR 7414; February 11, 2016), which replaced the term PCEs with physical or biological features (PBFs). In addition, NMFS and USFWS' recently issued a final rule revising the regulatory definition of "destruction or adverse modification" of critical habitat (81 FR 7214; February 11, 2016), which refers to PBFs, not PCEs. The shift in terminology does not change the approach used in conducting an analysis of the effects of the proposed action on critical habitat, which is the same regardless of whether the original designation identified PCEs or PBFs. In this biological assessment, we use the term PBFs to include PCEs, as appropriate for the specific critical habitat, for NMFS species.

critical habitat are impaired and provide limited conservation value. In the upper Sacramento River, above-optimal water temperatures can constrain the extent of suitable spawning habitat, and unscreened water diversions provide a risk of entrainment to juvenile winter-run Chinook salmon, with riparian habitat often degraded by channelization, levee construction, and rip-rap bank protection; some complex, productive habitats with floodplains remain in parts of the system (e.g., Yolo and Sutter Bypasses) (National Marine Fisheries Service 2009: 181). NMFS (2009: 183) concluded that critical habitat in the Sacramento River is degraded and has low conservation value. NMFS (2009: 203) also noted that critical habitat within the Delta is degraded because channelized, leveed, and riprapped channels typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. NMFS (2009: 205) also noted that opening of the DCC (leading to the low-survival interior Delta) and water diversions from unscreened intakes leading to entrainment also degrade winter-run Chinook salmon critical habitat in the Delta. The discussion provided in Appendix 4.A, Section 4.A.1.4, *Threats and Stressors*, in also generally discusses baseline conditions that are relevant to critical habitat for winter-run Chinook salmon.

Good *et al.* (2005) described the threats to the winter-run Chinook salmon ESU as follows: That there is only a single extant population that is spawning outside of its historical range within an artificial habitat that is vulnerable to drought and other catastrophic conditions such as loss of cold-water pool and temperature control.

As described in more detail in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.1.3.6, *Status and Trends*, estimates of the winter-run Chinook salmon population reached nearly 120,000 adult fish in the late 1960s before declining to under 200 fish in the 1990s (Fisher 1994; California Department of Fish and Wildlife 2014) in Appendix 4.A). Adult abundance remained very low through the mid-1990s, and was less than 500 fish in some years (California Department of Fish and Wildlife 2014). From the mid-1990s through 2006, adult escapement showed a trend of increasing abundance, up to around 20,000 fish in 2005 and 2006. However, recent population estimates have declined since the 2006 peak, with escapement estimates for 2007 through 2014 ranging from 738 adults (2011) to 5,959 (2013). The 2011 estimate of 738 was the lowest since the all-time low of 144 in 1994. Poor ocean productivity (Lindley et al. 2009), drought conditions during 2007–2009, and low in-river survival (National Marine Fisheries Service 2011a) are suspected to have contributed to the recent decline in escapement of adult winter-run Chinook salmon.

Lindley *et al.* (2007) assessed that the Sacramento River winter-run Chinook salmon ESU was at moderate risk of extinction based on a population viability analysis criterion (>5% risk of extinction within 100 years) and at low risk of extinction based on other criteria, including population size, population decline, rate and effect of catastrophe on population, and hatchery influence. However, Lindley *et al.* (2007: 13) noted that "an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. A single catastrophe could extirpate the entire Sacramento River winter-run Chinook salmon ESU, if its effects persisted for four or more years. The entire stretch of the Sacramento River used by winter-run Chinook salmon is within the zone of influence of Mt. Lassen. Some other possible catastrophes include a prolonged drought that depletes the cold water storage of Lake Shasta or some related failure to manage cold water storage, a spill of toxic materials with effects that persist for four years, or a disease outbreak." Trends in the criteria described by Lindley *et al.*

(2007) include continued low abundance, a negative growth rate within the population over the last two generations (6 years), and an increased risk from catastrophic events (wildfires, oil spills, extended drought conditions, poor ocean rearing conditions) as the population has declined. Hatchery influence on wild stocks, although not a problem with present stocks, could become a problem if cohorts of wild fish were to experience lowered survival, similar to the loss of eggs and alevins as the result of temperature control failure in the upper Sacramento River in 2014, or other reductions in overall population. During times when the ESU is in decline due to marine and freshwater conditions, naturally reproducing winter-run Chinook salmon are less able to withstand high harvest rates (California Hatchery Scientific Review Group 2012). Impacts from the salmon ocean fishery, consistent with the fishery operation since 2000, would not be expected to negatively affect the abundance during periods of positive population growth, but during times of negative population growth the impacts of the fishery at levels over the last decade would appreciably increase the risk of extinction. Therefore, NMFS, which addresses the ocean harvest impacts on this ESU from commercial and recreational ocean salmon fisheries managed under the Pacific Coast Salmon Fishery Management Plan, concluded the fisheries were likely to jeopardize the continued existence of the ESU, and included a reasonable and prudent alternative (RPA) that required NMFS to implement an interim RPA for the 2010 and 2011 fishing years and develop and implement a new management framework for the ocean fishery addressing impacts to Sacramento River winter-run Chinook salmon before the 2012 ocean salmon fishery season (National Marine Fisheries Service April 30, 2012 memo).

The most recent 5-year status review (National Marine Fisheries Service 2011) on winter-run Chinook salmon concluded that the ESU continues to be at high risk of extinction. Williams *et al.* (2011) concluded that the ESU status remains the same as when it was examined by Good *et al.* (2005), *i.e.*, "in danger of extinction" and will remain so until another low-risk population is established within its historical spawning range. The most recent biological information suggests that the extinction risk for the winter-run Chinook salmon ESU has not decreased since 2005 (previous status review), and that several listing factors have contributed to the recent decline in abundance, including drought and poor ocean conditions (National Marine Fisheries Service 2011).

Extreme drought conditions in California are causing increased stress to winter-run Chinook in the form of low flows reducing rearing and migratory habitats, higher water temperatures affecting survival, and likely higher-than-normal predation rates (State Water Resources Control Board 2015). Limited cold water storage and loss of temperature control out of Keswick Dam from mid-August through the fall, resulting in an increased potential for incubation mortality over the 15 year average of 73% (e.g., mortality of 95% of winter-run Chinook salmon eggs and fry) occurred in 2014(SWRCB 2015; Rea pers. comm.). Additionally, the Net Delta Outflow Index (NDOI) was modified from an outflow 7,100 cfs to no less than 4,000 cfs during the months of April through June and no less than 3,000 cfs in July (SWRCB 2015). Reductions in outflow in an effort to preserve the cold-water pool may have the potential to reduce survival of out-migrating winter-run Chinook salmon during their migration through the North Delta, through via increased predation mediated by hydrodynamic and habitat mechanisms (State Water Resources Control Board 2015). Reduced outflow increases tidal excursion upstream (reduced daily proportion of positive velocities) into the waterways in the North Delta region, leading to a reduction in the proportion of positive daily flows passing Georgiana Slough and/or an open Delta Cross Channel, which may increase juvenile entrainment into Georgiana Slough and, if open, the Delta Cross Channel (State Water Resources Control Board 2015). Survival of migrating juvenile salmonids has been shown to be lower when salmon are entrained into these two migration routes as compared to the Sacramento River and Steamboat Slough (Singer *et al.* 2013; Perry *et al.* 2010).

4.5.2 Chinook Salmon, Central Valley Spring-Run ESU

Central Valley (CV) spring-run Chinook salmon were originally listed as threatened on September 16, 1999 (64 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Fish Hatchery (FRFH) spring-run Chinook salmon program has been included as part of the CV spring-run Chinook salmon ESU in the most recent CV spring-run Chinook salmon listing decision (70 FR 37160, June 28, 2005). Although there have been observations of springtime running Chinook salmon returning to the San Joaquin tributaries in recent years, there is insufficient information to determine the specific origin of these fish, and whether or not they are straying into the basin or returning to natal streams (NMFS 2016: 8). More information is needed when considering whether or not the presence of these fish would warrant a change to the ESU boundary (NMFS 2016: 8-9). Additionally, there may be interest in modifying the ESU boundary in the future when spring-run Chinook salmon are successfully reintroduced into the San Joaquin River Basin and/or into Central Valley habitats upstream of currently impassable barriers (NMFS 2016: 9; 78 FR 79622; NMFS 2014). Based on the most recent 5-year status review, NMFS (2016: 9) is not recommending a change to the boundary of this ESU at present (2016). Note that the analyses presented in Chapter 5, *Effects Analysis for Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, considers potential effects of the PA on San Joaquin River spring-run Chinook salmon, which are considered to represent both the reintroduced population as part of the San Joaquin River Restoration Program, and springtime running Chinook salmon mentioned above.

Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488). Critical habitat for the CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba, and American Rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks, and the Sacramento River, as well as portions of the northern Delta (Figure 4.A.2-2 in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*).

The PBFs of spring-run Chinook salmon critical habitat are discussed in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.2.2, *Critical Habitat*. Within the action area, and as described by NMFS (2009: 185), in the mainstem Sacramento River, critical habitat is degraded by overlap of spring-run Chinook salmon with fall-run spawning, with additional degradation by relatively warm water releases from Shasta Reservoir. Rearing and migration habitats are affected by levee construction leading to loss of natural river function and floodplain connectivity, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use (National Marine Fisheries Service 2009: 185). Within the Delta, NMFS (2009: 205) noted that the status of spring-run Chinook salmon critical habitat in the Delta is highly degraded and that substantial changes (e.g., as shown by the pelagic organism decline) are occurring, but noted that it was not immediately clear how such changes affect spring-run Chinook salmon. Other degradation of critical habitat within the Delta is more apparent and includes the elimination of the fringing marshes (leading to less availability of forage species, for example) and habitat simplification by levee construction and riprapping (National Marine Fisheries Service 2009: 103-104), which may reduce shelter from predation, for example. NMFS (2009: 103-104) also noted degradation of critical habitat within the Delta from SWP/CVP operations, e.g., direct (entrainment loss) and indirect (predation, contaminants, entrainment of phytoplankton and zooplankton) effects. Additional degradation of spring-run Chinook salmon critical habitat within the Delta occurs from heavy urbanization and industrial activities that lower water quality and introduce contaminants (National Marine Fisheries Service 2009: 104). The discussion provided in Appendix 4.A Section 4.A.2.5, *Threats and Stressors*, in also generally discusses baseline conditions that are relevant to critical habitat for spring-run Chinook salmon.

Good et al. (2005) described the threats to the CV spring-run Chinook salmon ESU as falling into three broad categories: loss of historical spawning habitat, degradation of remaining habitat, and genetic threats from the Feather River Fish Hatchery spring-run Chinook salmon program. Other likely important threats and stressors include nonnative predators, commercial and recreational harvest, entrainment at water withdrawal facilities, toxin exposure, and increased water temperatures. Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.2.5, *Threats and Stressors*, in discusses these issues in more detail.

The CV spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance between 1960 and recent years (Figure 4.A.2-4 in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*). The total spring-run Chinook salmon escapement count for Feather River Fish Hatchery, Butte Creek, Mill Creek, Deer Creek, Antelope Creek, Cottonwood Creek, Clear Creek, and Battle Creek in 2013 was 23,697 adults, which was the highest count since 2005 (23,093 adults) and over three times that of 2011 (7,408 adults) (California Department of Fish and Wildlife 2014). However, abundance declined considerably in 2014 (9,901 adults) and even more so in 2015 (5,635 adults) (California Department of Fish and Wildlife 2016). Sacramento River tributary populations in Mill, Deer, and Butte Creeks are probably the best trend indicators for the Central Valley spring-run Chinook ESU as a whole because these streams contain the primary independent populations in the ESU. Generally, there was a positive trend in escapement in these waterways between 1992 and 2005, after which there was a steep decline until 2010 (Figure 4.A.2-5 in Appendix 4.A). Adult spring-run salmon escapement to Mill, Deer, and Butte Creeks in was estimated to be 18,135 fish in 2013; 6,592 fish in 2014; and only 964 fish in 2015 (California Department of Fish and Wildlife 2016). Escapement numbers are dominated by Butte Creek returns, with the contribution of Butte Creek fish to total numbers in these three creeks being >90% in 2013, 77% in 2014, and ~60% in 2015 (California Department of Fish and Wildlife 2016). In 2012, Battle Creek saw the highest number of returns in recent history (799 fish), with declines to 608 fish in 2013, 429 fish in 2014, and 181 fish in 2015 (California Department of Fish and Wildlife 2014). Individuals have only recently begun spawning in Battle Creek, where they spawned historically, and greater access upstream for spawning and rearing has been facilitated by some of the initial actions from the Battle Creek Salmon and Steelhead Restoration Project, scheduled for full completion in 2020 (NMFS 2016: 19).

The most recent viability assessment of CV spring-run Chinook salmon was conducted during NMFS's 2016 status review (National Marine Fisheries Service 2016). This review found that on balance the biological status of the ESU had probably improved since the last status review

(2010) through 2014, with two of the three extant independent populations improving from high extinction risks to moderate extinction risks. The third extant independent population, Butte Creek, has remained at low risk, and all viability metrics had been trending in a positive direction, up until 2015 (NMFS 2016: 17). The Butte Creek spring-run Chinook salmon population has increased in part due to extensive habitat restoration and the accessibility of floodplain habitat in the Sutter-Butte Bypass for juvenile rearing in the majority of years. Additionally, spring-run Chinook salmon in both Battle Creek and Clear Creek continue to repopulate those watersheds, and now fall into the moderate extinction risk category for abundance. In contrast, most dependent spring-run populations have been experiencing continued and somewhat drastic declines (NMFS 2016: 17).

Extreme drought conditions are causing increased stress to spring-run Chinook salmon populations in the form of low flows reducing rearing and migratory habitats, higher water temperatures affecting survival, and likely higher-than-normal predation rates. Modification to flow and operational criteria may reduce through-Delta survival of juvenile migrating spring-run Chinook salmon and may modify their designated critical habitat during April and May (State Water Resources Control Board 2015). Changes in Sacramento River outflow during April and May can possibly delay adult spring-run Chinook salmon migration. Low export levels are not expected to appreciably affect survival of juvenile spring-run Chinook salmon emigrating through the Delta (State Water Resources Control Board 2015). Drought conditions and current reservoir storage levels have been forecasted to impact suitable water temperatures in the Upper Sacramento River and Clear Creek. Temperature effects on Clear Creek and in the Upper Sacramento may lead to higher pre-spawn mortality of adult spring-run Chinook salmon and reduced egg viability if temperatures exceed 60°F during August and early September, as well as greater mortality of incubating eggs and pre-emergent fry if temperatures exceed 56°F after September 15 (State Water Resources Control Board 2015).

As described by NMFS (2016: 18), the CV spring-run Chinook salmon ESU has experienced two drought periods over the past decade. From 2007 to 2009, and now 2012 to 2015, the Central Valley experienced drought conditions and low river and stream discharges, which are generally associated with lower survival of Chinook salmon. The impacts of the recent drought years and warm ocean conditions on the juvenile life stage will not be fully realized by the viability metrics until they manifest in potential low run size returns in 2015 through 2018. This is already being realized with very low returns in 2015 (NMFS 2016: 18).

4.5.3 Steelhead, California Central Valley DPS

California Central Valley (CCV) steelhead (*O. mykiss*) were originally listed as threatened on March 19, 1998 (63 FR 13347). On June 14, 2004, after a complete status review of 27 west coast salmonid ESUs and DPSs, NMFS proposed that CCV steelhead remain listed as threatened (69 FR 33102). Following a new status review (Good et al. 2005), on January 5, 2006, NMFS reaffirmed the threatened status of CCV steelhead and applied the DPS policy to the species because the resident and anadromous life forms of *O. mykiss* remain “markedly separated” as a consequence of physical, ecological, and behavioral factors, and therefore warranted delineation as separate DPSs (71 FR 834). In addition, NMFS added the Feather River Fish Hatchery and Coleman National Fish Hatchery steelhead hatchery programs as part of the listed DPS on January 5, 2006 (71 FR 834). On August 15, 2011, NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (National Marine Fisheries Service 2011a).

Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488). Critical habitat for CCV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope Creeks in the Sacramento River basin; the San Joaquin River, including its tributaries, and the waterways of the Delta (Figure 4.A.3-2 in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*).

The PBFs of CCV steelhead critical habitat are discussed in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.3.3, *Critical Habitat*. As with winter-run and spring-run Chinook salmon, and as previously described by NMFS (2009), critical habitat for CCV is degraded, generally because of the same issues outlined for Chinook salmon. In the mainstem Sacramento River, critical habitat for rearing and migration is degraded by levee construction leading to loss of natural river function and floodplain connectivity, direct loss of floodplain and riparian habitat, and effects to water quality associated with agricultural, urban, and industrial land use (National Marine Fisheries Service 2009: 186). In the American River, NMFS (2009: 192) noted that there is general consensus that critical habitat for CCV steelhead is impaired, with particular concern being CVP operational effects: warm water temperatures during embryo incubation, rearing, and migration; flow fluctuations during embryo incubation and rearing; and limited flow-dependent habitat availability during rearing. Recent gravel augmentation efforts have resulted in improvements to the spawning habitat function of the lower American River (Zeug *et al.* 2014). Within the Delta, NMFS (2009: 112-113) noted similar types of degradation of CCV steelhead critical habitat as previously described for spring-run Chinook salmon with respect to degradation of the migration corridor and estuarine areas, such as direct/indirect effects of SWP/CVP operations in the south Delta (e.g., entrainment risk and associated predation) and entry into the interior Delta through the DCC, as well as other effects such as seasonal agricultural diversions and water quality impairment from municipal/agricultural discharge.

The primary threat to CCV steelhead is the loss of historical adult staging/holding, spawning, and rearing habitat that is no longer accessible to upstream migrating steelhead. Access to this habitat has been blocked by artificial structures (i.e., dams and weirs) associated with water storage and conveyance; diversions; flood control; and municipal, industrial, agricultural, and hydropower purposes (Figure 4.A.3-1 in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*) (McEwan and Jackson 1996; McEwan 2001; Reclamation 2004; Lindley et al. 2006; National Marine Fisheries Service 2007). These impediments and barriers to upstream passage limit the geographic distribution of steelhead to lower elevation habitats in the Central Valley, which not only lack the boulders, large wood, gravel riffles, and side channels of upstream areas, but also are more prone to temperature effects when reservoir levels cannot be maintained for water temperature control below dams. Lack of access to higher-elevation and cooler aquatic habitat (most of which is above dams) will increase the risk that catastrophic climate change events pose to CCV steelhead. Other limiting factors that affect steelhead distribution, abundance, and survival are high water temperatures, low flows and flow fluctuations, limited spawning and rearing habitat, poor quality of the remaining rearing habitat, blocked or delayed passage, unscreened river diversions, predation, contaminants, harvest, hatchery operations, and disease.

Lindley et al. (2007) developed viability criteria for Central Valley salmonids. Using data through 2005, Lindley et al. (2007) found that data were insufficient to determine the status of any of the naturally spawning populations of CCV steelhead, except for those spawning in rivers adjacent to hatcheries, which were likely to be at high risk of extinction due to extensive spawning of hatchery-origin fish in natural areas.

The widespread distribution of wild steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV populations are very small, are not monitored, and may lack the resilience to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change (National Marine Fisheries Service 2011a). The genetic diversity of CCV steelhead has likely been affected by low population sizes and high numbers of hatchery fish relative to wild fish. Status reviews of this DPS have identified hatchery fish influence as a significant threat to its genetic integrity and diversity. Williams et al. (2011) identify the increasing dominance of hatchery fish relative to naturally produced fish as a significant concern. Potential threats to natural steelhead from hatchery programs include (1) mortality of natural steelhead in fisheries targeting hatchery origin fish, (2) competition for prey and habitat, (3) predation by hatchery origin fish on younger natural fish, (4) disease transmission, and (5) genetic introgression by hatchery-origin fish that spawn naturally and interbreed with local natural populations. Overall, impacts from hatcheries continue to be an ongoing threat to this DPS. The life-history diversity of the DPS is mostly unknown, as very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.

In its latest 5-year status review, NMFS determined that the CCV steelhead DPS should remain classified as threatened. However, NMFS (2011a) determined that the status of the CCV steelhead DPS had worsened since the previous review (Good et al. 2005), and that the DPS faces an even greater extinction risk (National Marine Fisheries Service 2011a). This review found that the decline in natural production of steelhead had continued unabated since the 2005 status review, and the level of hatchery influence on the DPS corresponds to a moderate risk of extinction (National Marine Fisheries Service 2011a). As a result, NMFS recommended that its status be reassessed in 2–3 years if the DPS did not positively respond to improved environmental conditions and management actions.

Drought conditions are causing increased stress on steelhead populations in the form of low flows reducing rearing and migratory habitats, above-normal water temperatures affecting survival, and likely higher-than-normal predation on juvenile steelhead. Steelhead survival is expected to be low in 2015 in all tributaries and migratory pathways and is likely to result in a smaller returning year class of steelhead from those juvenile steelhead emigrating this year (State Water Resources Control Board 2015).

4.5.4 Green Sturgeon, Southern DPS

There are two DPSs of North American green sturgeon: the Northern DPS, which includes all populations in the Eel River and northward; and the Southern DPS, which includes all populations south of the Eel River. The Northern DPS currently spawns in the Klamath River in California and the Rogue River in Oregon, and is listed as a Species of Concern (69 FR 19975;

April 15, 2004). Only the Southern DPS is found in the Delta and the Sacramento River and its tributaries.

In its final rule to list the Southern DPS as threatened (71 FR 17757; April 7, 2006), NMFS cited threats of concentration of the only known spawning population into a single river (Sacramento River), loss of historical spawning habitat, mounting threats with regard to maintenance of habitat quality and quantity in the Delta and Sacramento River, and an indication of declining abundance based upon salvage data at the State and Federal salvage facilities. Included in the listing are green sturgeon originating from the Sacramento River basin, including the spawning population in the Sacramento River and green sturgeon living in the Sacramento River, the Delta, and the San Francisco Estuary.

On September 8, 2008, NMFS proposed critical habitat for the Southern DPS (73 FR 52084). NMFS made a final critical habitat designation for the Southern DPS on October 9, 2009 (74 FR 52300). Designated areas include the Sacramento River, lower Feather River, and lower Yuba River; the Delta; and Suisun, San Pablo, and San Francisco Bays (Figure 4.A.4-2 in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*). The PBFs of Southern DPS critical habitat are discussed in Appendix 4.A, Section 4.A.4.3, *Critical Habitat*. NMFS (2009: 134) concluded that critical habitat for the Southern DPS is degraded over its historical condition, and that it does not provide the full extent of conservation values necessary for the recovery of the species, particularly in the upstream riverine habitat. The types of critical habitat degradation that have occurred are similar to those described previously for winter-run and spring-run Chinook salmon, and are also described generally in Appendix 4.A, Section 4.A.4.4, *Threats and Stressors*. NMFS (2009: 134) noted that alterations to critical habitat in the Delta also may have a particularly strong impact on the survival and recruitment of juvenile green sturgeon because of the protracted rearing time in the Delta and estuary.

The primary threat to the Southern DPS is the reduction in habitat and spawning area due to dams (such as Keswick, Shasta, and Oroville). The Anderson-Cottonwood Irrigation District irrigation dam is not thought to be passable to green sturgeon and could possibly block access to 15% of the remaining spawning habitat in the Upper Sacramento River. Spawning is limited to one population in the Sacramento River, making green sturgeon highly vulnerable to catastrophic events. Continuing threats include migration barriers, insufficient flow, increased water temperatures, juvenile entrainment in water export facilities, nonnative forage species, competitors, predators, poaching, pesticides and heavy metals, and local harvest (Biological Review Team 2005). As long-lived, late maturing fish that spawn periodically, green sturgeon are particularly susceptible to threats from overfishing. Green sturgeon are regularly caught in the sport, commercial, and tribal fisheries, particularly in Oregon and Washington commercial fisheries.

Relatively little is known about the North American green sturgeon, particularly those that spawn in the Sacramento River (The Nature Conservancy et al. 2008). Adult populations in the less-altered Klamath and Rogue Rivers are fairly constant, with a few hundred spawning adults typically harvested annually by tribal fisheries. In the Sacramento River, the green sturgeon population is believed to have declined over the last two decades, with current spawning run size estimated to be in the hundreds (Biotelemetry Laboratory 2014). In the Feather and Yuba rivers, green sturgeon sightings are extremely limited. Spawning in these watersheds is rarely recorded, although spawning in the Feather River was documented in 2011 (Seesholtz et al. 2012). In the San Joaquin and South Fork Trinity Rivers, the green sturgeon population appears to be extirpated.

Green sturgeon juveniles, subadults, and adults are widely distributed in the Delta and estuary areas including San Pablo Bay (Beamesderfer et al. 2004). The Delta serves as a migratory corridor, feeding area, and juvenile rearing area for North American green sturgeon in the southern DPS. Adults migrate upstream primarily through the western edge of the Delta into the lower Sacramento River between March and June (Adams et al. 2002). Larvae and post-larvae are present in the lower Sacramento River and North Delta between May and October, primarily in June and July (California Department of Fish and Game 2002). Juvenile green sturgeon have been captured in the Delta during all months of the year (Borthwick et al. 1999; California Department of Fish and Game 2002). Catches of 1- and 2-year-old Southern DPS green sturgeon on the shoals in the lower San Joaquin River, at the CVP/SWP fish salvage facilities, and in Suisun and San Pablo Bays, indicate that some fish rear in the estuary for at least 2 years (California Department of Fish and Game 2002). Larger juvenile and subadult green sturgeon occur throughout the estuary, possibly temporarily, after spending time in the ocean (California Department of Fish and Game 2002; Kelly et al. 2007). Green sturgeon have been observed throughout the action area at various life stages in sample data from young-of-the-year collected in spring and summer at Red Bluff Division Dam in the Sacramento River, juveniles salvaged from CVP/SWP water projects, and subadults sampled by the California Department of Fish and Wildlife in San Pablo Bay. Adult green sturgeon have been documented in the Yolo Bypass, but these individuals usually end up stranded against the Fremont Weir (Thomas et al. 2013), and if not rescued, could have population effects.

The Southern DPS is at substantial risk of future population declines (Adams et al. 2007). The potential threats faced by the green sturgeon include enhanced vulnerability due to the reduction of spawning habitat into one concentrated area on the Sacramento River; lack of good empirical population data; vulnerability of long-term cold water supply for egg incubation and larval survival; loss of juvenile green sturgeon to entrainment at the project fish collection facilities in the South Delta and agricultural diversions within the Sacramento River and Delta systems; alterations of food resources due to changes in the Sacramento River and Delta habitats; and exposure of juvenile, sub-adult, and adult life stages to various sources of contaminants throughout the basin.

Modifications to flow and water quality are not likely to reduce riverine or through-Delta survival of juvenile green sturgeon (State Water Resources Control Board 2015). Modification of flows from April through May have the possibility of delaying migration of juvenile, sub-adult and adult green sturgeon (State Water Resources Control Board 2015).

Effects of low flow on green sturgeon likely plays an important role in population performance, and although the mechanism is not completely understood, the NMFS 2002 and 2005 status reviews documented it as a potential threat to the viability of the Southern DPS of green sturgeon (Adams et al. 2002; National Marine Fisheries Service 2005).

4.5.5 Killer Whale, Southern Resident DPS

Three distinct forms of killer whales, termed residents, transients, and off shores, are recognized in the northeastern Pacific Ocean. Resident killer whales in U.S. waters are distributed from Alaska to California, with four distinct communities recognized: Southern, Northern, Southern Alaska, and Western Alaska (Kahn et al. 2002, 2004). Of these, only the Southern Resident DPS is listed as endangered under the ESA.

NMFS listed the Southern Resident killer whale DPS as endangered under the ESA on November 18, 2005 (70 FR 69903). Their range in the Northeastern Pacific Ocean overlaps with other that of the transient, resident, and offshore populations. The Southern Resident DPS consists of three pods designated J, K and L, each containing 25, 19, and 35 members, respectively (Center for Whale Research 2015). These pods generally spend late spring, summer, and fall in inland waterways of Washington State and British Columbia. They are also known to travel as far south as central California and as far north as the Queen Charlotte Islands. Winter and early spring movements are largely unknown for this DPS.

NMFS designated critical habitat for the Southern Resident DPS under the ESA on November 29, 2006 (71 FR 69054). NMFS identified the following PBFs essential for conservation of the Southern Resident DPS: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow migration, resting, and foraging. The critical habitat designation includes three specific marine areas of Puget Sound, Washington, but does not include any areas in California (Appendix 4.A, *Status of the Species and Critical Habitat Accounts*).

As discussed in the original listing notice (70 FR 69903 November 18, 2005) the three main human-caused factors that may continue to impede the recovery of this species and have affected the Southern Resident DPS population are contaminants, vessel traffic, and reductions in prey availability. Southern Resident DPS are thought to rely heavily upon salmon as their main source of prey (about 96% of their diet) throughout the areas and times for which reliable data on prey consumption is available (Ford and Ellis 2006). Studies have indicated that Chinook salmon generally constitute a large percentage of the Southern Resident DPS diet, with some indications that Chinook are strongly preferred at certain times in comparison to other salmonids (Ford and Ellis 2006; Hanson et al. 2010). Results have also suggested that Southern Residents are consuming Chinook salmon from ESUs from California to British Columbia (Hanson et al. 2010). The historical abundance of Southern Residents was estimated based on genetic data to have ranged from 140 to 200 individuals (Kahn et al. 2002; National Marine Fisheries Service 2008). The population was depleted by live captures for aquarium programs during the 1960s and 1970s (Balcombe et al. 1982;). Following a steep decline of 20% between 1996 and 2001 (from 97 whales to 78) (Krahn et al. 2002, 2004), the population was listed as endangered in the United States and Canada. As of summer 2015, the population totaled 81 individuals (Center for Whale Research 2015). Because the population is small and the probability of quasi-extinction[9]

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[9] Quasi-extinction is defined as the stage at which 10 or fewer males or females remain, or a threshold from which the population is not expected to recover (National Marine Fisheries Service 2009).

is sufficiently likely, NMFS (2008) has determined that representation from all three pods is necessary to meet biological criteria for Southern Resident DPS downlisting and recovery.

Many Chinook salmon populations have declined substantially from historical levels of abundance and are listed as threatened or endangered under the ESA. Drought conditions will only exacerbate problems that already exist inland and in the coastal ocean, leading to less prey resources for killer whales. Studies have shown that whales travelled over a greater area and their movement patterns were more complex in the late 1990s, when prey availability was low. Researchers have found that survival and birth rates in the Southern Resident DPS of killer whale population are correlated with coast-wide abundance of salmon. High levels of legacy pollutants (dichlorodiphenyltrichloroethane [DDT], polychlorinated biphenyls [PCBs], and polybrominated diphenyl ethers [PBDEs]) may be keeping the whale population from increasing at the rate required for recovery of the population. Increased energy expenditure or insufficient prey may result in poor nutrition, which could lead to reproductive or immune effects or, if severe enough, death. A reduction in prey is also likely to work in concert with other threats to produce an adverse effect. For example, insufficient prey could cause whales to rely upon their fat stores, which contain high contaminant levels, impairing reproductive success or compromising immune function. Searching more aggressively for prey will increase the probability of encountering vessel traffic, which is known to interfere with the ability to communicate and find food, affecting their health and survival.

4.5.6 Delta Smelt

The description of the environmental baseline for Delta Smelt was adapted from the environmental baseline presented in the Biological Assessment of Potential Effects on Listed Fishes from the West False River Emergency Drought Barrier Project (ICF International 2015).

4.5.6.1 Status of the Species within the Action Area

The Action Area functions as a migratory corridor, as rearing habitat, and as spawning habitat for Delta Smelt. A summary of the general spatial distribution of life stages was provided by Merz et al. (2011), and is shown in Table 4-6. Given the long list of stressors discussed in the USFWS (2008) OCAP BO, the range-wide status of the Delta Smelt is currently declining. Although there was a spike in the population in 2011, the declining abundance of Delta Smelt is clear (Figure 4-6). The 2014 fall midwater trawl index was the second lowest ever; the 2015 index was the lowest ever. The 2016 Spring Kodiak Trawl index is the lowest since the survey began in 2002, and the 2015 20-mm Survey Index is also the lowest since the survey began in 1995. The 2015 Summer Townet Survey age–0 Delta Smelt abundance index is 0.0, which is the lowest index reported in the history of this survey (implemented in 1959) and is consistent with the downward trend observed in recent years (Figure 4-6). This abundance trend has been influenced by multiple factors, some of which are affected or controlled by CVP and SWP operations and others that are not (U.S. Fish and Wildlife Service 2008:189). Although long-term decline of the Delta Smelt was strongly affected by ecosystem changes caused by non-indigenous species invasions and other factors influenced but not controlled by CVP and SWP operations, the CVP and SWP have played an important direct role in that decline, especially in terms of entrainment and habitat-related impacts that add

Table 4-6. Average Annual Frequency (Percent) of Delta Smelt Occurrence by Life Stage, Interagency Ecological Program Monitoring Program, and Region

Region	Average Annual Frequency (%)										
Life Stage:	**Larvae (<15 mm)**	**Sub-Juvenile (≥15, <30 mm)**		**Juvenile (30–55 mm)**			**Sub-Adult (>55 mm)**	**Mature Adults (>55 mm)**		**Pre-Spawning[a]**	**Spawning[a]**
Monitoring Program:	**20-mm**	**20-mm**	**STN**	**20-mm**	**STN**	**FMWT**	**FMWT**	**BS**	**BMWT**	**KT**	**KT**
Years of Data Used:	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2006**	**2002–2009**	**2002–2009**
Time Period:	**Apr–Jun**	**Apr–Jul**	**Jun–Aug**	**May–Jul**	**Jun–Aug**	**Sep–Dec**	**Sep–Dec**	**Dec–May**	**Jan–May**	**Jan–Apr**	**Jan–May**
San Francisco Bay	NS	NS	NS	NS	NS	NS	NS	0.0	0.0	NS	NS
West San Pablo Bay	NS	NS	NS	NS	NS	0.2	0.0	0.0	1.2	NS	NS
East San Pablo Bay	0.0	1.0	0.0	2.8	3.6	0.7	0.6	NS	2.7	NS	NS
Lower Napa River	7.3	7.7	3.3	13.3	14.0	1.7	0.8	NS	NS	14.3	11.8
Upper Napa River	11.6	21.2	NS	12.0	NS	NS	NS	NS	NS	NS	NS
Carquinez Strait	5.7	9.3	1.1	24.4	33.7	1.9	3.3	NS	5.4	16.7	0.0
Suisun Bay (SW)	17.8	18.3	1.3	17.5	26.9	4.3	4.3	NS	4.3	23.3	5.6
Suisun Bay (NW)	2.2	8.9	1.1	21.7	34.8	7.3	10.0	NS	8.7	23.3	5.6
Suisun Bay (SE)	19.5	24.9	11.0	20.9	45.7	11.0	12.1	NS	6.5	28.3	6.9
Suisun Bay (NE)	17.8	19.2	33.6	29.7	66.7	20.3	29.3	NS	28.3	48.3	13.9
Grizzly Bay	16.3	27.6	17.9	42.9	72.8	15.0	19.6	NS	30.4	30.0	5.6
Suisun Marsh	21.4	33.6	14.2	18.5	19.2	22.8	27.2	NS	NS	62.0	23.1
Confluence	35.7	41.6	25.7	29.2	36.1	20.2	24.5	1.8	17.4	30.0	10.4
Lower Sacramento River	16.5	37.0	43.3	26.2	55.5	22.9	37.1	NS	18.8	54.4	17.8
Upper Sacramento River	10.8	8.2	1.3	0.0	0.0	2.7	8.0	5.8	16.7	21.7	15.3
Cache Slough and Ship Channel	17.2	47.3	NS	54.3	NS	9.8	26.7	NS	NS	33.9	21.1
Lower San Joaquin River	28.0	24.5	4.1	5.1	5.6	2.6	3.5	0.9	12.6	30.6	9.7
East Delta	14.6	8.8	0.0	1.2	0.0	0.0	0.0	1.6	NS	5.7	2.3
South Delta	18.4	10.8	0.0	1.4	0.3	0.0	0.0	0.3	NS	7.1	1.1
Upper San Joaquin River	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	NS
Sacramento Valley	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	NS

	Average Annual Frequency (%)										
Region Life Stage:	**Larvae (<15 mm)**	**Sub-Juvenile (≥15, <30 mm)**		**Juvenile (30–55 mm)**			**Sub-Adult (>55 mm)**	**Mature Adults (>55 mm)**		**Pre-Spawning[a]**	**Spawning[a]**
Monitoring Program:	**20-mm**	**20-mm**	**STN**	**20-mm**	**STN**	**FMWT**	**FMWT**	**BS**	**BMWT**	**KT**	**KT**
Years of Data Used:	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2009**	**1995–2006**	**2002–2009**	**2002–2009**
Time Period:	**Apr–Jun**	**Apr–Jul**	**Jun–Aug**	**May–Jul**	**Jun–Aug**	**Sep–Dec**	**Sep–Dec**	**Dec–May**	**Jan–May**	**Jan–Apr**	**Jan–May**

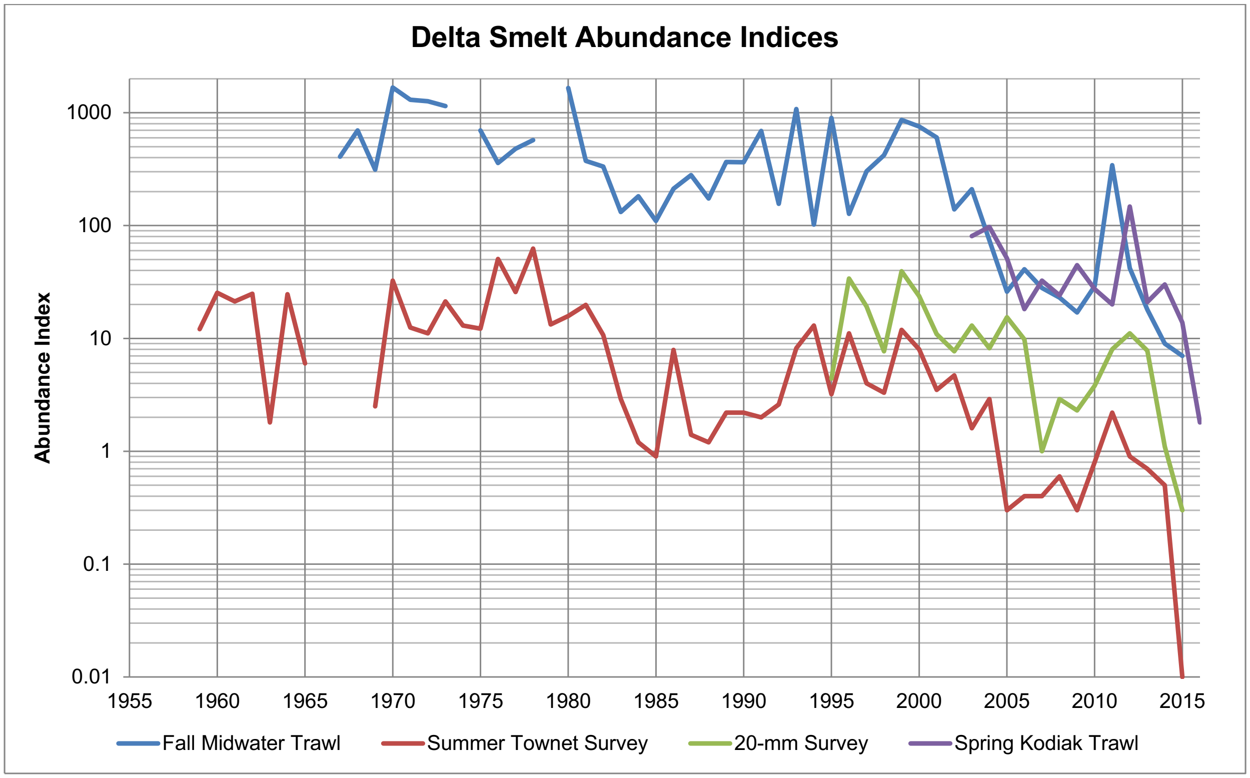
[a] Gonadal stages of male and female Delta Smelt found in Spring Kodiak Trawl database were classified by California Department of Fish and Wildlife following Mager (1996). Descriptions of these reproduction stages are available at: <http://www.dfg.ca.gov/delta/data/skt/eggstages.asp>.

Mature adults, pre-spawning: Reproductive stages[a]: females 1–3; males 1–4.

Mature adults: spawning: Reproductive stages[a]: females 4; males 5.

20-mm = 20-millimeter Townet
BMWT = Bay Midwater Trawl.
BS = Beach Seine.
FMWT = Fall Midwater Trawl.
Source: Merz et al. 2011

KT = Kodiak Trawl.
NS = indicates no survey conducted in the given life stage and region.
SKT = Spring Kodiak Trawl.
STM = Summer Tow-Net.



Source: ftp://ftp.delta.dfg.ca.gov/Delta%20Smelt/, https://www.wildlife.ca.gov/Regions/3, and http://www.dfg.ca.gov/delta/data/skt/bibliography.asp Accessed: 10/27/2015 and 6/29/2016 .Note: The Summer Townet Survey index for 2015 is 0.0, but is shown as 0.01 to allow plotting on the logarithmic scale.

Figure 4-6. Delta Smelt Abundance Indices

increments of additional mortality to the stressed Delta Smelt population (U.S. Fish and Wildlife Service 2008: 189). Past CVP and SWP operations have been one of the factors influencing Delta Smelt abiotic and biotic habitat suitability, health, and mortality (U.S. Fish and Wildlife Service 2008: 189).

While CVP and SWP operations and introduction of non-native species into the Delta have contributed to the long term decline in Delta Smelt abundance, other factors may be influencing trends in abundance as well. Climate change has become an ever-growing concern as it relates to potential effects to listed fish species. Increasing air temperature, sea level rise, and increased variability in hydrology are predicted to occur under future climatic conditions. Changes in each of these can influence the extent, availability, and quality of Delta Smelt habitat, which may affect the distribution of Delta Smelt in the estuary and other biological characteristics such as the timing of the spawning window (Brown et al. 2013). In particular, drought conditions, which can amplify various Delta Smelt stressors in the Delta, are expected to occur more frequently in the future. Some of these effects have already been observed during the current drought.

As described in DWR and Reclamation's March 2015 Biological Review for Endangered Species Act Compliance with the WY 2015 Drought Contingency Plan April through September Project Description, written as part of the March 24 Temporary Urgency Change Petition to SWRCB[10], research presented at the Interagency Ecological Program (IEP) workshop (March 18–20, 2015) showed that the current drought impacts Delta Smelt in a number of ways. The following is adapted from the summary in the Biological Review, which provides references to the specific presentations providing the information presented below[11]. The drought can reduce the area of habitat to which Delta Smelt migrate or disperse for spawning and reduce food availability for adults and for juveniles moving there to rear. Drought can indirectly impact reproductive potential by lowering the number of oocytes females produce. This is brought about by a link between dryer hydrological conditions and elevated water temperature, which may increase metabolic needs, resulting in less energy available for oocyte production. Generally, water temperatures in the Delta are driven by ambient atmospheric conditions (e.g., air temperature and insolation), although water temperatures at shorter time and smaller spatial scales can also be influenced by riverine flow (Wagner et al. 2011). Warming water temperature shortens the spawning window, which causes fewer clutches to be produced per female. Both of these mechanisms combine with low adult abundance to impair population fecundity. Lower outflow also tends to reduce turbidity. Delta smelt use turbid water to avoid predators and they also use it as foraging habitat. Otolith analysis has revealed that since 1999, Delta Smelt experienced an 8% decline in growth between dry and wet years and spawning is more successful in the north Delta during drought. The quality of Delta Smelt habitat is further compromised by concentrations of herbicides such as diuron and hexazinone, which may be present in higher concentrations during low outflow conditions (due to a limited dilution effect) and have synergistic effects that reduce food availability for juveniles. Furthermore, warm, slow

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[10] Available at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/2015/biorev2_aprsep.pdf. Accessed: 10/27/2015. The sources of the specific statements are provided in that document.

[11] Additional information to that presented in the Biological Review is provided, with appropriate citation as necessary.

moving water characterized by drought promotes conditions in which parasites like Ich (*Ichthyophthirius multifiliis*) and cyanobacteria like *Microcystis* thrive. Ich causes skin lesions to form on a variety of fish and has an increased prevalence among captive Delta Smelt above 17°C. *Microcystis* is a cyanobacterium that can produce toxic hepatotoxins that became established throughout the Delta in 2000; it thrives in water above 17°C with low turbulence. This highly toxic cyanobacterium is known to kill phytoplankton, zooplankton and compromise fish health. *Microcystis* is typically observed during the late summer and is found in the south Delta, east Delta, and lower San Joaquin River subregions. However, *Microcystis* blooms extended into December of 2014, presumably due to higher water temperatures associated with the drought. Finally, the abundance of non-native Delta Smelt predators, such as black bass, increased in the Delta in response to the drought in 2014, mainly because it expanded their preferred habitat. The same pattern was found for non-native competitors, such as clams like *Corbicula*, which seem to be expanding throughout the Delta despite the drought.

4.5.6.2 Status of Critical Habitat within the Action Area

The existing physical appearance and hydrodynamics of the Action Area have changed substantially from the environment in which native fish species like Delta Smelt evolved. The Action Area once consisted of tidal marshes with networks of diffuse dendritic channels connected to floodplains of wetlands and upland areas (Moyle 2002). The in-Delta channels were further connected to drainages of larger and smaller rivers and creeks entering the Action Area from the upland areas. In the absence of upstream reservoirs, freshwater inflow from smaller rivers and creeks and the Sacramento and San Joaquin Rivers were highly seasonal and more strongly and reliably affected by precipitation patterns than they are today. Consequently, variation in hydrology, salinity, turbidity, and other characteristics of the Delta aquatic ecosystem was greater in the past than it is today (Kimmerer 2002b). For instance, in the early 1900s, the location of maximum salinity intrusion into the Delta during dry periods varied from Chipps Island in the lower Delta to Stockton along the San Joaquin River and Merritt Island in the Sacramento River (DWR Delta Overview[12]). Operations of upstream reservoirs have reduced spring flows while releases of water for Delta water export and increased flood control storage have increased late summer and fall inflows (Knowles 2002), though Delta outflows have been increasingly constrained during late summer-fall over the past several decades (Cloern and Jassby 2012). The USFWS (2008) OCAP BO aimed to ensure greater variability in Delta outflow and the extent of the low salinity zone by inclusion of an RPA action setting X2 and reservoir operation requirements in fall of wet and above normal water years.

Channelization, conversion of Delta islands to agriculture, and water operations have substantially changed the physical appearance, water salinity, water clarity, and hydrology of the Action Area. As a consequence of these changes, most life stages of the Delta Smelt are now distributed across a smaller area than historically (Arthur et al. 1996, Feyrer et al. 2007). Wang (1991) noted in a 1989 and 1990 study of Delta Smelt larval distribution that, in general, the San Joaquin River was used more intensively for spawning than the Sacramento River. Though not restricting spawning per se, based on particle tracking modeling, export of water by the CVP and SWP would usually restrict reproductive success of spawners in the San Joaquin River by

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[12] http://baydeltaoffice.water.ca.gov/sdb/tbp/deltaoverview/delta_overview.pdf

entraining most larvae during downstream movement from spawning sites to rearing areas (Kimmerer and Nobriga 2008). Prior to the USFWS (2008) OCAP BO, there was one, non-wet year exception to this generalization: in 2008, Delta Smelt entrainment was managed under a unique system of restrictions imposed by the Court in NRDC v Kempthorne. The USFWS (2008) OCAP BO subsequently limited CVP/SWP operations to reduce entrainment of adult, larval, and early juvenile Delta Smelt.

As described in recent BOs such as the USFWS (2014) BO on the Georgiana Slough Floating Fish Guidance Structure, a number of factors in addition to SWP/CVP have affected Delta Smelt critical habitat in the Action Area, e.g., contaminants and *Microcystis*, both of which may affect Delta Smelt prey. Introduced species have also impacted the Action Area in several ways including added predation to adult and juvenile Delta Smelt from introduced piscivorous fishes, changes in prey composition due to the introduction of several copepod species, added competition for food resources from introduced filter feeders, and submerged aquatic vegetation (particularly *Egeria densa*) that traps sediment and provides habitat for introduced piscivorous fishes. The USFWS (2008) OCAP BO included an RPA action to restore 8,000 acres of tidal habitat in order to mitigate for Delta productivity lost because of the hydrodynamic influence of the south Delta export facilities. Additional restoration actions are planned under the State's EcoRestore program, which are likely to provide benefits to Delta Smelt habitat conditions.

In addition to the general status of critical habitat in the action area described above, further information on drought-related impacts was provided in the Section 4.5.6.1, *Status of the Species within the Action Area*.

4.5.7 Riparian Brush Rabbit

A habitat assessment was performed on December 18, 2015 for the riparian brush rabbit at the proposed Head of Old River Gate construction site. No suitable habitat for the riparian brush rabbit was found at or near the proposed Head of Old River Gate construction area. See Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.5.7, *Head of Old River Gate Habitat Assessment*, for complete details. Riparian brush rabbit (*Sylvilagus bachmani riparius*) was listed as endangered under the ESA on February 23, 2000 (65 FR 8881). It is also listed as endangered under the CESA. Critical habitat has not been designated for riparian brush rabbit.

One of eight subspecies of brush rabbit in California, the riparian brush rabbit occupies a range that is disjunct from other brush rabbits, near sea level on the northwestern floor of the San Joaquin Valley (U.S. Fish and Wildlife Service 1998). Its historical distribution may have extended along portions of the San Joaquin River and its tributaries on the valley floor from at least Stanislaus County to the Sacramento–San Joaquin River Delta (Delta) (Orr 1935 in U.S. Fish and Wildlife Service 1998). Populations are known to have historically occurred in riparian forests on the valley floor along the San Joaquin and Stanislaus Rivers and some tributaries of the San Joaquin River (U.S. Fish and Wildlife Service 1998). One population estimate within this historical range was about 110,000 individuals (U.S. Fish and Wildlife Service 1998).

Remaining populations of riparian brush rabbits occur in only two locations in San Joaquin County. One population is at an approximately 258-acre (104-hectare) patch in Caswell

Memorial State Park on the Stanislaus River immediately southeast of the action area. The other population is located in several small, isolated or semi-isolated patches immediately west and southwest of Lathrop, totaling approximately 270 acres (109 hectares) along Paradise Cut and Tom Paine Slough and channels of the San Joaquin River in the south Delta (Kelly, pers. comm. 2015; Kelly et al. 2011; Williams et al. 2002), see Figure 6.2-1 for the locations of riparian brush rabbit occurrences relative to the PA. In addition, a captive breeding program has established a population on Faith Ranch, which is owned by the winemaking Gallo family (U.S. Fish and Wildlife Service 2007c).

The primary threats to the survival of riparian brush rabbit are the limited extent of its existing habitat, extremely low numbers of individual animals, and few extant populations. The small sizes of its remaining populations, the localization of the behavior of the subspecies, and the highly limited and fragmented nature of remaining habitat restrict natural dispersal and put the species at risk from a variety of environmental factors. The existing population sizes do not meet the minimum population sizes that Thomas (1990) suggests are required to assure the medium- to long-term persistence of birds or mammals (i.e., the geometric mean of population size should be 1,000 for species with normally varying numbers and about 10,000 for species exhibiting a high variability in population size). Therefore, the species is considered at a high risk of imminent extinction from several consequent threats related to population genetics, demographics, and environmental stochasticity (U.S. Fish and Wildlife Service 1998).

The south Delta population (Paradise Cut and Tom Paine Slough) of riparian brush rabbit is located south of the action area, near Mossdale (See Figure 6.2-1). This area is on private land, and watercourses are managed for flood control, not wildlife management. Surveys conducted by the Endangered Species Recovery Program (ESRP) under contract with DWR have identified the known occurrences of riparian brush rabbit in the action area (see Figure 6.2-1); these surveys are considered incomplete because of lack of property access. However, riparian brush rabbit suitable habitat does not occur in the construction footprint of the Head of Old River (HOR) gate or adjacent area as described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts*, Section 4.A.5.7, *Head of Old River Gate Habitat Assessment*.

4.5.8 San Joaquin Kit Fox

San Joaquin kit fox (*Vulpes macrotis mutica*) was listed as endangered under the ESA on March 11, 1967 (32 FR 4001). It was listed as threatened species under the CESA in 1971. In 2010, USFWS completed a 5-year review for this species, and determined that the San Joaquin kit fox continues to meet the definition of endangered. Critical habitat has not been designated for San Joaquin kit fox.

San Joaquin kit fox historically occurred in alkali scrub/shrub and arid grasslands throughout the level terrain of the San Joaquin Valley floor from southern Kern County north to Tracy in San Joaquin County, and up into more gradual slopes of the surrounding foothills and adjoining valleys of the interior Coast Range (U.S. Fish and Wildlife Service 2010: 1). Currently, the entire range of the San Joaquin kit fox appears to be similar to what it was at the time of the 1998 Recovery Plan; however, population structure has become more fragmented, and at least some of the resident satellite subpopulations, such as those at Camp Roberts, Fort Hunter Liggett, Pixley National Wildlife Refuge (NWR), and the San Luis NWR, have apparently been locally extirpated, and portions of the range now appear to be frequented by dispersers rather than resident animals (U.S. Fish and Wildlife Service 2010: 15).

Habitat loss and fragmentation from urbanization and agricultural expansion are the principal factors in the decline of the San Joaquin kit fox in the San Joaquin Valley (Laughrin 1970; Jensen 1972; Morrell 1975; Knapp 1978). By 1979, an estimated 6.7% of the San Joaquin Valley floor's original native habitat south of Stanislaus County remained untilled and undeveloped (U.S. Fish and Wildlife Service 1983). Cypher et al. (2013) estimated that only 4,267km^2 of high suitable habitat and 5,569km^2 of medium suitable habitat remain, with much of the habitat highly fragmented. The majority of these habitat areas were located in the southern portion of the kit fox range, with 67% and 35% of this high and medium suitable habitat occurring in Kern and San Luis Obispo counties, respectively. In the northern range, continued urbanization, primarily in Contra Costa and Alameda Counties, water storage and conveyance projects, road construction, energy development, and other activities continue to reduce and fragment remaining grassland habitats. These land conversions contribute to kit fox declines through displacement, isolation of remaining populations, creation of barriers to movement, mortality, and a reduction of prey populations (U.S. Fish and Wildlife Service 1998).

4.5.8.1 Occurrences of San Joaquin Kit Fox in the Action Area

Available occurrence data indicates that the density of the San Joaquin kit fox population north of Santa Nella is very low; kit fox in the Northern Range have either experienced extirpation or have fallen below detectable numbers (Clark, et al 2007). The population density north of I-580 along the east coast range foothills is extremely low, if the species has not been extirpated from that area altogether. Orloff et al. (1986) found kit fox in Alameda and San Joaquin counties, but were unable to document the presence of kit foxes in Contra Costa County (Smith, et al 2006).

From 1991 to 1992, Bell and Ralls observed kit foxes at 3 sites in Contra Costa County, and 1 site in San Joaquin County, and a possible kit fox track was recorded at one site that encompassed both Alameda and San Joaquin counties. However, subsequent work in Alameda and Contra Costa counties with baited camera stations on public land and spotlight surveys on roads through potential kit fox habitat found no evidence of kit fox presence, even in areas where they had been documented earlier (Smith, et al 2006).

Smith et. al. (2006) surveyed 213 km within 24 properties in Alameda, Contra Costa, and San Joaquin counties using trained scat detection dogs, a proven effective survey technique for San Joaquin kit fox. Additionally, aircraft surveys were conducted to locate dens. No evidence for kit fox was found in the northern range. The study concluded that kit fox occur in the northern range in extremely low densities or only intermittently, if they have not been extirpated (Smith et al 2006). Currently, kit fox observations in the Northern Range are rare and no populations are known to occur there (Cypher et al 2013).

In February 2003, the Endangered Species Recovery Program surveyed DWR's property using scat detection dogs, including DWR land north of the intake channel, around Clifton Court Forebay, around Banks PP, and along the California Aqueduct to the south extent of Bethany Reservoir. No kit fox sign was observed and no kit fox scats were found.

In 1992 and 1993, DWR staff surveyed a 500 foot corridor from Clifton Court Forebay and Old River and along the South Bay Aqueduct to the city of Fremont. Several hundred burrows large enough to be classified as potential kit fox dens were identified. Using track medium, the burrows were monitored for 3 consecutive days. No kit fox tracks were observed at any of the burrows or anywhere in the alignment, and no other sign of kit fox were observed. (Bradbury, unpubl data).

In 1994, DWR and CDFG completed spotlight and camera surveys around Clifton Court Forebay, along the Banks Pumping Plant intake channel, along the length of the California Aqueduct to Patterson, CA, and along the length of the South Bay Aqueduct through Livermore. Additionally, because culverts are often used as artificial dens, every culvert along the California Aqueduct and Southbay Aqueduct in those same areas were searched for kit fox; culverts occur approximately every 1/10 mile. No San Joaquin kit fox were observed or photographed (Bradbury unpubl data). In Kern County, San Joaquin kit fox are readily observed and photographed along the California Aqueduct, and often use culverts for artificial dens (Bradbury pers obs 1989-2013).

There are limited records of San Joaquin Kit Fox in the CNDDB for the species' northern range, and only 28 records of the species north of I-580/205, which span almost 50 years; many are questionable in reliability relative to location accuracy and identification. Clark et al. 2007 analyzed CNDDB records of San Joaquin kit foxes and their results indicate that many of the records may be misidentification of coyote pups. Most of the records from the northern range are more than 30 years old and were apparently re-creations of recalled occurrences, and at least some have factual errors.

An example of a likely factual error is record #561 from 1987, which states that the fox was observed near a wind generator, but there have been no wind generators in the area delineated for the occurrence. Additionally, only 2 records are of kit fox in agricultural areas (based on occurrence delineation and description of habitat):

1. "1 juvenile kit fox observed during daylight in Jun 1991" in an agricultural field north of the town of Byron (record #575); it is unlikely that a juvenile kit fox would be away from its den at such a young age, especially during the day;
2. One along an Old River levee in 1991 (record #60), based on a print on a track pad; it is unlikely a kit fox would be in a riparian zone almost 3 miles from suitable grassland habitat. Neither record is confirmed by follow-up surveys.

Based on the description of the sighting on number 1, and the location and basis for number 2, both records have a high potential to be identification error.

There are just 5 records for kit fox north of I-580/205 in the last 20 years, although there have been numerous surveys completed during that time. Two records are based on tracks, with no apparent confirmation through follow-up surveys.

Only one record is of kit fox in an area consistent with the project location and habitat type: record #34 adjacent to the Tracy Pumping Plan intake. This record well indicates the likelihood of mistaken records in the CNDDB from observers unfamiliar with the species:

- Observer indicates there were 40 dens in what is approximately a 3 acre area, including approximately 10 “recent dens.”
- Observer notes hearing a “yip”, indicating a kit fox was present.
- Observer concludes that the small area supports a small population of kit fox, for several years.
- Observer cites observations of kit fox by Western Area Power Administration employees.

What the observer is describing is a cluster of holes created by a colony of California ground squirrels, with potentially a coyote or red fox in the area, based on the following.

- The observer is obviously counting holes, not dens. Ten “recent [kit fox] dens” in an area that size is highly unlikely; kit fox are not colonial and dens are spread among very large areas.
- An observer familiar with the species would know that kit fox have a very distinct “roop” call; a “yip” is more characteristic of a red fox or coyote.
- Kit fox are not communal like ground squirrels; the small area would not support a “small population” of kit fox.
- Non-biologists regularly mistake red foxes and young coyotes for kit foxes (pers ob). Red foxes and coyotes are much more likely to be active during the day than kit fox, when workers are likely to see them. Biologists without sufficient experience with kit foxes will also sometimes mistake coyote pups with kit foxes, as coyote pups can look remarkably similar to adult kit foxes (Clark et al. 2007).

On February 4, 2016, DWR staff with kit fox life history expertise surveyed the site; there were approximately 30 burrow holes, and 6 showed signs of recent excavation, but all were too small for kit fox use and were obviously ground squirrel burrows. Canid scats was observed at two locations in the immediate area but were too large for kit fox, and were identified as red fox scat. The conclusion based on the above analysis is that the record is unreliable.

On June 30, 2016, California Department of Fish and Wildlife indicated that some experts believe San Joaquin kit fox may still occur in the action area (pers. comm. Brooke Jacobs).

4.5.8.2 Suitability of Kit Fox Habitat in the Action Area

Kit fox are optimally adapted to arid environments with sparse vegetation. Cypher et al 2013 evaluated habitat in the kit fox range based on habitat use where kit fox populations were robust and persistent. Desert scrub, grassland, and short ruderal grassland had the highest habitat values to the species. Field crops, vineyards, and pasture had low value, as did riparian habitats. Kit fox are unable to use croplands to any significant extent (Warrick, et al 2007). Higher rainfall totals in the Northern Range support higher and increasing densities of competitors and predators such as coyotes, red fox, gray fox and bobcats, which puts the arid habitat-adapted kit fox at a great disadvantage (Orloff et al 1986).

Kit fox in the northern range, if they persist there at all, have large home ranges (USFWS 1998); Cypher suggests this is due to moderate to poor quality habitat available in the region (Cypher 2013). Kit fox family groups require between 1,500 and 2,000 acres of optimal habitat, and considerably more habitat where habitat quality is moderate or poor (Spiegel Bradbury 1992, Cypher et al. 2007); for the entire counties of Contra Costa and Alameda combined, there are less than 5,000 acres of high suitability habitat (Cyper et al. 2013), only enough to support a few family groups of kit fox (Spiegel Bradbury 1992, Cypher et al. 2007), and only if it is contiguous and accessible (Cypher et al. 2013).

The northern range habitat that is usable by kit fox is characterized by medium suitability habitat grasslands which may not be able to sustain populations of kit fox (Cypher 2013). The grassland habitats of the northern range may lack important components needed by kit fox, and this may prevent it from surviving in the region (Clark et al. 2007). Grassland vegetation is often taller and more dense than optimal for kit fox use (Cypher et al. 2013).

Irrigated agricultural fields in northern San Joaquin County were the result of conversion of marsh and riparian forest; kit fox probably did not occupy these irrigated fields to any extent, if at all (Clark et al. 2007). The rocky, clay soils in the Northern Range are not optimal for kit fox denning, typically harder than Southern Range soils; the species relies on enlarging California ground squirrel burrows due to the hard soils (Clark et al. 2007). Orloff found that kit fox use up to 20 or more dens in their home range, so the species would be limited to areas with active ground squirrel colonies (Clark et al. 2007). Additionally, kit fox in the Northern Range rely on California ground squirrels as primary prey (in the Southern Range, where kit fox populations persist, the primary prey is kangaroo rats, which are not present in the Northern Range); California ground squirrels are a diurnal species (kit fox are nocturnal) and not considered an optimal prey species; they are also susceptible to reduced populations from poisoning campaigns (Orloff et al 1986, Clark et al 2007)

Irrigated agricultural lands are typically devoid of kit fox (Warrick et al. 2007, Jensen 1973, Morrell 1975). Cultivated and irrigated agricultural lands may be used as accessory areas adjacent to and in association with expansive natural lands, but kit fox require large blocks of high suitable natural lands and are unable to rely solely on agricultural lands for survival (Cypher et al 2007, 2013). Irrigated and cultivated land limit availability of dens through disking, flooding, and squirrel control (Warrick et al. 2007, Cyper et al. 2007). Dens are a necessity for the species to escape interspecific domination, predation and displacement by coyotes and red fox which are well adapted to use irrigated and cultivated lands, and are primary causes of mortality for kit fox (Orloff et al 1986, Clark et al 2007). Furthermore, cultivated lands have low prey availability for kit fox (Warrick et al. 2007).

Grassland and agricultural habitats common in the Northern Range often have dense vegetation greater than 18 inches high that reduces visibility for the fox and likely increases risk of predation by coyotes and red fox, and thus are avoided by kit fox (Cypher et al. 2007). Non-grazed grasslands in the Northern Range associated with levees, fallow and idle lands have tall, dense vegetation that kit fox would avoid. Vineyards are problematic because of vegetation height, density, lack of visibility in all directions, and force movement in one direction (Cypher et al. 2007).

Significant barriers interfere with kit fox movement north from populated areas, and east and west between fragments of available habitat, including major interstate and other highways, aqueducts and large canals, reservoirs, housing development, dense and or tall agriculture vegetation, utility centers and other human structures with impassable fences (Bradbury, pers obs). High densities of wind generators and associated infrastructure reduce available habitat, prey, and dens (Orloff et al. 1986), and produce extremely loud noise on frequent windy nights that may interfere with kit fox hunting adaptation (ability to hear prey) (Bradbury, pers ob).

If kit fox persist north of I-580/205, they are likely relegated to the large tracts of grazed grassland west of the California Aqueduct where barriers to movement are minimal, increasing their ability to use the large home ranges needed to survive (Orloff et al 1986, Clark et al 2007, Cypher et al 2007, 2013).

The area around the project construction footprint is primarily characterized by unsuitable denning and foraging habitat. The available moderate to high quality habitat is highly fragmented and surrounded by multiple barriers, including numerous waterbodies and waterways, human development and activity areas, high use roadways, and non-traversable (by kit fox) agricultural lands such as vineyards. Much of the naturals lands are characterized by tall and weedy ruderal vegetation, large shrubs, and wetlands. The traversable agricultural lands are irrigated and cultivated, habitats avoided by kit fox.

4.5.9 California Least Tern

The California least tern (*Sternula antillarum browni*) is listed as endangered under both ESA and CESA. The species was listed by the California Fish and Game Commission pursuant to CESA) (Fish and Game Code, Sections 2050 *et seq.)* on June 27, 1971, and by the USFWS pursuant to the ESA on October 13, 1970 (35 FR 8491). The California least tern is also designated as a state fully protected species. Critical habitat has not been designated for this species.

The historical breeding range of the California least tern extends along the Pacific Coast from approximately Moss Landing to the southern tip of Baja California (Grinnell and Miller 1944). However, since about 1970, colonies have been reported north to San Francisco Bay (U.S. Fish and Wildlife Service 2006b). The nesting range in California is somewhat discontinuous as a result of the availability of suitable estuarine shorelines, where California least terns often establish breeding colonies. Marschalek (2006) identified six geographic population clusters along the Pacific Coast in California, including San Diego, Camp Pendleton, Los Angeles/Orange County, Ventura County, San Luis Obispo/Monterey County, and San Francisco Bay. The majority of the California population is concentrated in three counties: San Diego, Orange, and Los Angeles.

Statewide surveys in 2010 estimated a minimum of 6,437 breeding pairs, with about 85% of the breeding colonies occurring in Southern California and only a small percentage (6.3% or 406 breeding pairs) occurring in the San Francisco Bay Area (Marschalek 2011). Statewide, the growth of the breeding population has been dramatic since state and federal listing of the California least tern, from only several pairs in the late 1960s to a current minimum of 6,437 pairs (Marschalek 2011). Marschalek (2011) reported on monitoring activities at six active breeding colonies in the San Francisco Bay Area in 2010, with a total number of breeding pairs estimated at approximately 406.

The loss, degradation, and disturbance of suitable coastal strand and estuarine shoreline habitat are the primary reasons for the historical reduction of California least tern populations. Most extant colonies occur on small patches of degraded nesting habitat surrounded on all sides by human activities. The majority of colony sites are in areas that were incidentally created during development projects. Further expansion and recovery of the California least tern population may require the creation or restoration of habitat (U.S. Fish and Wildlife Service 2006b).

Recently, three California least tern nesting sites have been reported from the vicinity of the action area, Pittsburg Power Plant, Bufferlands, and Montezuma Wetlands (see Figure 6.4-1) (Marschalek 2011). The Pittsburg Power Plant nesting location in Pittsburg is over 15 miles from the nearest water conveyance facility on the very western edge of the action area. This nesting location is not considered successful, in 2010, Marschalek (2011) documented no breeding pairs at this site. This was the third time in the last 4 years that least terns did not nest at this site.

The Bufferlands, a part of the Sacramento Regional Wastewater Treatment Facility, is approximately three miles from the northernmost extent of the water conveyance facility. This site supported one successful breeding pair for three years (2009, 2010, and 2011) (Marschalek 2010 and 2011; Frost 2013). In 2012, one breeding pair created two unsuccessful nests and in 2013, no nesting was attempted (Frost 2014). There are no breeding records beyond 2013. Because this site hosted only one nesting pair, it is not considered a colony.

California least terns have nested at the Montezuma Wetlands on the eastern edge of Suisun Marsh near Collinsville since 2006. This colony is over 15 miles from the nearest covered activity location. This colony site was unintentionally created as part of a wetlands restoration project that requires increasing the elevation of certain areas prior to flooding (Marschalek 2008). A pile of sand and shells, formed during excavation of the wetland restoration site, attracted terns to the site, which to date has prevented completion of the restoration project. Marschalek (2011) reports 23 breeding pairs (0.036%), 17 nests, and at least five fledglings from this breeding colony in 2010.

There is one record of a California least tern foraging in the Clifton Court Forebay from 1994 (Yee et al. 1995). However, California least tern is not expected to be foraging at the forebay because it is 20 miles from the nearest nesting site (Pittsburg), which is currently not supporting breeding.

The action area is on the eastern fringe of the more successful breeding area of South San Francisco Bay. The locations of current or historic colonies are greater than 2 miles from construction areas, the typical distance California least terns will travel from their colonies to forage (Atwood and Minsky 1983). For this reason, it is very unlikely that California least terns will forage in or near the water conveyance facility footprint.

4.5.10 Western Yellow-billed Cuckoo

The Western distinct population segment (DPS) of the yellow-billed cuckoo (*Coccyzus americanus occidentalis*) was listed as threatened under the ESA on October 2, 2014 (79 FR 59991-60038). Western yellow-billed cuckoo is also listed as an endangered species under the CESA.

The historical distribution of the western yellow-billed cuckoo extended throughout the Central Valley, where Belding (1890) still considered the species common. In the mid-1940s, Grinnell and Miller (1944) still considered the Central Valley distribution to extend from Bakersfield to Redding.

Currently, the only known breeding populations of western yellow-billed cuckoo are in several disjunct locations in California, Arizona, and western New Mexico (Halterman 1991; Johnson *et al.* 2007; Dettling *et al.* 2015; Stanek 2014; Parametrix Inc. and Southern Sierra Research Station 2015). Yellow-billed cuckoos winter in South America from Venezuela to Argentina (Hughes 1999; Sechrist *et al.* 2012) after a southern migration that extends from August to October (Laymon 1998). They migrate north and arrive at California breeding grounds between May and July, but primarily in June (Gaines and Laymon 1984; Hughes 1999; 78 FR 61621).

Studies conducted in 1986 and 1987 indicate that at that time there were approximately 31 to 42 pairs in California (Laymon and Halterman 1987). While a few occurrences have been detected elsewhere recently, including near the Eel River, the only locations in California that currently sustain breeding populations include the Colorado River system in Southern California, the South Fork Kern River east of Bakersfield, and isolated sites along the Sacramento River in California just north of the action area (See Figure 2A.25-1 in California Department of Water Resources 2013a) (Laymon and Halterman 1989; Laymon 1998; Halterman 2001; Hammond 2011; Dettling *et al.* 2014; Stanek 2014; Parametrix Inc. and Southern Sierra Research Station 2015). In 2013, there were two unconfirmed audible occurrences along the American River Parkway approximately 5 miles from the action area. These two occurrences were less than 5 miles apart along the river and heard on the same day (EBird 2015). In 2015 there was a confirmed visual occurrence along the American River located in proximity to both the 2013 audible occurrences and approximately 5 miles from the action area (EBird 2015).

Designation of critical habitat for the Western DPS of yellow-billed cuckoo was published in the Federal Register on August 15, 2014 (57 FR 48547-48652). There is no designated critical habitat for the Western DPS of yellow-billed cuckoo in the action area.

Historical declines of the western yellow-billed cuckoo are attributed to the removal of riparian forests in California for agricultural and urban expansion. Habitat loss and degradation continue to be the most significant threats to remaining populations. Habitat loss continues as a result of bank stabilization and flood control projects, urbanization along edges of watercourses, agricultural activities, and river management that alter flow and sediment regimes. Nesting cuckoos are also sensitive to habitat fragmentation that reduces patch size (Hughes 1999). Pesticide use associated with agricultural practices may affect behavior and cause death or potentially affect prey populations (Hughes 1999). Predation is a significant source of nest failures, which have been recorded at 80% in some areas (Hughes 1999). Fragmentation of occupied habitats could make nest sites more accessible and more vulnerable to predation. Nestlings and eggs are vulnerable to predation by snakes, small mammals, and birds.

While there are only two historical records in the action area (California Department of Fish and Wildlife 2013), the species is known to have been historically common in riparian habitat throughout the Central Valley, from Kern County north to Redding (Laymon 1998) (see Figure 2A.25-2 in California Department of Water Resources 2013a).

There are no recently confirmed western yellow-billed cuckoo breeding locations in the action area. In summer 2009, DWR detected one and possibly two yellow-billed cuckoos in a remnant patch of riparian forest near Delta Meadows (Delta Habitat Conservation and Conveyance Program 2011). However, breeding status was not confirmed. The two historic sightings and the two recent sightings of yellow-billed cuckoo near the action area are presumed to be migrating birds.

Most riparian corridors in the action area do not support sufficiently large riparian patches or the natural geomorphic processes that provide suitable cuckoo breeding habitat (Greco 2013); however, the species likely continues to migrate along the Sacramento River and other drainages to northern breeding sites in the Sutter Basin and Butte County. Several remnant riparian patches near Mandeville and Medford Islands provide suitable riparian vegetation for cuckoos, but may not provide sufficiently large patch size to support breeding cuckoos.

4.5.11 Giant Garter Snake

Giant garter snake (*Thamnophis gigas*) was listed as threatened under the ESA on October 20, 1993 (58 FR 54033). Giant garter snake is also listed as threatened under the CESA. The *Draft Recovery Plan for the Giant Garter Snake* was completed in 1999 (U.S. Fish and Wildlife Service 1999b) and a 5-year review was completed in 2012 (U.S. Fish and Wildlife Service 2012). USFWS is currently preparing a revised draft recovery plan for the giant garter snake. Critical habitat has not been designated for giant garter snake.

Occurrence records indicate that giant garter snakes are distributed in 13 unique population clusters coinciding with historical flood basins, marshes, wetlands, and tributary streams of the Central Valley (Hansen and Brode 1980; Brode and Hansen 1992; U.S. Fish and Wildlife Service 1999b). These populations are isolated, without protected dispersal corridors to other adjacent populations. USFWS recognizes these 13 extant populations (58 FR 54053) as including Butte Basin, Colusa Basin, Sutter Basin, American Basin, Yolo Basin-Willow Slough, Yolo Basin-Liberty Farms, Sacramento Basin, Badger Creek-Willow Creek, Coldani Marsh, East Stockton Diverting Canal and Duck Creek, North and South Grassland, Mendota, and Burrel-Lanare. These populations extend from Fresno north to Chico and include portions of 11 counties: Butte, Colusa, Glenn, Fresno, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Sutter, and Yolo (U.S. Fish and Wildlife Service 1999b:9, 11–12).

Habitat loss and fragmentation, flood control activities, changes in agricultural and land management practices, predation from introduced and native species, parasites, and water pollution are the main causes for the decline of giant garter snake. Conversion of Central Valley wetlands for agriculture and urban uses has resulted in the loss of as much as 95% of historical habitat for giant garter snake (Wylie et al. 1997). In areas where giant garter snake has adapted to agriculture, maintenance activities such as vegetation and rodent control, bankside grading or dredging, and discharge of contaminates, threaten their survival (Hansen and Brode 1980; Hansen and Brode 1993; U.S. Fish and Wildlife Service 1999b; Wylie et al. 2004). In developed areas, threats of vehicular mortality also are increased. Paved roads likely have a higher rate of mortalities than dirt or gravel roads due to increased traffic and traveling speeds. The loss of wetland habitat is compounded by elimination or compaction of adjacent upland and associated bankside vegetation cover, as well as water fouling; these conditions are often associated with cattle grazing (Thelander 1994). While irrigated pastures may provide the summer water that giant garter snakes require, high stocking rates may degrade habitat by removing protective plant cover and underground and aquatic retreats such as rodent and crayfish burrows (Hansen 1986; U.S. Fish and Wildlife Service 1999b; Szaro et al. 1985). However, cattle grazing may provide an important function in controlling invasive vegetation that can compromise the overall value of wetland habitat.

The action area is in the Mid-Valley Recovery Unit identified in the draft recovery plan (U.S. Fish and Wildlife Service 1999b), and three of the 13 giant garter snake populations identified by USFWS are located in the action area along the periphery of the Delta, including the Yolo Basin-Willow Slough, Yolo Basin-Liberty Farms, and Coldani Marsh-White Slough populations (Figure 6.6-1) (U.S. Fish and Wildlife Service 1999b). The rarity and isolation of giant garter snake from within the remainder the Delta suggest the lack of other extant populations in the area. While giant garter snakes may have occupied this region at one time, longstanding reclamation of wetlands for intense agricultural applications has eliminated most suitable habitat (Hansen 1986). Recent sightings of giant garter snakes in the Central Delta on Webb and Empire Tracts and on Jersey and Bradford Islands (Hansen pers. comm. 2015), however, suggest giant garter snakes are using portions of the Central Delta previously thought to be unoccupied.

4.5.12 California Red-legged Frog

California red-legged frog (*Rana draytonii*) was listed as threatened pursuant to the ESA in 1996 (61 FR25813). A recovery plan was prepared for this species by USFWS in 2002 (U.S. Fish and Wildlife Service 2002), and a 5-year review was initiated in 2011 (76 FR 30377). California red-legged frog is also considered a species of special concern by CDFW.

The historical range of the California red-legged frog generally extends south along the coast from the vicinity of Point Reyes National Seashore, Marin County, California, and inland from the vicinity of Redding, Shasta County, California, southward along the interior Coast Ranges and Sierra Nevada foothills to northwestern Baja California, Mexico (U.S. Fish and Wildlife Service 2007b). While there are a few historical records from several Central Valley locales (Jennings and Hayes 1994), Fellers (2005) considers persistent occupancy in the lowlands of the Central Valley unlikely due to extensive annual flooding.

The current range is generally characterized based on the current known distribution. USFWS (2007b) notes that while the California red-legged frog is still locally abundant in portions of the San Francisco Bay Area and the Central Coast, only isolated populations have been documented elsewhere within the species' historical range, including the Sierra Nevada, northern Coast Ranges, and northern Transverse Ranges.

Final designation of critical habitat for California red-legged frog was published in the Federal Register on March 17, 2010 (75 FR 12816–12959). There is no designated critical habitat for California red-legged frog in the action area. Critical habitat unit ALA-2 is located west of Clifton Court Forebay near the action area.

Habitat loss, degradation, and fragmentation are significant factors in declining populations of California red-legged frogs. Conversion of lands to agricultural and urban uses, overgrazing, mining, recreation, and timber harvesting have all contributed to habitat losses and disturbances. Urbanization often fragments habitat and creates barriers to dispersal (U.S. Fish and Wildlife Service 2002). Road densities generally increase because of urbanization. Roads can create significant barriers to frog dispersal (Reh and Seitz 1990) and reduce population densities due to mortality caused by automobile strikes (Fahrig et al. 1995; Yolo County Habitat Conservation Plan/Natural Community Conservation Plan Joint Powers Agency 2009).

In the action area, California red-legged frog has been detected only in aquatic habitats within the grassland landscape west and southwest of Clifton Court Forebay and in the vicinity of Brentwood and Marsh Creek along the west-central edge of the action area, and in some upland sites in the vicinity of Suisun Marsh (See Figure 6.7-1). These areas are within the easternmost edge of the current range of California red-legged frog within the Coast Ranges. While there are several recent records of the species in the Sierra Nevada foothills, California red-legged frog is not known to occur in the agricultural habitats of the Central Valley. The California Natural Diversity Database (CNDDB) contains records for several occurrences along Marsh Creek and Clifton Court Forebay and the western edge of the Suisun Marsh (California Department of Fish and Wildlife 2013). Occupied habitats are characterized by grassland foothills with stock ponds and slow-moving perennial drainages. The species is not known to occur, nor is it expected to occur, elsewhere in the action area.

4.5.13 California Tiger Salamander

The Central California distinct population segment of California tiger salamander (which overlaps with the action area) is federally listed as threatened (50 FR 47212–47248, August 4, 2004). California tiger salamander is also listed as threatened under the California Endangered Species Act (CESA).

Historically, California tiger salamander occurred throughout the grassland and woodland areas of the Sacramento and San Joaquin River Valleys and surrounding foothills, and in the lower elevations of the central Coast Ranges (Barry and Shaffer 1994). The species is found in relatively dry landscapes where its range is limited by its aestivation and winter breeding habitat requirements, which are generally defined as open grassland landscapes with ephemeral pools and with ground squirrel and pocket gopher burrows (Barry and Shaffer 1994).

Within the coastal range, the species currently occurs from southern San Mateo County south to San Luis Obispo County, with isolated populations in Sonoma and northwestern Santa Barbara Counties (California Department of Fish and Wildlife 2010). In the Central Valley and surrounding Sierra Nevada foothills, the species occurs from northern Yolo County southward to northwestern Kern County and northern Tulare and Kings Counties (California Department of Fish and Wildlife 2010).

Final designation of critical habitat for the Central California Population of California tiger salamander was published in the Federal Register on August 23, 2005 (70 FR 49380-49458). There is no designated critical habitat for California tiger salamander in the action area. Critical habitat Unit 2, the Jepson Prairie Unit, is located west of the action area.

Conversion of land to residential, commercial, and agricultural activities is considered the most significant threat to California tiger salamanders, resulting in destruction and fragmentation of upland and/or aquatic breeding habitat and killing of individual California tiger salamanders (Twitty 1941; Shaffer et al. 1993; Jennings and Hayes 1994; Fisher and Shaffer 1996; Loredo and van Vuren 1996; Davidson et al. 2002; California Department of Fish and Game 2010). Roads can fragment breeding habitats and dispersal routes in areas where they traverse occupied habitat. Features of road construction, such as solid road dividers, can further impede migration, as can other potential barriers such as berms, pipelines, and fences.

Several occurrences of California tiger salamander are located immediately west of Clifton Court Forebay, near the action area (See Figure 6.8-1). Current occupancy of some of these sites was confirmed by larval surveys conducted between 2009 and 2011 by DWR. There are numerous additional occurrences of California tiger salamander in vernal pool and pond habitats in the grassland foothills west of the action area and south of Antioch. Vernal pool habitats in Yolo and Solano Counties west of Liberty Island and in the vicinity of Stone Lakes in Sacramento County also provide suitable habitat for the species.

4.5.14 Valley Elderberry Longhorn Beetle

Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) is listed as threatened under the ESA (45 FR 52803). On October 2, 2006, the USFWS, in their 5-year review, recommended this species be removed from the endangered species list (U.S. Fish and Wildlife Service 2006a). On October 2, 2012, USFWS issued a proposed rule to remove the species from the endangered species list (77 FR 60238). However, USFWS withdrew the proposed rule on September 17, 2014 based on their determination that the proposed rule did not fully analyze the best available information (79 FR 55873).

Valley elderberry longhorn beetle is one of three species of *Desmocerus* in North America and one of two subspecies of *D. californicus*. The valley elderberry longhorn beetle subspecies is a narrowly defined, endemic taxon, limited to portions of the Central Valley generally below 3,000 feet in elevation (U.S. Fish and Wildlife Service 1999a).

Historically, valley elderberry longhorn beetle presumably occurred throughout the Central Valley from Tehama County to Fresno County (79 FR 55880). The historic range was recently revised to no longer include Tulare and Shasta Counties (79 FR 55880). Little is known about the historical abundance of valley elderberry longhorn beetle. The extensive destruction of its habitat, however, suggests that the beetle’s range has been largely reduced and fragmented (U.S. Fish and Wildlife Service 1984).

The current distribution of valley elderberry longhorn beetle is similar to its historic range, though it is “uncommon or rare, but locally clustered”. Currently, valley elderberry longhorn beetle is known from 17 hydrologic units and 36 discrete geographical locations within the Central Valley (79 FR 55872-55873).

The USFWS promulgated the final ruling designating critical habitat for valley elderberry longhorn beetle on August 8, 1980 (45 FR 52804). Two critical habitat areas were designated along portions of the American River in Sacramento County (the Sacramento Zone and the American River Parkway Zone). Critical habitat for valley elderberry longhorn beetle is not located within the action area.

The current distribution of valley elderberry longhorn beetle in the action area is largely unknown. There are only three reported occurrences of valley elderberry longhorn beetle in the action area, including one along Middle River north of Tracy and two occurrences along small drainages between the Sacramento River and the Sacramento Deep Water Ship Channel in the vicinity of West Sacramento (See Figure 6.9-1(California Department of Fish and Wildlife 2013). There are additional historical occurrences from along the Sacramento River corridor and Putah Creek in Yolo County (Jones & Stokes 1985, 1986, 1987; U.S. Fish and Wildlife Service 1984; Barr 1991; Collinge et al. 2001). Comprehensive surveys for the species or its host plant, elderberry, have not been conducted and thus the population size and location of the species in the action area is unknown. Distribution is typically based on the occurrence of elderberry shrubs, which are known to occur along riparian corridors throughout the action area, including the Sacramento River, Stanislaus River, San Joaquin River, and along smaller natural and channelized drainages, as well as in upland habitats.

4.5.15 Vernal Pool Fairy Shrimp

Vernal pool fairy shrimp is listed as threatened under the ESA throughout its range (59 *Federal Register* [FR] 48136). In September 2007, USFWS published a 5-year review recommending that the species remain listed as threatened. In addition, on May 25, 2011, USFWS initiated a new 5-year review to determine if the species should remain listed as endangered.

There is little information on the historical range of vernal pool fairy shrimp. The species is currently known to occur in a wide range of vernal pool habitats in the southern and Central Valley areas of California, and in two vernal pool habitats in the Agate Desert area of Jackson County, Oregon (U.S. Fish and Wildlife Service 2005). It has the largest geographical range of listed fairy shrimp in California, but is seldom abundant (Eng et al. 1990). The species is currently found in fragmented habitats across the Central Valley of California from Shasta County to Tulare and Kings Counties, in the central and southern Coast Ranges from Napa County to Los Angeles County, and inland in western Riverside County, California (U.S. Fish and Wildlife Service 2005, 2007a; California Department of Fish and Wildlife 2013).

The final rule designating critical habitat for vernal pool fairy shrimp was published in the Federal Register on February 10, 2006 (71 FR 7118–7316). Designated critical habitat for vernal pool fairy shrimp is located along the northern margin of Suisun Marsh and west of Clifton Court Forebay near Byron. The designated critical habitat for vernal pool fairy shrimp is in Unit 11D (10,707 total acres; an estimated 9,579 acres in the action area). The primary constituent elements (PCEs) of critical habitat for vernal pool fairy shrimp include: (1) topographic features characterized by mounds and swales, and depressions within a matrix of surrounding uplands that result in complexes of continuously, or intermittently, flowing surface water in the swales connecting the pools; (2) depressional features including isolated vernal pools with underlying restrictive soil layers that become inundated during winter rains and that continuously hold water for a minimum time period (18 days for vernal pool fairy shrimp); (3) food sources, such as detritus occurring in the pools, single-celled bacteria, algae, and dead organic matter; and (4) structure within the pools vernal pools consisting of organic and inorganic materials that provide shelter.

Habitat loss and fragmentation were identified as the largest threats to the survival and recovery of vernal pool species. Habitat loss generally is a result of agricultural conversion from rangelands to intensive farming, urbanization, aggregate mining, infrastructure projects (such as roads and utility projects), and recreational activities (such as off-highway vehicles and hiking) (U.S. Fish and Wildlife Service 2005). Habitat fragmentation occurs when vernal pool complexes are broken into smaller groups or individual vernal pools and become isolated from each other because of activities such as road development and other infrastructure projects (U.S. Fish and Wildlife Service 2005).

Vernal pool fairy shrimp has been reported from several locations in the action area (See Figure 6.10-1) (U.S. Fish and Wildlife Service 2005, 2007a; California Department of Fish and Wildlife 2013). In general, in the action area, vernal pools that may support the species occur in Jepson Prairie, in the CDFW Tule Ranch Unit of the Yolo Bypass Wildlife Area, in the Stone Lakes Wildlife Refuge, west of Clifton Court Forebay near the town of Byron, and along the eastern and northern boundary of Suisun Marsh. Other potential vernal pool habitat occurs along the eastern boundary of Stone Lakes (See Figure 2A.37-2 in California Department of Water Resources 2013a). Vernal pool fairy shrimp were observed at seven locations in the south Stone Lakes area and in three locations in the Clifton Court Forebay during 2009 surveys conducted by the DWR (Appendix 4.C, *Vernal Pool Surveys*). A comprehensive survey of vernal pools or habitat for vernal pool fairy shrimp has not been conducted in the action area.

4.5.16 Vernal Pool Tadpole Shrimp

Vernal pool tadpole shrimp (*Lepidurus packardi*) was listed as endangered throughout its range under the ESA on September 19, 1994 (59 FR 48136). In September 2007, USFWS published a 5-year review recommending that the species remain listed as endangered. In addition, on May 25, 2011, USFWS initiated a new 5-year review to determine if the species should remain listed as endangered.

Historically, vernal pool tadpole shrimp probably did not occur outside of the Central Valley and Central Coast regions (U.S. Fish and Wildlife Service 2005). Currently, vernal pool tadpole shrimp occurs in the Central Valley of California and in the San Francisco Bay Area (See Figure 2A.38-1 in California Department of Water Resources 2013a). The species has a patchy distribution across the Central Valley of California from Shasta County southward to northwestern Tulare County (U.S. Fish and Wildlife Service 2007a). In the Central Coast Vernal Pool Region, the vernal pool tadpole shrimp is found the San Francisco National Wildlife Refuge and on private land in Alameda County near Milpitas (U.S. Fish and Wildlife Service 2007a; California Department of Fish and Wildlife 2013). The largest concentration of vernal pool tadpole shrimp occurrences is found in the Southeastern Sacramento Vernal Pool Region, where the species occurs on a number of public and private lands in Sacramento County (U.S. Fish and Wildlife Service 2005, 2007a).

Final designation of critical habitat for vernal pool tadpole shrimp was published in the Federal Register on February 10, 2006 (71 FR 7118–7316). Designated critical habitat for vernal pool tadpole shrimp is located along the northern margin of Suisun Marsh, outside the action area. The PCEs of critical habitat for vernal pool tadpole shrimp include: (1) topographic features characterized by mounds and swales, and depressions within a matrix of surrounding uplands that result in complexes of continuously, or intermittently, flowing surface water in the swales connecting the pools; (2) depressional features including isolated vernal pools with underlying restrictive soil layers that become inundated during winter rains and that continuously hold water for a minimum time period (41 days for vernal pool tadpole shrimp); (3) food sources, such as detritus occurring in the pools, and single-celled bacteria, algae, and dead organic matter; and (4) structure within the pools vernal pools consisting of organic and inorganic materials that provide shelter.

Habitat loss and fragmentation were identified as the largest threats to the survival and recovery of vernal pool species. Habitat loss generally is a result of agricultural conversion from rangelands to intensive farming, urbanization, aggregate mining, infrastructure projects (such as roads and utility projects), and recreational activities (such as off-highway vehicles and hiking) (U.S. Fish and Wildlife Service 2005). Habitat fragmentation occurs when vernal pool complexes are broken into smaller groups or individual vernal pools and become isolated from each other because of activities such as road development and other infrastructure projects (U.S. Fish and Wildlife Service 2005).

Vernal pool tadpole shrimp has been reported from several locations in the action area (See Figure 2A.38-2 in California Department of Water Resources 2013a) (U.S. Fish and Wildlife Service 2005, 2007a; California Department of Fish and Wildlife 2013). In general, within the action area, vernal pools that may support the species occur in Jepson Prairie, in CDFW’s Tule Ranch Unit of the Yolo Bypass Wildlife Area, in the Stone Lakes, and along the eastern and northern boundary of Suisun Marsh (See Figure 6.10-1)). Vernal pool tadpole shrimp was found in six locations in the Stone Lakes area during 2009 surveys conducted by DWR (Appendix 4.C, *Vernal Pool Surveys*). No vernal pool tadpole shrimp were found in vernal pools surveyed near Clifton Court Forebay. A comprehensive survey of vernal pools or habitat for the vernal pool tadpole shrimp has not been conducted throughout the action area.

4.5.17 Least Bell’s Vireo

Activities associated with north delta intakes, reusable tunnel material areas, the HOR gate, Clifton Court Forebay modification, water conveyance facilities, transmission lines, geotechnical exploration, and unsited safe haven intervention sites may affect least Bell’s vireo. Effects on modeled least Bell’s vireo habitat is described in Section 6.11 *Effects on Least Bell’s Vireo*. Modeled habitat is described in Section 4.A.15.7 *Species Habitat Suitability Model*.

Least Bell’s vireo (*Vireo bellii pusillus*) was listed as endangered under the ESA on May 2, 1986 (51 FR 16474-16482). The species is also listed as endangered under the CESA. Least Bell’s vireo is one of four subspecies of Bell’s vireo and is the only subspecies that breeds entirely in

California and northern Baja California. Arizona Bell's vireo (*V. bellii arizonae*) is found along the Colorado River and may occur on the California side, but otherwise occurs throughout Arizona, Utah, Nevada, and Sonora, Mexico (Kus 2002a).

Since ESA listing in 1986, populations have gradually increased and the subspecies has recolonized portions of its historical range. Increases are attributed primarily to riparian restoration and efforts to control the brood parasite brown-headed cowbird (Kus 1998 and Kus and Whitfield 2005 in Howell et al. 2010). By 1998, the total population was estimated at 2,000 pairs and recolonization was reported along the Santa Clara River in Ventura County, the Mojave River in San Bernardino County, and sites in Monterey and Inyo Counties (Kus and Beck 1998; Kus 2002a; U.S. Fish and Wildlife Service 2006c). A single nest was reported from Santa Clara County near Gilroy in 1997 (Roberson et al. 1997). Still, the distribution remained largely restricted to San Diego County (76%) and Riverside County (16%) (U.S. Fish and Wildlife Service 2006c).

By 2005, the population had reached an estimated 2,968 breeding pairs (U.S. Fish and Wildlife Service 2006c) with increases in most southern California Counties and San Diego County (primarily Camp Pendleton Marine Corps Base) supporting roughly half of the current population (U.S. Fish and Wildlife Service 2006c). Recent occurrences have suggested a range expansion to the northern extent of the subspecies' historical breeding range.

Final designation of critical habitat for least Bell's vireo was published in the Federal Register on February 2, 1994 (59 FR 14845-4867). There is no designated critical habitat for least Bell's vireo in the action area.

A major factor leading to declines in populations of least Bell's vireo is the loss and degradation of riparian woodland habitat throughout the species' range. Habitat loss and degradation can occur through clearing of vegetation for agriculture, timber harvest, development, or flood control (U.S. Fish and Wildlife Service 1998).

Other than recent activity in the Yolo Bypass Wildlife Area, are no records of least Bell's vireos breeding in the action area since at least the 1970s. Two singing males were detected in the Yolo Bypass Wildlife Area in mid-April 2010, and again in 2011 (California Department of Fish and Wildlife 2013). In 2010, a vireo was seen in this area carrying nesting material, a sign of breeding (Whistler, pers. comm. 2015). However, no least Bell's vireos were detected in the Yolo Bypass Wildlife Area during surveys in 2012. One singing male was detected in 2013, and surveys were not conducted in 2014. The next-nearest most recent occurrence (noted above) is approximately 7 miles south of the action area at the San Joaquin River National Wildlife Refuge in the San Joaquin and Tuolumne River floodplain (Howell et al. 2010). This occurrence includes three nests sites between 2005 and 2007, all on a recently restored portion of San Joaquin River National Wildlife Refuge lands known as Hagemann's Fields 6 and 9. The 2005 and 2006 nests were successful, and the 2007 nest was not. The 2005 and 2006 nest sites were in a 3-year-old arroyo willow with understory plants including mugwort, sunflower, gumplant, and creeping wild rye. The 2007 nest was in a dead arroyo willow (Howell et al. 2010).

4.6 References

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4.6.2 Personal Communications

Bradbury, Mike. pers. comm. Statement made at a TTT meeting on July 2, 2015. Mr. Bradbury is the California WaterFix permitting lead for 404/2081/Section 7 compliance, and a Program Manager II.

Hansen, E.C. March 2015—Phone conversation regarding presences of Giant Garter Snakes in the Delta.

Kelly, Patrick. Professor at California State University at Stanislaus and Director of Endangered Species Recovery Program. December 2015—email to Heather Swinney with a shapefile attachment containing RBR records for the South Delta (and elsewhere) including data submitted to the CNDDB and one more recent record at Durham Ferry from Patrick Kelly (Endangered Species Program at Stanislaus State University) which was then forward to Rebecca Sloan at ICF.

Rea, Maria. Assistant Regional Administrator, West Coast Region, National Marine Fisheries Service. January 16, 2015—letter to Mr. Ron Milligan, Operations Manager, Central Valley Project, U.S. Bureau of Reclamation, regarding estimated number of juvenile Sacramento River winter-run Chinook salmon expected to enter the Sacramento-San Joaquin Delta during water year 2015.

Whisler, Edward. July 13, 2015—Email regarding survey effort and results for Least Bells' Vireo in the Yolo Bypass. Williams, D. F. 1988. *Ecology and Management of the Riparian Brush Rabbit in Caswell Memorial State Park*. California Department of Parks and Recreation, Lodi, CA. Interagency Agreement 4-305-6108.

5 Effects Analysis for Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale

5.1 Introduction

The potential effects of the proposed action (PA) on listed species under NMFS jurisdiction are evaluated in this section. Those species include the following.

- Chinook salmon, Sacramento River winter-run ESU
- Chinook salmon, Central Valley spring-run ESU[1]
- Steelhead, California Central Valley DPS
- Green sturgeon, southern DPS
- Killer whale, Southern Resident DPS

These species are evaluated with regard to the deconstructed effects of the PA, i.e. water facility construction, water facility maintenance, water facility operations, conservation measures, monitoring activities, and cumulative effects. Effects on southern resident killer whales are addressed qualitatively in a separate subsection from the other species because killer whales occur outside the Bay-Delta and would not be exposed to the direct effects of the action.

Scientific uncertainty exists with respect to the potential effects of the PA on listed fishes. As described in Section 3.4.7, *Collaborative Science and Adaptive Management Program*, of Chapter 3, the Collaborative Science and Adaptive Management Program will help to address scientific uncertainty by guiding the development and implementation of scientific investigations and monitoring for both permit compliance and adaptive management, and applying new information and insights to management decisions and actions.

Each subsection of this effects analysis also provides an analysis of effects on critical habitat for winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon. For all four species, designated critical habitat is present in the Delta and adjacent areas, including upstream areas within the action area. The analysis includes, as necessary, potential effects on the following physical or biological features (PBFs)[2] of critical habitat for each species.

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[1] As described in Section 4.5.2 *Chinook Salmon, Central Valley Spring-Run ESU* of Chapter 4, *Action Area and Environmental Baseline*, this effects analysis includes consideration of San Joaquin River spring-run Chinook salmon, which are considered to represent both the population reintroduced as part of the San Joaquin River Restoration Program, and spring-running Chinook salmon observed in San Joaquin River tributaries in recent years.

[2] The designations of critical habitat for listed species have generally used the term primary constituent elements (PCEs). NMFS and USFWS' recently issued a final rule amending the regulations for designating critical habitat (81 FR 7414; February 11, 2016), which replaced the term PCEs with physical or biological features (PBFs). In addition, NMFS and USFWS recently issued a final rule revising the regulatory definition of "destruction or adverse modification" of critical habitat (81 FR 7214; February 11, 2016), which refers to PBFs, not PCEs. The shift in terminology does not change the approach used in conducting an analysis of the effects of the proposed action on

- Sacramento River Winter-run Chinook salmon
  - access from Pacific Ocean to spawning areas in the upper Sacramento River;
  - the availability of clean gravel for spawning substrate;
  - adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles;
  - water temperatures for successful spawning, egg incubation, and fry development;
  - habitat areas and prey that are not contaminated;
  - riparian habitat that provides for successful juvenile development and survival; and
  - access downstream so that juveniles can migrate from spawning grounds to San Francisco Bay and the Pacific Ocean.
- Sacramento River spring-run Chinook salmon and California Central Valley steelhead
  - spawning habitat with water quantity and quality conditions and substrate supporting spawning, incubation and larval development;
  - freshwater rearing habitat with water quantity and quality, floodplain connectivity, forage, and natural cover supporting juvenile development, growth, mobility, and survival;
  - freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover supporting juvenile and adult mobility and survival; and
  - estuarine areas free of obstruction and excessive predation supporting mobility and survival, with water quantity, water quality, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater, and natural cover and forage supporting growth, maturation and survival.
- Green sturgeon (for freshwater riverine systems and estuarine habitats)
  - food resources for larval, juvenile, subadult, and adult life stages;
  - water flow regime with flow magnitude, duration, seasonality, and rate-of-change supporting growth, survival, and migration of all life stages;
  - water quality including temperature, salinity, oxygen content, and other chemical characteristics supporting growth and viability of all life stages;

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critical habitat, which is the same regardless of whether the original designation identified PCEs or PBFs. In this biological assessment, we use the term PBFs to include PCEs, as appropriate for the specific critical habitat.

  - migratory corridor free of obstruction and excessive predation with water quantity and quality conditions supporting safe and timely passage of juveniles and adults within and between riverine, estuarine and marine habitats;
  - water depth sufficient (>5 m) for holding pools supporting adults and subadults;
  - substrate type or size (for freshwater riverine systems but not estuarine habitat) supporting egg deposition, egg and larval development, subadult and adult holding, and adult spawning; and
  - sediment quality (*i.e*, chemical characteristics) supporting growth and viability of all life stages.

5.2 Effects of Water Facility Construction on Fish

5.2.1 Preconstruction Studies (Geotechnical Exploration)

Geotechnical investigations in open water at the proposed locations for the water conveyance facilities and alignments have the potential to affect listed salmonids and green sturgeon and their designated critical habitat. Approximately 100 over-water borings are currently proposed to collect geotechnical data at the proposed locations of the north Delta intakes, barge landings, tunnel alignment crossings, HOR gate, and CCF facilities (Table 3.2-4). Site-specific studies will investigate several geotechnical properties of these sites, including the stability of canal embankments and levees, liquefaction of soils, seepage through coarse-grained soils, settlement of embankments and structures, subsidence, and soil-bearing capacity. Specific field activities will include drilling of sample soil borings, cone penetration, and other *in situ* tests (slug tests, aquifer/pumping tests, and test pits) to evaluate subsurface conditions. In-water borings will be conducted using a mud rotary method in which a conductor casing will be pushed into the sediment to isolate the drilling area, drilling fluids (bentonite), and cuttings from the surrounding water. Drilling fluids and cuttings will be contained within the conductor casing and returned to a recirculation tank on the drill ship or barge where they will be transferred to drums for storage and disposal.

DWR plans to restrict in-water drilling to the approved in-water work window (August 1 to October 31) between the hours of sunrise and sunset. The 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. A number of AMMs are proposed to avoid or minimize potential turbidity, suspended sediment, and other water quality impacts (e.g., bentonite or contaminant spills) on listed species and aquatic habitat during geotechnical activities: *Worker Awareness Training; Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan (SWPPP); Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan (SPCCP); Hazardous Material Management Plan (HMMP);* and *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material; and Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

Restricting in-water geotechnical activities to August 1 to October 31 will avoid the primary migration and rearing seasons of juvenile salmonids and primary migration seasons of adults in the Delta with the exception of adult steelhead, which may peak in abundance during the late summer and fall months (September-October). There is some potential for winter-run juveniles (less than 60 mm in length) to occur in the lower Sacramento River and Delta in October but this is uncommon; typically, the earliest that juveniles would be expected to occur in the action area is November or December (del Rosario et al. 2013). The proposed in-water work window period will also avoid the peak upstream migration period of adult green sturgeon (late February to early May). However, post-spawning adults (returning downriver following spawning) and rearing juveniles may be present through the summer and fall and therefore subject to the potential effects of geotechnical activities during the in-water work window.

With containment of all in-water drilling activities to closed systems and implementation of the AMMs identified above, potential water quality effects of geotechnical drilling activities would be limited to temporary, localized increases in turbidity, suspended sediment, and noise during barge operations (e.g., anchoring of barges) and drilling activities (e.g., installation and removal of conductor casings) that will dissipate rapidly and return to baseline levels shortly after cessation of daily activities. If present, any listed salmonids or green sturgeon that may be present during the in-water work period would likely be large, active adults and juveniles that are capable of avoiding such disturbances with minimal harassment or risk of injury (see Section 5.2.2.4.3). Evidence suggests that young-of-the-year juvenile green sturgeon overwinter in upstream reaches of the Sacramento River before entering the Delta; based on the size distribution of juveniles observed at the export facilities in the southern Delta, most juveniles that occur in the action area of the proposed water conveyance facilities would be older juveniles >100 mm in length. Therefore, effects on steelhead and green sturgeon will likely be limited to harassment in response to temporary, localized increases in turbidity, suspended sediment, and noise.

Geotechnical activities may affect the designated critical habitat of listed salmonids and green sturgeon through suspension and deposition of sediment or direct disturbance of channel sediments and benthic food resources at the drilling sites. However, these effects are expected to be insignificant based on the low intensity, brief duration, and small areas affected; avoidance of vegetation and other potential sources of cover and food for fish (e.g., instream woody debris); and the general low quality of rearing habitat for juvenile salmonids and green sturgeon at the proposed facilities (see 6.1.1.3, North Delta Intakes. 6.1.1.4, Barge Landings, 6.1.1.5, Head of Old River Gate, and 6.1.1.6, Clifton Court Forebay). Consequently, with implementation of the proposed in-water work window and AMMs, geotechnical exploration is not likely to adversely affect the designated critical habitat of listed salmonids or green sturgeon.

5.2.2 North Delta Intakes

5.2.2.1 Deconstruct the Action

Three intakes will be constructed on the east bank of the Sacramento River between Clarksburg and Courtland at river miles (RMs) 41.1, 39.4, and 36.8 (Intakes 2, 3, and 5) (Appendix 3.A *Map Book for the Proposed Action*). Each intake will divert a maximum of 3,000 cfs from the Sacramento River. 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 the Intermediate Forebay; 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). Additional details on the intake design, construction methods, and proposed construction schedule are described in Chapter 3.

Construction of each intake is projected to take approximately 4 to 5 years. All in-water activities will be restricted to June 1-October 31 to minimize exposure of listed fish species to construction-related impacts on water quality and other hazards. Constructing each intake will involve installing a sheet pile cofferdam in the river during the first construction season, which will isolate the in-water work area during the remaining years of construction and become permanent components of the intake structure. Following closure of the cofferdam, fish rescue and salvage activities will be performed to collect any stranded fish and return them to the river. Dewatering of the cofferdam will be performed using a screened intake to prevent entrainment of fish. Water pumped from within the cofferdams will be treated (removing all sediment), using settling basins or Baker tanks, and returned to the river. After the cofferdams are dewatered, dredging, foundation pile driving, and other construction activities will proceed within the confines of the cofferdams.

Clearing and grading of the waterside slope of the levee will be required prior to installing the sheetpile cofferdam and rock slope protection (riprap), depending on site conditions (e.g., presence of vegetation). Following cofferdam installation, an excavator operated from a barge and/or the top of the levee would be used to install riprap on the adjacent levee slope to provide permanent erosion protection to the levee, cofferdam, and intake facility.

It is assumed that after the intakes are completed, the area in front of each intake will need to be dredged to provide appropriate flow conditions at the intake entrance. Preliminary estimates of these areas are provided in Appendix 5.H *Construction Effects Tables for Salmonids and Green Sturgeon*; these are only approximate and are based on preliminary geotechnical data. If required, the dredging will occur during the approved in-water work window and will be minimized to the extent practicable. It is also assumed that periodic maintenance dredging may be needed to maintain appropriate flow conditions during operation of the intakes.

Construction of the intake facilities would result in permanent and temporary impacts on habitat in the Sacramento River. It is currently estimated that 6.6 acres of tidal perennial habitat and 1.02 linear miles of channel margin habitat would be permanently replaced by the intake structures (including foundation piles), transition walls, and riprap (Table 3.4-1). Temporary impacts, including water quality impacts and disturbance of benthic habitat associated with dredging and other in-water construction activities, is estimated to affect approximately 20.1 acres of tidal perennial habitat. Temporary impacts on channel margin habitat occur within the same footprint as permanent impacts.

Construction activities that could potentially affect winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon include cofferdam installation, levee clearing and grading, riprap placement, dredging, and barge operations. All other construction activities, including construction of the sedimentation basins, intermediate forebay, and associated facilities, will be isolated from the Sacramento River and not result in effects to listed fish species or aquatic habitat in the Sacramento River.

5.2.2.2 Turbidity and Suspended Sediment

Construction activities that disturb the riverbed and banks within the footprints of the north Delta intake facilities may temporarily increase turbidity and suspended sediment levels in the Sacramento River. These activities include cofferdam installation and removal, levee clearing and grading, riprap placement, dredging, and barge operations. Potential turbidity and sediment impacts on listed fish species and aquatic habitat will be minimized by restricting in-water construction activities to June 1 through October 31. In addition, DWR proposes to implement a number of AMMs to avoid or minimize potential turbidity, suspended sediment, and other water quality impacts on listed species and aquatic habitat: *Worker Awareness Training; Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan (SWPPP); Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan (SPCCP); Hazardous Material Management Plan (HMMP); Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material; and Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

Construction-related turbidity and suspended sediment may occur during winter and spring due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with implementation of the proposed erosion and sediment control measures (AMM4) and other BMPs to ensure the effectiveness of these measures (*AMM2, Construction Best Management Practices and Monitoring*), the potential for adverse water quality effects outside the in-water construction window will be insignificant.

5.2.2.2.1 Assess Species Exposure

5.2.2.2.1.1 Salmonids

The Sacramento River is the primary migration route utilized by adult winter-run Chinook salmon, spring-run Chinook salmon, and steelhead to access upstream spawning areas in the Sacramento River basin, and the primary migration route for juveniles entering the Delta and estuary from upstream spawning and rearing areas. Restricting impact pile driving to June 1 to October 31 avoids the primary migration periods of winter- and spring-run adults and juveniles, and the primary migration period of steelhead juveniles in the action area. In some years, a small proportion of the total number of winter-run (adults) and spring-run Chinook salmon (adults and juveniles) and steelhead (juveniles) migrating through the action area may occur as late as June and July although water temperatures frequently exceed suitable ranges by late June or early July. Steelhead adults are more likely to be exposed to construction-generated turbidity and sedimentation based on the timing of upstream migration, which generally extends from late summer through fall in the lower Sacramento River (August through November with a peak in September-October). There is some potential for winter-run juveniles (less than 60 mm in length) to occur in the lower Sacramento River and Delta in October but this is uncommon; typically, the earliest that juveniles would be expected to occur in the action area is November or December (del Rosario et al. 2013).

5.2.2.2.1.2 Green Sturgeon

The in-water construction period (June 1–October 31) avoids the peak upstream migration period of green sturgeon (late February to early May) although migration through the Delta may extend through June or July. However, adults may be present in the Delta throughout the year; following their migration and spawning in upstream reaches (April through early July), adults may hold for several months and then migrate back downstream in the fall or winter or move out of the river quickly during spring and summer (Heublein et al. 2009). Juvenile green sturgeon may be present in the Delta year-round and therefore may occur in the action area during in-water construction activities. Evidence suggests that young-of-the-year juvenile green sturgeon overwinter in upstream reaches of the Sacramento River before entering the Delta where they continue to rear for up to three years before entering the ocean (Kynard et al. 2005).

5.2.2.2.2 Assess Species Response

5.2.2.2.2.1 Salmonids

Depending on the level of exposure, suspended sediment can cause lethal, sublethal, and behavioral effects in fish (Newcombe and Jensen 1996). For salmonids, elevated suspended sediment has been linked to a number of behavioral and physiological responses indicative of stress (gill flaring, coughing, avoidance, and increase in blood sugar levels) (Bisson and Bilby 1982; Sigler et al. 1984; Berg and Northcote 1985; Servizi and Martens 1992). High suspended sediment levels can clog gill tissues, interfering with respiration and increasing physiological stress. Very high levels can directly damage gill tissues, resulting in physical injury and even death.

Migrating adults have been reported to avoid high silt loads or cease migration when avoidance is not possible (Cordone and Kelley 1961, as cited in Bjornn and Reiser 1991). Bell (1991) cited a study in which adult salmon did not move in streams where the sediment concentration exceeded 4,000 milligrams per liter (mg/L) (because of a landslide). Juveniles tend to avoid streams that are chronically turbid (Bisson and Bilby 1982; Lloyd 1987) or move laterally or downstream to avoid turbidity plumes (Sigler et al. 1984; Lloyd 1987; Servizi and Martens 1992). Juvenile coho salmon have been reported to avoid turbidities exceeding 70 NTU (Bisson and Bilby 1982) and cease territorial behavior when exposed to a pulse of turbidity of 60 NTU (Berg 1982). Such behavior could result in displacement of juveniles from preferred habitat or protective cover, which may reduce growth and survival by affecting foraging success or increasing their susceptibility to predation.

Laboratory studies have demonstrated that chronic or prolonged exposure to high turbidity and suspended sediment levels can lead to reduced growth rates. For example, Sigler et al. (1984) found that juvenile coho salmon and steelhead trout exhibited reduced growth rates and higher emigration rates in turbid water (25–50 NTU) compared to clear water. Reduced growth rates generally have been attributed to an inability of fish to feed effectively in turbid water (Waters 1995). Chronic exposure to high turbidity and suspended sediment also may affect growth and survival by impairing respiratory function, reducing tolerance to disease and contaminants, and causing physiological stress (Waters 1995).

During cofferdam installation, levee clearing and grading, riprap placement, dredging, and barge operations, turbidity and suspended sediment levels in the river are anticipated to exceed ambient river levels in the immediate vicinity of these activities, creating turbidity plumes that may extend several hundred feet downstream of construction activities. NMFS (2008a) reviewed observations of turbidity plumes during installation of riprap for bank protection projects along the Sacramento River and concluded that visible plumes are expected to be limited to only a portion of the channel width, extend no more than 1,000 feet downstream, and dissipate within hours of cessation of in-water activities. Based on these observations, NMFS concluded that turbidity levels produced by such activities could disrupt normal feeding and sheltering behavior of salmonids (National Marine Fisheries Service 2008a).

Although specific thresholds associated with behavioral, sublethal, and lethal effects are not available, it can be reasonably assumed that the effects of proposed in-water construction activities on listed fish species will be limited to brief exposures and likely avoidance of elevated turbidity and suspended sediment based on the limited spatial and temporal extent of turbidity plumes and proximity of unaffected habitat in the action area. Dredging will likely generate the most continuous sources of elevated turbidity and sedimentation but will affect a relatively small portion of the channel during daylight hours only, resulting in only minor disruptions in migration, holding, and rearing behavior. Adult salmonids would be expected to readily avoid high turbidity and suspended sediment and move to adjacent holding areas or continue their migration in deeper, offshore portions of the channel. Because of their small size and reliance on shallower, nearshore waters and associated cover, displacement of juvenile salmonids from these areas could increase their vulnerability to predators, potentially increasing mortality. However, utilization of nearshore areas by juvenile salmon and steelhead is generally reduced by June and July because most juveniles are large, actively migrating smolts that are known to move rapidly through the Delta and estuary during their seaward migration (Williams 2006).

In addition to the water quality impacts discussed above, increases in sediment loads in the Sacramento River can bury river substrates that support important food organisms (benthic invertebrates) for juvenile salmonids and green sturgeon. The natural channel substrate in this portion of the Sacramento River is dominated by fine sediment (sand and silt) that is frequently disturbed by high flows and human activities (e.g., boat wakes). Although suspended sediment generated by construction activities would be expected to cause some sedimentation of the channel downstream of the construction sites, potential reductions in abundance or production of benthic invertebrates would not be expected to affect the availability of food or foraging habitat for salmonids because of the localized, temporary nature of the disturbance, and adaptations of the local invertebrate fauna to sediment disturbance.

5.2.2.2.2.2 Green Sturgeon

No specific information is available to evaluate the potential responses of green sturgeon to increased turbidity and suspended sediment. Green sturgeon may be affected in similar ways to salmonids but may be less sensitive to high turbidity when foraging because of their greater reliance on touch and electroreception (versus sight) to locate prey. However, green sturgeon are potentially more sensitive to sedimentation impacts on benthic invertebrate communities due to their benthic forging behavior and year-round presence in the Delta.

5.2.2.2.3 Assess Risk to Individuals

5.2.2.2.3.1 Salmonids

Increases in turbidity and suspended sediment levels during in-water construction activities will be temporary and localized, and unlikely to reach levels causing direct injury to anadromous salmonids. Juvenile salmonids, if holding or rearing in the affected areas, are likely to respond by avoiding or moving away from affected shoreline areas, disrupting normal activities and increasing their exposure to predators. Such disruptions are expected to be brief and unlikely to adversely affect the growth of individual salmonids. However, there could be minor losses due to increased predation mortality.

5.2.2.2.3.2 Green Sturgeon

Based on the expected responses of green sturgeon to construction-related increases in turbidity and suspended sediment levels, the potential effects of increased turbidity and suspended sediment during construction of the proposed intakes are considered insignificant. Although green sturgeon are more sensitive to reductions in benthic food resources, the small spatial and temporal scale of impacts on these food resources is unlikely to affect access to food resources and individual foraging success.

5.2.2.2.4 Assess Effects on Designated Critical Habitat

5.2.2.2.4.1 Salmonids

Increases in turbidity and suspended sediment levels during construction of the proposed intakes will affect the PBFs or essential physical and biological features of the designated critical habitat of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead. Elevated turbidity and suspended sediment generated by in-water construction activities would primarily affect the physical and biological features of freshwater rearing habitat and migration corridors through temporary degradation of water quality, increases in exposure to mod-channel predators, and potential sedimentation of potential food-producing areas. These effects will have only a localized and temporary effect on critical habitat in the action area.

5.2.2.2.4.2 Green Sturgeon

Increases in turbidity and suspended sediment levels during construction of the proposed intakes will affect the PBFs of designated critical habitat for southern DPS green sturgeon. These effects would be limited to localized, temporary degradation of the physical and biological features of water quality and potential sedimentation of food-producing areas. No long-term or permanent effects on critical habitat are expected.

5.2.2.3 Contaminants

Construction of the north Delta intakes poses an exposure risk to listed fish species from potential spills of hazardous materials from construction equipment, barges and towing vessels, and other machinery, and from potential mobilization of contaminated sediment. The risk of accidental spills of contaminants and other hazardous materials will exist throughout the construction period but will be highest during in-water construction activities due to the proximity of construction activities to the Sacramento River.

5.2.2.3.1 Accidental Spills

Construction of the north Delta intakes could result in accidental spills of contaminants, including oil, fuel, hydraulic fluids, concrete, paint, and other construction-related materials, resulting in localized water quality degradation and potential adverse effects on listed fish species. Potential effects of contaminants on fish include direct injury and mortality (e.g., damage to gill tissue causing asphyxiation) or delayed effects on growth and survival (e.g., increased stress or reduced feeding), depending on the type of contaminant, extent of the spill, and exposure concentrations. The risk of such effects is highest during in-water construction activities, including cofferdam installation, levee grading and armoring, and barge operations, because of the proximity of construction equipment to the Sacramento River.

Implementation of Appendix 3.F *General Avoidance and Minimization Measures,* AMM 5 *Spill Prevention, Containment, and Countermeasure Plan* and AMM14 *Hazardous Materials Management* is expected to minimize the potential for contaminant spills and guide rapid and effective response in the case of inadvertent spills of hazardous materials. With implementation of these and other required construction BMPs (e.g., AMM 3 *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to the Sacramento River from in-water or upland sources would be effectively minimized.

5.2.2.3.2 Disturbance of Contaminated Sediments

Contaminants may also enter the aquatic environment through disturbance, resuspension, or discharge of contaminated soil and sediments from construction sites. Sediments act as a sink or source of contaminant exposure depending on local hydrologic conditions, habitat type, and frequency of disturbance. Sediment is a major sink for more persistent chemicals that have been introduced into the aquatic environment, with most organic and inorganic anthropogenic chemicals and waste materials accumulating in sediment (Ingersoll 1995). Thus, resuspension of contaminated sediments may have adverse effects on fish that encounter sediment plumes or come into contact with deposited or newly exposed sediment. Suspended sediment can also adversely affect fish by causing localized increases in chemical oxygen demand in waters in or near plumes.

The proposed intake sites are downstream of the City of Sacramento where sediments have been affected by historical and current urban discharges from the city. No information on sediment contaminants at these sites is currently available. Metals, PCBs, and hydrocarbons (typically oil and grease) are common urban contaminants that are introduced to aquatic systems via nonpoint-source stormwater drainage, industrial discharges, and municipal wastewater discharges. Many of these contaminants readily adhere to sediment particles and tend to settle out of solution relatively close to the primary source of contaminants. PCBs are persistent, adsorb to soil and organic matter, and accumulate in the food web. Lead and other metals also will adhere to particulates and can bioaccumulate to levels sufficient to cause adverse biological effects. Mercury is also present in the Sacramento River system and could be sequestered in riverbed sediments. Hydrocarbons biodegrade over time in an aqueous environment and do not tend to bioaccumulate or persist in aquatic systems.

Dredging has the potential to release contaminants from disturbed sediments into the water column during construction and maintenance dredging at the proposed intakes. Current estimates indicate the total dredging and channel disturbance would affect 12.1 acres of the riverbed adjacent to the cofferdams at the north Delta intakes. Measured sediment plumes from hydraulic dredging operations (Hayes et al. 2000) suggest that less than 0.1% of disturbed sediments and associated contaminants would likely be re-suspended during cutterhead dredging operations. In sediments, only a small fraction of the total amount of heavy metals and organic contaminants is dissolved. In the case of heavy metals, releases during dredging may be largely due to the resuspension of fine particles from which the contaminants may be desorbed, and in the case of organic contaminants, most of the chemicals released into the dissolved phase would be expected to be bound to dissolved organic matter. Therefore, the potential release of contaminants from suspended sediment is expected to be limited because many of the chemical constituents preferentially adsorb or attach to organically enriched or fine particles of sediment.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material* in Appendix 3.F *General Avoidance and Minimization Measures*. These measures include the preparation and implementation of a pre-construction sampling and analysis plan (SAP) to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (e.g., silt curtains) to achieve compliance with existing Basin Plan objectives will be an important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

5.2.2.3.3 Assess Species Exposure

Exposure to contaminated sediments, either through direct exposure (e.g., swimming through plumes of resuspended sediment) or foraging on contaminated food sources, may be deleterious to endangered and threatened salmon, steelhead, and green sturgeon. Toxic compounds can be absorbed through dermal contact, ingestion, or uptake through the gills. Point sources where discharge occurs and hydraulic conditions drop suspended sediment in specific areas may create “hot spots” of contaminants, which may contain contaminant levels significantly higher than ambient water levels (EPA 1994). Prolonged exposure of fish and their prey organisms, either through external contact or ingestion of contaminated food sources, can also lead to adverse effects through bioaccumulation.

5.2.2.3.3.1 Salmonids

The potential for contaminant spills would exist throughout the construction period with the highest risk occurring during in-water construction activities. The proposed in-water work window (June 1-October 31) will avoid the peak winter and spring migration and rearing periods of anadromous salmonids. Based on the general timing of migration of adult and juveniles in the action area, in-water work activities could overlap with the occurrence of winter-run Chinook salmon and spring-run Chinook salmon adults in June (possibly July for spring-run Chinook salmon), spring-run Chinook salmon and steelhead juveniles in June, and steelhead adults from August through October. These exposures are expected to be brief because most juveniles and adults are actively migrating through the action area during these months. However, exposure to contaminants may occur at other times of the year due to potential exposure of newly exposed sediment that will remain after dredging is completed.

5.2.2.3.3.2 Green Sturgeon

The in-water construction period (June 1–October 31) will avoid the peak upstream migration period of green sturgeon (late February to early May) although adults may be present in the action area during their outmigration in summer, fall, and winter. Juvenile green sturgeon may be present in the Delta year-round and therefore subject to exposure to contaminants during in-water construction activities (June 1-October 31) as well as other times of the year when they may encounter newly exposed sediment. Compared to salmonids, green sturgeon are more likely to be exposed to contaminated sediments and food sources because of their relatively long residence time (3-4 years for rearing juveniles) and prolonged contact with sediment both externally (e.g., resting and foraging on the bottom) and through ingestion of benthic food organisms.

5.2.2.3.4 Assess Species Response

5.2.2.3.4.1 Salmonids

The potential effects of contaminants on fish generally range from physiological stress, potentially resulting in delayed effects on growth, survival, and reproductive success, to direct mortality (acute toxicity) depending on the concentration, toxicity, solubility, bioavailability, and duration of exposure, as well as the sensitivity of the species and life stage. Studies have shown that dredging contaminated sediments increases particulate-bound contaminants in waters next to or near to the dredge, producing deleterious effects on species that occupy those areas. (Bellas et al. 2007; Bocchetti et al. 2008; Engwall et al. 1998; Sundberg et al. 2007; Sturve et al. 2005; Yeager et al. 2010). Heavy metals (Cd, Cu, Hg, Ni, Pb, Zn, Ag, Cr, As) and organic contaminants (PAHs, PCBx, pesticides) are of most concern. Generally, toxic metal and pesticide contamination can cause acute toxicity in aquatic organisms (as seen in some first flush events in urban creeks and streams) which may result in death from high concentrations, or chronic (sublethal) effects which reduces the organism's health and may lessen survival over time. Increased levels of heavy metals are detrimental because they interfere with metabolic functions through inhibition of enzyme activity, decrease neurological function, degrade cardiovascular output, and can act as mutagens, teratogens, or carcinogens to organisms that are exposed to them (Rand et al. 1995; Goyer 1996). Charged particles (metals like copper) can also interfere with ion exchange channels in sensitive membranes or structures like gills or olfactory rosettes. Lipophilic compounds in fine sediment, such as toxic polyaromatic hydrocarbons (PAHs) can be absorbed through lipid membranes of gill tissue, providing a pathway for exposure if fish swim through a sediment plume. Exposure to PAHs and other aromatic compounds typical of petroleum hydrocarbon contamination from industry, spills, and engine exhausts was shown to suppress immune responses in Chinook salmon (Varanasi et al. 1993; Arkoosh et al. 1998, 2001). Dredge plumes may also cause short lived changes in dissolved oxygen (DO), pH, hydrogen sulfide (H_2S), and ammonia (NH_3).

Toxic substances used at construction sites, including gasoline, lubricants, and other petroleum-based products, can also enter the aquatic environment as a result of accidental spills or leakage from machinery or storage containers. These substances can kill aquatic organisms through exposure to lethal concentrations or chronic exposure to non-lethal levels that cause physiological stress and increased susceptibility to other sources of mortality. In addition to the direct effects of exposure described above, contaminants can enter the aquatic food web and accumulate in fish through their diet, leading to lethal and sublethal effects, including effects on behavior, tissues and organs, reproduction, growth, and immune system (Connon et al. 2009).

5.2.2.3.4.2 Green Sturgeon

The potential effects of contaminants and general exposure mechanisms described above are generally applicable to green sturgeon. However, green sturgeon are more likely to be exposed to contaminated sediments and food sources because of their benthic behavior, diet, and relatively long residence of juveniles in the Delta (3-4 years). In addition, the relatively high metabolic oxygen requirements of green sturgeon (Mayfield and Cech 2004) increases their susceptibility to reductions in dissolved oxygen levels in bottom waters caused by dredging, which can adversely affect blood circulation, nervous system responses, food digestion, and other physiological functions.

5.2.2.3.5 Assess Risk to Individuals

5.2.2.3.5.1 Salmonids

Implementation of the proposed *Spill Prevention, Containment, and Countermeasure Plan* (AMM 5), *Hazardous Materials Management* (AMM6), and *Stormwater Pollution Prevention Plan* (AMM3) are expected to minimize the potential for spills or discharges of contaminants into the Sacramento River during construction of the proposed intakes. Adherence to all preventative, response, and disposal measures in the approved plans are expected to reduce the potential effects to listed fish species to discountable levels. No information is available on potential contaminant risks associated with disturbance and exposure of sediments resulting from dredging and other construction activities at the intake construction sites. However, this risk is expected to be minimized by developing and implementing a SAP to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. While some exposure of listed salmonids to sediment-borne contaminants may be unavoidable, these exposures are expected to be brief because of the limited aerial extent of in-water construction areas (pile driving, dredging, and barge operations), implementation of BMPs to limit the extent of sediment plumes originating from these areas, and the relatively short periods of time that juveniles and adults are likely to spend in the affected areas.

5.2.2.3.5.2 Green Sturgeon

The proposed AMMs to minimize the potential for spills or discharges of contaminants into the Sacramento River during construction of the proposed intakes are also expected to be protective of green sturgeon. Compared to salmonids, however, green sturgeon are considered to be at higher risk of exposure to contaminated sediments because of their benthic orientation, diet, and relatively long residence of juveniles in the Delta (3-4 years). Although in-water pile driving, dredging, and barge operations at the water conveyance facilities will disturb a small fraction of the potential habitat available to juveniles in the Delta, the potential for harm or mortality of some individuals from contaminant exposures may be magnified by their year-round presence (including the in-water construction period) and potential for exposure at multiple construction sites (north Delta intakes, barge landings, CCF, and HOR gate) during their residence in the Delta.

5.2.2.3.6 Assess Effects on Designated Critical Habitat

5.2.2.3.6.1 Salmonids

The potential release of contaminants through spills or sediment disturbance could affect the PBFs of designated critical habitat for listed salmonids through adverse effects on water quality and food resources (reduced abundance of benthic invertebrates and consumption of contaminated benthic invertebrates).

5.2.2.3.6.2 Green Sturgeon

The potential release of contaminants through spills or sediment disturbance could affect the PBFs of designated critical habitat for green sturgeon through adverse effects on water quality and food resources (reduced abundance of benthic invertebrates and consumption of contaminated benthic invertebrates).

5.2.2.4 Underwater Noise

During construction of the north Delta intakes, activities that are likely to generate underwater noise include pile driving, riprap placement, dredging, and barge operations. Pile driving poses the greatest risk to fish because the levels of underwater noise produced by impulsive types of sounds often reach levels of sufficient intensity to injure or kill fish within a certain radius of the source piles (Popper and Hastings 2009). Other activities such as riprap placement, dredging, and barge operations generally produce more continuous, lower energy sounds below the thresholds associated with direct injury but may cause avoidance behavior or temporary hearing loss or physiological stress if avoidance is not possible or exposure is prolonged (Popper and Hastings 2009).

During construction of the north Delta intakes, underwater noise levels of sufficient intensity to cause direct injury or mortality of fish could occur over a period of 12-42 days during the proposed in-water work period (June 1-October 31) for up to 2 years at each intake location. Restriction of pile driving activities to June 1-October 31 will avoid the primary migration seasons of adult winter-run Chinook salmon, spring-run Chinook salmon, and sturgeon, and the primary juvenile rearing and migration seasons of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead. However, because of the potential occurrence of salmonids and green sturgeon (see below) during pile driving activities, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory methods or other non-impact driving methods (e.g., drill-shaft methods) to install the cofferdam sheet piles and foundation piles. The degree to which vibratory and non-impact driving methods can be performed is uncertain at this time (due to uncertain geologic conditions at the proposed intake sites) although reasonable assumptions are applied to sheet pile installation in the following analysis. If impact pile driving is required, DWR, in coordination with the USFWS, NMFS, and CDFW, will evaluate the feasibility of other protective measures including dewatering, physical devices (e.g., bubble curtains), and operational measures (e.g., restricting pile driving to specific times of the day) to limit the intensity and duration of underwater noise levels when listed fish species may be present. Coordination, implementation, and monitoring of these measures will be performed in accordance with the underwater sound control and abatement plan, which includes hydroacoustic monitoring to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and corrective actions to be taken should the thresholds be exceeded. These measures may include additional physical or operational measures to further limit the magnitude and/or duration of underwater noise levels.

5.2.2.4.1 Assess Species Exposure

5.2.2.4.1.1 Salmonids

The Sacramento River is the primary migration route utilized by adult winter-run Chinook salmon, spring-run Chinook salmon, and steelhead to access upstream spawning areas in the Sacramento River basin, and the primary migration route for juveniles entering the Delta and estuary from upstream spawning and rearing areas. Restricting impact pile driving to June 1 to October 31 avoids the primary migration periods of winter- and spring-run adults and juveniles, and the primary migration period of steelhead juveniles in the action area. In some years, a small proportion of the total number of winter-run and spring-run Chinook salmon (adults and juveniles) and steelhead (juveniles) migrating through the action area may occur as late as June and July although water temperatures frequently exceed suitable ranges by late June or early July. Steelhead adults may be exposed to pile driving noise to a greater extent based on the timing of upstream migration, which generally extends from late summer through fall in the lower Sacramento River (August through November with a peak in September-October). There is some potential for winter-run juveniles (less than 60 mm in length) to occur in the lower Sacramento River and Delta in October but this is uncommon; typically, the earliest that juveniles would be expected to occur in the action area is November or December (del Rosario et al. 2013).

5.2.2.4.1.2 Green Sturgeon

The in-water construction period (June 1–October 31) will avoid the peak upstream migration period of green sturgeon (late February to early May) although post-spawning adults may encounter pile driving noise during their outmigration in summer and fall. Juvenile green sturgeon are present in the Delta year-round and are therefore subject to pile driving noise during the in-water construction period. Although the timing of their downstream movements is unknown, the risk of juveniles encountering pile driving noise during construction of the north Delta intakes is relatively high because this route serves as the primary migration route for juveniles entering the Delta from natal rearing areas in the upper Sacramento River.

5.2.2.4.2 Assess Species Response

5.2.2.4.2.1 Salmonids

Pile driving and other sources of anthropogenic noise have the potential to disrupt fish hearing and adversely affect fish through a broad range of behavioral, physiological, or physical effects (McCauley et al. 2003, Popper and Hastings 2009). These effects may include behavioral responses, physiological stress, temporary and permanent hearing loss, tissue damage (auditory and non-auditory), and direct mortality depending on the intensity and duration of exposure. In salmonids and most other teleost fish, the presence of a swim bladder to maintain buoyancy increases their vulnerability to direct physical injury (i.e., tissue and organ damage) from underwater noise (Hastings and Popper 2005). Underwater noise may also damage hearing organs that may temporarily affect hearing sensitivity, communication, and ability to detect predators or prey (Popper and Hastings 2009). Underwater noise may also cause behavioral effects (e.g., startle or avoidance responses) that can disrupt or alter normal activities (e.g., migration, holding, or feeding) or expose individuals to increased predation risk.

Pile driving noise has received increasing attention in recent years because of its potential to cause direct injury or mortality of fish and other aquatic animals. Factors that may influence the magnitude of effects include species, life stage, and size of fish; type and size of pile and hammer; frequency and duration of pile driving; site characteristics (e.g., depth); and distance of fish from the source. Dual interim criteria representing the acoustic thresholds associated with the onset of physiological effects in fish have been established to provide guidance for assessing the potential for injury resulting from pile driving noise (Fisheries Hydroacoustic Working Group 2008) (Table 5.2-1). The dual criteria for impact pile driving are (1) 206 decibels (dB) for peak sound pressure level (SPL); and (2) 187 dB for cumulative sound exposure level (SEL) for fish larger than 2 grams, and 183 dB SEL for fish smaller than 2 grams. The peak SPL threshold is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative SEL threshold is considered the total amount of acoustic energy that a fish can receive from single or multiple strikes without injury. The cumulative SEL threshold is based on the total daily exposure of a fish to noise from sources that are discontinuous (in this case, noise that occurs up to 12 hours a day, with 12 hours between exposures). This assumes that the fish is able to recover from any effects during this 12-hour period. These criteria relate to impact pile driving only. Vibratory pile driving is generally accepted as an effective measure for minimizing or eliminating the potential for injury of fish from pile driving operations.

Table 5.2-1. Interim Criteria for Injury to Fish from Pile Driving Activities.

Interim Criteria	Agreement in Principle
Peak Sound Pressure Level (SPL)	206 dB re: 1µPa (for all sizes of fish)
Cumulative Sound Exposure Level (SEL)	187 dB re: 1µPa^2-sec—for fish size ≥ 2 grams 183 dB re: 1µPa^2-sec—for fish size < 2 grams

In the following analysis, the potential for injury to fish from exposure to pile driving sounds was evaluated using a spreadsheet model developed by NMFS to calculate the distances from the pile that sound attenuates to the peak or cumulative criteria. These distances define the area in which the criteria are expected to be exceeded as a result of impact pile driving. The NMFS spreadsheet calculates these distances based on estimates of the single-strike sound levels for each pile type (measured at 10 meters from the pile) and the rate at which sound attenuates with distance. In the following analysis, the standard sound attenuation rate of 4.5 dB per doubling of distance was used in the absence of other data. To account for the exposure of fish to multiple pile driving strikes, the model computes a cumulative SEL for multiple strikes based on the single-strike SEL and the number of strikes per day or pile driving event. The NMFS spreadsheet also employs the concept of "effective quiet". This assumes that cumulative exposure of fish to pile driving sounds of less than 150 dB SEL does not result in injury.

Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Popper et al. 2006). NMFS generally assumes that a noise level of 150 dB root mean square (RMS) is an appropriate threshold for behavioral effects. NMFS acknowledges this uncertainty in other BiOps but believes this noise level is appropriate for identifying the potential for behavioral effects of pile driving sound on fish until new information indicates otherwise (e.g., National Marine Fisheries Service 2015).

5.2.2.4.2.2 Green Sturgeon

The interim criteria in Table 5.2-1 are assumed to be applicable to green sturgeon based on general similarities in anatomy and physiology (e.g., presence of a swim bladder) to other fishes for which data are available.

5.2.2.4.3 Assess Risk to Individuals

Table 5.2-2 presents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds based on application of the NMFS spreadsheet model and the assumptions presented in Appendix 3.E *Pile Driving Assumptions for the Proposed Action*. This analysis considers only those pile driving activities that could generate noise levels sufficient to exceed the interim injury thresholds in the Sacramento River or other waters potentially supporting listed fish species. These activities include impact pile driving in open water, in cofferdams adjacent to open water, or on land within 200 feet of open water. For cofferdam sheet piles, it is assumed that approximately 70% of the length of each pile can be driven using vibratory pile driving, with impact driving used to finalize pile placement. For the intake structure foundation piles, the current design assumes the use of impact pile driving only. However, some degree of attenuation is expected assuming that the cofferdams can be fully dewatered. Therefore, predictions are shown for two scenarios, one in which dewatering results in a 5 dB reduction in reference noise levels, and one in which no attenuation is possible (no dewatering or other forms of attenuation). All computed distances over which pile driving sounds are expected to exceed the injury and behavioral thresholds assume an unimpeded sound propagation path. However, site conditions such as major channel bends and other in-water structures can reduce these distances by impeding the propagation of underwater sound waves.

Table 5.2-2. Extent, Timing, and Duration of Pile Driving Noise Levels Predicted to Exceed the Interim Injury and Behavioral Thresholds at the North Delta Intake Sites

Facility or Structure	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 187 dB SEL Injury Threshold[1, 2] (feet)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Construction Season	Timing of Pile Driving	Duration of Pile Driving (days)
Intake 2						
Cofferdam	30	2,814	13,058	Year 8	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 9	Jun–Oct	19
Foundation (with attenuation)	20	1,522	15,226	Year 9	June-Oct	19
Intake 3						
Cofferdam	30	2,814	13,058	Year 7	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 8	Jun–Oct	14
Foundation (with attenuation)	20	1,522	15,226	Year 8	June-Oct	14
Intake 5						
Cofferdam	30	2,814	13,058	Year 5	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 6	Jun–Oct	19
Foundation (with attenuation)	20	1,522	15,226	Year 6	June-Oct	19

[1] Computed distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL). Calculation assumes that single strike SELs <150 dB do not accumulate to cause injury. Accordingly, once the distance to the cumulative injury threshold exceeds the distance to effective quiet, increasing the number of strikes does not increase the presumed injury distance.

[2] Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

Sound monitoring data collected during similar types of pile driving operations indicate that single-strike peak SPLs exceeding the interim injury thresholds are expected to be limited to areas within 30 feet of the cofferdam sheet piles and 20-46 feet of the intake foundation piles, depending on whether cofferdams can be dewatered (Table 5.2-2).

Based on a cumulative (daily) threshold of 187 dB SEL, the risk of injury is calculated to extend up to 5,628 feet (2,814 x 2) during installation of the cofferdams and 6,560 feet (3,280 x 2) during installation of the foundation piles (3,044 feet if the cofferdams can be dewatered) assuming an unimpeded propagation path.[3] The predictions in Table 5.2-2 apply to one intake location; the current construction schedule indicates that pile driving in a given year would occur at one intake only with the exception of Year 8 in which cofferdam installation at Intake 2 may

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[3] Based on the estimated number of pile strikes per day, the computed distances to the injury thresholds are governed by the distance to "effective quiet" (150 dB SEL).

coincide with foundation pile installation at intake 3 (Appendix 3.D *Construction Schedule for the Proposed Action*). In this case, there would be no overlap in the potential noise impact areas although fish migrating through the action area could be potentially exposed to pile driving noise over two reaches totaling 12,188 feet. Based on the duration of pile driving activities, such conditions could occur for up to 14 days based on the duration of foundation pile installation.

The potential for behavioral effects would extend beyond the distances associated with potential injury. Based on a threshold of 150 dB RMS, the potential for behavioral effects is calculated to extend up to 13,058 feet away during cofferdam sheet pile installation, and 32,800 feet away during intake foundation pile installation (15,226 feet away if the cofferdams can be dewatered) assuming an unimpeded propagation path. However, the extent of noise levels exceeding the injury and behavioral thresholds would be constrained to varying degrees by major channel bends that range from approximately 1,500 to 12,000 feet away from each intake facility.

For each intake facility, the current construction schedule indicates that cofferdam sheet piles would be installed over a period of 42 days at each intake location within the in-water construction season (June 1-October 31; August 1-September 30 if feasible) followed by installation of the intake foundation piles over a period of 14-19 days during the following season.

5.2.2.4.3.1 Salmonids

Pile driving noise may adversely affect adult and juvenile salmonids that are holding, migrating, or rearing near the intake sites. During pile driving activities, underwater noise levels sufficient to cause injury or mortality would extend across the entire width of the river and up to 3,280 feet away from the source piles. As previously discussed, exposure of salmonids to pile driving noise during the in-water construction period would be limited to a small proportion of adult and juvenile Chinook salmon and steelhead that may be migrating downstream through the action area in June and July, and to a larger proportion of adult steelhead that may begin their upstream migration in the Sacramento River in late summer and peak in abundance in early fall (September-October). Peak SPLs exceeding the injury criteria would be limited to small areas immediately adjacent to source piles (20–46 feet) and thus would affect 3-10% of the total channel width available for adults and juvenile to pass (see Appendix 3.E *Pile Driving Assumptions for the Proposed Action*). However, the potential for injury still exists because migrating adults and juveniles would be faced with passing through channel reaches of up to 6,560 feet long in which noise levels are predicted to exceed the cumulative injury thresholds. During the in-water construction period, most adults and juveniles that are likely to encounter pile driving noise would be actively migrating through the affected reaches, thus minimizing the duration of their exposure to underwater noise levels sufficient in intensity to cause injury or mortality. At the maximum cruising speeds reported for adult Chinook salmon and steelhead (up to 4 feet per second, respectively [Bell 1986]), adults would be able to swim through reaches up to 6,560 feet long in less than one hour and thus avoid cumulative exposures associated with potential injury. Published and unpublished data from telemetry studies of acoustic-tagged young-of-year and yearling smolts (80-170 mm fork length) also indicate rapid downstream migration rates, ranging from approximately 9 to 29 miles per day for fish released at upstream locations and detected leaving the Delta (Michel et al. 2012; Jason Hassrick, personal communication).

As noted above, pile-driving noise can disrupt or alter the behavior of fish, resulting in adverse effects on survival, growth, and reproductive success. For migrating salmonids, pile driving noise can potentially delay or block migrations or result in avoidance responses that could increase their exposure to other stressors such as elevated water temperatures, predators, or increased metabolic demands associated with prolonged delays. Based on a threshold of 150 dB RMS, the potential for behavioral effects is predicted to extend up to 13,058 feet away during cofferdam sheet pile installation and 32,800 feet away during intake foundation pile installation (15,226 feet away if the cofferdams can be dewatered) assuming an unimpeded propagation path. While evidence suggests that pile-driving operations may disrupt normal migratory behavior in salmonids (Feist et al. 1996), the risk of adverse effects associated with such delays is expected to be low because of the rapid migration rates of juveniles and adults expected to occur in the action area at the time of pile driving, and daily opportunities for juveniles and adults to pass the affected areas at night (dusk to dawn) when pile driving activities will cease. Nevertheless, juvenile salmonids that may be holding, sheltering, or feeding in these areas following initiation of pile driving activities each day may be forced to leave protective cover or exhibit alarm responses that could make them more vulnerable to predators.

Although the potential exists for injury or mortality of listed salmonids to occur at the north Delta intake sites due to pile driving noise, several actions are proposed to minimize this risk. Restriction of pile driving activities to June 1 through October 31 will avoid the primary rearing periods for anadromous salmonids in the lower Sacramento River, which is considered the most sensitive life stage to pile driving noise. The extent to which vibratory and other non-impact pile driving methods (e.g., drilling) will be used is unknown at this time but would be expected to substantially reduce the extent, intensity, and duration of pile driving noise potentially encountered by listed fish species. Furthermore, implementation of *AMM9 Underwater Sound Control and Abatement Plan* includes the use of a number of coordination, mitigation, and monitoring measures to avoid and minimize potential impacts on listed fish species, including 1) coordination with NMFS, USFWS, and CDFW during the design process to communicate any changes in proposed pile driving methods as updated design and geotechnical information becomes available; 2) potential use of a number of physical attenuation devices, including pile caps, bubble curtains, air-filled fabric barriers, and isolation piles; 3) implementation of hydroacoustic monitoring and operational protocols to maintain pile driving noise levels within specified limits; 4) monitoring the in-water work area for stressed or injured fish and temporarily stopping work to determine appropriate actions if stressed or injured fish are observed; 5) initiating impact pile driving with a "soft-start" to provide fish an opportunity to move away from the area before the standard force is applied; and 6) managing the timing and duration of daily pile driving operations, including operation of multiple pile drivers, to provide opportunities for fish to pass or leave the affected areas with minimal exposure to potentially harmful noise levels.

5.2.2.4.3.2 Green Sturgeon

As discussed above, green sturgeon may be exposed to pile driving noise as adults during their downriver migration from spawning areas in the summer and fall, and as juveniles during their 3-4-year residence period in the Delta. Factors that may limit exposure of green sturgeon to the direct effects of pile driving noise at the north Delta intakes include an avoidance response to pile driving noise, as observed for Atlantic salmon (Krebs et al. 2016; see below), and the rapid migration rate of adults through the action area; recent telemetry studies indicate that adult green sturgeon migrate rapidly to and from spawning areas in the upper Sacramento River, traversing the lower Sacramento River and estuary in less than one week (Heublein et al. 2009); tag detections at Knights Landing (RM 145) and Rio Vista Bridge (RM 21) equated to average migration rates of 1-3 miles per hour (1.5-4.4 feet per second) for summer and fall outmigrants. Kelly and Klimley (2011) studied movements of adult green sturgeon in San Francisco Bay and reported an average swimming speed of 1.6-2 feet per second and a maximum recorded speed of 7 feet per second. The lower range of these swimming speeds are generally in the range of sustained swimming speeds reported for other sturgeon species (e.g., Peake 2006). At these swimming speeds, green sturgeon adults would be able to pass through the potential impact reaches (pile driving noise exceeding the cumulative threshold of 187 dB are predicted to extend 5,628 feet for cofferdam sheet piles and 3,044-6,560 feet for intake foundation piles) in 1.2 hours or less and thus avoid exposures associated with potential injury.

The potential for injury and mortality is higher for juvenile green sturgeon because of their year-round presence in the Delta and potential for encountering pile driving noise at multiple locations during their 3-4 residence period. Juveniles may be at higher risk of exposure in the north Delta because of their need to pass through this region during their downstream movement to estuarine rearing areas. The timing of these movements are unknown but could overlap with the proposed in-water construction period. Factors that may limit exposure of juveniles to pile driving noise include the relatively large size of juveniles residing in the Delta. Based on the size distribution of juveniles observed at the export facilities in the southern Delta, most juveniles potentially encountering pile driving noise at the proposed intakes would be actively swimming juveniles (>100 mm in length) capable of avoiding or swimming away from areas of elevated noise. Although no data are available for green sturgeon, monitoring of acoustically-tagged Atlantic sturgeon (*Acipenser oxyrhinchus*) in the immediate vicinity of test pile locations in the Hudson River indicated that sturgeon avoided these areas during active pile driving (impact driving of 1.2-, 2.4-, and 3.0-meter steel piles), and did not remain long enough in these areas to be exposed to cumulative levels of noise sufficient to cause physiological effects (Krebs et al. 2016). Such behavior may disrupt or delay the movements of juveniles attempting to move through the affected reaches although opportunities to pass will occur at night (dusk to dawn) when pile driving activities will cease.

NMFS has also expressed concern about the potential for adverse effects of noise from tunnel boring (TBM) operations on listed fish species in the Delta, noting that green sturgeon may be especially sensitive. Tunnel boring operations can generate groundborne vibrations and noise that may be detected by sturgeon and other fishes living on the bed or in the water column above active tunneling operations. There are no studies that specifically relate groundborne vibration to resulting underwater sound pressure levels, but the levels associated with tunnel boring operations are likely comparable to those produced by vibratory driving, boats, and other sources of continuous sounds. These sounds are not expected to exceed thresholds associated with injury or mortality although behavioral effects may occur. However, in Atlantic sturgeon, Krebs et al. (2016) found no evidence of an avoidance response to vibratory driving. Assuming this observation is generally applicable to green sturgeon, tunnel boring noise is not likely to adversely affect green sturgeon.

5.2.2.4.4 Assess Effects on Designated Critical Habitat

5.2.2.4.4.1 Salmonids

Underwater noise levels from pile driving and other construction activities will affect the designated critical habitat of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead through temporary degradation of the PBFs of migratory habitat (i.e., unobstructed migratory pathways). Adverse effects on critical habitat would occur within areas subjected to noise levels associated with potential injury and behavioral effects, as described above. Underwater noise levels of sufficient intensity to cause direct injury or mortality of fish could occur over a period of 12-42 days during the proposed in-water work period (June 1-October 31) over a 2-year period at each intake location. Underwater noise levels will return to baseline levels following cessation of pile driving and other construction activities, and would not result in long-term impacts on critical habitat.

5.2.2.4.4.2 Green Sturgeon

The effects of underwater noise on the designated critical habitat of green sturgeon would be similar to that described for salmonids.

5.2.2.5 Fish Stranding

Installation of cofferdams in the Sacramento River has the potential to strand and subject fish to direct exposure to dewatering and other construction activities within the enclosed cofferdams. Sheet pile installation will be limited to the proposed in-water construction period (June 1-October 31) to avoid the peak abundance of listed fish species in the action area. When listed fish species may be present, DWR proposes to minimize potential stranding losses by implementing a fish rescue and salvage plan (Appendix 3.F *General Avoidance and Minimization Measures*, *AMM 8 Fish Rescue and Salvage Plan*). This plan will be submitted to the fish and wildlife agencies (NMFS, USFWS, CDFW) for review and approval prior to implementation. The plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that would apply to all in-water activities with the potential to strand fish. All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist. The biologist, in consultation with a designated agency biologist, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. For example, collection methods will likely vary depending on whether or to what extent (water depth) dewatering can be achieved.

5.2.2.5.1 Assess Species Exposure

5.2.2.5.1.1 Salmonids

Restriction of cofferdam construction and other in-water activities to June 1-October 31will avoid the primary migration and rearing periods of anadromous salmonids. Based on the general timing of migration of adult and juveniles in the action area, the potential for exposure of juvenile salmon and steelhead is relatively low. A higher risk of exposure exists for adult steelhead, especially in September and October when migration typically peaks in the Sacramento River.

5.2.2.5.1.2 Green Sturgeon

The in-water construction period (June 1–October 31) will avoid the peak upstream migration period of green sturgeon (late February to early May) although adults (including post-spawning adults) and rearing juveniles may be present in the Delta year-round and therefore subject to stranding during the proposed in-water construction period.

5.2.2.5.2 Assess Species Response

5.2.2.5.2.1 Salmonids

Most Chinook salmon and steelhead that are likely to be present in the action area at the time of cofferdam installation are likely to be large, migrating adults and juveniles that would be expected to avoid or move away from active construction areas, minimizing their risk of being stranded. Although present in low numbers, smaller, rearing juveniles would be at a higher risk of entrapment. Any stranded fish may experience stress and potential mortality in response to poor water quality (e.g., low dissolved oxygen) and would ultimately die as a result of dewatering or injuries caused by dredging or pile driving within the enclosed cofferdam.

5.2.2.5.2.2 Green Sturgeon

No specific information is available to evaluate the potential responses of green sturgeon to construction activities or their susceptibility to being stranded in cofferdams. However, most green sturgeon that are likely to be present in the action area at the time of cofferdam installation would be relatively large, highly mobile adults and juveniles that are capable of readily avoiding active construction areas.

5.2.2.5.3 Assess Risk to Individuals

5.2.2.5.3.1 Salmonids

With the implementation of a fish rescue and salvage plan (AMM8), the likelihood of stranding and subsequent injury or mortality of individual salmonids would be low. Although proposed fish rescue and salvage activities are expected to minimize these risks, some losses may still occur because of varying degrees of effectiveness of the collection methods and potential injury or mortality associated with capture, handling, and relocation of fish (Kelsch and Shields 1996, Reynolds 1996).

5.2.2.5.3.2 Green Sturgeon

The potential for injury or mortality of green sturgeon from stranding and fish rescue and salvage activities would be similar to that described for salmonids. Because of differences in size, behavior, and morphology of green sturgeon, alternative methods may be required to rescue and relocate any stranded individuals.

5.2.2.5.4 Assess Effects on Designated Critical Habitat

5.2.2.5.4.1 Salmonids

The potential for stranding during in-water construction activities would have a temporary adverse effect on the PBFs of the designated critical habitat of listed salmonids (e.g., safe and unobstructed migratory corridors).

5.2.2.5.4.2 Green Sturgeon

The potential for stranding during in-water construction activities would have a temporary adverse effect on the PBFs of the designated critical habitat of green sturgeon (safe and unobstructed migratory corridors).

5.2.2.6 Direct Physical Injury

During construction of the north Delta intakes, fish could be injured or killed by direct contact with equipment or materials that enter or operate within the open waters of the Sacramento River. Potential mechanisms include fish being crushed by falling rock (riprap), impinged by sheetpiles, entrained by dredges, or struck by propellers. In addition to the proposed work window (June 1-October 31), the potential for injury of listed fish species would be minimized to the extent practicable by limiting the duration of in-water construction activities and implementing the AMMs described in Appendix 3.F *General Avoidance and Minimization Measures*. Applicable AMMs include *Worker Awareness Training; Erosion and Sediment Control Plan; Disposal of Spoils, Reusable Tunnel Material, and Dredged Material; Barge Operations Plan; and Fish Rescue and Salvage Plan.*

5.2.2.6.1 Assess Species Exposure

5.2.2.6.1.1 Salmonids

Restriction of in-water activities to June 1-October 31 will avoid the primary migration and rearing periods of anadromous salmonids. Based on the general timing of migration of adult and juveniles in the action area, the potential for exposure for most species and life stages would be June and July although steelhead adults may also be present from August through October.

5.2.2.6.1.2 Green Sturgeon

Restriction of in-water activities to June 1-October 31 will avoid the peak upstream migration period of green sturgeon (late February to early May). However, a relatively high potential for exposure exists for adults (including post-spawning adults) and rearing juveniles that may be present in the Delta year-round and therefore subject to injury during the proposed in-water construction period.

5.2.2.6.2 Assess Species Response

5.2.2.6.2.1 Salmonids

As described above, most Chinook salmon and steelhead that are likely to be present in the action area during in-water construction activities are likely to be large, migrating adults and juveniles that would be expected to avoid or move away from active construction areas.

5.2.2.6.2.2 Green Sturgeon

Similarly, most green sturgeon that are likely to occur in the action area during in-water construction activities would be adults and large juveniles that are capable of avoiding active construction areas.

5.2.2.6.3 Assess Risk to Individuals

5.2.2.6.3.1 Salmonids

There is a low risk of injury or mortality of salmonids based on the likely response to active construction activities (See 5.2.2.4.3.1).

5.2.2.6.3.2 Green Sturgeon

There is a low risk of injury or mortality of green sturgeon based on the likely response to active construction activities.

5.2.2.6.4 Assess Effects on Designated Critical Habitat

5.2.2.6.4.1 Salmonids

The potential for injury during in-water construction activities would have a temporary adverse effect on the PBFs of the designated critical habitat of listed salmonids (safe and unobstructed migratory corridors).

5.2.2.6.4.2 Green Sturgeon

The potential for injury during in-water construction activities would have a temporary adverse effect on the PBFs of the designated critical habitat of listed salmonids (safe and unobstructed migratory corridors).

5.2.2.7 Loss/Alteration of Habitat

Construction of the proposed intake facilities would result in temporary to permanent losses or alteration of aquatic habitat on the Sacramento River. Temporary effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed. The following analysis focuses on longer-term to permanent losses or alteration of habitat associated with construction activities. These impacts total approximately 20.1 acres of tidal perennial habitat and 1.02 linear miles of channel margin habitat that encompass the in-water work areas and permanent footprints of intake structures. The footprint of each intake structure, including cofferdams, transition wall structures, and bank protection (riprap), would result in the permanent loss of approximately 6.6 acres of tidal perennial habitat and 1.02 linear miles of shoreline and associated riparian vegetation. At each intake location, these structures would encompass 1,600-2,000 linear feet of shoreline and 35 feet (5-7%) of the total channel width.

During construction activities, DWR will implement *AMM2 Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness.

DWR proposes to offset unavoidable impacts to the designated critical habitat of winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon through restoration of tidal marsh and channel margin habitat (SRA cover) at an approved restoration site or the purchase of conservation credits at an approved conservation bank.

5.2.2.7.1 Assess Species Exposure

5.2.2.7.1.1 Salmonids

All migrating and/or rearing salmonids that occur in the action area during construction of the intake facilities would be potentially exposed to the physical alteration of channel margin habitat (i.e., changes in water depths, velocities, substrate, and cover conditions) and permanent losses of aquatic habitat within the footprints of the intake structures.

5.2.2.7.1.2 Green Sturgeon

All migrating and/or rearing green sturgeon that occur in the action area during construction of the intake facilities would be potentially exposed to the physical alteration of channel margin habitat (i.e., changes in water depths, velocities, substrate, and cover conditions) and permanent losses of aquatic habitat within the footprints of the intake structures.

5.2.2.7.2 Assess Species Response

5.2.2.7.2.1 Salmonids

The leveed, channelized reaches of the Sacramento River near the proposed intakes primarily function as a migration corridor for adult and juvenile salmonids. The PBFs of migration and rearing habitat for salmonids have been degraded from historical conditions, and are unlikely to support high densities of juvenile salmonids. The temporary and permanent footprints of the intake facilities are characterized by steep, riprap-armored levee slopes with low quantities of overhanging and instream woody cover. Vegetation densities are low and much of the levee slope is unshaded. About 98% of the shoreline has less than 25% overhead cover (primarily from overhanging vegetation), and about 23% of the shoreline has less than 5% overhead cover. Shallow water is limited to a narrow band along the steep levee slope and there is no off-channel or floodplain habitat.

During and following construction, no significant changes would be expected in passage conditions (water depths and velocities) for adults because of their use of deeper, offshore portions of the channel for holding and migration. Some reduction is expected in the quality of rearing and passage conditions for juveniles due to permanent losses of shallow water habitat, the structural and hydraulic changes associated with the presence of cofferdams and riprap, and removal of vegetation within the temporary and permanent footprints of the intake.

5.2.2.7.2.2 Green Sturgeon

The leveed, channelized reaches of the Sacramento River near the proposed intakes primarily function as a migration corridor for adult green sturgeon migrating to upstream spawning areas, post-spawning adults migrating downstream from spawning areas, and juveniles migrating downstream to the estuary. Potential impacts would be limited to potential reductions in low-quality foraging habitat (nearshore benthic habitat) for green sturgeon within the temporary and permanent footprints of the intakes.

5.2.2.7.3 Assess Risk to Individuals

5.2.2.7.3.1 Salmonids

Temporary and permanent losses or alteration of habitat at the proposed intake sites are expected to have insignificant effects on migrating adult salmonids; passage conditions for adults would remain unobstructed during and following the construction of the intake facilities. Although the proposed locations of the intakes currently provide low quality rearing habitat for juvenile salmonids, construction of the intakes would further degrade this habitat by eliminating shallow water habitat and adversely affecting associated rearing and refuge functions, including protection from predatory fish that occupy deeper offshore waters of the Sacramento River. In addition, cofferdams, riprap, and other artificial structures provide physical and hydraulic conditions that may attract certain predatory fish species (e.g., striped bass, largemouth bass, Sacramento pikeminnow) and potentially increase their ability to ambush juvenile salmonids and other fishes.

5.2.2.7.3.2 Green Sturgeon

Based on the largely migratory function of the channel reaches near the intake facilities, construction of the intake facilities is unlikely to adversely affect passage conditions or foraging habitat of adult and juvenile green sturgeon. The loss or alteration of potential foraging habitat within the temporary and permanent footprints of the intake facilities is unlikely to have a measurable effect on growth and survival of individuals because it represents a very small proportion of the total amount of habitat available to adults and juveniles during their residence in the Delta and estuary.

5.2.2.7.4 Assess Effects on Designated Critical Habitat

5.2.2.7.4.1 Salmonids

Impacts to the designated critical habitat of listed salmonids include temporary and permanent impacts on juvenile rearing and migration habitat, as described above. DWR proposes to offset impacts to the designated critical habitat of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead through restoration of tidal perennial habitat and channel margin habitat at an approved restoration site and/or the purchase of conservation credits at an approved conservation bank (Table 3.4-1).

5.2.2.7.4.2 Green Sturgeon

Impacts to the designated critical habitat of southern DPS green sturgeon include temporary and permanent impacts on adult migration and juvenile rearing and migration habitat, as described above. DWR proposes to offset impacts to the designated critical habitat of green sturgeon through restoration of tidal perennial habitat at an approved restoration site and/or the purchase of conservation credits at an approved conservation bank (Table 3.4-1).

5.2.3 Barge Landings

5.2.3.1 Deconstruct the Action

Barge landings will be constructed at each of the TBM launch shaft sites for the loading and unloading of construction equipment, materials, fill, and tunnel spoils. A total of seven barge landings are currently proposed (Appendix 3.A *Map Book for the* Proposed Action) at the following locations:

- Snodgrass Slough north of Twin Cities Road (adjacent to proposed intermediate forebay)
- Little Potato Slough (Bouldin Island south)
- San Joaquin River (Venice Island south)
- San Joaquin River (Mandeville Island east at junction with Middle River)
- Middle River (Bacon Island north)
- Middle River (Victoria Island northwest)
- Old River (junction with West Canal at Clifton Court Forebay)

These locations are approximate but represent the general areas for these facilities based on their proximity to the launch shaft sites. 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. Additional details on the design, construction methods, and proposed construction schedule for the barge landings are described in Chapter 3.

Major construction elements of this action include barge landing construction, levee clearing and armoring (as necessary), and barge operations. The barge landings will be constructed over a period of 2 years. The specific design of the barge landings is unknown at this time. Docks supported by steel piles are currently proposed although floating barges will be used where possible to minimize in-water construction activities. Docks would each occupy an overwater area of approximately 300 by 50 feet (0.34 acre) spanning 5-9% of the total channel widths at the proposed locations. Some clearing and armoring of the levee may be required to provide access and protect the levee from wave erosion; such effects are included within the footprint estimate (30 acres total) for barge landings.

Following construction, these facilities will operate for 5-6 years serving the TBM launch and retrieval sites as well as other construction sites as needed. During construction of the tunnels and other water conveyance facilities, it is projected that up to 15,000 barge trips may be added to the daily vessel traffic in the action area. If these trips are divided evenly among the 7 proposed barge landings and spread over the number of days for 5.5 years, this corresponds conservatively to an average of 7.5 barge trips per day (1.1 per landing). To protect aquatic habitat and listed fish species, the barge operations plan (AMM7) will require barges and towing vessels to comply with standard navigation and operating rules to avoid or minimize physical disturbances and water quality impacts in the navigable waterways of the Delta. Where avoidance is not possible, the plan will include provisions to minimize effects as described in Appendix 3.F *General Avoidance and Minimization Measures*, Section 3.F.2.7.4 *Environmental Training* and Section 3.F.2.7.5 *Dock Approach and Departure Protocol*.

Construction of the barge landings would result in temporary impacts on water quality and permanent impacts on physical habitat within the footprints of the barge landings. The barge docks will affect a total of approximately 22.4 acres of tidal perennial habitat that includes the in-water work areas and docks, piers, and mooring structures. Each dock will be in use for the duration of construction activities (5-6 years) at the TBM shaft sites and other construction sites (e.g., north Delta intakes) as needed, and will be removed at the completion of construction. All piles will either be removed or cut at the mudline.

5.2.3.2 Turbidity and Sedimentation

Pile driving, riprap placement, and barge operations will be the principal sources of turbidity and suspended sediment during construction of the barge landings. These activities will result in disturbance of the channel bed and banks, resulting in periodic increases in turbidity and suspended sediment in the adjacent waterways. Barge operations will have temporary effects on turbidity and suspended sediment at the barge landings as well as along the routes that will be used to transport construction materials between the barge landings and existing commercial ports in the Delta and estuary.

Potential turbidity and sediment impacts on listed fish species and aquatic habitat will be minimized by restricting in-water construction activities to August 1 through October 31 at most locations[4]. In addition, DWR proposes to develop and implement a *Barge Operations Plan*, which includes specific measures to minimize bed scour, bank erosion, loss of submerged and emergent vegetation, and disturbance of benthic communities (Appendix 3.F *General Avoidance and Minimization Measures*). Other AMMs that are proposed to avoid or minimize potential turbidity, suspended sediment, and other water quality impacts include *Worker Awareness Training; Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan (SWPPP); Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan (SPCCP); Hazardous Material Management Plan; and Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F *General Avoidance and Minimization Measures*).

Some potential exists for construction-related turbidity and suspended sediment to occur during winter and spring due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with implementation of the proposed erosion and sediment control measures (AMM4) and other BMPs to ensure the effectiveness of these measures (*AMM2, Construction Best Management Practices and Monitoring*), no adverse water quality effects are anticipated outside of the in-water construction season.

5.2.3.2.1 Assess Species Exposure

5.2.3.2.1.1 Salmonids

The proposed timing of in-water construction activities at the barge landings (August through October) avoids the peak winter and spring migration and rearing periods of listed salmonids in the Delta. However, this period overlaps with the upstream migration of adult steelhead, which may enter the Delta in late summer (August-September) and peak in abundance in the fall and winter months in the Sacramento and San Joaquin River (September through January).[5] Following construction, these facilities will be operated year-round as needed to serve the TBM launch sites and other construction sites. Consequently, the potential exists for exposure of listed salmonids to potential physical disturbances, noise, and water quality effects of barge operations at all times of the year.

5.2.3.2.1.2 Green Sturgeon

The in-water construction period (August 1–October 31) will avoid the peak upstream migration period of green sturgeon (late February to early May) although adults (post-spawning adults), subadults, and rearing juveniles may be present in the Delta year-round and therefore potentially exposed to increases in turbidity and suspended sediment during the in-water construction period and year-round barge operations.

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[4] In-water construction activities at the north Delta intakes (Intake 3 and 5) and CCF, which may include barge landings, will be conducted June 1-October 31 and July 1-November 30, respectively.

[5] See section 5.2.2.2.1 for potential exposure of listed fish species at the north Delta intakes.

5.2.3.2.2 Assess Species Response

5.2.3.2.2.1 Salmonids

Based on the timing of in-water construction activities, adult steelhead may encounter localized increases in turbidity and suspended sediment at the barge landings during pile driving, riprap placement, and barge operations. Increases in nearshore turbidity and suspended sediment levels are also expected along the barge routes used to transport construction materials between the barge landings and commercial ports in the Delta and estuary.

As described in Section 5.2.2.2.2.1 *Salmonids,* turbidity and suspended sediment levels that are likely to be generated by these activities are not expected to reach levels that would cause direct injury to listed salmonids. Increases in nearshore turbidity and suspended sediment levels from waves generated by passing tug boats and barges are expected by short lived and infrequent based on the average increase of 7.5 trips per day throughout the entire action area. With implementation of the proposed AMMs to avoid or minimize potential turbidity, suspended sediment, and other water quality impacts (see section 5.2.3.3, *Contaminants*) on listed species and aquatic habitat, these activities are expected to result in temporary, localized increases in turbidity and suspended sediment levels that dissipate rapidly with distance from the source and return to baseline levels following cessation of activities. The effects on adult steelhead would likely be limited to harassment of individuals that encounter turbidity plumes.

5.2.3.2.2.2 Green Sturgeon

No specific information is available to evaluate the potential responses of green sturgeon to increased turbidity and suspended sediment. Green sturgeon may be affected in similar ways to salmonids but may be less sensitive to high turbidity when foraging because of their greater reliance on touch and electroreception (versus sight) to locate prey. However, green sturgeon are potentially more sensitive to the effects of barge operations on benthic invertebrate communities because of their benthic foraging behavior. Wave erosion and deposition of resuspended sediment in nearshore areas from barges and tug boats operating at the barge landings or along the barge routes can reduce food availability by dislodging or burying benthic substrates.

5.2.3.2.3 Assess Risk to Individuals

5.2.3.2.3.1 Salmonids

Increases in turbidity and suspended sediment levels during in-water construction activities at the barge landings will be temporary and localized, and unlikely to reach levels causing direct injury to anadromous salmonids. Because of the temporary, localized nature of elevated turbidity and suspended sediment, any disruptions of the normal behavior are expected to be brief and have insignificant effects on individual salmonids.

5.2.3.2.3.2 Green Sturgeon

Based on their large sizes, mobility, and benthic feeding adaptations, green sturgeon are unlikely to be affected by increases in turbidity and suspended sediment during construction of the .barge landings. Potential effects on food availability at the barge landings and along the barge routes are unlikely to affect green sturgeon feeding success and growth because of the small amount of habitat potentially affected at the barge landings and minor increases in number and frequency of barges operating in the Delta.

5.2.3.2.4 Assess Effects on Designated Critical Habitat

5.2.3.2.4.1 Salmonids

Increases in turbidity and suspended sediment levels during construction of the barge landings will affect the PBFs of designated critical habitat of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead. Elevated turbidity and suspended sediment generated by in-water construction activities and barge operations would primarily affect the PBFs of freshwater rearing habitat and migration corridors through temporary degradation of water quality and sedimentation of potential food-producing areas. As discussed above, water quality impacts will be localized and temporary and therefore the effect to the conservation value of rearing and migration habitat is insignificant. Increases in nearshore turbidity and suspended sediment levels from waves generated by passing tug boats and barges will extend the geographic area of effects on critical habitat but these effects are expected to be short-lived and infrequent based on the average daily increase in vessel trips throughout the entire action area.

5.2.3.2.4.2 Green Sturgeon

Increases in turbidity and suspended sediment levels during construction of the barge landings will affect the PBFs of designated critical habitat for southern DPS green sturgeon. . These effects would be limited to localized, temporary effects on the PBFs of freshwater riverine habitat through temporary degradation of water quality and sedimentation of potential food-producing areas. No long-term or permanent effects on critical habitat are expected.

5.2.3.3 Contaminants

Construction of the barge landings poses an exposure risk to listed fish species from potential spills of hazardous materials from construction equipment, barges and towing vessels, and other machinery, and from potential mobilization of contaminated sediment. The risk of accidental spills of contaminants and other hazardous materials during construction of the barge landings would be similar to that described for the north Delta intakes (section 5.2.2.3) due to the proximity of construction activities to the waters of the Delta. Implementation of Appendix 3.F *General Avoidance and Minimization Measures,* AMM 5 *Spill Prevention, Containment, and Countermeasure Plan* and AMM14 *Hazardous Materials Management* is expected to minimize the potential for introduction of contaminants into surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials. These AMMs include the use of watertight forms and other containment structures to prevent spills or discharge of raw concrete, wash water, and other contaminants from entering surface waters and other sensitive habitats during casting of the barge decks and other overwater activities. With implementation of these and other required construction BMPs (e.g., AMM 3 *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to Delta waters from in-water and overwater sources would be effectively minimized.

Contaminants may also enter the aquatic environment through disturbance, resuspension, or discharge of contaminated soil and sediments from construction sites. Because the barge landings would be constructed on Delta waterways adjacent to major agricultural islands, these sites are more likely to contain agricultural-related toxins such as copper and organochlorine pesticides. As described in Section 5.2.2.3 *Contaminants*, sediments act as a sink or source of contaminant exposure and resuspension of contaminated sediments may have adverse effects on fish that encounter sediment plumes or come into contact with newly exposed sediment.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under Appendix 3.F *General Avoidance and Minimization Measures,* AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material.* These measures include the preparation and implementation of a pre-construction sampling and analysis plan (SAP) to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (e.g., silt curtains) to achieve compliance with existing Basin Plan objectives will be an important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

5.2.3.3.1 Assess Species Exposure

5.2.3.3.1.1 Salmonids

The potential for contaminant spills would exist throughout the construction period but the highest risk to listed fish species and aquatic habitat would occur during in-water construction activities. These activities will be restricted to the in-water work period (August 1–October 31) to avoid the peak winter and spring migration and rearing periods of anadromous salmonids. However, this period overlaps with the upstream migration of adult steelhead, which may enter the Delta in late summer (August-September) and peak in abundance in the fall and winter months in the Sacramento and San Joaquin Rivers (September through January). The potential also exists for all listed salmonids that occur in the action area during their seasonal migration and rearing periods to encounter elevated contaminant levels through direct exposure to newly exposed sediment or uptake via their food sources (benthic invertebrates).

5.2.3.3.1.2 Green Sturgeon

The in-water construction period (August 1–October 31) will avoid the peak upstream migration period of green sturgeon (late February to early May) although adults (including post-spawning adults) and rearing juveniles may be present in the Delta year-round and therefore potentially subject to contaminant exposure during the in-water work window as well as other times of the year when they may encounter newly disturbed or exposed sediment. In comparison to salmonids, green sturgeon are more likely to be exposed to contaminated sediments and food sources because of their relatively long residence time (3-4 years for rearing juveniles) and prolonged contact with sediment both externally (e.g., resting and foraging on the bottom) and through ingestion of benthic food organisms.

5.2.3.3.2 Assess Species Response

5.2.3.3.2.1 Salmonids

As described in section 5.2.2.3, the discharge of contaminants into the aquatic environment can cause direct or indirect effects on fish depending on the type, concentrations, and fate of contaminants. In addition to direct exposure from spills or re-suspension of contaminated sediments, contaminants can enter the aquatic food web and accumulate in fish through their diet, leading to lethal and sublethal effects, including effects on behavior, tissues and organs, reproduction, growth, and immune system (Connon et al. 2009).

5.2.3.3.2.2 Green Sturgeon

The potential effects of contaminants and general exposure mechanisms described above are also applicable to green sturgeon.

5.2.3.3.3 Assess Risk to Individuals

5.2.3.3.3.1 Salmonids

Implementation of the proposed *Spill Prevention, Containment, and Countermeasure Plan* (AMM 5), *Hazardous Materials Management* (AMM6), and *Stormwater Pollution Prevention Plan* (AMM3) is expected to minimize the potential for spills or discharges of contaminants into the Delta waterways during construction of the barge landings. Adherence to all preventative, response, and disposal measures in the approved plans are expected to reduce the potential effects to listed fish species to discountable levels. No information is available on potential contaminant risks associated with disturbance and exposure of sediments resulting from pile driving and barge operations. However, this risk is expected to be minimized by developing and implementing a SAP to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Some exposure of listed salmonids to sediment-borne contaminants or elevated contaminants in food organisms may be unavoidable because of the potential dispersal of contaminants during construction and continued disturbance of contaminated sediments during year-round barge operations. However, these exposures are expected to be minimized by the limited aerial extent of in-water construction areas (pile driving and barge operations), implementation of BMPs to limit the extent of sediment plumes originating from these areas, and the relatively short periods of time that juveniles and adults are likely to spend in the affected areas.

5.2.3.3.3.2 Green Sturgeon

The proposed AMMs to minimize the potential for spills or discharges of contaminants into the Delta waterways during construction of barge landings are also expected to protect green sturgeon. Compared to salmonids, however, green sturgeon are considered to be at higher risk of exposure to contaminated sediments because of their benthic orientation, diet, and relatively long residence of juveniles in the Delta (3-4 years). Although in-water pile driving and barge operations at the water conveyance facilities will disturb a small fraction of the potential habitat available to juveniles in the Delta, the potential for harm or mortality of some individuals from contaminant exposures may be magnified by their year-round presence and potential for exposure at multiple construction sites (north Delta intakes, barge landings, and HOR gate) during their residence in the Delta.

5.2.3.3.4 Assess Effects on Designated Critical Habitat

5.2.3.3.4.1 Salmonids

The potential release of contaminants through spills or sediment disturbance could affect the PBFs of designated critical habitat of listed salmonids through adverse effects on water quality and food resources (direct exposure to sediment-borne contaminants or through consumption of contaminated benthic invertebrates) (see Section 5.2.2.3). Because of the widespread distribution of the proposed barge landings and barge routes in the Delta, the critical habitat for all listed salmonids could be affected.

5.2.3.3.4.2 Green Sturgeon

The potential release of contaminants through spills or sediment disturbance could affect the PBFs of designated critical habitat of green sturgeon through adverse effects on water quality and food resources (reduced abundance of benthic invertebrates and consumption of contaminated benthic invertebrates).

5.2.3.4 Underwater Noise

During construction of the barge landings, activities that are likely to generate underwater noise include in-water pile driving, riprap placement, and barge operations. Pile driving conducted in or near open water poses the greatest risk to fish because the levels of underwater noise produced by impulsive types of sounds often reach levels of sufficient intensity to injure or kill fish within a certain radius of the source piles (Popper and Hastings 2009). Other activities such as riprap placement and barge operations generally produce more continuous, lower energy sounds below the thresholds associated with direct injury but may cause avoidance behavior or temporary hearing loss or physiological stress if avoidance is not possible or exposure is prolonged (Popper and Hastings 2009).

Impact pile driving at the barge landing sites would potentially produce underwater noise levels of sufficient intensity and duration to cause injury to fish. Currently, it is estimated that each barge landing would require vibratory and/or impact driving of 107 steel pipe piles (24-inch diameter) to construct the dock and connecting bridge. Based on the concurrent operation of 4 impact pile drivers at each site and an estimated installation rate of 60 piles per day, pile driving noise would be expected to occur over a period of 2 days at each barge landing.

DWR proposes to minimize the potential exposure of listed fish species to pile driving noise by conducting all pile driving between August 1 and October 31 when most species are least likely to occur in the action area. In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when listed fish species may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and identify corrective actions to be taken should the thresholds be exceeded.

5.2.3.4.1 Assess Species Exposure

5.2.3.4.1.1 Salmonids

Restricting impact pile driving to the in-water work period (August 1–October 31) will avoid the primary migration and rearing periods of anadromous salmonids. However, this period coincides with the initiation of adult steelhead migration in the Delta in late summer and increasing numbers through the fall. Based on the general timing of migration in the action area, adult steelhead could be exposed to pile driving at the barge landings throughout the in-water work period.

5.2.3.4.1.2 Green Sturgeon

Restricting pile driving to August 1-October 31 will avoid the peak upstream migration period of green sturgeon (late February to early May) although adults (including post-spawning adults) and rearing juveniles may be present in the Delta year-round and therefore subject to exposure to pile driving noise during this period.

5.2.3.4.2 Assess Species Response

5.2.3.4.2.1 Salmonids

As described in Section 5.2.2.4, the potential responses of fish to pile driving noise can range from behavioral effects to direct injury or mortality, depending on a number of biological, physical, and exposure variables. Sound exposure criteria currently in use by state and federal resource and transportation agencies in California, Oregon, and Washington to evaluate the potential for injury to pile driving activities are presented in Table 5.2-1. The peak SPL is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative SEL is considered the total amount of acoustic energy that a fish can receive from a single or multiple strikes without injury. Pile driving and other sources of construction noise may also cause behavioral responses that could disrupt or delay normal activities, potentially leading to adverse effects on survival, growth, and reproductive success. Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Popper et al. 2006); however, it is generally assumed that 150 dB RMS is an appropriate threshold for behavioral effects.

5.2.3.4.2.2 Green Sturgeon

The interim criteria in Table 5.2-1 are assumed to be applicable to green sturgeon based on general similarities in anatomy and physiology (e.g., presence of a swim bladder) to other fishes for which data are available.

5.2.3.4.3 Assess Risk to Individuals

Table 5.2-3 presents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds at the barge landings based on application of the NMFS spreadsheet model and the assumptions presented in Appendix 3.E *Pile Driving Assumptions for the Proposed Action*. During installation of the dock piles, it is assumed that approximately 70% of the length of each pile can be driven using vibratory pile driving, with impact driving used to finalize pile placement.

Table 5.2-3. Extent, Timing, and Duration of Pile Driving Noise Levels Predicted to Exceed the Interim Injury and Behavioral Thresholds at the Barge Landing Sites.

Facility	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 187 dB SEL Injury Threshold[1, 2] (feet)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Number of Construction Seasons	Timing of Pile Driving	Duration of Pile Driving (days)
Barge Landings						
Dock piles	46	1,774	9,607	1 (Year 1 or 2)	Aug–Oct	2

[1] Computed distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL). Calculation assumes that single strike SELs <150 dB do not accumulate to cause injury. Accordingly, once the distance to the cumulative injury threshold exceeds the distance to effective quiet, increasing the number of strikes does not increase the presumed injury distance.

[2] Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, vibratory driving or other non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

Sound monitoring data collected during similar types of pile driving operations indicate that single-strike peak SPLs exceeding the interim injury thresholds are expected to be limited to areas within 46 feet of the source piles with no attenuation and 20 feet with attenuation (Table 5.2-3). Based on a cumulative (daily) threshold of 187 dB, the risk of injury is calculated to extend 1,774 feet away from the source piles without attenuation and 823 feet away from the source piles with attenuation.[6] Based on a threshold of 150 dB RMS, the potential for behavioral effects is calculated to extend 9,607 and 4,458 feet, respectively. However, the extent of noise levels exceeding the injury and behavioral thresholds would be constrained to varying degrees by major channel bends that typically occur within 700-8,500 feet of the barge landing sites. Pile driving activities at each site are projected to take place over a 2-day period during a single construction season. The current schedule indicates that pile driving at multiple sites would occur within the same construction season although the specific timing at individual sites is unknown (Appendix 3.D *Pile Driving*).

5.2.3.4.3.1 Salmonids

Restriction of pile driving activities to August 1 through October 31 will avoid the primary juvenile rearing and migration periods for anadromous salmonids in the Delta, which is considered the most sensitive life stage to underwater noise. Most salmonids that are likely to encounter pile driving noise would be upstream migrating adult steelhead. Peak SPLs exceeding the injury criteria would be limited to a radius of 20-46 feet around the source piles, affecting approximately 4-35% of the total channel width available for adults to pass (Appendix 3.E *Pile Driving Assumptions for the Proposed Action*). However, the potential for injury still exists because migrating adults would be faced with passing through channel reaches of up to 3,548 feet long (1,774 x 2) in which all or most of the channel width would be subjected to noise levels exceeding the cumulative injury thresholds. However, based on the reported maximum reported cruising speeds of adult steelhead (3-4 feet per second [Bell 1986]), adults would be capable of migrating through the affected reaches in less than 30 minutes, thus avoiding cumulative exposures associated with potential injury.to underwater noise levels. As discussed in section 5.2.2.4.3.1, pile driving noise can potentially delay or block migrations or result in avoidance

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[6] In this case, the distance to the injury thresholds are governed by the distance to "effective quiet" (150 cB SEL).

responses that could increase the exposure of adults to other stressors such as elevated water temperatures or increased metabolic demands associated with prolonged delays. However, the risk of adverse effects associated with such delays is expected to be low because of the rapid migration rates of adults, daily opportunities for adults to pass the affected areas at night (dusk to dawn), and the short duration of pile driving activities at each construction site (2 days).

To further minimize the risk of injury and mortality of steelhead from pile driving noise, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when listed fish species may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and identify corrective actions to be taken should the thresholds be exceeded. In addition, DWR will work with contractors to minimize pile driving activities at barge landing facilities by using floating docks instead of pile-supported docks wherever feasible, considering the load requirements of the landings and site conditions.

5.2.3.4.3.2 Green Sturgeon

Green sturgeon are also at risk of being injured or killed by pile driving noise at the barge landings. Post-spawning adults migrating down the Sacramento River in summer and fall may enter the DCC, Georgiana Slough, and other routes potentially leading to the barge landing sites. Juveniles are considered at higher risk because of their year-round presence in the Delta and potential for encountering pile driving noise at multiple locations during their 3-4 residence period. As discussed in section 5.2.2.4.3.2, evidence exists for avoidance of pile driving noise in other sturgeon species. Although such behavior may disrupt or delay the movements or foraging activities of juveniles in proximity to the barge landings, the risk of adverse effects is expected to be limited by daily opportunities for juveniles to leave the affected areas at night (dusk to dawn) and the short duration of pile driving activities at each site (2 days). To further limit the potential magnitude of take, DWR will implement an underwater sound control and abatement plan (AMM9), and perform hydroacoustic monitoring to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and identify corrective actions to be taken should the thresholds be exceeded.

5.2.3.4.4 Assess Effects on Designated Critical Habitat

5.2.3.4.4.1 Salmonids

Underwater noise levels from pile driving and other construction activities will affect the designated critical habitat of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead through temporary degradation of the PBFs of migratory habitat (i.e., unobstructed migratory pathways). Adverse effects on critical habitat would occur within areas subjected to noise levels associated with potential injury and behavioral effects, as described above. These effects would occur for up to 2 days at each barge landing site. Underwater noise levels will return to baseline levels following cessation of pile driving and other construction activities, and would not result in long-term impacts on critical habitat.

5.2.3.4.4.2 Green Sturgeon

The effects of underwater noise on the designated critical habitat of green sturgeon would be similar to that described for salmonids.

5.2.3.5 Fish Stranding

No actions are proposed at the barge landings that could result in stranding of fish or require fish rescue and salvage activities.

5.2.3.6 Direct Physical Injury

During construction of barge landings, fish could be injured or killed by direct contact with equipment or materials that are operated or placed in open waters of the adjacent Delta channels. Potential mechanisms include fish being crushed by falling rock (riprap), impinged by dock piles, and struck or entrained by vessels or propellers. In addition to the proposed work window (August 1-October 31), the potential for injury of listed fish species would be minimized by limiting the duration of in-water construction activities to the extent practicable and implementing the following AMMs: *General Avoidance and Minimization Measures*. Applicable AMMs include *Worker Awareness Training; Erosion and Sediment Control Plan; Disposal of Spoils, Reusable Tunnel Material, and Dredged Material; Barge Operations Plan; and Fish Rescue and Salvage Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

Operational effects of barge operations, including effects that could take place during transits of the Delta between barge loading and unloading facilities, include propeller entrainment and wave-induced shoreline impacts (e.g., dewatering, loss of benthic food organisms).

5.2.3.6.1 Assess Species Exposure

5.2.3.6.1.1 Salmonids

Restriction of pile driving to August 1-October 31will avoid the primary winter and spring migration and rearing periods of anadromous salmonids. However, this period overlaps with the upstream migration of adult steelhead, which may enter the Delta in late summer (August-September) and peak in abundance in the fall and winter months in the Sacramento and San Joaquin Rivers (September through January). Barge operations would continue year-round for 5-6 years following construction, potentially affecting all listed species of salmonids occurring in the Delta during their rearing and migration life stages.

5.2.3.6.1.2 Green Sturgeon

Restriction of in-water activities to August 1-October 31 will avoid the peak upstream migration period of green sturgeon (late February to early May) although adults (including post-spawning adults) and rearing juveniles may be present in the Delta year-round and therefore subject to injury during construction and operation of the barge landings.

5.2.3.6.2 Assess Species Response

5.2.3.6.2.1 Salmonids

Most anadromous salmonids that are likely to be present in the action area during construction of the barge landings are likely to be large, migrating adult steelhead that would be expected to avoid active construction areas and thus avoid injury. However, year-round barge operations could affect all listed species of salmonids occurring in the Delta during their rearing and migration life stages. These potential effects include direct injury or mortality of fish from entrainment into tug boat propellers. Although there are few direct observations of fish being seriously injured or killed by boat traffic (Rosen and Hales, 1980; Gutreuter et al. 2003), there is general agreement that the shear stresses caused by propellers result in mortality to early life stages (eggs and larval stages of fish), and that juvenile and adult fish are much less susceptible to entrainment because of their greater swimming capability (Morgan II et al., 1976; Holland, 1986; Killgore et al., 2001; Wolter and Arlinghaus 2003).

The potential effects of vessel traffic also include wave-induced disturbances or dewatering of nearshore (littoral) areas (Wolter and Arlinghaus 2003). The magnitude of these forces is related to channel morphology and vessel size and speed, but can result in significant disturbance to nearshore (littoral) communities, including juvenile fishes which can suffer from disorientation and stranding in nearshore areas during vessel passage, potentially leading to reduced survival and growth (Wolter and Arlinghaus 2003).

5.2.3.6.2.2 Green Sturgeon

The discussion above is assumed to generally apply to green sturgeon. Although green sturgeon are assumed to have a lower risk of interactions with vessels because of their use of deep water and benthic habitat, sturgeon in general may be susceptible to vessel interactions because of their surface-oriented behavior (e.g., breaching) as observed for white sturgeon, and anecdotal evidence of vessel interactions for other sturgeon species (NMFS 2014).

5.2.3.6.3 Assess Risk to Individuals

5.2.3.6.3.1 Salmonids

During construction of the barge landings, there is a low risk of injury of adult steelhead based on their likely response to noise, turbidity, and other construction-related disturbances at the barge landing sites (see 5.2.2.2.2 and 5.2.2.4.3). No information exists on the characteristics of vessels that are most likely to interact with listed salmonids or the rates of these interactions. Although implementation of the barge operations plan (AMM7) is expected to minimize potential interactions, the frequency of such interactions will likely increase and result in an elevated risk of direct injury (e.g., propeller strikes) of juvenile and adult salmonids. Year-round barge traffic will also increase the frequency of wave-induced shoreline disturbances, which could adversely affect rearing juveniles that depend on shallow nearshore areas for resting, feeding, and protection from predators. However, an average increase of 7.5 trips per day over the entire action area suggests that any increases in injury or harassment of listed salmonids would be expected to be small.

5.2.3.6.3.2 Green Sturgeon

Similar to salmonids, there is a low risk of injury of green sturgeon during construction of the barge landings based on their likely response to noise, turbidity, and other construction-related disturbances. Green sturgeon are also at risk of direct injury from increases in vessel traffic at the barge landings and along the routes that will be used to transport construction materials between the barge landings and existing commercial ports in the Delta and estuary. Although green sturgeon are assumed to have a lower risk of interactions with vessels because of their use of deep water and benthic habitat, sturgeon in general may be susceptible to vessel interactions because of their surface-oriented behavior (e.g., breaching) as observed for white sturgeon, and anecdotal evidence from other sturgeon species (NMFS 2014).

5.2.3.6.4 Assess Effects on Designated Critical Habitat

5.2.3.6.4.1 Salmonids

The potential for injury during in-water construction activities would have an adverse effect on the PBFs of the designated critical habitat of listed salmonids (safe and unobstructed migratory corridors).

5.2.3.6.4.2 Green Sturgeon

The potential for injury during in-water construction activities would have an adverse effect on the PBFs of the designated critical habitat of southern DPS green sturgeon (safe and unobstructed migratory corridors).

5.2.3.7 Alteration/Loss of Habitat

Construction of the barge landings and the operation of barges during and after construction would result in temporary to permanent losses or alteration of aquatic habitat in several channels of the east, south, and north Delta that are within the designated critical habitat of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and southern DPS green sturgeon. Temporary effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed. The following analysis focuses on longer-term to permanent losses or alteration of habitat associated with construction activities. These impacts encompass a total of approximately 22.4 acres of tidal perennial habitat that include the in-water work areas and permanent footprints of docks, mooring structures, and other in-water and overwater structures. The aquatic footprints of the individual barge landings would encompass 0.34 acre of overwater structures, encompassing approximately 300 linear feet of shoreline and 5-19% of the total width of the river or slough. This is considered a permanent alteration of habitat that would exist throughout the construction period (7-8 years).

During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. To further minimize adverse effects to aquatic habitat associated with barge operations, DWR also proposes to implement a *Barge Operations Plan*, which includes specific measures to minimize bed scour, bank erosion, loss of submerged and emergent vegetation, and disturbance of benthic communities (Appendix 3.F *General Avoidance and Minimization Measures*). DWR proposes to offset unavoidable impacts to the designated critical habitat of CCV steelhead and southern DPS green sturgeon through restoration of aquatic and channel margin habitat at an approved restoration site and/or the purchase of conservation credits at an approved conservation bank.

5.2.3.7.1 Assess Species Exposure

5.2.3.7.1.1 Salmonids

All migrating and/or rearing salmonids that occur in the action area during construction and operation of the barge landings would be potentially exposed to the physical alteration of channel margin habitat (i.e., changes in water depths, velocities, substrate, and cover conditions) and permanent losses of aquatic habitat within the footprints of the docks, mooring structures, and other in-water and overwater structures.

5.2.3.7.1.2 Green Sturgeon

All migrating and/or rearing green sturgeon that occur in the action area during construction and operation of the barge landings would be potentially exposed to the physical alteration of channel margin habitat (i.e., changes in water depths, velocities, substrate, and cover conditions) and permanent losses of aquatic habitat within the footprints of the docks, mooring structures, and other in-water and overwater structures.

5.2.3.7.2 Assess Species Response

5.2.3.7.2.1 Salmonids

Habitat conditions for anadromous salmonids in the vicinity of the proposed barge landings are degraded from historical conditions and the habitat likely functions primarily as a migration corridor for adults migrating to upstream spawning areas and juveniles migrating downstream to the estuary. The PBFs supporting the migration and rearing of steelhead in the action area have been degraded by altered flow patterns, levee construction, extensive riprapping, and loss of natural wetland and floodplain habitat. Because the barge landings will likely be sited in areas with steep levees, deep nearshore areas, and minimal obstructions to barge access and operations, it is unlikely that the construction and operation of the barge landings will substantially degrade the PBFs of critical habitat relative to current conditions. During and following construction, no measurable changes would be expected in channel widths or passage conditions (water depths and velocities) for adults because of their use of deeper, offshore portions of the channel for holding and migration. Some reductions are expected in the quality of passage and rearing conditions for juveniles due to the removal of aquatic and riparian vegetation, the addition of riprap to the levee slope, and the installation of artificial in-water and overwater structures within the permanent footprints of the barge landings. These actions would generally result in loss of cover, benthic food resources, and changes in physical and hydraulic conditions that may increase exposure of migrating juveniles to predation.

As previously discussed, adult and juvenile salmonids would likely avoid the barge landing sites during active periods of construction due to increased turbidity and suspended sediment, noise, and other construction-related disturbances (see 5.2.2.2.2.1 and 5.2.2.4.3.1). Although these sites lack high-quality rearing habitat, the addition of artificial in-water and overwater structures could further degrade the suitability of the sites for juvenile rearing and migration. Docks, piles, and barges provide shade and cover that may attract certain predatory fish species (e.g., striped bass, largemouth bass, Sacramento pikeminnow) and potentially increase their ability to ambush juvenile salmonids and other fishes. These structures may also improve predation opportunities for piscivorous birds (e.g., gulls, terns, cormorants) by providing perch sites immediately adjacent to open water. In addition, the elimination or disturbance of benthic habitat and associated invertebrate communities due to pile installation and scour would result in localized reductions in benthic food production that would likely persist for the duration of barge operations. This represents a permanent alteration of habitat that would exist throughout the construction period (2 years) and continue during operation of the barge landings (5-6 years).

5.2.3.7.2.2 Green Sturgeon

Habitat conditions for green sturgeon near the proposed barge landings are degraded from historical conditions and likely functions primarily as a migration corridor for adults migrating to upstream spawning areas and as foraging habitat for juveniles. Based on the expected changes in habitat conditions resulting from the construction of the barge landings, impacts to the PBFs of green sturgeon critical habitat would primarily be caused by the loss of foraging habitat within the permanent footprints of the barge landings.

5.2.3.7.3 Assess Risk to Individuals

5.2.3.7.3.1 Salmonids

Temporary and permanent losses or alteration of habitat at the proposed barge landing site are expected to have insignificant effects on migrating adult salmonids; passage conditions for adults would remain unobstructed throughout the construction period. Although the proposed barge landing sites currently provide low quality rearing habitat for juvenile salmonids, construction of the barge landings would further degrade this habitat by removing any existing vegetation from the levee slope and nearshore areas, placing riprap on the levee slope, and installing artificial in-water and overwater structures within the temporary and permanent footprints of the barge landings. These actions will generally result in loss of cover, benthic food resources, and changes in physical and hydraulic conditions that may increase predation opportunities. This is unlikely to significantly affect the growth of juvenile salmonids because of the low quality of existing habitat for rearing salmonids. However, the lack of cover for juvenile fish and presence of structural and overhead cover for predators may increase the risk of predation by increasing the amount of predator habitat and/or susceptibility of juvenile salmonids to predation.

5.2.3.7.3.2 Green Sturgeon

Similar to Section 5.2.3.1 construction of the barge landings is unlikely to adversely affect adult sturgeon, and would have minimal effects on rearing and passage conditions for juveniles. The primary effects would be similar to that of salmonids above on critical habitat of green sturgeon, with the loss of potential foraging habitat (benthic habitat) within the temporary and permanent footprints of the barge landings. This is unlikely to have a measurable effect on growth and survival of juvenile green sturgeon because it represents a very small proportion of the total amount of habitat available to juveniles during their residence in the Delta and estuary.

5.2.3.7.4 Assess Effects on Designated Critical Habitat

5.2.3.7.4.1 Salmonids

Impacts to the designated critical habitat of listed salmonids include permanent impacts on adult migration and juvenile rearing and migration habitat, as described above. DWR proposes to offset impacts to the designated critical habitat of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead through restoration of tidal perennial habitat at an approved restoration site[7] and/or the purchase of conservation credits at an approved conservation bank (Table 3.4-1).

5.2.3.7.4.2 Green Sturgeon

Impacts to the designated critical habitat of green sturgeon include permanent impacts on adult migration and juvenile rearing and migration habitat, as described above. DWR proposes to offset impacts to the designated critical habitat of green sturgeon through restoration of tidal perennial habitat at an approved restoration site and/or the purchase of conservation credits at an approved conservation bank (Table 3.4-1).

5.2.4 Head of Old River Gate

5.2.4.1 Deconstruct the Action

An operable gate (Head of Old River [HOR] gate) will be constructed at the HOR to prevent migrating juvenile salmonids (San Joaquin River-origin steelhead, spring-run Chinook salmon, and fall-run Chinook salmon) from entering Old River from the San Joaquin River, and thereby minimize their exposure to the CVP/SWP pumping facilities. The gate will be located in Old River approximately 400 feet downstream of the junction of Old River with the San Joaquin River (Appendix 3.A *Map Book for the Proposed Action*). The gate will be 210 feet long and 30 feet wide, with a top elevation of +15 feet (Appendix 3.C *Conceptual Engineering Report*, Volume 2, Sheets 11, 12, and 13), and include seven bottom-hinged gates, fish passage structure, boat lock, control building, boat lock operator's building, and communications antenna. Additional details on the design, construction methods, and proposed construction schedule for the HOR gate are described in Chapter 3.

Construction of the HOR gate is expected to take 2 years. The HOR gate will be constructed in two phases using cofferdams to isolate and dewater half the channel during the first phase and the other half during the second phase. All in-water construction work, including cofferdam installation, riprap placement, dredging, and barge operations, would be restricted to August 1-November 30 to minimize or avoid potential effects on listed fish species. In addition, all pile driving requiring the use of an impact pile driver in or near open water (cofferdams and foundation piles) will be restricted to the in-water work period to avoid or minimize exposure of listed species to potentially harmful underwater noise levels. Construction of the HOR gate will require dredging of approximately 500 feet of channel (150 feet upstream to 350 feet downstream from the proposed gate) and removal of up to 1,500 cubic yards of material with a barge-mounted hydraulic or a sealed clamshell dredge. The need for additional clearing and grading of the site for construction, staging, and other support facilities is expected to be minimal because of the presence of existing access roads and staging areas that have been used in the past for installation of a temporary rock barrier.

Construction of the HOR gate will result in temporary impacts on water quality and permanent impacts on physical habitat within the footprint of the gate and channel reaches that would be

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[7] Some combination of channel margin and tidal perennial habitat, sited and designed in coordination with NMFS and CDFW, may be targeted to achieve these benefits, consistent with restoring south Delta historical habitat function and processes (see 3.4.3.1.3).

affected by dredging. These impacts encompass a total of approximately 2.9 acres of tidal perennial habitat that includes the permanent footprint of the gate, fish passage structure, and boat lock.

5.2.4.2 Turbidity and Suspended Sediment

Construction activities would result in disturbance of the channel bed and banks, resulting in temporary increases in turbidity and suspended sediment levels in Old River and potentially the San Joaquin River. These activities include cofferdam construction (sheet pile installation), dredging, levee clearing and grading, riprap placement, and barge operations. All other sediment-disturbing activities will be outside or isolated from the active channel and would not result in the discharge of sediment to the river. Water pumped from the cofferdams will be treated (removing all sediment) using settling basins or Baker tanks, and returned to the river. In addition to the in-water work window, a number of AMMs are proposed to avoid or minimize potential impacts on water quality and listed fish species during construction of the HOR gate. These AMMs include *Worker Awareness Training; Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan (SWPPP); Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan (SPCCP); Hazardous Material Management Plan;* and *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F *General Avoidance and Minimization Measures*).

5.2.4.2.1 Assess Species Exposure

5.2.4.2.1.1 Salmonids

Restriction of these activities to the in-water work period (August 1–November 30) will avoid the primary winter and spring migration and rearing periods of anadromous salmonids. However, this period overlaps with the upstream migration of adult steelhead in October and November and the downstream migration of juvenile steelhead (yearling and older smolts) in November. San Joaquin River (SJR)-basin spring-run Chinook salmon (yearling smolts) may also be present in November, assuming juveniles exhibit similar emigration patterns to Sacramento River spring-run populations

5.2.4.2.1.2 Green Sturgeon

Both adult and juvenile green sturgeon are known to occur in the lower reaches of the San Joaquin River and Delta. The risk of exposure of adults to construction activities at the HOR may be lower than other regions of the Delta because of the location and timing of construction activities relative to the primary migration route (Sacramento River) and timing of upstream migration (late February to early May). Juvenile green sturgeon may be present year-round and therefore could be exposed to in-water construction activities and associated increases in turbidity, suspended sediment, and other construction-related disturbances during the proposed in-water construction period.

5.2.4.2.2 Assess Species Response

5.2.4.2.2.1 Salmonids

As described in section 5.2.2.2, turbidity and suspended levels typically generated by in-water construction activities are not expected to reach levels that would cause direct injury to salmonids. All steelhead and spring-run Chinook salmon that are likely to be present in the action area during the in-water work window would be expected to be large, actively migrating adults and juveniles (yearling or older smolts) that are known to move rapidly through the Delta during their upstream and downstream migrations (see 5.2.2.4.3.1). With implementation of the AMMs, in-water construction activities would result in temporary, localized increases in turbidity and suspended sediment that dissipate rapidly with distance from the source and return to baseline levels following cessation of activities. The effects on adult and juvenile steelhead would likely be limited to harassment of individuals that encounter turbidity plumes.

Increases in suspended sediment during in-water construction activities may result in localized sediment deposition in the vicinity of the HOR gate, potentially degrading food-producing areas by burying benthic substrates that support important food organisms (benthic invertebrates) for juvenile salmonids. Because of the localized nature of these effects and brief exposure of migrating juveniles to reduced food availability, no measurable effect on growth or survival of juveniles is expected.

5.2.4.2.2.2 Green Sturgeon

No specific information is available to evaluate the potential responses of green sturgeon to increased turbidity and suspended sediment. Green sturgeon may be affected in similar ways to salmonids although green sturgeon may be less sensitive to short-term increases in suspended sediments or turbidity because of their use of olfactory cues as opposed to vision to locate prey. Any reductions in the availability of foraging habitat and food availability due to sedimentation of benthic habitat may force green sturgeon to seek alternative foraging areas but this would likely have no measurable effects on growth or survival because the affected area represents a very small proportion of the total amount of foraging habitat available to green sturgeon in the Delta and estuary.

5.2.4.2.3 Assess Risk to Individuals

5.2.4.2.3.1 Salmonids

Based on the expected responses of salmonids to construction-related increases on turbidity and suspended sediment, any disruptions of the normal behavior are expected to be brief, but may potentially increase predation on juveniles.

5.2.4.2.3.2 Green Sturgeon

Based on the expected responses of green sturgeon to construction-related increases in turbidity and suspended sediment levels, the potential effects of increased turbidity and suspended sediment during construction of the HOR gate is expected to be insignificant. Although green sturgeon are more sensitive to reductions in benthic food resources, the small spatial and temporal scale of impacts on these food resources is unlikely to affect access to food resources and individual foraging success.

5.2.4.2.4 Assess Effects on Designated Critical Habitat

5.2.4.2.4.1 Salmonids

Increases in turbidity and suspended sediment levels during construction of the HOR gate will affect the PCEs of the designated critical habitat of CCV steelhead. Elevated turbidity and suspended sediment generated by in-water construction activities would primarily affect the PCEs of freshwater rearing habitat and migration corridors through temporary degradation of water quality and potential sedimentation of potential food-producing areas. These effects will be localized and temporary and therefore unlikely to significantly affect the conservation value of rearing and migration habitat in the action area.

5.2.4.2.4.2 Green Sturgeon

Increases in turbidity and suspended sediment levels during construction of the HOR gate will affect the PBFs of the designated critical habitat for southern DPS green sturgeon. These effects would be limited to localized, temporary degradation of the PBFs of water quality and potential sedimentation of food-producing areas. No long-term or permanent effects on critical habitat are expected.

5.2.4.3 Contaminants

Construction of the HOR gate poses an exposure risk to listed fish species from potential spills of hazardous materials from construction equipment, barges and towing vessels, and other machinery, and from potential mobilization of contaminated sediment. The risk of accidental spills of contaminants and other potentially hazardous materials would be similar to that described for the north Delta intakes (section 5.2.2.3) due to the proximity of construction activities to the waters of the Delta. Implementation of AMM 5, *Spill Prevention, Containment, and Countermeasure Plan*, and AMM14 *Hazardous Materials Management* (see Appendix 3.F *General Avoidance and Minimization Measures*) is expected to minimize the potential for introduction of contaminants into surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials. With implementation of these and other required construction BMPs (e.g., AMM 3, *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to Delta waters from in-water or upland sources would be effectively minimized.

Contaminants may also enter the aquatic environment through disturbance, resuspension, or discharge of contaminated soil and sediments from construction sites. As described in section 5.2.2.3, sediments act as a sink or source of contaminant exposure, and resuspension of contaminated sediments may have adverse effects on fish that encounter sediment plumes or come into contact with deposited or newly exposed sediment. Contaminated sediments may be present in Old River and within the footprint of the proposed HOR gate because of the proximity of the site to major municipal, industrial, and agricultural areas. The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material* in Appendix 3.F *General Avoidance and Minimization Measures.* These measures include the preparation and implementation of a pre-construction sampling and analysis plan (SAP) to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (e.g., silt curtains) to achieve compliance with existing Basin Plan objectives will be an important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

5.2.4.3.1 Assess Species Exposure

5.2.4.3.1.1 Salmonids

The potential for contaminant spills or releases would exist throughout the construction period but the highest risk would occur during in-water construction activities. The timing of in-water construction activities (August 1–November 30) overlaps with the upstream migration of adult steelhead starting in October and November and the downstream migration of juvenile steelhead (yearling and older smolts) in November. SJR-basin spring-run Chinook salmon (yearling smolts) may also be present in November, assuming juveniles exhibit similar emigration patterns to Sacramento River spring-run populations. Potential exposure to contaminant spills during in-water construction activities is expected to be brief because most adult and juvenile salmonids that may be present will be actively migrating through the action area during these months. However, exposure to contaminants may occur at other times of the year due to potential exposure of newly exposed sediment that will remain after construction is completed.

5.2.4.3.1.2 Green Sturgeon

The risk of exposure of adult green sturgeon to potential contaminant spills at the HOR may be lower than other regions of the Delta because of the location and timing of construction activities relative to the primary migration route (Sacramento River) and timing of upstream migration (late February to early May). Juvenile green sturgeon may be present year-round and therefore could be exposed to potential contaminant spills as well as potential contaminants in newly exposed sediment throughout the year. In comparison to salmonids, green sturgeon are more likely to be exposed to contaminated sediments and food sources because of their relatively long residence time (3-4 years for rearing juveniles) and prolonged contact with sediment both externally (e.g., resting and foraging on the bottom) and through ingestion of benthic food organisms.

5.2.4.3.2 Assess Species Response

5.2.4.3.2.1 Salmonids

As described in Section 5.2.2.3, the discharge of contaminants into the aquatic environment can cause direct or indirect effects on fish depending on the type, concentrations, and fate of contaminants. In addition to direct exposure from spills or re-suspension of contaminated sediments, contaminants can enter the aquatic food web and accumulate in fish through their diet, leading to lethal and sublethal effects, including effects on behavior, tissues and organs, reproduction, growth, and immune system (Connon et al. 2009).

5.2.4.3.2.2 Green Sturgeon

The potential effects of contaminants and general exposure mechanisms described above are also applicable to green sturgeon.

5.2.4.3.3 Assess Risk to Individuals

5.2.4.3.3.1 Salmonids

Implementation of the proposed *Spill Prevention, Containment, and Countermeasure Plan* (AMM 5), *Hazardous Materials Management* (AMM6), and *Stormwater Pollution Prevention Plan* (AMM3) is expected to minimize the potential for spills or discharges of contaminants into Old River. Adherence to all preventative, response, and disposal measures in the approved plans are expected to reduce the potential effects to listed fish species to discountable levels. No information is available on potential contaminant risks associated with disturbance and exposure of sediments resulting from pile driving and barge operations. However, this risk is expected to be minimized by developing and implementing a SAP to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Some exposure of listed salmonids to sediment-borne contaminants or elevated contaminants in food organisms may be unavoidable because of the potential dispersal of contaminants during construction and continued disturbance and exposure of sediments during construction and maintenance dredging.

5.2.4.3.3.2 Green Sturgeon

The proposed AMMs to minimize the potential for spills or discharges of contaminants into Old River during construction of the HOR gate are also expected to protect green sturgeon. Compared to salmonids, however, green sturgeon are considered to be at higher risk of exposure to contaminated sediments because of their benthic orientation, diet, and relatively long residence of juveniles in the Delta (3-4 years). Although in-water pile driving, dredging, and barge operations will disturb a small fraction of the potential habitat available to juveniles in the Delta, the potential for harm or mortality of some individuals from contaminant exposures may be magnified by their year-round presence and potential for exposure at multiple construction sites (north Delta intakes, barge landings, and CCF) during their residence in the Delta.

5.2.4.3.4 Assess Effects on Designated Critical Habitat

5.2.4.3.4.1 Salmonids

The potential release of contaminants through spills or sediment disturbance could affect the PBFs of the designated critical habitat of CCV steelhead and SJR basin spring-run Chinook salmon through adverse effects on water quality and food resources (reduced abundance of benthic invertebrates and consumption of contaminated benthic invertebrates).

5.2.4.3.4.2 Green Sturgeon

The potential release of contaminants through spills or sediment disturbance could affect the PBFs of the designated critical habitat of green sturgeon through adverse effects on water quality and food resources (reduced abundance of benthic invertebrates and consumption of contaminated benthic invertebrates).

5.2.4.4 Underwater Noise

During construction of the HOR gate, activities that are likely to generate underwater noise include in-water pile driving, riprap placement, dredging, and barge operations. Pile driving conducted in or near open water poses the greatest risk to fish because the levels of underwater noise produced by impulsive types of sounds often reach levels of sufficient intensity to injure or kill fish within a certain radius of the source piles (Popper and Hastings 2009). Other activities such as riprap placement, dredging, and barge operations generally produce more continuous, lower energy sounds below the thresholds associated with direct injury but may cause avoidance behavior or temporary hearing loss or physiological stress if avoidance is not possible or exposure is prolonged (Popper and Hastings 2009).

Impact pile driving at the barge landing sites would potentially produce underwater noise levels of sufficient intensity and duration to cause injury to fish. Currently, it is estimated that the HOR gate would require the installation of 550 temporary sheet piles (275 piles per season) to construct the cofferdams and 100 14-inch steel pipe or H-piles (50 piles per season) to construct the foundation. Based on an assumed installation rate of 15 piles per day, pile driving would be expected to occur up to 19 days per season during installation of the sheet piles, and up to 4 days per season during installation of the foundation piles. DWR proposes to minimize the potential exposure of listed fish species to pile driving noise by conducting all in-water construction activities between August 1 and November 30. In addition, DWR proposes to minimize the risk of injury to fish by using vibratory methods or other non-impact driving and attenuation methods to the extent feasible. Sheet piles will be installed starting with a vibratory hammer, then switching to impact hammer if refusal is encountered before target depths. For the purposes of the following analysis, it is assumed that approximately 70% of the sheet piles can be driven using a vibratory hammer, followed by an estimated 210 strikes to drive the sheet piles to the final depth using an impact hammer. For the foundation piles, the current design assumes the use of impact pile driving only. However, some degree of attenuation is expected assuming that the cofferdams can be fully dewatered. Therefore, predictions are shown for two scenarios, one in which dewatering results in a 5 dB reduction in reference noise levels, and one in which no attenuation is possible (no dewatering or other forms of attenuation). It is possible that cast-in-drilled-hole concrete piles will be used to construct the foundation depending on the results of geotechnical evaluations and final design. Based on the potential for injury of listed fish species, DWR may also implement other protective measures on accordance with an underwater sound control and abatement plan (Appendix 3.F *General Avoidance and Minimization Measures*, *AMM9 Underwater Sound Control and Abatement Plan*).

5.2.4.4.1 Assess Species Exposure

5.2.4.4.1.1 Salmonids

Based on the in-water work window of August 1-November 30, pile driving activities overlap with the upstream migration of adult steelhead in October and November and the downstream migration of juvenile steelhead (yearling and older smolts) in November. SJR-basin spring-run Chinook salmon (yearling smolts) may also be present in November, assuming juveniles exhibit similar emigration patterns to Sacramento River spring-run populations.

5.2.4.4.1.2 Green Sturgeon

Both adult and juvenile green sturgeon are known to occur in the lower reaches of the San Joaquin River and Delta. The risk of exposure of adult green sturgeon to pile driving noise at the HOR gate may be lower than other regions of the Delta because of the location and timing of construction activities relative to the primary migration route (Sacramento River) and timing of upstream migration (late February to early May). Juvenile green sturgeon may be present year-round and therefore could be exposed to pile driving noise during the proposed in-water construction period.

5.2.4.4.2 Assess Species Response

5.2.4.4.2.1 Salmonids

As described in Section 5.2.2.4, the potential responses of fish to pile driving noise can range from behavioral effects to direct injury or mortality, depending on a number of biological, physical, and exposure variables. Sound exposure criteria currently in use by state and federal resource and transportation agencies in California, Oregon, and Washington to evaluate the potential for injury to pile driving activities are presented in Table 5.2-1. The peak SPL is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative SEL is considered the total amount of acoustic energy that a fish can receive from a single or multiple strikes without injury. Pile driving and other sources of construction noise may also cause behavioral responses that could disrupt or delay normal activities, potentially leading to adverse effects on survival, growth, and reproductive success. Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Popper et al. 2006); however, it is generally assumed that 150 dB RMS is an appropriate threshold for behavioral effects.

5.2.4.4.2.2 Green Sturgeon

The interim criteria in Table 5.2-1 are assumed to be applicable to green sturgeon based on general similarities in anatomy and physiology (e.g., presence of a swim bladder) to other fishes for which data are available.

5.2.4.4.3 Assess Risk to Individuals

Table 5.2-2 presents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds at the HOR gate based on application of the NMFS spreadsheet model and the assumptions presented in Appendix 3.E *Pile Driving Assumptions for the Proposed Action*.

Table 5.2-4. Extent, Timing, and Duration of Pile Driving Noise Levels Predicted to Exceed the Interim Injury and Behavioral Thresholds at the Head of Old River Gate.

Facility	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 187 and 183 dB SEL Injury Threshold[1] (feet)	Distance to 150 dB RMS Behavioral Threshold[1] (feet)	Number of Construction Seasons	Timing of Pile Driving	Duration of Pile Driving per Season (days)
Head of Old River Gate						
Cofferdams	30	2,063	13,058	2	Aug–Nov	19
Foundation (no attenuation)	46	1,774[2]	9,607	2	Aug–Nov	4
Foundation (with attenuation)	20	823[2]	4,458	2	Aug–Nov	4

[1] Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, vibratory driving or other non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

[2] Computed distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL). Calculation assumes that single strike SELs <150 dB do not accumulate to cause injury. Accordingly, once the distance to the cumulative injury threshold exceeds the distance to effective quiet, increasing the number of strikes does not increase the presumed injury distance..

Sound monitoring data collected during similar types of pile driving operations indicate that single-strike peak SPLs exceeding the interim injury thresholds are expected to be limited to areas within 30 feet of the cofferdam sheet piles and 20-46 feet of the foundation piles, depending on whether cofferdams can be dewatered (Table 5.2.4). Based on a cumulative (daily) threshold of 187 dB SEL, the risk of injury is calculated to extend up to 4,126 feet (2,063 x 2) during installation of the cofferdams and 3,548 feet (1,774 x 2) during installation of the foundation piles (1,646 feet if the cofferdams can be dewatered) assuming an unimpeded propagation path. Based on a threshold of 150 dB RMS, the potential for behavioral effects is calculated to extend up to 13,058 feet away during cofferdam sheet pile installation, and 9,607 feet away during foundation pile installation (4,458 feet away if the cofferdams can be dewatered) assuming an unimpeded propagation path. However, the extent of noise levels exceeding the injury and behavioral thresholds would be constrained by major channel bends or levees located approximately 1,500 feet downstream of the proposed construction site in Old River, and approximately 700 feet upstream where levees at the junction of the San Joaquin River and Old River which would create a major impediment to sound propagation. The potential for effects could occur during two construction seasons (August 1-November 30) for up to 19 days during cofferdam installation and 4 days during foundation pile installation.

5.2.4.4.3.1 Salmonids

Pile driving activities from August 1 through November 30 may overlap with the upstream migration of adult steelhead in October and November and the downstream migration of juvenile steelhead and spring-run Chinook salmon (yearling or older smolts) in November. During cofferdam and foundation pile installation, peak SPLs exceeding the injury criteria would be limited to areas immediately adjacent to the source piles (20-46 feet), affecting approximately 27-61% of the total channel width available for adults to pass (75 feet). However, adults and juveniles passing the construction site during active pile driving operations would be potentially subject to cumulative noise exposures exceeding 187 dB SEL over areas extending across the entire width of Old River and upstream and downstream up to 2,063 feet away. Consequently, underwater noise levels capable of causing injury could affect adults and juveniles attempting to pass the construction site in Old River or migrating in the San Joaquin River and attempting to pass the Old River junction. However, the distances over which these levels would occur would likely be constrained by a major channel bend located approximately 1,500 feet downstream of the proposed construction site in Old River, and by levees at the junction of the San Joaquin River and Old River approximately 700 feet upstream of the site. Based on the general migration rates and reported swimming speeds of migrating adults and juvenile salmonids (smolts) (see Section 5.2.2.4.3), adult and juvenile steelhead within the range of sizes that are likely to occur in Old River and the San Joaquin River during pile driving activities would be capable of swimming through the affected reaches within a few hours and thus avoid or minimize their exposure to potentially harmful levels of underwater noise. Similarly, any delays in migration due to avoidance behavior are expected to be minor because of the rapid migration rates of juveniles and adults and daily opportunities for juveniles and adults to pass the affected areas at night when pile driving activities will cease. Nevertheless, juvenile salmonids that may be holding, sheltering, or feeding in these areas following initiation of daily pile driving activities may be forced to leave protective cover or exhibit alarm responses that could make them more vulnerable to predators.

Thus, the potential exists for some injury and mortality of steelhead and juvenile salmon to occur from pile driving noise during the proposed in-water construction period at the HOR gate. To minimize this risk, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when listed fish species may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and identify corrective actions to be taken should the thresholds be exceeded.

5.2.4.4.3.2 Green Sturgeon

Potential exposure of adult green sturgeon to pile driving noise at the HOR gate is lower than other regions of the Delta because of the timing of pile driving relative to the spring spawning migration of adults and the distance of the HOR gate from their principal migration corridor. Juveniles are considered at higher risk because of their year-round presence in the Delta and potential for encountering pile driving noise at multiple locations during their 3-4 residence period. As discussed in section 5.2.2.4.3.2, evidence exists for avoidance of pile driving noise in other sturgeon species. Although such behavior may disrupt or delay the movements or foraging activities of juveniles in proximity to the Old River gate, the risk of adverse effects is expected to be reduced by daily opportunities for juveniles to leave the affected areas at night (dusk to dawn). This risk will be further reduced by implementing an underwater sound control and abatement plan (AMM9), and performing hydroacoustic monitoring to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and identify corrective actions to be taken should the thresholds be exceeded.

5.2.4.4.4 Assess Effects on Designated Critical Habitat

5.2.4.4.4.1 Salmonids

During construction of the HOR gate, underwater noise levels from pile driving and other construction activities will affect the designated critical habitat of CCV steelhead through temporary degradation of the PBFs of migratory habitat (i.e., unobstructed migratory pathways). Adverse effects on critical habitat would occur within areas subjected to noise levels associated with potential injury and behavioral effects, as described above. These effects would occur for approximately 19 days during installation of the sheet piles, and 4 days during installation of the foundation piles. Underwater noise levels will return to baseline levels following cessation of pile driving and other construction activities, and would not result in long-term impacts on critical habitat.

5.2.4.4.4.2 Green Sturgeon

The effects of underwater noise on the designated critical habitat of green sturgeon would be similar to that described for salmonids.

5.2.4.5 Fish Stranding

Installation of cofferdams to isolate construction areas for the HOR gate has the potential to strand and subject fish to direct exposure to dewatering and construction activities within the enclosed cofferdams. Sheet pile installation will be limited to the proposed in-water construction period (August 1-November 30) to avoid the peak abundance of listed fish species in the action area. When listed fish species may be present, DWR proposes to minimize potential stranding losses by implementing a fish rescue and salvage plan (Appendix 3.F *General Avoidance and Minimization Measures*, *AMM8 Fish Rescue and Salvage Plan*). The plan will be submitted to the fish and wildlife agencies (NMFS, USFWS, CDFW) for review and approval prior to implementation. The plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that would apply to all in-water activities with the potential to entrap fish. All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist. The biologist, in consultation with a designated agency biologist, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. For example, collection methods will likely vary depending on whether or to what extent (water depth) dewatering can be achieved.

5.2.4.5.1 Assess Species Exposure

5.2.4.5.1.1 Salmonids

Closure of the cofferdams and potential stranding of fish may overlap with the upstream migration of adult steelhead in October and November and the downstream migration of juvenile steelhead (yearling and older smolts) in November. SJR-basin spring-run Chinook salmon (yearling smolts) may also be present in November, assuming juveniles exhibit similar emigration patterns to Sacramento River spring-run populations.

5.2.4.5.1.2 Green sturgeon

Both adult and juvenile green sturgeon are known to occur in the lower reaches of the San Joaquin River and Delta. The risk of stranding of adult green sturgeon in cofferdams at the HOR gate may be lower than other regions of the Delta because of the location and timing of construction activities relative to the primary migration route (Sacramento River) and timing of upstream migration (late February to early May). Juvenile green sturgeon may be present year-round and therefore subject to stranding during the proposed in-water construction period.

5.2.4.5.2 Assess Species Response

5.2.4.5.2.1 Salmonids

Stranding of adult steelhead and juvenile steelhead and spring-run Chinook salmon in the cofferdams is considered unlikely because migrating adults and yearling or older smolts would be expected to avoid active construction areas (see 5.2.2.2.2 and 5.2.2.4.3).

5.2.4.5.2.2 Green Sturgeon

No specific information is available to evaluate the potential responses of green sturgeon to construction activities or their susceptibility to being stranded in cofferdams. However, most green sturgeon that are likely to be present in the action area at the time of cofferdam installation would be relatively large, highly mobile adults and juveniles that are capable of readily avoiding active construction areas.

5.2.4.5.3 Assess Risk to Individuals

5.2.4.5.3.1 Salmonids

With implementation of a fish rescue and salvage plan (AMM8), the likelihood of stranding and subsequent injury or mortality of individual salmonids would be low. Although proposed fish rescue and salvage activities are expected to minimize these risks, some losses may still occur because of varying degrees of effectiveness of the collection methods and potential injury or mortality associated with capture, handling, and relocation of fish (Kelsch and Shields 1996, Reynolds 1996).

5.2.4.5.3.2 Green Sturgeon

The potential for stranding of green sturgeon is similar to that described for salmonids.

5.2.4.6 Direct Physical Injury

During construction of the HOR gate, fish could be injured or killed by direct contact with equipment or materials that are operated or placed in open waters of Old River. Potential mechanisms include fish being impinged by sheetpiles, entrained by dredges, or struck by propellers during barge operations. DWR proposes to minimize the potential for injury of listed fish species by conducting all in-water construction activities between August 1 and November 30. In addition to the proposed work window (August 1-November 30, the potential for injury of listed fish species would be minimized to the extent practicable by limiting the duration of in-water construction activities and implementing the AMMs described in Appendix 3.F *General Avoidance and Minimization Measures*. Applicable AMMs include *Worker Awareness Training; Erosion and Sediment Control Plan; Disposal of Spoils, Reusable Tunnel Material, and Dredged Material; Barge Operations Plan; and Fish Rescue and Salvage Plan.*

5.2.4.6.1 Assess Species Exposure

5.2.4.6.1.1 Salmonids

During in-water construction activities of the HOR gate, the potential for injury of listed salmonids would exist in October and November for adult steelhead and November for juvenile steelhead and (yearling and older smolts). SJR-basin spring-run Chinook salmon (yearling smolts) may also be present in November, assuming juveniles exhibit similar emigration patterns to Sacramento River spring-run populations.

5.2.4.6.1.2 Green Sturgeon

Both adult and juvenile green sturgeon are known to occur in the lower reaches of the San Joaquin River and Delta. Potential exposure of adult green sturgeon to in-water construction activities at the HOR gate may be lower than other regions of the Delta because of the location and timing of construction activities relative to the primary migration route (Sacramento River) and timing of upstream migration (late February to early May). Juvenile green sturgeon may be present year-round and therefore could be exposed to in-water construction activities and potential injury during the proposed in-water construction period.

5.2.4.6.2 Assess Species Response

5.2.4.6.2.1 Salmonids

Most salmonids that are likely to be present in the action area at the time in-water construction activities are likely to be large, migrating adults and juveniles that would be expected to avoid or move away from active construction areas.

5.2.4.6.2.2 Green Sturgeon

Similarly, most green sturgeon that are likely to occur in the action area are likely to be large, actively swimming adults and juveniles that are capable of avoiding active construction areas.

5.2.4.6.3 Assess Risk to Individuals

5.2.4.6.3.1 Salmonids

There is a low risk of injury of salmonids based on the likely response to active construction activities.

5.2.4.6.3.2 Green Sturgeon

There is a low risk of injury of green sturgeon based on the likely response to active construction activities.

5.2.4.6.4 Assess Effects on Designated Critical Habitat

5.2.4.6.4.1 Salmonids

The potential for injury during in-water construction activities would have a temporary adverse effect on the PBFs of the designated critical habitat of CCV steelhead and juvenile steelhead and SJR-basin spring-run Chinook salmon (safe and unobstructed migratory corridors).

5.2.4.6.4.2 Green Sturgeon

The potential for injury during in-water construction activities would have a temporary adverse effect on the PBFs of the designated critical habitat of southern DPS green sturgeon (safe and unobstructed migratory corridors).

5.2.4.7 Loss/Alteration of Habitat

Construction of the HOR gate would result in temporary and permanent losses or alteration of aquatic habitat in Old River. Temporary effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed (Sections 5.2.4.2, 5.2.4.3, and 5.2.4.4). The following analysis focuses on longer-term to permanent impacts on physical habitat associated with construction activities. These impacts are estimated to encompass approximately 2.9 acres of tidal perennial habitat within the footprint of the cofferdams, permanent structures (gate, fish passage structure, and boat lock), and upstream and downstream channel areas that will be dredged. During the construction period (2 years), the cofferdams will affect up to 100 feet of the channel length and 75 feet (50%) of the channel width. No additional impacts associated with construction staging, access, or levee clearing/armoring are anticipated because of the presence of existing roads, staging areas, and riprap that have been used in recent years to install the temporary rock barrier.

During construction activities, DWR will implement Appendix 3.F *General Avoidance and Minimization Measures*, *AMM2 Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities. These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. DWR proposes to offset unavoidable impacts to the designated critical habitat of CCV steelhead, SJR-basin spring-run Chinook salmon and southern DPS green sturgeon through restoration of aquatic and channel margin habitat at an approved restoration site and/or the purchase of conservation credits at an approved conservation bank.

5.2.4.7.1 Assess Species Exposure

5.2.4.7.1.1 Salmonids

All migrating or rearing salmonids that occur in the action area during construction of the HOR gate would be potentially exposed to the physical alteration of aquatic and channel margin habitat within the footprints of the cofferdams, permanent structures, and dredged areas.

5.2.4.7.1.2 Green Sturgeon

All migrating or rearing green sturgeon that occur in the action area during construction of the HOR gate would be potentially exposed to the physical alteration of aquatic and channel margin habitat within the footprints of the cofferdams, permanent structures, and dredged areas.

5.2.4.7.2 Assess Species Response

5.2.4.7.2.1 Salmonids

Old River in the action area of the HOR gate is within the designated critical habitat of CCV steelhead. Habitat conditions for anadromous salmonids in the action area of the HOR gate are degraded from historical conditions and the habitat likely functions primarily as a migration corridor for adults migrating to upstream spawning areas and juveniles migrating downstream to the estuary and ocean. The PBFs supporting the migration and rearing of steelhead in the action area have been degraded by altered flow patterns, levee construction, extensive riprapping, and loss of natural wetland and floodplain habitat. Because of these conditions and past disturbance associated with the annual installation of a temporary rock barrier at the site, it is unlikely that the construction of the HOR gate will substantially degrade the PBFs of critical habitat relative to current conditions. During construction, fish passage past the construction site would be maintained by constructing half the structure in one year and the remaining half in the following year. Increased water velocities resulting from constriction of the flow may result in delays in migration and increased energy expenditure by adults to pass the site but these effects are not expected to significantly affect migration timing or the condition of migrating adults based on the strong swimming abilities of adults and the distances over which potentially higher velocities would be encountered (up to 100 feet).

Some reductions is expected in the quality of passage and rearing conditions for juvenile salmonids due to changes in hydraulic conditions associated with the cofferdams, potential bed scour adjacent to the cofferdams, and dredging both upstream and downstream of the proposed barrier. Potential impacts to the PBFs of critical habitat for CCV steelhead would generally result in loss of shallow water habitat, instream cover, benthic food resources, and altered hydraulic conditions that may increase exposure of migrating juveniles to predation. The installation of cofferdams in Old River may attract predator fish species (e.g., striped bass) and potentially increase their ability to ambush juvenile salmonids and other fishes. In addition, the constriction of flow and increases in water velocities and turbulence at the interface of the cofferdams and the river may concentrate and disorient juvenile salmonids, further enhancing the risk of predation. In addition, the elimination or disturbance of benthic habitat and associated invertebrate communities due to pile installation, scour, and dredging would result in localized reductions in benthic substrates that support important food organisms (benthic invertebrates) for juvenile salmonids. This represents a permanent alteration of habitat that would exist throughout the construction period (3 years).

5.2.4.7.2.2 Green Sturgeon

Old River in the action area of the HOR gate is within the designated critical habitat of southern DPS green sturgeon. Based on the degraded status of habitat in Old River near the HOR gate, this area likely functions primarily as a migration corridor for adult green sturgeon and low-quality foraging habitat for juveniles. Based on the expected changes in habitat conditions resulting from the construction of the HOR gate, impacts to the PCEs of green sturgeon critical habitat would primarily be caused by the loss of foraging habitat within the footprints of the cofferdams, permanent structures, and channel areas upstream and downstream of the structure that will be dredged. Because of their benthic nature and strong swimming abilities, green sturgeon would likely be unaffected by the changes in hydraulic conditions described above..

5.2.4.7.3 Assess Risk to Individuals

5.2.4.7.3.1 Salmonids

Changes in physical and hydraulic conditions during construction of the HOR gate are expected to have insignificant effects on migrating adult salmonids; suitable passage conditions for adults would be maintained throughout the construction period by limiting construction to half the channel width during each year of construction. Although the proposed construction site currently provides low quality habitat for juvenile salmonids, the installation of the in-channel structures and dredging would further degrade this habitat by altering hydraulic conditions and eliminating shallow water habitat, instream cover, and benthic food resources within these areas. This is unlikely to affect the growth of juvenile salmonids because of the low quality and likely minimal use of this habitat by rearing salmonids under existing conditions. However, the lack of cover for juvenile fish and the structural and hydraulic changes associated with the presence of the cofferdams may increase the risk of predation by increasing the amount of predator habitat and/or susceptibility of juvenile salmonids to predation as they pass the construction site.

5.2.4.7.3.2 Green Sturgeon

Based on the degraded status of habitat in Old River near the HOR gate, construction of the HOR gate is unlikely to adversely affect adult sturgeon, and would have minimal effects on rearing and passage conditions for juveniles. The primary effect of construction on the critical habitat of Southern DPS green sturgeon is the loss of potential foraging habitat (benthic habitat) within the footprints of the permanent in-channel structures and dredged area. This is unlikely to have a measurable effect on growth and survival of green sturgeon because it represents a very small proportion of the total amount of habitat available to juveniles during their residence in the Delta and estuary.

5.2.4.7.4 Assess Effects on Designated Critical Habitat

5.2.4.7.4.1 Salmonids

Impacts to the designated critical habitat of CCV steelhead include permanent impacts on juvenile migration and rearing habitat, as described above. DWR proposes to offset impacts to the designated critical habitat of steelhead through restoration of tidal perennial habitat at an approved restoration site and/or the purchase of conservation credits at an approved conservation bank (Table 3.4-1).

5.2.4.7.4.2 Green Sturgeon

Impacts to the designated critical habitat of green sturgeon include permanent impacts on juvenile migration and rearing habitat, as described above. DWR proposes to offset impacts to the designated critical habitat of green sturgeon through restoration of tidal perennial habitat at an approved restoration site and/or the purchase of conservation credits at an approved conservation bank (Table 3.4-1).

5.2.5 Clifton Court Forebay

5.2.5.1 Deconstruct the Action

Construction activities at Clifton Court Forebay (CCF) that may potentially affect listed salmonids and green sturgeon include expansion and dredging of SCCF, construction of divider wall and east/west embankments, dewatering and excavation of NCCF, construction of NCCF outlet canals and siphons, and construction of a SSCF intake structure and NCCF emergency spillway. The estimated 7-year construction period will be phased, beginning with expansion of SCCF (Phases 1, 2, and 3); construction of the divider wall between NCCF and SCCF (Phase 4); construction of the west and east embankments (Phase 5); and construction of the NCCF east, west, and north side embankments (Phases 6, 7, and 8). Details on the design, construction methods, and proposed construction schedule for CCF are described in Chapter 3.

Permanent impacts on aquatic habitat include the loss of an estimated 258 acres of tidal perennial habitat in CCF that would be replaced by permanent fill and structures associated with the new CCPP, perimeter and divider embankments, outlet canals and siphons, and intake structure and spillway (Mapbook M3.A).

5.2.5.2 Turbidity and Suspended Sediment

In-water construction activities at CCF would result in elevated turbidity and suspended sediment levels in CCF and Old River. The principal sources of increased turbidity and suspended sediment are dredging, cofferdam construction (sheet pile installation and removal), levee clearing and grading, and riprap placement. Minor increases in turbidity and suspended sediment in CCF and Old River are also expected during construction of the CCPP, embankments, outlet canal and siphons, SSCF intake structure, and North CCF (NCCF) emergency spillway. All other sediment-disturbing activities within cofferdams, upland areas, or non-fish-bearing waters pose little or no risk to listed fish species or aquatic habitat.

The potential for adverse effects of elevated turbidity and suspended sediment on listed fish species would be minimized by restricting all in-water construction to July1-November 30, limiting the duration of these activities to the extent practicable, and implementing the AMMs described in Appendix 3.F *General Avoidance and Minimization Measures* to protect listed fish species from water quality impairment. These measures include *Worker Awareness Training; Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan (SWPPP); Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan (SPCCP);* and *Hazardous Material Management Plan, and Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material Plan.*

Dredging of CCF will result in the suspension of large volumes of sediment and potential secondary effects on water quality, including potential re-suspension of contaminants and reductions in dissolved oxygen levels associated with the decomposition of vegetation and organic material in disturbed sediments. In addition to implementing the AMMs listed above, DWR proposes to limit the potential exposure of listed species to water quality impacts by restricting the timing, extent, and frequency of major sediment-disturbing events. For example, DWR proposes to limit the extent of dredging impacts in CCF by restricting daily operations to two dredges operating for 10-hour periods (daylight hours) within 200-acre cells enclosed by silt curtains (representing approximately 10% of total surface area of CCF). In addition, dredging will be monitored and regulated through the implementation of the *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material Plan*, which includes preparation of a sampling and analysis plan, compliance with NPDES and SWRCB water quality requirements during dredging activities, and compliance with applicable in-water work windows established by CDFW, NMFS, and USFWS.

Some potential exists for construction-related turbidity and suspended sediment to occur during winter and spring due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with implementation of the proposed erosion and sediment control measures (AMM4) and other BMPs to ensure the effectiveness of these measures (*AMM2, Construction Best Management Practices and Monitoring*), no adverse water quality effects are anticipated outside of the in-water construction season.

5.2.5.2.1 Assess Species Exposure

5.2.5.2.1.1 Salmonids

The timing of in-water construction activities (July 1–November 30) will avoid the sensitive winter and spring migration, spawning, and early rearing periods of listed fish species in the Delta. However, based on continued operation of CCF and potential entrainment of listed fish species into CCF during construction activities, in-water construction activities may affect adult steelhead which may be present in the Delta in late summer or fall (starting as early as August for Sacramento River steelhead). In addition, extending in-water construction activities into November results in the potential exposure of juvenile steelhead (yearling and older smolts), spring-run Chinook salmon (yearling smolts), and winter-run Chinook salmon (young-of-the year). SJR-basin spring-run Chinook salmon juveniles may also be present in November, assuming juveniles exhibit similar emigration patterns to Sacramento River spring-run populations.

5.2.5.2.1.2 Green Sturgeon

Both adult and juvenile green sturgeon are known to occur in the lower reaches of the San Joaquin River and Delta. The in-water construction period (July 1–November 30) will avoid the peak upstream migration period of green sturgeon (late February to early May) although adults (post-spawning adults) and juveniles may be present in the Delta year-round and therefore potentially exposed to increases in turbidity and suspended sediment in CCF during the in-water construction period. Salvage of green sturgeon generally peaks in the summer although few are generally encountered at the Skinner and Tracy salvage facilities in recent years (NMFS 2015).

5.2.5.2.2 Assess Species Response

5.2.5.2.2.1 Salmonids

As described for the north Delta intakes, turbidity and suspended levels typically generated by in-water construction activities are not expected to reach levels that would cause direct injury to salmonids. All steelhead that may be present in CCF and Old River during the in-water work window would be large, actively migrating adults and juveniles (smolts) that are capable of avoiding active construction areas. With implementation of the AMMs, in-water construction activities would result in temporary, localized increases in turbidity and suspended sediment that dissipate rapidly with distance from the source and return to baseline levels following daily in-water activities. The effects on adult and juvenile steelhead would likely be limited to harassment of individuals that encounter turbidity plumes.

Increases in suspended sediment during in-water construction activities may result in localized sediment deposition in CCF and Old River, potentially degrading food-producing areas by burying benthic substrates that support important food organisms (benthic invertebrates) for juvenile salmonids. However, CCF and the adjacent south Delta channels have been highly altered for the purpose of water conveyance and lack many of the attributes of functional migration and rearing habitat. Therefore, the potential effects of sedimentation on food production would likely have little or no effect on juvenile steelhead growth or survival due to the temporary, localized nature of these effects and low quality of existing habitat.

5.2.5.2.2.2 Green Sturgeon

No specific information is available to evaluate the potential responses of green sturgeon to increased turbidity and suspended sediment. Green sturgeon may be affected in similar ways to salmonids although green sturgeon may be less sensitive to short-term increases in suspended sediments or turbidity because of their use of olfactory cues as opposed to vision to locate prey. Any reductions in the availability of foraging habitat and food due to sedimentation of benthic habitat would likely have little or no effect on growth or survival due to the temporary, localized nature of these effects and low quality of existing habitat in CCF and adjacent south Delta channels.

5.2.5.2.3 Assess Risk to Individuals

5.2.5.2.3.1 Salmonids

Based on the expected responses of salmonids to construction-related increases on turbidity and suspended sediment, any disruptions of the normal behavior are expected to be brief and unlikely to cause adverse effects. With the implementation of the proposed AMMs, potential effects on listed salmonids are expected to be negligible.

5.2.5.2.3.2 Green Sturgeon

Based on their large size, mobility, and benthic feeding adaptations, green sturgeon are unlikely to be affected by increases in turbidity and suspended sediment during in-water construction activities at CCF.

5.2.5.2.4 Assess Effects on Designated Critical Habitat

5.2.5.2.4.1 Salmonids

Increases in turbidity and suspended sediment levels during construction of the new SCCF intake structure and NCCF emergency spillway will affect the PBFs of the designated critical habitat of CCV steelhead. Elevated turbidity and suspended sediment generated by in-water construction activities would primarily affect the PBFs of freshwater rearing habitat and migration corridors through temporary degradation of water quality and potential sedimentation of potential food-producing areas. These effects will be localized and temporary and therefore unlikely to significantly affect the conservation value of rearing and migration habitat in the action area.

5.2.5.2.4.2 Green Sturgeon

Increases in turbidity and suspended sediment levels during construction of the new SCCF intake structure and NCCF emergency spillway will affect the PBFs of the designated critical habitat for southern DPS green sturgeon. These effects would be limited to localized, temporary degradation of the PBFs of water quality and potential sedimentation of food-producing areas. No long-term or permanent effects on critical habitat are expected.

5.2.5.3 Contaminants

Dredging, excavation, and expansion of the CCF and construction of new water conveyance facilities presents an exposure risk to salmonids and green sturgeon from potential spills of hazardous materials from construction equipment and from potential exposure and re-suspension of contaminated sediment. The risk of accidental spills of contaminants and other potentially hazardous materials would be similar to that described for the north Delta intakes (section 5.2.2.3) due to the proximity of construction activities to the waters of CCF and adjacent waterways. Implementation of AMM 5, *Spill Prevention, Containment, and Countermeasure Plan*, and AMM14 *Hazardous Materials Management* (see Appendix 3.F *General Avoidance and Minimization Measures*) is expected to minimize the potential for introduction of contaminants into surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials. With implementation of these and other required construction BMPs (e.g., AMM 3, *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to Delta waters from in-water or upland sources would be effectively minimized.

As described in Section 5.2.2.3 *Contaminants*, contaminated sediments can adversely affect fish through direct exposure from mobilized sediment or indirect exposure through accumulation of contaminants in the food web. Consequently, dredging, excavation, and expansion of CCF poses a substantial short-term and long-term risk of exposure of fish and other aquatic organisms to elevated concentrations of contaminants. Current estimates indicate the dredging will affect up to 1,932 acres of CCF while expansion of the SCCF will create an additional 590 acres of newly exposed sediment. The proximity of the south Delta to agricultural, industrial, and municipal sources indicates that a broad range of contaminants that are toxic to fish and other aquatic biota, including metals (e.g., copper, mercury), hydrocarbons, pesticides, and ammonia, could be present. Mud and silt in south Delta waterways have been shown to contain elevated concentrations of contaminants, including mercury, pesticides (chlorpyrifos, diazinon, DDT), and other toxic substances (California State Water Resources Control Board 2010). Impairments in Delta waterways also include heavy metals such as selenium, cadmium, and nickel (G. Fred Lee & Associates 2004). Thus, exposure and resuspension of sediments during in-water construction could lead to degradation of water quality and adverse effects on fish or their food resources in the action area.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material* in Appendix 3.F *General Avoidance and Minimization Measures*. These measures include the preparation and implementation of a pre-construction sampling and analysis plan (SAP) to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (e.g., silt curtains) to achieve compliance with existing Basin Plan objectives will be important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

5.2.5.3.1 Assess Species Exposure

5.2.5.3.1.1 Salmonids

The potential for contaminant spills would exist throughout the construction period with the highest risk occurring during in-water construction activities. Based on the general timing of migration of listed salmonids in the action area, the potential for direct exposure to contaminants would exist for steelhead adults in August-November, and juvenile steelhead (yearling and older smolts), juvenile spring-run Chinook salmon (yearling smolts), and juvenile winter-run Chinook salmon (young-of-the year) in November. SJR-basin spring-run Chinook salmon juveniles may also be present in November, assuming juveniles exhibit similar emigration patterns to Sacramento River spring-run populations. However, exposure to contaminants may occur throughout the year and persist after construction due to the exposure of newly exposed sediment, and repeated resuspension or exposure of sediments by wind, currents, and subsequent maintenance dredging.

5.2.5.3.1.2 Green Sturgeon

The risk of exposure of adult green sturgeon to potential contaminant spills at CCF may be lower than other regions of the Delta because of the location and timing of construction activities relative to the primary migration route (Sacramento River) and timing of upstream migration (late February to early May). Juvenile green sturgeon may be present year-round and therefore could be exposed to potential contaminant spills as well as potential contaminants in newly exposed sediment throughout the year. In comparison to salmonids, green sturgeon are more likely to be exposed to contaminated sediments and food sources because of their relatively long residence time (3-4 years for rearing juveniles) and prolonged contact with sediment both externally (e.g., resting and foraging on the bottom) and through ingestion of benthic food organisms.

5.2.5.3.2 Assess Species Response

5.2.5.3.2.1 Salmonids

As described in section 5.2.2.3, the discharge of contaminants into the aquatic environment can cause direct or indirect effects on fish depending on the type, concentrations, and fate of contaminants. In addition to direct exposure from spills or re-suspension of contaminated sediments, contaminants can enter the aquatic food web and accumulate in fish through their diet, leading to lethal and sublethal effects, including effects on behavior, tissues and organs, reproduction, growth, and immune system (Connon et al. 2009).

5.2.5.3.2.2 Green Sturgeon

The potential effects of contaminants and general exposure mechanisms described above are also applicable to green sturgeon.

5.2.5.3.3 Assess Risk to Individuals

5.2.5.3.3.1 Salmonids

Implementation of the proposed *Spill Prevention, Containment, and Countermeasure Plan* (AMM 5), *Hazardous Materials Management* (AMM6), and *Stormwater Pollution Prevention Plan* (AMM3) is expected to minimize the potential for spills or discharges of contaminants into Old River. Adherence to all preventative, response, and disposal measures in the approved plans are expected to reduce the potential effects to listed fish species to discountable levels. No information is available on potential contaminant risks associated with disturbance and exposure of sediments in CCF. However, this risk is expected to be minimized by developing and implementing a SAP to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Some exposure of listed salmonids to sediment-borne contaminants or elevated contaminants in food organisms may be unavoidable because of the potential dispersal of contaminants during construction and continued disturbance and exposure of sediments during maintenance dredging and natural sediment transport processes.

5.2.5.3.3.2 Green Sturgeon

The proposed AMMs to minimize the potential for spills or discharges of contaminants during proposed construction activities at CCF also expected to protect green sturgeon. Compared to salmonids, however, green sturgeon are considered to be at higher risk of exposure to contaminated sediments because of their benthic orientation, diet, and relatively long residence of juveniles in the Delta (3-4 years), which increases the duration of exposure at CCF as well as the probability of encountering elevated contaminants at other construction sites (north Delta intakes, barge landings, and HOR gate).

5.2.5.3.4 Assess Effects on Designated Critical Habitat

5.2.5.3.4.1 Salmonids

The potential release of contaminants through spills or sediment disturbance could affect the PBFs of the designated critical habitat of CCV steelhead through adverse effects on water quality and food resources (reduced abundance of benthic invertebrates and consumption of contaminated benthic invertebrates). With implementation of the proposed AMMs, the risk of adverse effects of contaminants on critical habitat would be negligible.

5.2.5.3.4.2 Green Sturgeon

The potential release of contaminants through spills or sediment disturbance could affect the PBFs of the designated critical habitat of southern DPS green sturgeon through adverse effects on water quality and food resources (reduced abundance of benthic invertebrates and consumption of contaminated benthic invertebrates). With implementation of the proposed AMMs, the risk of adverse effects of contaminants on critical habitat would be negligible.

5.2.5.4 Underwater Noise

During construction of the CCF water conveyance facilities, activities that are likely to generate underwater noise include in-water pile driving, riprap placement, dredging, and barge operations. Pile driving conducted in or near open water poses the greatest risk to fish because the levels of underwater noise produced by impulsive types of sounds often reach levels of sufficient intensity to injure or kill fish within a certain radius of the source piles (Popper and Hastings 2009). Other activities such as riprap placement, dredging, and barge operations generally produce more continuous, lower energy sounds below the thresholds associated with direct injury but may cause avoidance behavior or temporary hearing loss or physiological stress if avoidance is not possible or exposure is prolonged (Popper and Hastings 2009).

Pile driving conducted in or near open water can produce underwater noise of sufficient intensity to injure or kill fish within a certain radius of the source piles. Pile driving information for CCF is available for the embankments, divider wall, siphon at NCCF outlet, and siphon at Byron Highway (Appendix 3.E *Pile Driving Assumptions for the Proposed Action*). Pile driving operations include the installation of an estimated 10,294 temporary sheet piles to construct the cofferdams for the embankments and divider wall, and 2,160 14-inch diameter concrete or steel pipe piles to construct the siphon at the NCCF outlet. Pile driving for the siphon under Byron Highway is not addressed in the following analysis because all pile driving would be conducted on land and more than 200 feet from water potentially containing listed fish species. A total of 4 construction seasons will likely be required to complete pile driving operations based on the estimated duration of pile installation (Appendix 3.D *Construction Schedule for the Proposed Action*).

DWR proposes to minimize the potential exposure of listed fish species to pile driving noise by conducting all in-water construction activities between July 1 and November 30. In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when listed fish species may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and identify corrective actions to be taken should the thresholds be exceeded.

5.2.5.4.1 Assess Species Exposure

5.2.5.4.1.1 Salmonids

Based on continued operation of CCF and potential entrainment of listed fish species into CCF during in-water construction activities (July 1-November 30), potential exposure of listed salmonids to pile driving noise would exist for adult steelhead in August-November, and juvenile steelhead (yearling and older smolts), spring-run Chinook salmon (yearling smolts), and winter-run Chinook salmon (young-of-the year) in November. SJR-basin spring-run Chinook salmon juveniles may also be present in November, assuming juveniles exhibit similar emigration patterns to Sacramento River spring-run populations.

5.2.5.4.1.2 Green Sturgeon

Both adult and juvenile green sturgeon are known to occur in CCF and the adjacent south Delta channels. The in-water construction period (July 1–November 30) will avoid the peak upstream migration period of green sturgeon (late February to early May) although adults (post-spawning adults) and juveniles may be present in the Delta year-round and therefore potentially exposed to pile driving noise during the in-water construction period.

5.2.5.4.2 Assess Species Response

5.2.5.4.2.1 Salmonids

As described for the north Delta intakes, the potential responses of fish to pile driving noise can range from behavioral effects to direct injury or mortality, depending on a number of biological, physical, and exposure variables. Sound exposure criteria currently in use by state and federal resource and transportation agencies in California, Oregon, and Washington to evaluate the potential for injury to pile driving activities are presented in Table 5.2-5. The peak SPL is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative SEL is considered the total amount of acoustic energy that a fish can receive from a single or multiple strikes without injury. Pile driving and other sources of construction noise may also cause behavioral responses that could disrupt or delay normal activities, potentially leading to adverse effects on survival, growth, and reproductive success. Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Popper et al. 2006); however, it is generally assumed that 150 dB RMS is an appropriate threshold for behavioral effects.

5.2.5.4.2.2 Green Sturgeon

The interim criteria in Table 5.2-1 are assumed to be applicable to green sturgeon based on general similarities in anatomy and physiology (e.g., presence of a swim bladder) to other fishes for which data are available.

5.2.5.4.3 Assess Risk to Individuals

Table 5.2-5 presents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds during installation of cofferdam sheet piles for the embankments and divider wall, and the structural piles for the NCCF siphon based on application of the NMFS spreadsheet model and the assumptions presented in Appendix 3.E *Pile Driving Assumptions for the Proposed Action*. For cofferdam sheet piles, it is assumed that approximately 70% of the length of each pile can be driven using vibratory pile driving, with impact driving used to finalize pile placement. For the NFFC siphon piles, the current design assumes the use of impact pile driving only. However, some degree of attenuation is expected assuming that the cofferdams can be fully dewatered. Therefore, predictions are shown for two scenarios, one in which dewatering results in a 5 dB reduction in reference noise levels, and one in which no attenuation is possible.

Table 5.2-5. Extent, Timing, and Duration of Pile Driving Noise Levels Predicted to Exceed the Interim Injury and Behavioral Thresholds at CCF.

Facility	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 187 dB SEL Injury Threshold[1, 2] (feet)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Number and Timing of Construction Seasons	Timing of Pile Driving	Duration of Pile Driving (days)
Clifton Court Forebay						
Embankment Cofferdams	30	2,814	13,058	1 (Year 5)	Jul–Nov	85
Divider Wall	30	2,814	13,058	1 (Year 4)	Jul–Nov	86
NCCF Siphon (no attenuation)	46	1,774	9,607	2 (Years 2-3)	Jul–Nov	72
NCCF Siphon (with attenuation)	20	823	4,458	2 (Years 2-3)	Jul–Nov	72

[1] Computed distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL). Calculation assumes that single strike SELs <150 dB do not accumulate to cause injury. Accordingly, once the distance to the cumulative injury threshold exceeds the distance to effective quiet, increasing the number of strikes does not increase the presumed injury distance.

[2] Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, vibratory driving or other non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

Sound monitoring data collected during similar types of pile driving operations indicate that single-strike peak SPLs exceeding the interim injury thresholds are expected to be limited to areas within 30 feet of the cofferdam sheet piles and 20-46 feet of the NCCF siphon piles (Table 5.2-5). Based on a cumulative (daily) threshold of 187 dB, the risk of injury is calculated to extend 2,814 feet away from the source piles during installation of cofferdam sheet piles and 1,774 feet during installation of the NCCF siphon piles (823 feet if the cofferdams can be dewatered).[8] Based on a threshold of 150 dB RMS, the potential for behavioral effects is calculated to extend 13,058 and 9,607 feet (4,458 if the cofferdams can be dewatered), respectively. Such exposures would occur over a period of up to 72 days (36 days per season) during installation of the NCCF siphon piles (second and third years of construction activities at CCF), 86 days during cofferdam construction for the divider wall (year 4), and 85 days during cofferdam construction for the embankments (year 5).

5.2.5.4.3.1 Salmonids

Based on the general migration timing of listed salmonids in the Delta, pile driving activities at CCF could overlap with the presence of adult steelhead in August-November, and juvenile steelhead (yearling and older smolts), spring-run Chinook salmon (yearling smolts), and winter-run Chinook salmon (young-of-the year) in November.

Peak SPLs exceeding the injury criteria would be limited to a distance of 30 feet from the cofferdam sheet piles, affecting a very small fraction of CCF during sheet pile installation. During installation of the NCCF siphon piles, peak SPLs exceeding the injury criteria would

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[8] In this case, the distance to the injury thresholds are governed by the distance to "effective quiet" (150 cB SEL).

extend 20-46 feet from the source piles, affecting approximately 7-15% of the width (300 feet) of the channel entrance available for fish to pass from CCF to the SFPF (assuming half-width construction of the NCCF siphon). Thus, adults and juvenile salmonids would continue to have access to large areas of CCF and sufficient area to pass the construction sites and avoid exposure to potentially harmful noise levels. However, areas subject to cumulative levels of pile driving noise exceeding the 187 dB cumulative SEL threshold are predicted to extend up to 2,814 feet away from the source piles during installation of the cofferdam sheet piles, affecting from 25-50% of CCF, and up to 1,774 feet away from the source piles during installation of the siphon piles, affecting 15-20% of CCF and the entire width of the channel entrance leading to the SFPF. Assuming a 5 dB reduction in noise levels can be achieved through dewatering of the cofferdams at the NCCF siphon, the distances to the 187 dB threshold can be approximately halved but noise levels would remain above the cumulative injury thresholds in all waters at the SFPF entrance channel and surrounding waters up to 823 feet away. Pile driving noise exceeding the 150 dB RMS would encompass much or all of CCF during installation of the cofferdam sheet piles and siphon piles (up to 9,607-13,058 feet), and thus could affect the behavior of all fish that are present or entrained into CCF during pile driving operations.

Thus, the potential exists for noise-related injury and mortality of listed salmonids that become entrained into CCF during active pile driving operations. This risk would exist for up to 36 days per year during construction of the NCCF siphon, and 86 days per year during installation of the embankment and divider wall cofferdams. This risk is particularly high in CCF because of limited opportunities to avoid pile driving noise and the presence of other stressors that may compound or contribute to poor survival in CCF, especially for juvenile salmonids that are subject to high pre-screen mortality rates in CCF (Gingras 1997, Clark et al. 2009). To minimize this risk, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when listed fish species may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and identify corrective actions to be taken should the thresholds be exceeded.

5.2.5.4.3.2 Green Sturgeon

The assessment above is assumed to be generally applicable to green sturgeon. Although capable of avoiding pile driving noise and other construction-related disturbances, juvenile and adult sturgeon have a relatively high risk of injury or behavioral effects from pile driving noise because of their year-round residence in the Delta. Similar to juvenile salmonids, this risk is particularly high in CCF where green sturgeon would have limited opportunities to avoid pile driving and other construction-generated noise that will likely affect much of the forebay during the four years of pile driving operations.

5.2.5.4.4 Assess Effects on Designated Critical Habitat

5.2.5.4.4.1 Salmonids

CCF is not part of the designated critical habitat for CCV steelhead and thus actions taken within the forebay itself do not affect the PBFs for migration and rearing. However, pile driving noise would occur in Old River and other adjacent channels during construction of the new SSCF intake structure and NCCF emergency spillway. This represents a temporary impact on the designated critical habitat of CCV steelhead. Elevated underwater noise levels would occur only during active pile driving operations and would return to baseline levels whenever pile driving operations cease each day. No long-term or permanent effects on critical habitat would occur.

5.2.5.4.4.2 Green Sturgeon

The designated critical habitat of DPS green sturgeon also does not include CCF but does include other waters in the Delta. Thus, pile driving noise in Old River during construction of the new SSCF intake structure and NCCF emergency spillway would result in a temporary impact on the designated critical habitat of southern DPS greens sturgeon. Elevated underwater noise levels would occur only during active pile driving operations and would return to baseline levels whenever pile driving operations cease each day. No long-term or permanent effects on critical habitat would occur.

5.2.5.5 Fish Stranding

Installation of cofferdams or silt curtains to isolate construction and dredging areas in CCF and the adjacent Old River channel has the potential to strand and subject fish to direct exposure to construction activities within the enclosed structures. Installation of cofferdams and silt curtains will be limited to the proposed in-water construction period (July 1-November 30) to avoid the peak abundance of listed fish species in the action area. When listed fish species may be present, DWR proposes to minimize potential stranding losses by implementing a fish rescue and salvage plan (Appendix 3.F *General Avoidance and Minimization Measures,* AMM8 *Fish Rescue and Salvage Plan*). This plan will be submitted to the fish and wildlife agencies (NMFS, USFWS, CDFW) for review and approval prior to implementation. The plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that would apply to all in-water activities with the potential to entrap fish. All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist. The biologist, in consultation with a designated agency biologist, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. Collection methods may include seines, dip nets, and electrofishing if permitted.

5.2.5.5.1 Assess Species Exposure

5.2.5.5.1.1 Salmonids

Based on continued operation of CCF and potential entrainment of listed fish species into CCF during in-water construction activities (July 1-November 30), the potential for stranding of listed salmonids exists for adult steelhead in August-November, and juvenile steelhead (yearling and older smolts), spring-run Chinook salmon (yearling smolts), and winter-run Chinook salmon (young-of-the year) in November. SJR-basin spring-run Chinook salmon juveniles may also be present in November, assuming juveniles exhibit similar emigration patterns to Sacramento River spring-run populations.

5.2.5.5.1.2 Green sturgeon

Both adult and juvenile green sturgeon are known to occur in CCF and the adjacent south Delta channels. The in-water construction period (July 1–November 30) will avoid the peak upstream migration period of green sturgeon (late February to early May) although adults (post-spawning adults) and juveniles may be present in the Delta year-round and therefore potentially subject to stranding during the in-water construction period.

5.2.5.5.2 Assess Species Response

5.2.5.5.2.1 Salmonids

Although capable of avoiding active construction areas, juvenile and adult steelhead are at some risk of being stranded within the cofferdams or silt curtains. Any stranded fish within the cofferdams would likely be killed by subsequent dewatering and construction within the enclosed structures. The fate of steelhead that may become stranded within the 200-acre cells surrounded by silt curtains in CCF is less certain. Although CCF is not considered suitable rearing and migration habitat for salmonids, confinement and prolonged exposure (months) to elevated turbidity, suspended sediment, and noise inside the silt curtains would result in further degradation of habitat conditions and increased exposure to predation.

5.2.5.5.2.2 Green Sturgeon

The potential for stranding of green sturgeon within the cofferdams or silt curtains is assumed to be similar to that of salmonids.

5.2.5.5.3 Assess Risk to Individuals

5.2.5.5.3.1 Salmonids

The risk of stranding of steelhead and subsequent injury or mortality is low based on the minimal overlap in timing of cofferdam closure and silt curtain deployment with the migration timing of adult and juvenile steelhead in the action area. Where practical, this risk will be reduced further by conducting fish rescue and salvage activities. However, it may be impractical or infeasible to rescue fish from the large areas surrounded by cofferdams and silt curtains in CCF. Regardless, such measures may not significantly reduce the overall risk of mortality because of the low survival of steelhead and other listed fish species in CCF under baseline conditions.

5.2.5.5.3.2 Green Sturgeon

The potential for stranding and associated risks of injury or mortality of green sturgeon are assumed to be similar to that of steelhead.

5.2.5.5.4 Assess Effects on Designated Critical Habitat

5.2.5.5.4.1 Salmonids

The potential for stranding would have a temporary adverse effect on the PBFs of designated critical habitat of CCV steelhead (safe and unobstructed migratory corridors) in Old River within the aquatic footprints of the SSCF intake structure and NCCF emergency spillway. Most of the waters affected by cofferdams and silt curtains would be confined to CCF which is not part of the designated critical habitat of steelhead or other listed salmonids.

5.2.5.5.4.2 Green Sturgeon

The potential for stranding would have a similar effect on the designated critical habitat of southern DPS green sturgeon

5.2.5.6 Direct Physical Injury

Fish could be injured or killed by direct contact with equipment or materials during in-water construction activities in CCF and the adjacent Old River channel. Potential mechanisms include fish being crushed by rock (riprap), impinged by sheetpiles, entrained by dredges, or struck by propellers. In addition to the proposed in-water work period, DWR proposes to implement a number of AMMs to minimize the potential for impacts on listed fish species, including *Worker Awareness Training; Erosion and Sediment Control Plan; Disposal of Spoils, Reusable Tunnel Material, and Dredged Material; Barge Operations Plan; Underwater Sound Control and Abatement Plan, and Fish Rescue and Salvage Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

5.2.5.6.1 Assess Species Exposure

5.2.5.6.1.1 Salmonids

Based on continued operation of CCF and potential entrainment of listed fish species into CCF during in-water construction activities (July 1-November 30), the potential for direct injury of listed salmonids would exist for adult steelhead in August-November, and juvenile steelhead (yearling and older smolts), spring-run Chinook salmon (yearling smolts), and winter-run Chinook salmon (young-of-the year) in November. SJR-basin spring-run Chinook salmon juveniles may also be present in November, assuming juveniles exhibit similar emigration patterns to Sacramento River spring-run populations.

5.2.5.6.1.2 Green Sturgeon

Both adult and juvenile green sturgeon are known to occur in CCF and the adjacent south Delta channels. The in-water construction period (July 1–November 30) will avoid the peak upstream migration period of green sturgeon (late February to early May) although adults (post-spawning adults) and juveniles may be present in the Delta year-round and therefore subject to direct injury during the in-water construction period.

5.2.5.6.2 Assess Species Response

5.2.5.6.2.1 Salmonids

Most salmonids that are likely to be present in the action area at the time in-water construction activities are likely to be large, migrating adults and juveniles that would be expected to avoid or move away from active construction areas.

5.2.5.6.2.2 Green Sturgeon

Similarly, most green sturgeon that are likely to occur in the action area are likely to be large, actively swimming adults and juveniles that are capable of avoiding active construction areas.

5.2.5.6.3 Assess Risk to Individuals

5.2.5.6.3.1 Salmonids

There is a low risk of injury of salmonids based on their likely response to active construction activities.

5.2.5.6.3.2 Green Sturgeon

There is a low risk of injury of green sturgeon based on the likely response to active construction activities.

5.2.5.6.4 Assess Effects on Designated Critical Habitat

5.2.5.6.4.1 Salmonids

The potential for injury during in-water construction activities would have a temporary adverse effect on the PBFs of the designated critical habitat of CCV steelhead (safe and unobstructed migratory corridors) in Old River within the aquatic footprints of the SSCF intake structure and NCCF emergency spillway. Most of the waters where injury could occur would be confined to CCF which is not part of the designated critical habitat of steelhead or other listed salmonids.

5.2.5.6.4.2 Green Sturgeon

The potential for injury would have a similar effect on the designated critical habitat of southern DPS green sturgeon.

5.2.5.7 Loss/Alteration of Habitat

Construction of the new water conveyance facilities at CCF would result in temporary to permanent losses or alteration of aquatic habitat in CCF and, near the new SCCF intake and the NCCF emergency spillway, in the Old River. Temporary effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed. The following analysis focuses on permanent impacts on physical habitat associated with construction activities. Cofferdam installation, dredging, embankment construction, and construction of CCPP, NCCF emergency spillway, and SCCF intake, and NCCF canal and siphons would affect an estimated 1,932 acres of tidal perennial habitat (Mapbook M3.A) through changes in water depths, vegetation, and substrate. Permanent impacts on aquatic habitat encompass an estimated 30,750 linear feet of shoreline and 258 acres of tidal perennial habitat in CCF that would be replaced by cofferdams, permanent fill, and in-water structures associated with the new CCPP, embankments, canals and siphons, and intake structure and spillway. This is considered a permanent alteration of habitat that would exist throughout the construction period (4 years).

During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. Compensation for unavoidable impacts on aquatic habitat in CCF is not proposed because CCF is not considered suitable habitat for listed salmonids or green sturgeon, and is not part of their designated critical habitat.

5.2.5.7.1 Assess Species Exposure

5.2.5.7.1.1 Salmonids

All migrating or rearing salmonids that occur in the action area during construction activities would be potentially exposed to physical losses and alteration of aquatic and channel margin habitat in CCF and the adjacent Old River channel.

5.2.5.7.1.2 Green Sturgeon

All migrating or rearing green sturgeon that occur in the action area during construction activities would be potentially exposed to physical losses and alteration of aquatic habitat in CCF and the adjacent Old River channel.

5.2.5.7.2 Assess Species Response

5.2.5.7.2.1 Salmonids

As described in Section 5.2.4, *HOR Gate*, the PBFs of critical habitat supporting migration and rearing of steelhead in the south Delta have been degraded from historical conditions. CCF and the adjacent south Delta channels have been highly altered for the purpose of water conveyance and lack many of the PBFs of critical habitat of listed salmonids due to alteration of natural flow patterns, high predator densities, levee clearing and armoring, channel dredging, entrainment, and lost connectivity of migration corridors. Because salmonids that are entrained into CCF generally suffer high mortality rates (pre-screening losses) (Gingras 1997, Clark et al. 2009), CCF is not considered suitable habitat for listed salmonids, and has been excluded from the designated critical habitat of listed salmonids. Some reductions are expected in the quality of passage and rearing conditions for juvenile salmonids due to habitat loss and increases in predator habitat associated with alteration of hydraulic conditions and losses of shallow water habitat, instream cover, and benthic food resources within the dredged areas and permanent footprints of the water conveyance facilities. Overall, however, these changes are not expected to significantly affect migration and rearing success of adult and juvenile steelhead in the action area because of the low quality of existing habitat conditions.

5.2.5.7.2.2 Green Sturgeon

Based on the degraded status of aquatic habitat in the south Delta and the lack of suitable passage conditions for anadromous fish in CCF, the anticipated effects of construction activities on aquatic habitat are not expected to significantly affect overall migration and rearing success of adult and juvenile green sturgeon in the action area. Dredging in CCF is expected to temporarily degrade potential foraging habitat for green sturgeon by disrupting benthic invertebrates. This would incrementally affect portions of CCF as dredging proceeds but is not expected to adversely affect feeding and growth of green sturgeon because of the availability of undisturbed habitat in adjacent waters.

5.2.5.7.3 Assess Risk to Individuals

5.2.5.7.3.1 Salmonids

Because of the degraded status of aquatic habitat in CCF and Old River, projected changes in physical habitat associated dredging and expansion of CCF and construction of the new water conveyance facilities is not expected to significantly affect the survival, growth, or reproduction of individual salmonids.

5.2.5.7.3.2 Green Sturgeon

Because of the degraded status of aquatic habitat in CCF and Old River, projected changes in physical habitat associated dredging and expansion of CCF and construction of the new water conveyance facilities is not expected significantly affect the survival, growth, or reproduction of individual green sturgeon.

5.2.5.7.4 Assess Effects on Designated Critical Habitat

5.2.5.7.4.1 Salmonids

Impacts to the designated critical habitat of CCV steelhead would be limited to temporary and permanent impacts on migration and juvenile rearing habitat in Old River due to construction of the new SSCF intake structure and North CCF (NCCF) emergency spillway. DWR proposes to offset impacts to the designated critical habitat of CCV steelhead through restoration of tidal marsh or channel margin (SRA cover) habitat at an approved restoration site or purchase of conservation credits at an approved conservation bank. Compensation for impacts on aquatic habitat in CCF is not proposed because CCF is not considered suitable habitat for listed salmonids, and is not part of their designated critical habitat. Consequently, no long-term effects on the conservation value of designated critical habitat are expected.

5.2.5.7.4.2 Green Sturgeon

Impacts to the designated critical habitat of southern DPS green sturgeon would be limited to temporary and permanent impacts on migration and juvenile rearing habitat in Old River due to construction of the new SSCF intake structure and North CCF (NCCF) emergency spillway. DWR proposes to offset impacts to the designated critical habitat of green sturgeon through restoration of tidal marsh or channel margin (SRA cover) habitat at an approved restoration site or purchase of conservation credits at an approved conservation bank. Compensation for impacts on aquatic habitat in CCF is not proposed because CCF is not considered suitable habitat for green sturgeon and is not part of their designated critical habitat. Consequently, no long-term effects on the conservation value of designated critical habitat are expected.

5.3 Effects of Water Facility Maintenance on Fish

5.3.1 North Delta Intakes

Maintenance of the proposed intake facilities (including intakes, pumping plants, sedimentation basins, and solids lagoons) includes regular visual inspections and adjustments of the facilities to maintain compliance with engineering and performance standards, routine maintenance, and periodic repairs of mechanical, structural, and electrical components. Emergency maintenance is also anticipated. It is anticipated that major equipment repairs and overhauls would be conducted at a centralized maintenance shop at one of the intake facilities or at the intermediate pumping plant site.

Maintenance activities that could affect listed fish species and aquatic habitat include hydraulic dredging or mechanical excavation of accumulated sediment around the intake structures; periodic removal of debris and biofouling organisms (e.g., algae, clams, mussels) from the log boom, fish screen panels, cleaning system, and other structural and mechanical elements exposed to the river; and levee maintenance activities, including repairs (e.g., RSP replacement) and vegetation control on the waterside levee slope. It is anticipated that in-river dredging will be required every 2-3 years on average. A formal dredging plan describing specific maintenance dredging activities will be developed prior to dredging activities. Guidelines related to dredging activities and disposal and reuse of spoils, including compliance with in-water work windows and turbidity standards, are described in AMM6, *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F *General Avoidance and Minimization*

Measures). The replacement of RSP may necessitate access and work either from the levee crest (e.g., using an excavator) or from the water (e.g., using a barge and crane).

During maintenance activities, in-water dredging and riprap replacement pose the highest risk to listed fish species because of the potential for direct injury or harassment of fish. As described in Section 5.2.1, *Preconstruction Studies (Geotechnical Exploration)*, restriction of dredging, riprap replacement, and other in-water activities to the proposed in-water work window (June 1-October 31) will minimize the exposure of listed fish species to turbidity and suspended sediment, noise, and other construction-related hazards (e.g., direct physical injury). It is assumed that in-river maintenance dredging and riprap replacement will also be restricted to this period. Restriction of in-river activities to these months would avoid the peak winter and spring migration and rearing seasons of listed salmonids with the exception of adult steelhead, which may peak in abundance in the action area during the late summer and fall months (September–October). This period also avoids the peak upstream migration period of adult green sturgeon in the Sacramento River (late February to early May); however, adults (including post-spawning adults) and rearing juveniles may be present in the Delta year-round and therefore subject to dredging activities throughout the proposed in-water work window.

As described in Section 5.2.1, *Preconstruction Studies (Geotechnical Exploration)*, dredging and riprap replacement could result in harassment of fish from increases in turbidity, suspended sediment, and noise; injury or mortality from entrainment or direct contact with active dredges, vessels (e.g., propeller strikes), or materials (e.g., riprap); and adverse effects on rearing habitat from loss or degradation of benthic habitat and associated food resources. The likelihood of exposure of listed fish species and critical habitat is expected to be low based on the location and timing of maintenance activities relative to the distribution, abundance, and timing of sensitive life stages; the low quality of rearing habitat at the proposed intake locations; and the localized, temporary nature of maintenance activities. Potential adverse effects on listed species and designated critical habitat will be further minimized by implementing a number of construction and maintenance AMMs to limit the extent and duration of potential impacts on aquatic habitat: *Worker Awareness Training; Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan (SWPPP); Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan (SPCCP); Hazardous Material Management Plan;* and *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material; and Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

5.3.2 Barge Landings

Maintenance activities at the barge landings would likely include regular or periodic visual inspections, routine maintenance, and periodic repairs of the docking, loading, and unloading facilities. Maintenance activities also include the replacement of riprap to repair eroded or damaged portions of the waterside levee slope and crown. Vegetation control measures would be performed as part of levee maintenance. Where in-water work is required, maintenance activities will be restricted to the proposed in-water work window (August 1–October 31) to minimize exposure of juvenile salmonids. However, this window overlaps with the upstream migration of adult steelhead in later summer and fall. In addition, juvenile and adult green sturgeon may be present in the Delta year-round and therefore potentially present during the in-water work window. Potential adverse effects on listed species and designated critical habitat will be minimized by implementing a number of construction and maintenance AMMs to limit the extent and duration of potential impacts on aquatic habitat: *Worker Awareness Training; Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan (SWPPP); Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan (SPCCP); Hazardous Material Management Plan;* and *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material; and Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

5.3.3 Head of Old River Gate

Maintenance of the Head of Old River (HOR) gate, including fishway, boat lock, and navigation structures, includes require regular visual inspections and adjustments of the facilities to maintain compliance with engineering and performance standards, and periodic repairs to prevent mechanical, structural, and electrical failures. Emergency maintenance is also anticipated. Routine maintenance includes regular servicing and repair of motors, compressors, and control systems, and periodic repairs to the mechanical and structural elements of the gate, fishway, and boat lock. Maintenance activities include periodic dredging to remove accumulated sediment from around the gate structure, dewatering of the gate facilities for inspection and maintenance, and replacement of riprap to repair eroded or damaged portions of the waterside levee slope. Vegetation control measures would be performed as part of levee maintenance.

Maintenance dredging may be required every 3 to 5 years to remove sediment that may potentially interfere with navigation, fish passage, and gate operations. Dredging would be conducted with a hydraulic or sealed clamshell dredge operated from a barge or from the top of the levee. A floating turbidity control curtain will be used to limit the dispersion of suspended sediment during dredging operations. A formal dredging plan describing specific maintenance dredging activities will be developed prior to dredging activities. Guidelines related to dredging activities and disposal and reuse of spoils, including compliance with in-water work windows and turbidity standards, are described in Appendix 3.F *General Avoidance and Minimization Measures,* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*.

Each gate bay would be inspected annually at the end of the wet season for sediment accumulation. Each miter or radial gate bay would include stop log guides and pockets for stop log posts to facilitate the dewatering of individual bays for inspection and maintenance. Major maintenance could require a temporary cofferdam upstream and downstream for dewatering. When listed fish species may be present during dewatering operations, DWR proposes to minimize potential stranding losses by implementing a fish rescue and salvage plan (Appendix 3.F *General Avoidance and Minimization Measures, AMM8 Fish Rescue and Salvage Plan*).

Maintenance activities that have the greatest potential to affect listed species and critical habitat are dredging and cofferdam installation and dewatering. As described in Section 5.2.3 *Barge Landings*, restriction of dredging, cofferdam installation, and other in-water activities to the proposed in-water work window (August 1–November 30) will avoid the primary winter and spring migration period of juvenile steelhead. Adult steelhead may be present in the late summer and fall and therefore may be exposed to maintenance activities during the proposed in-water work window. There is a low risk of exposure of adult green sturgeon based on the location and timing of in-water maintenance activities. However, juvenile green sturgeon may be present in the Delta year-round and therefore potentially present in the action area during in-water maintenance activities.

As described in Section 5.2.4, *Head of Old River*, dredging, cofferdam installation, and riprap placement could result in harassment of listed fish species from increases in turbidity, suspended sediment, and noise; direct injury or mortality from stranding, entrainment, or direct contact with equipment or materials during cofferdam installation, dredging, barge operations, and riprap placement; and adverse effects on rearing and migration habitat from loss or degradation of benthic habitat and potential increases in predator habitat. However, the likelihood of exposure of listed fish species from these sources is considered low based on the location and timing of these activities relative to the distribution, abundance, and timing of sensitive life stages; the low quality of rearing habitat in Old River; and the localized, temporary nature of maintenance activities. DWR proposes to minimize potential effects on listed fish species and aquatic habitat by preparing and implementing a formal dredging plan describing specific maintenance dredging activities, including compliance with in-water work windows and turbidity standards, as described in AMM6, *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F *General Avoidance and Minimization Measures*). If cofferdam installation is required, DWR proposes to minimize potential stranding losses by implementing a fish rescue and salvage plan (Appendix 3.F *General Avoidance and Minimization Measures, AMM8 Fish Rescue and Salvage Plan*). Potential adverse effects on listed species and designated critical habitat will be further minimized by implementing a number of construction and maintenance AMMs to limit the extent and duration of potential impacts on aquatic habitat: *Worker Awareness Training; Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan (SWPPP); Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan (SPCCP); Hazardous Material Management Plan;* and *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material; and Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

5.3.4 Clifton Court Forebay

Maintenance of the water conveyance facilities and other infrastructure at CCF (including Clifton Court Pumping Plant [CCPP], divider and perimeter embankments, outlet canals and siphons, South CCF [SCCF] intake structure, and North CCF [NCCF] emergency spillway) will include regular visual inspections and adjustments of the facilities to maintain compliance with engineering and performance standards, and periodic repairs to prevent mechanical, structural, and electrical failures. Emergency maintenance is also anticipated. Maintenance requirements potentially affecting listed fish species and aquatic habitat in CCF and Old River include dredging or mechanical excavation of accumulated sediment around the pumping, intake, and outlet facilities, and embankment maintenance activities, including repairs (e.g., RSP replacement) and vegetation control on the divider and perimeter embankments. With upstream sediment removal at the north Delta sedimentation facilities and expansion of storage capacity at CCF, the need for additional dredging of NCCF and SCCF over the first 50 years following construction is expected to be minimal. (The aquatic weed control program is analyzed in Section 5.4.1 *Proposed Delta Exports and Related Hydrodynamics*).

As described in Section 5.2.5, *Clifton Court Forebay*, restriction of maintenance dredging, embankment repairs, and other in-water activities to the proposed in-water work window (July 1–November 30) will avoid the periods when juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead are most likely to occur in the south Delta. The risk of exposure of adult winter-run and spring-run Chinook salmon is considered negligible based on the location and timing of maintenance activities. Small numbers of juvenile steelhead and spring-run Chinook salmon may be exposed to maintenance activities in November while adult steelhead may be present from August through November. Juvenile and adult green sturgeon may be present in the Delta year-round and therefore potentially present in the action area during in-water maintenance activities.

As described in Section 5.2. 5, *Clifton Court Forebay*, dredging, levee repairs, and other in-water activities could result in harassment of listed fish species from increases in turbidity, suspended sediment, and noise; direct injury or mortality from stranding, entrainment, or direct contact with equipment or materials during cofferdam installation, dredging, barge operations, and riprap placement; and adverse effects on rearing and migration habitat from loss or degradation of benthic habitat and potential increases in predator habitat. However, the likelihood of exposure of listed fish species from these sources is considered low based on the location and timing of these activities relative to the distribution, abundance, and timing of sensitive life stages; the low quality of rearing and migration habitat in CCF and Old River; and the localized, temporary nature of maintenance activities. Potential adverse effects on listed species and designated critical habitat[9] will be further minimized by implementing a number of construction and maintenance AMMs to limit the extent and duration of potential impacts on aquatic habitat: *Worker Awareness Training; Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan (SWPPP); Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan (SPCCP); Hazardous Material Management Plan;* and *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material; and Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

5.4 Effects of Water Facility Operations on Fish

5.4.1 Proposed Delta Exports and Related Hydrodynamics

The assessment of the effects of Delta water facility operations on winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon is divided into five main sections. Section 5.4.1.1 *Deconstruct the Action* cross-references the appropriate sections of Chapter 3 and the appendices of Chapter 5. Section 5.4.1.2, *Assess Species Exposure*, examines the general temporal and spatial occurrence of the species in the Delta, before specifically examining the potential for exposure to the different elements of the PA. Section 5.4.1.3, *Assess Species Response to the Proposed Action*, examines how the different elements of the PA could affect fish, e.g., through entrainment or changes in river flow. Section 5.4.1.4, *Assess Risk to Individuals*, considers the potential for risk to individuals given the exposure and species

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[9] Old River only; CCF is not part of the designated critical habitat of CCV steelhead and southern DPS green sturgeon.

response described in Sections 5.4.1.2 and 5.4.1.3. Section 5.4.1.5, *Effects of the Action on Designated Critical Habitat*, assesses the potential effects of the PA on critical habitat for the fish; for all four species, critical habitat has been designated and is present in the action area. The analysis of critical habitat focuses on potential effects to the following relevant PBFs for each species in the Delta and adjacent areas:

- Winter-run Chinook salmon: access from the Pacific Ocean to spawning areas in the upper Sacramento River; habitat areas and prey that are not contaminated; riparian habitat that provides for successful juvenile development and survival; access downstream so that juveniles can migrate from spawning grounds to San Francisco Bay and the Pacific Ocean

- Spring-run Chinook salmon and Central Valley steelhead: freshwater migration corridors; estuarine areas

- Green sturgeon (for estuarine habitats): food resources; water flow; water quality; migratory corridor; water depth; and sediment quality.

5.4.1.1 Deconstruct the Action

Water facility operations are described in Section 3.3 *Operations and Maintenance of New and Existing Facilities* of Chapter 3, *Description of the Proposed Action*. Important modeling methods and results simulating operations of the PA and NAA are provided in Appendix 5.A *CalSim II Modeling and Results* and Appendix 5.B *DSM2 Modeling and Results*. These results are used to provide the assessment of proposed Delta exports and related hydrodynamics.

5.4.1.2 Assess Species Exposure

The following account of species exposure to the effects of proposed Delta exports and related hydrodynamics is adapted from the account by NMFS (2009) in the OCAP BiOp, with updated information as pertinent.

5.4.1.2.1 Salmonids

5.4.1.2.1.1 Winter-Run Chinook Salmon

5.4.1.2.1.1.1 Temporal Occurrence

Adult winter-run Chinook salmon first enter the San Francisco Bay Estuary from the Pacific Ocean starting in November (Table 5.4-1). Adults continue to enter the bay throughout the winter months and into late spring (May/June), passing through the Delta region as they migrate upriver towards their spawning grounds below Keswick Dam (CVP/SWP operations BA; U.S. Fish and Wildlife Service 2001, 2003a). This broad period of juvenile outmigration helps the species adapt to variable conditions in the ocean that can differentially affect individuals depending on when they enter the ocean (Johnson 2015). Therefore, 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. As a result, this effects analysis evaluates effects of the PA during the entire period of winter-run Chinook salmon occurrence in the Delta, including evaluating each month of the period of presence distinctly where possible and appropriate (e.g., Table 5.4-8).

The main pulse of emigrating juvenile winter-run Chinook salmon from the upper Sacramento River enter the Delta in December and January and can extend through April, depending on the water year type[10]. Beach seines and mid-water trawls on the mainstem Sacramento River near the City of Sacramento indicate that some fish enter the Delta as early as mid-November and early December (U.S. Fish and Wildlife Service 2001, 2003a). Monitoring by the USFWS at Chipps Island in the western Delta indicates that winter-run are detected leaving the Delta from September through June, with a peak in emigration occurring in March and April. This peak in emigration timing is supported by the pattern of recoveries of winter-run sized Chinook salmon at the SWP's Skinner Fish Protection Facility and the CVP's Tracy Fish Collection Facility (TFCF) in the South Delta. A pattern of greatest temporal occurrence in the west Delta during late February/March/early April, indicating emigration, is indicated by genetic identification of winter-run Chinook juveniles caught at Chipps Island (Pyper et al. 2013), with this pattern also generally seen in salvage of genetically identified winter-run Chinook juveniles at the south Delta export facilities (Harvey et al. 2014).

In addition to the seasonal component of juvenile emigration, distinct increases in recovered fish appear to be correlated with high precipitation events and increases in-river flow and turbidity following rain events (U.S. Fish and Wildlife Service 2001, 2003a). Based on analysis of scales, winter-run smolts enter the ocean environment at an average fork length of 118 mm, indicating a freshwater residence time of approximately 5 to 9 months, most of which is presumed to occur upstream between RBDD and the Delta. Otolith microchemistry studies indicate that around 47-65% of adult winter-run that returned to spawn in 2007 – 2009 reared as juveniles in non-natal habitats (i.e., outside the Sacramento River upstream of Knights Landing), of which around 11-36% were within the Delta. The time period spent within the Delta by these fish ranged from approximately 2 to 8 weeks (~14-56 days; Phillis, pers. comm.). This contrasts with estimates of residence time of ~40-120 days from winter-run-sized juveniles captured in monitoring at Knights Landing and Chipps Island (del Rosario et al. 2013).

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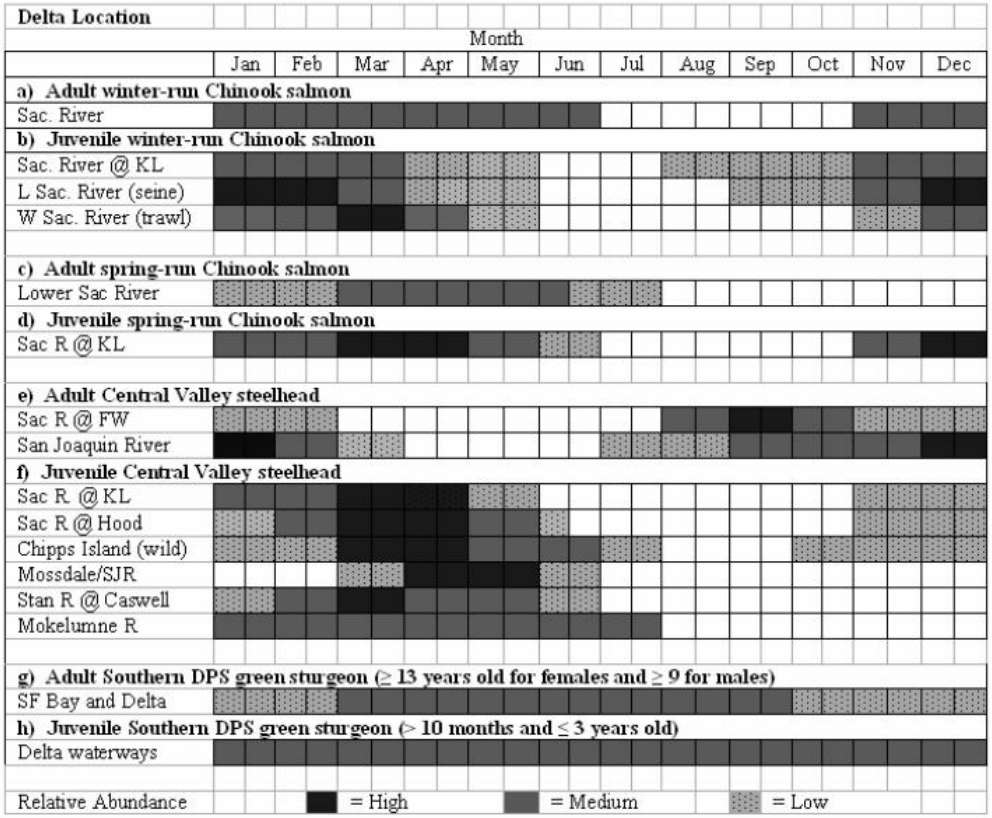
[10] Note that timings discussed in this section are largely based on length-at-date assignments of Chinook salmon race, which have some uncertainty (Harvey et al. 2014).

Table 5.4-1. Temporal Distribution of Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, Central Valley Steelhead, and Green Sturgeon within the Delta.



Delta Location																								
	Month																							
	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
a) Adult winter-run Chinook salmon																								
Sac. River	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨									▨	▨	▨	▨
b) Juvenile winter-run Chinook salmon																								
Sac. River @ KL	▨	▨	▨	▨	▨	▨	░	░	░	░					░	░	░	░	░	░	▨	▨	▨	▨
L Sac. River (seine)	■	■	■	■	▨	▨	░	░	░	░							░	░	░	░	▨	▨	■	■
W Sac. River (trawl)	▨	▨	▨	▨	■	■	▨	▨	░	░											░	░	▨	▨
c) Adult spring-run Chinook salmon																								
Lower Sac River	░	░	░	░	▨	▨	▨	▨	▨	▨	▨	░	░	░										
d) Juvenile spring-run Chinook salmon																								
Sac R @ KL	▨	▨	▨	▨	■	■	■	■	▨	▨	░	░									▨	▨	■	■
e) Adult Central Valley steelhead																								
Sac R @ FW	░	░	░	░											▨	▨	■	■	▨	▨	░	░	░	░
San Joaquin River	■	■	▨	▨	░	░							░	░	░	░	▨	▨	▨	▨	▨	▨	■	■
f) Juvenile Central Valley steelhead																								
Sac R. @ KL	▨	▨	▨	▨	■	■	■	■	░	░											░	░	░	░
Sac R @ Hood	░	░	▨	▨	■	■	■	■	▨	▨	░										░	░	░	░
Chipps Island (wild)	░	░	░	░	■	■	■	■	▨	▨	▨	▨	░	░					░	░	░	░	░	░
Mossdale/SJR					░	░	■	■	■	■	░	░												
Stan R @ Caswell	░	░	▨	▨	■	■	▨	▨	▨	▨	░	░												
Mokelumne R	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨										
g) Adult Southern DPS green sturgeon (≥ 13 years old for females and ≥ 9 for males)																								
SF Bay and Delta	░	░	░	░	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	░	░	░	░	░	░
h) Juvenile Southern DPS green sturgeon (> 10 months and ≤ 3 years old)																								
Delta waterways	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Relative Abundance				■	= High					▨	= Medium						░	= Low						

Source: NMFS (2009: 335).

Note: KL = Knights Landing. FW = Fremont Weir.

5.4.1.2.1.1.2 Spatial Occurrence

The main adult winter-run migration route through the Delta region is believed to be the mainstem of the Sacramento River. However, there is the potential for adults to "stray" into the San Joaquin River side of the Delta while on their upstream migration, particularly early in the migratory season (November and December). Significant amounts of Sacramento River water flow into the San Joaquin River side of the Delta through the DCC (when open), Georgiana Slough, and Three Mile Slough. These sources of Sacramento River water can create false attraction into the lower San Joaquin River. Adult winter-run that choose this path would be delayed in their upstream migration while they mill in the lower San Joaquin River, searching for the distinctive olfactory cues of the Sacramento River. Adults could re-enter the Sacramento River through Georgiana Slough or the Delta reaches of the Mokelumne River system when the DCC is open. The extent of this delay and the proportion of adults moving into the lower San Joaquin River are unknown. Adult winter-run do not typically inhabit the San Joaquin River mainstem upstream of Middle River or within the waterways of the South Delta in any appreciable numbers (Yoshiyama *et al*. 1996, 1998, 2001).

Juvenile winter-run are present in the waterways of the North Delta (*i.e.*, Sacramento River, Steamboat Slough, Sutter Slough, Miner Slough, and Cache Slough complex), Central Delta (Georgiana Slough, DCC, Snodgrass Slough, and Mokelumne River complex below Dead Horse Island), South Delta leading to the CVP and SWP pumping facilities including Old and Middle Rivers, and the interconnecting waterways between these main channels such as Victoria Canal, Woodward Canal, and Connection Slough, and the western Delta including the main channels of the San Joaquin and Sacramento rivers and Three Mile Slough. NMFS (2009: 336) did not anticipate seeing adult winter-run upstream of Middle River on the San Joaquin River mainstem or within the waterways of the South Delta in any appreciable numbers. NMFS (2009: 336) also did not anticipate seeing any significant numbers of juvenile winter-run in the Eastern Delta near Stockton (*i.e.*, White Slough, Disappointment Slough, Fourteenmile Slough), or the mainstem of the San Joaquin River upstream of Columbia and Turner Cuts. Presence of winter-run adults and juveniles may occur in other parts of the Delta not described above.

5.4.1.2.1.2 Spring-Run Chinook Salmon

5.4.1.2.1.2.1 Temporal Occurrence

Adult spring-run enter the San Francisco Bay Estuary from the ocean in January to late February (Table 5.4-1). They move through the Delta prior to entering the Sacramento River system. Based on the available information for fish from the Sacramento River basin, spring-run show two distinct juvenile emigration patterns in the Central Valley. Fish may either emigrate to the Delta and ocean during their first year of life as YOY, typically in the following spring after hatching, or hold over in their natal streams and emigrate the following fall as yearlings. Typically, yearlings enter the Delta as early as November and December and continue to enter the Delta through at least March. They are larger and less numerous than the YOY smolts that enter the Delta from January through June. The peak of YOY spring-run presence in the Delta is during the month of April, as indicated by the recoveries of spring-run size fish in the CVP and SWP salvage operations and the Chipps Island trawls. Frequently, it is difficult to distinguish the YOY spring-run outmigration from that of the fall-run due to the similarity in their spawning and emergence times. The overlap of these two runs makes for an extended pulse of Chinook salmon smolts through the Delta each spring, frequently lasting into June. This broad period of juvenile outmigration helps the species adapt to variable conditions in the ocean that can differentially affect individuals depending on when they enter the ocean (Johnson 2015). Therefore, 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. As a result, this effects analysis evaluates effects of the PA during the entire period of spring-run Chinook salmon occurrence in the Delta, including evaluating each month of the period of presence distinctly where possible and appropriate (e.g., Table 5.4-8).

The temporal occurrence of SJR-basin spring-run Chinook salmon may ultimately be similar to the populations from the Sacramento River basin, although this will not be known until monitoring data are examined in the future. For the purposes of this effects analysis, the timing for the SJR-basin spring-run Chinook salmon (including the springtime running Chinook salmon from the tributaries, discussed below) is assumed to be similar to that of the Sacramento River basin populations.

5.4.1.2.1.2.2 Spatial Occurrence

Currently, the only recognized populations of spring-run occur in the Sacramento River basin. Historical populations that occurred in the river basins to the south (*i.e.*, southern Sierra watersheds) have been extirpated, although reintroduction of spring-run to the San Joaquin River has begun (NMFS 2016b). As previously described in Section 4.5.2 *Chinook Salmon, Central Valley Spring-Run ESU* in Chapter 4, *Action Area and Environmental Baseline*, although there have been observations of springtime running Chinook salmon returning to the San Joaquin tributaries in recent years, there is insufficient information to determine the specific origin of these fish, and whether or not they are straying into the basin or returning to natal streams (NMFS 2016: 8).

The main migration route for adult spring-run from the Sacramento River basin is the Sacramento River channel through the Delta. Similar to winter-run, Sacramento River basin adults may stray into the San Joaquin River side of the Delta due to the inflow of Sacramento River basin water through one of the interconnecting waterways branching off of the mainstem Sacramento River towards the San Joaquin River. Starting in February, the closure of the DCC radial gates minimizes the influence of this pathway, but flows in the channels of Georgiana and Three Mile Slough provide sufficient flows of water to the San Joaquin River to induce straying from “spurious” olfactory cues present in these waterways. SJR-basin spring-run Chinook salmon presumably use the San Joaquin River as their main migration pathway through the Delta, both as juveniles and adults.

Juvenile Sacramento River basin spring-run are present in the same waterways as winter-run in the North Delta, Central Delta, South Delta, and the interconnecting waterways, including the main channels of the San Joaquin and Sacramento rivers and Three Mile Slough. NMFS (2009: 337) did not anticipate seeing any significant numbers of juvenile spring-run in the Eastern Delta or the mainstem of the San Joaquin River upstream of Columbia and Turner Cuts; this situation has presumably changed with the reintroduction of spring-run to the San Joaquin River, and the SJR-basin spring-run Chinook salmon presumably occur in these areas.

5.4.1.2.1.3 Central Valley Steelhead

5.4.1.2.1.3.1 Temporal Occurrence

Adult steelhead have the potential to be found within the Delta during much of the year, although the primary period of occurrence is late summer/fall/winter (Table 5.4-1). Unlike Chinook salmon, steelhead can spawn more than once, so post-spawn adults (typically females) have the potential to move back downstream through the Delta after completing their spawning in their natal streams. These fish are termed runbacks or kelts. Typically, adult steelhead moving into the Sacramento River basin begin to enter the Delta during mid to late summer, with fish entering the Sacramento River system from July to early September. Kelts are typically seen later in the spring following spawning. Steelhead entering the San Joaquin River basin are believed to have a later spawning run. Adults enter the system starting in late October through December, indicating presence in the Delta a few weeks earlier. Typically water quality in the lower San Joaquin River is marginal during this time, with elevated water temperatures and low DO levels presenting barriers to upstream migration. Early winter rains help to break up these barriers and provide the stimulus to adult steelhead holding in the Delta to move up river towards their spawning reaches in the San Joaquin River tributaries. Fish may continue entering the system through the winter months. Juvenile steelhead are recovered in the USFWS Chipps Island trawls from October through July. There appears to be a difference in the emigration timing between wild and hatchery-reared steelhead smolts. Adipose fin-clipped hatchery fish are typically recovered at Chipps Island from January through March, with the peak in recoveries occurring in February and March. This time period corresponds to the schedule of hatchery releases of steelhead smolts from the different Central Valley hatcheries (Nobriga and Cadrett 2003, CVP/SWP operations BA). The timing of wild steelhead (unclipped) emigration is more spread out. Emigration occurs over approximately 6 months, with peaks in February and March, based on salvage records at the CVP and SWP fish collection facilities. Individual unclipped fish first begin to be collected in fall and early winter, and may extend through early summer (June and July). Wild fish that are collected at the CVP and SWP facilities late in the season may be from the San Joaquin River system, based on the proximity of the basin to the pumps and the timing of the spring pulse flows in the tributaries (April-May). The size of emigrating steelhead smolts typically ranges from 200 to 250 mm in length, with wild fish tending to be at the upper end of this range (Nobriga and Cadrett 2003, CVP/SWP operations BA). The broad period of juvenile outmigration helps the species adapt to variable conditions in the ocean that can differentially affect individuals depending on when they enter the ocean (Johnson 2015). Therefore, 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. As a result, this effects analysis evaluates effects of the PA during the entire period of steelhead occurrence in the Delta, including evaluating each month of the period of presence distinctly where possible and appropriate (e.g., Table 5.4-8).

5.4.1.2.1.3.2 Spatial Occurrence

Populations of CV steelhead occur throughout the watersheds of the Central Valley; however, the primary population source occurs within the watersheds of the Sacramento River basin. Small, apparently self-sustaining populations of steelhead exist in the Mokelumne River system (although influenced by the Mokelumne River Hatchery steelhead program), the Calaveras River (natural) and the Stanislaus River (natural). Furthermore, otolith microchemistry analysis has shown that juvenile *O. mykiss* collected from the Tuolumne and Merced rivers had maternal steelhead origins (Zimmerman *et al*. 2008). Upstream migrating adult steelhead enter both the

Sacramento River basin and the San Joaquin River basin through their respective mainstem river channels. Adult steelhead entering the Mokelumne River system (including Dry Creek and the Cosumnes River) and the Calaveras River system are likely to move up the mainstem San Joaquin River channel before branching off into the channels of their natal rivers. It is also likely that some adult steelhead bound for the San Joaquin River system may detour through the South Delta waterways and enter the San Joaquin River through Old River near Mossdale. However, due to the number of potential routes, the early entrance of adults into the Delta, and the potential for the DCC to remain open for a substantial portion of the upstream spawning migration, the "actual" route that an adult steelhead follows before committing to its natal watershed could be quite complex. Therefore, adult steelhead could be in any of the larger channels in the Delta region during their spawning migrations. Likewise, steelhead kelts could also be found in any of the channels of the Delta during their return to the ocean. Data for this particular life stage is lacking.

Outmigrating steelhead smolts enter the Delta primarily from the Sacramento River (North Delta region) and from the San Joaquin River (South Delta region). Steelhead smolts from the Mokelumne River system and the Calaveras River system enter the Eastern Delta. The Mokelumne River fish can either follow the north or south forks of the Mokelumne River through the Central Delta before entering the San Joaquin River at RM 22. Some fish may enter the San Joaquin River farther upstream if they diverge from the South Fork of the Mokelumne River into Little Potato Slough. Fish from the Calaveras River enter the San Joaquin River downstream of the Port of Stockton near RM 38. Steelhead smolts from the San Joaquin River basin enter the Delta at Mossdale. Prior to the installation of the temporary rock Head of Old River Barrier (HORB) on approximately April 15, steelhead smolts exiting the San Joaquin River basin can follow either of two routes to the ocean. Fish may either stay in the mainstem of the San Joaquin River and move northwards towards the Port of Stockton and the Central Delta, or they may enter the South Delta through the Head of Old River and move northwards towards the lower San Joaquin River through Old and Middle rivers and their associated network of channels and waterways. When the rock HORB is not installed, approximately 50 percent of the San Joaquin River flow is directed into Old River. This percentage increases if the CVP and SWP are pumping at elevated levels. In fact, in low flow conditions with high pumping rates, the net flow in the mainstem of the San Joaquin between the Port of Stockton and Old River may reverse direction and flow upstream into the Head of Old River. When the HORB is installed, flow in the San Joaquin River is retained in the mainstem and fish are directed northwards towards the Port of Stockton and eventually through the Central Delta. Given the multiple points of entry into the Delta system, CV steelhead are likely to be found in any of the waterways of the Delta, but particularly in the main channels leading to their natal river systems.

5.4.1.2.1.4 Exposure to North Delta Exports

The potential for exposure of listed salmonids to the NDD would be very similar in terms of timing to that described for the Delta Cross Channel by NMFS (2009: 402-403), as discussed in Section 5.4.1.2.1.7, *Exposure to Delta Cross Channel*. However, a greater proportion of Sacramento River basin fish would pass the NDD than the DCC because a portion of fish (~20-40%, based on Perry et al. [2010, 2012]) would be expected to enter Sutter/Steamboat Sloughs prior to reaching the DCC. Some fish would enter the Delta from the Yolo Bypass because of passage through the notch of the modified Fremont Weir[11]; Roberts et al. (2013) estimated this would range from a mean of ~8% in drier years to ~16% in wetter years for winter-run and spring-run Chinook salmon (Table 5.4-2 and Table 5.4-3). However, winter-run Chinook emigrate from the upper Sacramento River basin and so a greater proportion may be exposed to Fremont Weir compared to spring-run Chinook salmon, for which many individuals leave Butte Creek via the lower Sutter Bypass and therefore may not encounter the Fremont Weir notch. Any fish entering the Delta from the Yolo Bypass would avoid exposure to the NDD. No spring-run Chinook salmon from the San Joaquin River basin would be expected to be exposed to the NDD, other than occasional straying adults for which the effects would be insignificant because of their large size and swimming ability.

Table 5.4-2. Annual Percentage of Winter-Run Chinook Salmon Juveniles Approaching Fremont Weir That Would Be Entrained Onto the Yolo Bypass Under Existing Conditions and with Notching of Fremont Weir

Water Year	Water-Year Type	Existing Conditions	With Notch
1997	W	15.9	22.5
1998	W	4.9	11.1
1999	W	2.0	14.3
2000	AN	16.3	25.2
2001	D	0.0	7.5
2002	D	0.1	6.3
2003	AN	1.7	15.9
2004	BN	0.7	9.2
2005	AN	0.0	9.9
2006	W	6.2	13.9
2007	D	0.0	6.0
2008	C	0.0	11.6
2009	D	0.0	10.2
2010	BN	0.4	11.2
2011	W	2.5	13.2
Average (1997–2011)		3.4	12.5
Wet and Above Normal Water Year Average		6.2	15.7
Dry and Critical Water Year Average		0.0	8.3

Source: Roberts et al. 2013.

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[11] The notch modification would occur under the NAA and the PA.

Table 5.4-3. Annual Percentage of Spring-Run Chinook Salmon Juveniles Approaching Fremont Weir That Would Be Entrained Onto the Yolo Bypass Under Existing Conditions and with Notching of Fremont Weir

Water Year	Water-Year Type	Existing Conditions	With Notch
1997	W	13.2	21.1
1998	W	6.1	11.2
1999	W	1.1	13.7
2000	AN	8.0	18.4
2001	D	0.0	4.1
2002	D	0.1	7.6
2003	AN	0.7	14.0
2004	BN	0.5	10.6
2005	AN	0.0	11.5
2006	W	7.2	16.2
2007	D	0.0	8.7
2008	C	0.0	11.3
2009	D	0.0	6.5
2010	BN	0.5	12.3
2011	W	13.0	22.7
Average (1997–2011)		3.4	12.7
Wet and Above Normal Water Year Average		6.2	16.1
Dry and Critical Water Year Average		0.0	7.7

Source: Roberts et al. 2013.

5.4.1.2.1.5 Exposure to South Delta Exports

The potential for exposure to the effects of south Delta exports would follow the basic timing outlined in the earlier species-specific discussions and additional information presented for the Delta Cross Channel in Section 5.4.1.2.1.7, *Exposure to Delta Cross Channel*. Hydrodynamic effects of the south Delta export facilities could occur for juveniles emigrating from the Sacramento River basin and entering the interior Delta, principally at Georgiana Slough (the DCC generally would be closed during this period); the percentage of juveniles migrating down the main stem Sacramento River that use the Georgiana Slough migration pathway generally is around 10-30%[12] (Perry et al. 2010, 2012). Steelhead and spring-run Chinook salmon from the San Joaquin River basin would be expected to be exposed to the south Delta export facilities in greater frequency than salmonids from the Sacramento River basin because their migration pathways include the south Delta.

5.4.1.2.1.6 Exposure to Head of Old River Gate Operations

Of the listed salmonids occurring in the Delta, only steelhead and spring-run Chinook salmon from the San Joaquin River basin would be expected to be exposed to near-field effects of the HOR gate based on its geographic location. Operations of the gate would coincide with the

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[12] As previously described, a portion of fish would enter the Yolo Bypass, thereby making exposure to south Delta export effects unlikely. The 10-30% estimate applies to fish entering the Delta on the main stem Sacramento River.

migratory period of both juvenile (spring) and adult (fall/winter) steelhead, whereas the main coincidence with spring-run Chinook would be for juveniles and adults in spring (with a lesser overlap possibly in fall for any emigrating yearlings). Far-field effects of the HOR gate in terms of flow routing down the San Joaquin River would also affect steelhead and spring-run Chinook salmon from the San Joaquin basin, and could also affect winter-run and spring-run Chinook salmon and green sturgeon from the Sacramento River basin if occurring in the interior Delta.

5.4.1.2.1.7 Exposure to Delta Cross Channel

The proportion of juvenile Chinook salmon that enter the Delta from the Sacramento River is given in Table 6-34 of NMFS (2009: 402). Salvage and loss across months (http://www.usbr.gov/mp/cvo/fishrpt.html) represents fish presence in the South Delta (Table 5.4-1). The closure of the DCC gates under the NMFS (2009) BiOp's Action 4.1 is described in Section 3.3.2.4, *Operational Criteria for the Delta Cross Channel Gates*, and would be expected to result in nearly all juvenile salmonids from the Sacramento River basin encountering the DCC when the gates are closed. The majority of adult winter-run would migrate during the main period of DCC closure, whereas spring-run Chinook salmon and steelhead could encounter a mixture of open and closed gate configurations, depending on migration timing and gate operations.

5.4.1.2.1.8 Exposure to Suisun Marsh Facilities

5.4.1.2.1.8.1 Suisun Marsh Salinity Control Gates

Operation of the SMSCG from October through May coincides with the upstream migration of adult Central Valley anadromous salmonids. The late winter and spring downstream migration of Central Valley salmonids also overlaps with the operational period of the SMSCG. As adult Central Valley anadromous salmonids travel between the ocean and their natal Central Valley streams, Montezuma Slough provides an alternative route to their primary migration corridor through Suisun Bay. Fisheries sampling conducted by CDFW indicates many adult Central Valley salmon migrate upstream through Montezuma Slough (Edwards *et al*. 1996, Tillman *et al*. 1996), but the proportion of the total run utilizing this route is unknown.

5.4.1.2.1.8.2 Roaring River Distribution System

As described previously for the SMSCG, some anadromous salmonids (juveniles and adults) would occur in Montezuma Slough and therefore could be exposed to the RRDS, although the intake is screened.

5.4.1.2.1.8.3 Morrow Island Distribution System

NMFS (2009: 438) noted that Goodyear Slough is not a migratory corridor for listed salmonids, which would be likely to limit the potential for exposure to the MIDS.

5.4.1.2.1.8.4 Goodyear Slough Outfall

NMFS (2009: 438) suggested that listed salmonids are not likely to encounter the Goodyear Slough structure because of its location.

5.4.1.2.1.9 Exposure to North Bay Aqueduct

Listed salmonids may be present in the waterways adjacent to the Barker Slough Pumping Plant, however several years of monitoring have failed to consistently capture any salmonids during the winter Delta smelt surveys (1996 to 2004) in Lindsey Slough or Barker Slough. Captures of

Chinook salmon have usually occurred in the months of February and March and typically are only a single fish per net haul (http://www.delta.dfg.ca.goc/data/nba). Most Chinook salmon captured have come from Miner Slough, which is a direct distributary from the Sacramento River via Steamboat and Sutter Sloughs. No steelhead have been captured in the monitoring surveys between 1996 to 2004, the dates available on the DFG website. Based on the geographic location of the Barker Slough Pumping Plant in the north Delta, it is unlikely that any listed salmonids from the San Joaquin River basin would be exposed to the facility.

5.4.1.2.1.10 Exposure to Other Facilities

5.4.1.2.1.10.1 Contra Costa Canal Rock Slough Intake

As described by NMFS (2009: 411), winter-run Chinook salmon are present from approximately December through June based on salvage records from the CVP/SWP fish collection facilities. The peak occurrence of winter-run in the south Delta is from January through March. Juvenile spring-run are present in the South Delta in the vicinity of the CCWD diversions from January through June with peak occurrence from March through May. Central Valley steelhead may be present in the waters of the South Delta from October through July, but have peak occurrence from January through March (National Marine Fisheries Service 2009: 411).

5.4.1.2.1.10.2 Clifton Court Forebay Aquatic Weed Control Program

The application of aquatic herbicide to the waters of Clifton Court Forebay will occur during the summer months of July and August. The probability of exposing salmonids to the herbicide is very low due to the life history of Chinook salmon and steelhead in the Central Valley's Delta region. Migrations of juvenile winter-run and spring-run fish primarily occur outside of the summer period in the Delta. Historical salvage data indicates that in wet years, a few steelhead may be salvaged as late as early July, but this is uncommon and the numbers are based on a few individuals in the salvage collections. Based on typical water temperatures in the vicinity of the salvage facilities during this period, the temperatures would be incompatible with salmonid life history preferences, generally exceeding 70˚F by mid-June. Mechanical harvesting would occur on an as-needed basis and therefore listed salmonids could be exposed to this action, if entrained into the Forebay.

5.4.1.2.2 Green Sturgeon

5.4.1.2.2.1 Temporal Occurrence

NMFS (2009: 338) noted that adult green sturgeon enter the San Francisco Bay estuary in early winter (January/February) before initiating their upstream spawning migration into the Delta. Adults move through the Delta from February through April[13], arriving in the upper Sacramento River between April and June (Heublein 2006, Kelly *et al.* 2007). Following their initial spawning run upriver, adults may hold for a few weeks to months in the upper river (*i.e.*, GCID aggregation site; see Vogel 2005, 2008a) or immediately migrate back down river to the Delta. Those fish that hold upriver move back downstream later in the fall, during the first rains per the review by Klimley et al. (2015). Radio-tagged adult green sturgeon have been tracked moving downstream from the GCID aggregation site past Knights Landing during the summer and fall into November and December, following their upstream migrations the previous spring. It

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[13] This is consistent with the life history presented in a recent review by Klimley et al. (2015), whose Figure 1 showed upstream migration in March and April.

appears that pulses of flow in the river "trigger" downstream migration in the late fall, similar to behavior exhibited by adult green sturgeon on the Rogue and Klamath River systems (Erickson *et al.* 2002, Benson *et al.* 2007). Klimley et al. (2015: 1-2) noted "The southern DPS green sturgeon migrates in the spring to spawn in the Sacramento River and returns to the estuary in the fall, winter, and spring", suggesting that adults can be found in the Delta and estuary for much of the year.

Per NMFS (2009: 338), adults and sub-adults may also reside for extended periods in the western Delta as well as in Suisun and San Pablo bays. Like other estuaries along the west coast of North America, adult and sub-adult green sturgeon (from both Northern and Southern DPSs) frequently congregate in the tidal portions of the San Francisco Bay estuary during the summer and fall, with the recent review by Klimley et al. (2015) also suggesting that these fish may be present at this location in spring. It is not known exactly why these congregations occur, but they do not appear to be related to spawning activities, as most fish do not move upriver out of tidewater. Based on radio and acoustic tag data gathered to date from adult green sturgeon, fish that spawn in one river system do not spawn in other river systems.

Juveniles are believed to use the Delta for rearing for the first 1 to 3 years of their life before moving out to the ocean. Per NMFS (2009: 338), green sturgeon are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, with western Delta waterways having a higher likelihood of presence than eastern Delta waterways. Juveniles are recovered at the SWP and CVP fish collection facilities year round and range in size from 136 mm to 774 mm, with an average size of 330 mm (National Marine Fisheries Service 2009: 338).

5.4.1.2.2.2 Spatial Occurrence

As described by NMFS (2009: 340-341), adult green sturgeon are presumed to primarily use the mainstem of the Sacramento River through the Delta when making their upstream spawning migrations. During high water conditions that result in the flooding of the Yolo bypass, adult green sturgeon may also utilize the floodplain of the Yolo bypass to move northwards from Cache Slough to the Sacramento River at Fremont Weir. This has resulted in stranding during some years, as exemplified in April 2011 (Thomas et al. 2013). During other times of the year, green sturgeon may be present in any of the waterways of the Delta, based on sturgeon tag returns. Sturgeon report card data for 2007-2015 show that reported green sturgeon captures by anglers in or near the Delta were consistently high in Suisun Bay and the Sacramento River between Knights Landing and Chipps Island, with other high-ranking areas including San Pablo Bay and Carquinez Strait (Table 5.4-5), Green sturgeon captured in these locations have ranged from 12 inches to 86 inches. Other areas within the Delta reaching relatively high ranks of total reported captures included the Sacramento Deepwater Ship Channel (4th in 2015) and Montezuma Slough (5th in 2015). The report card data confirm that green sturgeon occur quite broadly within the Delta, with individuals also having been caught in Old River (8 fish from 2007-2015) and in the San Joaquin River between Stockton and the Highway 140 bridge upstream of the Delta (40 fish from 2007 to 2015). These fish ranged from 47 to 66 inches (Table 5.4-4).

The pattern of occurrence throughout the Delta from sturgeon report card data is consistent with the observations of NMFS (2009: 341), who noted that juvenile and sub-adult green sturgeon are found throughout the waters of the Delta, having been recovered at the CVP and SWP fish collection facilities and from areas on the San Joaquin River near San Andreas Shoals.

Table 5.4-4. Catch of Green Sturgeon from Sturgeon Report Cards, 2007-2015.

Location Name	Rank of Catch	Number of Anglers	Winter Catch	Spring Catch	Summer Catch	Fall Catch	Unknown Catch	Total	Number Measured	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
Sacramento River: Red Bluff to Hwy 32 bridge												
2010												
2011												
2012												
2013												
2014												
2015												
Sacramento River: Hwy 32 bridge to Colusa												
2010		18		7	15			22	22	47	65	57.6
2011												
2012		4			4			4	1	90	90	90
2013		3	0	0	4	0	0	4	0			
2014		4		1	3			4	2	70	84	77
2015		1		1				1				
Sacramento River: Red Bluff to Colusa												
2007	1	11	17	2	10	38		67	1	65		
2008		44	3	50	2	0		55	55	46.5	66	57.2
2009		49	3	51	1			53	53	46	84	56.9
Sacramento River: Colusa to Knights Landing												
2007		5	4	3		1	1	9				
2008	4	97	37	84	0	5		126	126	46	66	58.9
2009		61	24	45		1		70	70	46	66	56.7
2010		41		11	35			46	46	48	66	60
2011		4			4			4				
2012		2			2			2	1	72	72	72

Location Name	Rank of Catch	Number of Anglers	Winter Catch	Spring Catch	Summer Catch	Fall Catch	Unknown Catch	Total	Number Measured	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
2013		3	0	1	2	0	0	3	0			
2014		1			1			1	1	72	72	72
2015		3		2	1			3	1	64	64	64
Sacramento River: Knights Landing to Rio Vista												
2007		12	2	6	1	7		16	1	36		
2008	1	201	93	144	3	32		272	271	46	66	56.4
2009	2	174	67	139		11		217	217	46	66	55.7
2010	3	115		57	72		15	144	144	46	66	56.1
2011	4	6		4	1		1	7	3	14	71	34.3
2012	4	17		5	8		4	17	5	18	56	38.2
2013	3	12	0	7	5	0	7	19	12	14	74	32.7
2014	4	11		8	2		1	11	6	12	64	35.5
2015		6		4			2	6	4	25	54	42.5
Sacramento River: Rio Vista to Chipps Island												
2007	2	42	17	10	4	28	3	62	7	19	86	42
2008	1	212	100	84	14	74		272	271	46	71	54.7
2009	3	162	80	53	9	58		200	197	46	67	54.7
2010	2	176		75	55	6	90	226	226	46	66	54.2
2011	5	6		2	1	2	1	6	2	28	29	28.5
2012	2	28		10	4	1	17	32	8	18	72	39.5
2013	1	28	0	10	4	5	25	44	18	12	57	31.2
2014	1	29		17	24		3	44	10	12	40	28.4
2015	1	41	1	23	27		8	59	16	18	44	26.6
Feather River												
2007		1			2			2				
2008		2	1	1	0	0		2	2	51	60	55.5
2009		4	1	3				4	4	59	66	61.3

Location Name	Rank of Catch	Number of Anglers	Winter Catch	Spring Catch	Summer Catch	Fall Catch	Unknown Catch	Total	Number Measured	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
2010												
2011		1			1			1				
2012												
2013												
2014												
2015												
American River												
2007												
2008		1	1	0	0	0		1	1	57	57	57
2009								0				
2010												
2011												
2012												
2013		1	0	0	0	0	1	1	0			
2014												
2015												
Sacramento Deepwater Ship Channel												
2007		3		1		2		3	1	24		
2008		49	28	19	1	14		62	62	46	65	54.6
2009		38	27	9	2	16		54	54	46	66	54.6
2010		39		16	6	1	23	46	46	46	65	53.5
2011		1					1	1	1	21	21	21
2012		2			1		1	2				
2013		8	0	1	2	1	4	8	1	46	46	46
2014		5		4		1	1	6	1	30	30	30
2015	4	7		6	2		3	11	7	20	72	35.1
Yolo Bypass												

Location Name	Rank of Catch	Number of Anglers	Winter Catch	Spring Catch	Summer Catch	Fall Catch	Unknown Catch	Total	Number Measured	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
2007												
2008		15	5	12	0	1		18	18	48	66	58.1
2009		14	9	7		2		18	18	48	65	54.2
2010		22		14	11	1	3	29	29	46	66	58.6
2011												
2012												
2013												
2014												
2015												
Montezuma Slough												
2007		13	5	4	1	4		14	1	27		
2008		72	35	35	2	14		86	86	46	75	56.1
2009		84	39	44	9	16		108	107	46	65	54.2
2010		51		21	20	9	9	59	59	46	66	55.1
2011		2		2				2	2	22	24	23
2012		4		1	4	1		6	3	12	60	28
2013		6	0	1	4	0	2	7	3	24	28	25.3
2014		6		2	4	1		7	2	10	14	12
2015	5	9		2	6	1	2	11	5	20	39	30.6
Napa River												
2007		6	1	4	1	1		7	1	28		
2008		61	24	31	7	4		66	66	46	65.7	52.2
2009		80	34	42	11	2		89	83	46	66	53.5
2010		83		36	47	10	4	97	97	46	72	54.6
2011		3			4			4				
2012	5	8			8	2		10	3	28	36	31.7
2013		1	0	0	3	0	0	3	0			

Location Name	Rank of Catch	Number of Anglers	Winter Catch	Spring Catch	Summer Catch	Fall Catch	Unknown Catch	Total	Number Measured	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
2014		3		1	1		1	3	2	25	32	28.5
2015		9		3	5		1	9				
Petaluma River												
2007		1				1		1				
2008		3	3	1	0	0		4	4	48	57	52
2009		6	1	5				6	5	49	65	58
2010		20		6	14			20	18	46	65	53.9
2011												
2012		1			2			2	2	40	42	41
2013		1	0	1	0	0	0	1	1	60	60	60
2014												
2015												
San Joaquin River: Upstream of HWY 140 bridge												
2007												
2008		6	4	0	0	2		6	6	47	62	53
2009		1		1				1	1	64	64	64
2010		2		1			2	3	3	50	66	60.3
2011												
2012												
2013		1	0	0	0	0	1	1	0			
2014												
2015												
San Joaquin River: HWY 140 bridge to Stockton												
2007												
2008		8	1	7	0	1		9	9	49	66	58.1
2009		13	4	10		2		16	16	47	62	54.3
2010												

Location Name	Rank of Catch	Number of Anglers	Winter Catch	Spring Catch	Summer Catch	Fall Catch	Unknown Catch	Total	Number Measured	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
2011												
2012												
2013												
2014		2		1			1	2				
2015												
San Joaquin River: Stockton to Sherman Lake												
2008		36	20	8	2	17		47	47	46	65	53.3
2009		51	25	19	2	18		64	64	46	66	52.8
2010		37		19	13	6	10	48	48	46	65	53.5
2011		4			1	1	2	4				
2012												
2013		3	0	0	1	1	1	3	2	22	50	36
2014		7		6	2		1	9	2	27	74	50.5
2015		3		3	3		1	7	4	24	45	34.5
Old River												
2007												
2008		2	0	1	0	1		2	2	46.5	62	54.3
2009		2	1		1			2	2	46	47	46.5
2010		2		2				2	2	54	60	57
2011												
2012												
2013												
2014		1		1				1				
2015		1					1	1	1	27	27	27
San Pablo Bay												
2007	5	15	5	12	2	1		20	1	38		
2008	5	101	52	54	2	7		115	114	46	69	54.6

Location Name	Rank of Catch	Number of Anglers	Winter Catch	Spring Catch	Summer Catch	Fall Catch	Unknown Catch	Total	Number Measured	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
2009	5	95	32	66	7	7		112	109	46	65	53
2010	5	85	1	61	34	4	3	103	102	46	66	54
2011	1	19		6	9	11	2	28	11	21	59	37.5
2012		6		4	2			6				
2013	4	10	0	11	2	0	2	15	5	19	36	28.6
2014	3	15		15	3			18	6	17	40	29
2015	3	18		14	6	1	1	22	8	22	37	28.9
Carquinez Strait												
2008		60	22	25	9	8		64	64	46	66	54.4
2009		45	13	17	16	9		55	54	46	66	54.4
2010		44	2	16	27	6	5	56	56	46	66	54.9
2011	3	6		1	3	2	2	8	1	30	30	30
2012	3	9		8	3	3	6	20				
2013	5	9	0	9	1	2	1	13	1	30	30	30
2014	5	7		4	5		2	11	7	18	32	25.4
2015		10	1	3	3		4	10	5	14	35	27.6
Suisun Bay												
2007	4	23	4	9	3	14		30	5	22	40	30
2008	2	210	83	97	32	50		262	259	46	75	54.3
2009	1	266	101	110	35	79		325	324	46	66	53.7
2010	1	198		85	78	19	65	247	247	28	66	53.9
2011	2	15		2	8	4	6	20	4	13	27	21.8
2012	1	46		19	10	9	24	62	19	13	39	25.5
2013	2	31	0	8	17	2	11	38	11	8	48	29.5
2014	2	28		13	8	6	6	33	11	18	44	29.1
2015	2	40		18	14	6	9	47	20	19	45	27.7
Grizzly Bay												

Location Name	Rank of Catch	Number of Anglers	Winter Catch	Spring Catch	Summer Catch	Fall Catch	Unknown Catch	Total	Number Measured	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
2007		11	2	3	1	8		14				
2008		41	22	11	3	14		50	50	46	66	54.3
2009		47	26	14	6	13		59	59	46	65	52.8
2010		20		7	8		7	22	22	46	65	54.5
2011		2		1			2	3	2	33	36	34.5
2012		8		2	1		5	8				
2013		6	0	1	3	1	1	6	0			
2014		2		2				2				
2015		3		1		1	1	3	2		42	
San Francisco Bay: North of HWY 80												
2007		1	1			1		2				
2008		15	12	6	0	2		20	20	47	65	56.3
2009		11	7	3	1	3		14	14	49	65	57.2
2010		11		14	3	1		18	18	47	62	53.9
2011												
2012												
2013												
2014												
2015												
San Francisco Bay: South of HWY 80												
2007		1		1				1				
2008	3	124	121	19	4	22		166	163	46	66	55.9
2009	4	107	108	6	2	11		127	127	5	65	55.1
2010	4	83		90	3		11	104	104	46	65	54.9
2011												
2012		1			2		2	2	2	52	86	69
2013												

Location Name	Rank of Catch	Number of Anglers	Winter Catch	Spring Catch	Summer Catch	Fall Catch	Unknown Catch	Total	Number Measured	Minimum Length (inches)	Maximum Length (inches)	Average Length (inches)
2014												
2015		1			1			1	1	52	52	52
Source: Gleason et al. (2008), DuBois et al. (2009, 2010, 2011, 2012, 2014), DuBois (2013), DuBois and Harris (2015, 2016).												

5.4.1.2.2.3 Exposure to North Delta Exports

The temporal and spatial patterns of occurrence discussed in the previous two sections would influence the potential for exposure of green sturgeon to the NDD. Data specific to potential near-field exposure of green sturgeon to the NDD are not available, but as previously noted, juveniles can be present in the Delta year-round. See also the discussion from NMFS (2009: 403) related to the DCC (Section 5.4.1.2.2.6, *Exposure to Delta Cross Channel*).

5.4.1.2.2.4 Exposure to South Delta Exports

The temporal and spatial patterns of occurrence discussed in Sections 5.4.1.2.2.1, *Temporal Occurrence*, and 5.4.1.2.2.2, *Spatial Occurrence*, would influence the potential for exposure of green sturgeon to the effects of the south Delta export facilities; those sections were adapted from NMFS's (2009: 338, 340-341) assessment of the potential for exposure of green sturgeon to Delta exports and related hydrodynamics.

5.4.1.2.2.5 Exposure to Head of Old River Gate Operations

Green sturgeon juveniles (present year-round) and upstream-migrating adults (spring) could be exposed to the winter/spring and fall operations of the HOR gate. However, given that green sturgeon may be extirpated from the San Joaquin River (Israel and Klimley 2008), adults exposed to the HOR gate may be a small subset of individuals ultimately returning to the Sacramento River. Nevertheless, the occurrence of green sturgeon in reported catch in the San Joaquin River in and upstream of the HOR gate location (Table 5.4-5) indicates that some individuals could be exposed to HOR gate operations.

5.4.1.2.2.6 Exposure to Delta Cross Channel

NMFS (2009: 403) noted that little is known about the migratory behavior of juvenile green sturgeon in the Sacramento River basin. NMFS (2009: 403) also considered that it is likely that juvenile green sturgeon (larger than the 75 mm) will not enter the Delta prior to their first winter and thus would not be exposed to the open DCC gates. It is likely that these fish will enter the Delta sometime in the winter or spring following their hatching upriver and encounter both types of gate configurations as they enter the Delta. NMFS (2009: 403) noted that more information is required to accurately assess the migratory movements of juvenile sturgeon in the river system, as well as their movements within the Delta during their rearing phase in estuarine/Delta waters. Although newer information on juvenile movements is available—i.e., the summary by Klimley et al. (2015) of juvenile movements; see Section 5.4.1.3.2.2.*1 Indirect Mortality Within the Delta*—this information does not inform the exposure assessment for DCC given that it focused on green sturgeon juveniles released in the lower San Joaquin River. Adult green sturgeon are likely to encounter closed DCC gates during their upstream spawning migration in winter and early spring, but encounter open gates during their downstream migration in summer and fall following spawning (National Marine Fisheries Service 2009: 403).

5.4.1.2.2.7 Exposure to Suisun Marsh Facilities

5.4.1.2.2.7.1 Suisun Marsh Salinity Control Gates

Operation of the SMSCG from October through May coincides with the upstream migration of adult green sturgeon, which could be exposed to the gates during the up to 20 days of annual operation. Sub-adult green sturgeon can be found in Suisun Marsh year-round (Matern *et al.* 2002), and adult green sturgeon may also use Montezuma Slough as a migration route between the ocean and their natal spawning areas in the upper Sacramento River. Montezuma Slough is part of designated critical habitat for green sturgeon (74 FR 52300).

5.4.1.2.2.7.2 Roaring River Distribution System

The RRDS is located in Montezuma Slough which, as noted previously for the SMSCG, is designated critical habitat for green sturgeon.

5.4.1.2.2.7.3 Morrow Island Distribution System

NMFS (2009: 438) noted that Goodyear Slough, where MIDS is located, is not a migratory corridor for green sturgeon. However, Goodyear Slough is part of designated critical habitat for the species (74 FR 52300).

5.4.1.2.2.7.4 Goodyear Slough Outfall

As previously noted for MIDS, Goodyear Slough is not a migratory corridor for green sturgeon and NMFS (2009: 438) considered it unlikely that green sturgeon would encounter the Goodyear Slough outfall because of its location.

5.4.1.2.2.8 Exposure to North Bay Aqueduct

Green sturgeon are assumed to occur in the waters of Cache Slough and the Sacramento ship channel as green sturgeon have been caught in these waters by sport fisherman (National Marine Fisheries Service 2009: 416).

5.4.1.2.2.9 Exposure to Other Facilities

5.4.1.2.2.9.1 Contra Costa Canal Rock Slough Intake

Both juvenile and sub-adult green sturgeon are expected to be present year round in the South Delta as indicated by the salvage record (NMFS 2009: 411). Adult green sturgeon have been caught by sport fisherman in the mainstem of the San Joaquin River from Sherman Island to the Port of Stockton in most months of the year based on the draft 2007 sturgeon report card (California Department of Fish and Game 2008). Presence in the South Delta is assumed for the same period. During the 75 day pumping reduction from March 15 to May 31 and the 30 day no pumping period (April 1 to April 30), the effects of the CCWD action is significantly reduced or eliminated. In addition, Rock Slough is not part of designated critical habitat for green sturgeon (74 FR 52300).

5.4.1.2.2.9.2 Clifton Court Forebay Aquatic Weed Control Program

As described by NMFS (2009: 387-388), juvenile and sub-adult green sturgeon are recovered year-round at the CVP/SWP facilities, albeit in low numbers, and have higher levels of salvage during the months of July and August compared to the other months of the year. The reason for this distribution is unknown at present. Therefore, juvenile and sub-adult green sturgeons are likely to be present during the application of the herbicides as part of the aquatic weed control program, and could be exposed to mechanical removal efforts occurring on an as-needed basis.

5.4.1.3 Assess Species Response to the Proposed Action

The response of listed salmonids and green sturgeon to the proposed action is discussed in this section, with the potential effects divided into near-field and far-field effects. Near-field effects are those occurring close to an operations facility, e.g., predation at the NDD screens or the HOR gate. Far-field effects are those occurring over a broader area, e.g., lower through-Delta survival caused by less river flow downstream of the NDD.

5.4.1.3.1 Salmonids

5.4.1.3.1.1 Near-Field Effects

5.4.1.3.1.1.1 North Delta Exports

As described in Section 3.2.2.2, *Fish Screen Design*, the NDD will be provided with fish screens designed to minimize the risk that fish will be entrained into the intakes, or injured by impingement on the fish screens, during operations[14]. The process of the fish screen design has been and will continue to be subject to extensive collaborative discussions with the fish agencies affecting both final design and initial operations of the screens, during which their operations will be "tuned" to minimize risks to fish. As also described in Section 3.4.8 *Monitoring and Research Program*, a number of studies will be conducted to monitor NDD fish screen performance and allow refinement to meet design criteria.

5.4.1.3.1.1.1.1 Entrainment

Juvenile Chinook salmon at sizes of 30 mm or greater may occur near the north Delta intake structures (National Marine Fisheries Service 1997). Juvenile steelhead migrating downstream in the Sacramento River that will be exposed to the north Delta intakes typically range in length from approximately 150 to 250 mm. Based on a conservative body fineness ratio of 10 (from Delta Smelt estimates by Young et al. 1997) and applying the equations of Young et al. (1997), the NDD's fish screens with a 1.75-mm opening would be estimated to be effective at excluding juvenile Chinook salmon of 22-mm standard length and greater, as well as juvenile steelhead, which generally are larger than Chinook salmon during their Delta residence (McEwan 2001). Therefore, little to no entrainment of salmonids is expected at the proposed north Delta diversions. Note, however, that one juvenile Chinook salmon of 32-mm fork length—standard length would be slightly shorter—was collected during entrainment monitoring at the Freeport Regional Water Project intake in January 2012 (Kozlowski pers comm.), a facility with the same screen opening size as proposed for the NDD. This suggests occasional entrainment of very small Chinook salmon could occur at the north Delta intakes, although most would be expected to be excluded.

5.4.1.3.1.1.1.2 Impingement, Screen Contact, and Screen Passage Time

Juvenile salmonids would have the potential to contact and be impinged on the screens of the NDD. Experimental studies at the UC Davis Fish Treadmill facility found that Chinook salmon experienced frequent contact with the simulated fish screen but were rarely impinged (defined as prolonged screen contacts >2.5 minutes) and impingement was not related to any of the experimental variables examined (Swanson et al. 2004a). The extent to which the relatively benign experimental environment is representative of Sacramento River conditions is uncertain, but the proposed NDD intake screens would have a smooth screen surface and the potential for frequent screen cleaning (cycle time no more than 5 minutes), which would provide additional

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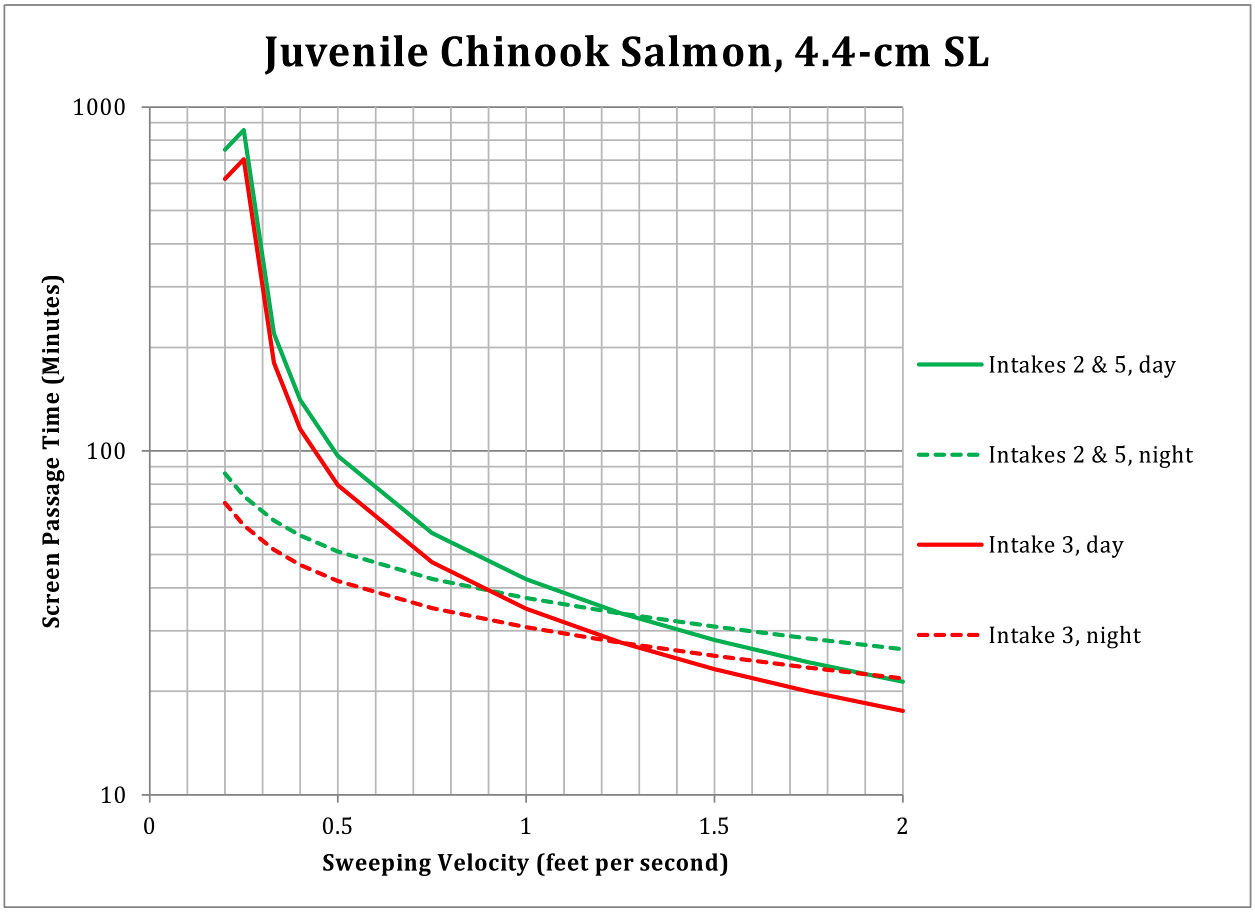
[14] Fish screens would be removed as necessary during maintenance, which could be accompanied by dewatering, for example (see Section 3.3.6.1.1, *Intake Dewatering*, of Chapter 3, *Description of the Proposed Action*). Pumping would not occur in bays with fish screens removed, and therefore there would be no risk of entrainment during these times.

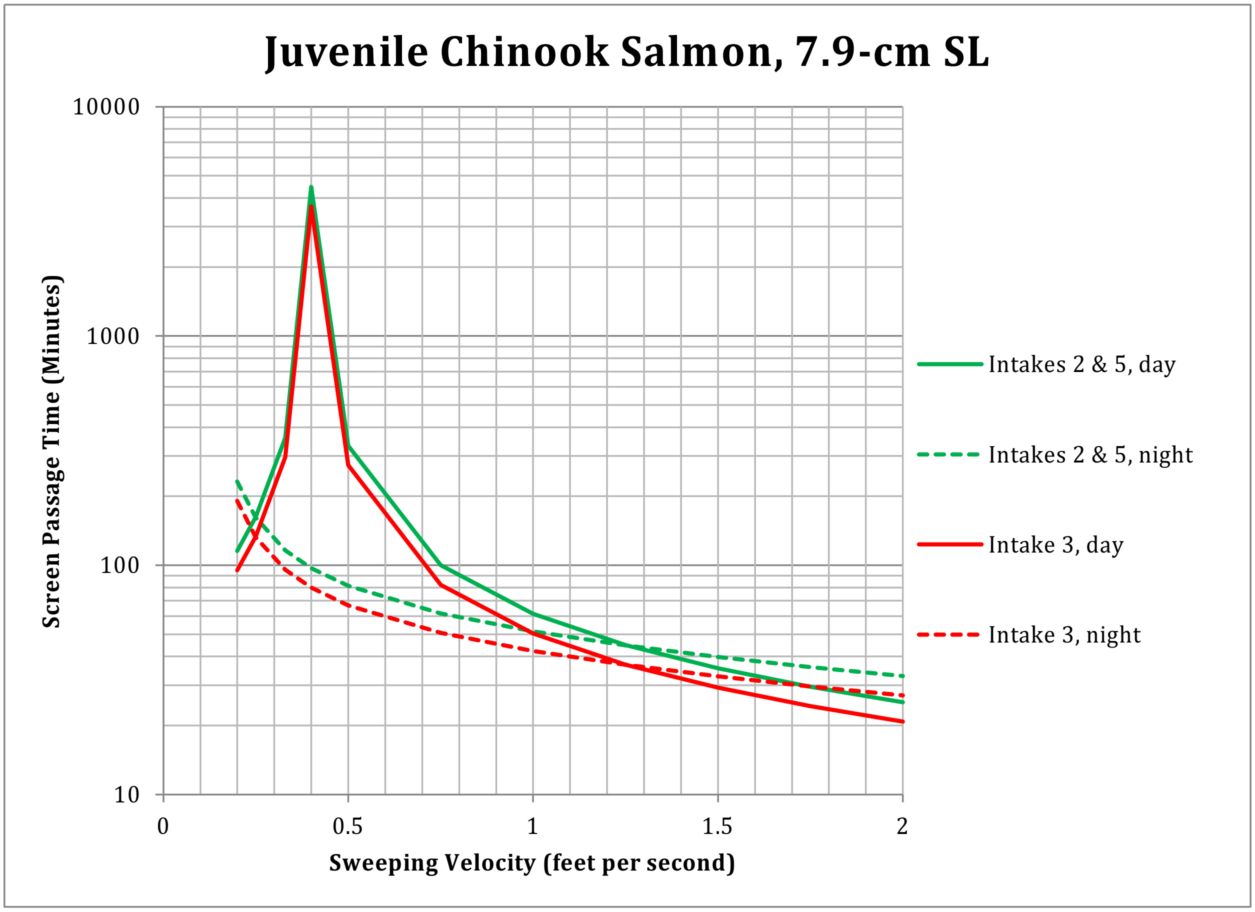
protection to minimize screen surface impingement of juvenile Chinook salmon and steelhead. The smooth surface also would serve to reduce the risk of abrasion and scale loss for any fish that does come into contact with the screens (Swanson et al. 2004a).

Although Swanson et al. (2004a) provide equations to estimate screen contact rate for juvenile Chinook salmon, preliminary calculations for this effects analysis suggested that these equations did not perform well for the lengths of screen proposed for the NDD. Additionally, the equations derived from this study, conducted in a two-foot wide channel, may not be wholly applicable to the effects of NDD, where fish will be in a much wider channel and may be able to move away from the screens or may not be in an area of the channel exposed to their effects. Screen passage time is another useful measure of potential effects on Chinook salmon, with shorter passage times being more desirable to limit the potential for adverse effects (e.g., predation or screen contact). Application of the relationships from Swanson et al. (2004a) for a representative winter water temperature of 12°C illustrated how screen passage time may differ in relation to sweeping velocity at an approach velocity of 0.2 ft/s (see methods description 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.D.1.1.1.1, *Screen Passage Time*) (Figure 5.4-1 and Figure 5.4-2). It should be noted that the equations of Swanson et al. (2004a) give very long screen passage times at certain sweeping velocity and approach velocity combinations, e.g., over 4,600 minutes for 7.9-cm fish along intakes 2 and 5 at sweeping velocity of 0.4 ft/s (Figure 5.4-2). Such estimates are far in excess of the duration of the experimental trials (120 minutes) used to derive the swimming data and therefore should be treated with caution. The peaks in the estimated screen passage times shown in Figure 5.4-1 and Figure 5.4-2 reflect the swimming response of the tested juvenile Chinook salmon and their general negative rheotaxis (swimming against the prevailing current). To the left of the peaks, swimming velocity was sufficient to give net upstream progress, so that in theory the fish would pass the screen in an upstream direction. To the right of the peaks, swimming velocity increases but does not keep up with the increase in sweeping velocity, resulting in fish passing the screen in a downstream direction. Very high estimated screen passage time at the peaks reflects fish that would be maintaining station in front of a screen for a long time. Larger fish have greater swimming ability, so their peak screen passage time is somewhat greater (Figure 5.4-2) than that of smaller fish (Figure 5.4-1). Swimming velocity is lower at night than during the day for a given set of flow conditions; this generally results in screen passage time decreasing as sweeping velocity increases over the full range of sweeping flows examined here, because screen passage velocity becomes more negative (i.e., fish move downstream more quickly). Longer screens increase screen passage time: for example, at a sweeping velocity of 0.4 ft/s during the night, a 7.9-cm juvenile would pass the screens of intakes 2 and 5 (each ~1,350 feet long) in ~97 minutes, compared to ~80 minutes for intake 3 (1,100 feet long) (Figure 5.4-1 and Figure 5.4-2). Juvenile salmonids migrating downstream close to shore may encounter several of the proposed intakes within a few hours, depending on travel time. Because of the lack of an established relationship between passage time, screen contact rate and injury or mortality, it is not possible to conclude with high certainty what the effects of the NDD may be on juvenile Chinook salmon or indeed on juvenile steelhead, which Swanson et al. (2004a) noted behaved similarly in the Fish Treadmill tests. This uncertainty would be addressed with monitoring and targeted studies examining impingement and passage time along the intakes. Swanson et al. (2004a) also found that at warmer temperatures (19°C), the larger fish had a greater tendency to move downstream with the current (negative rheotaxis), consistent with a behavioral shift to outmigration; this would result in considerably lower screen passage times.



Note: The total screen length for intakes 2 and 5 would be 1,350 feet each; intake 3's screen length would be 1,110 feet. Plot only includes mean responses and does not consider model uncertainty.

Figure 5.4-1. Estimated Screen Passage Time for Juvenile Chinook Salmon (4.4-cm Standard Length) Encountering Proposed NDD Fish Screens at Approach Velocity of 0.2 Feet per Second during the Day and Night.



Note: The total screen length for intakes 2 and 5 would be 1,350 feet each; intake 3's screen length would be 1,110 feet. Plot only includes mean responses and does not consider model uncertainty.

Figure 5.4-2. Estimated Screen Passage Time for Juvenile Chinook Salmon (7.9-cm Standard Length) Encountering Proposed NDD Fish Screens at Approach Velocity of 0.2 Feet per Second during the Day and Night.

5.4.1.3.1.1.1.3 Predation

Predation of juvenile salmonids at the NDD could occur if predatory fish aggregated along the screens, as has been observed at other long screens in the Central Valley (Vogel 2008b). The only study of predation along a long fish screen occurred at the Glenn Colusa Irrigation District's (GCID) Sacramento River pump station (Vogel 2008b). In that study, mean survival of tagged juvenile Chinook salmon along the fish screens (total length just under 1,300 feet) in 2007—this being the only year of the study in which flow-control blocks at the weir at the downstream end of the fish screen were removed, to reduce predatory fish concentration—was ~95%. However, the percentage of tagged juvenile Chinook salmon released at the upstream end of the fish screen that were recaptured at a downstream sampling location was similar or slightly greater than for fish released at the downstream end of the fish screen, when standardized for the distance that the fish had to travel to the recapture site. These data suggest that survival along the screen was at least similar to survival in the portion of the channel without the screen (i.e., screen survival was similar to baseline survival, if the latter is assumed to be represented by the channel downstream of the screen). However, test fish providing the estimate of survival in the channel downstream of the screen were released prior to the fish that were released at the upstream end of the fish screen, which could have confounded comparisons of relative survival between these groups if predatory fishes became partly satiated prior to the arrival of the fish released at the upstream end of the screen (thus making their survival relatively higher than otherwise would have occurred) (Vogel 2008b).

Although the GCID facility is closest in size to the proposed NDD and has received considerable study in terms of fish survival, the GCID facility and the proposed NDD screens are substantially different. The GCID facility is located along a relatively narrow oxbow channel (about 10 to 50 meters wide) in the middle Sacramento River near Hamilton City, while the north Delta intakes would be located on the much wider channel of the mainstem lower Sacramento River (about 150 to 180 meters wide). In addition, the fish tested at GCID were relatively small (mean length generally less than 70 mm; Vogel 2008b) in comparison to the sizes of salmonid that would occur near the NDD (e.g., winter-run Chinook salmon mean length generally would be greater than 70 mm; del Rosario et al. 2013), which could give different susceptibility to predation. Under the PA, there would be three intakes constituting the NDD, compared to only one for the GCID facility, so that the cumulative length of screen would be considerably greater for the PA. Therefore, there is uncertainty to what extent the results from the GCID studies may represent the situation at the NDD.

Analysis of potential predation of juvenile Chinook salmon using a bioenergetics approach (see the public draft BDCP's Appendix 5.F, *Biological Stressors on Covered Fish,* Section 5.F.3.2.1 [California Department of Water Resources 2013]) suggested that loss along the NDD[15] would be an order of magnitude lower than estimated at the GCID facility (e.g., for winter-run Chinook salmon the bioenergetics estimates were considerably less than 0.3%). These estimates are uncertain because of the various assumptions in the modeling and do not provide context for how such losses would compare to baseline losses without the NDD. Overall, there is potential for predation of juvenile salmonids along the NDD, which would constitute an adverse effect. Implementation of the localized reduction of predatory fishes at the NDD, if implemented, could reduce the potential for predation, although this measure is uncertain in its effectiveness and will be subject to adaptive management (see Appendix 3.H). Further discussion is provided in Section 5.5.2, *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities*. Studies in tidal channels in or near the Delta indicate that predator reduction can be effective, given sufficient effort. Sabal et al. (2016) found that survival of outmigrating juvenile Chinook salmon below Woodbridge Irrigation District Dam (in the tidal Mokelumne River upstream of the Delta) increased by 25-29% following striped bass removal, with the percentage change in survival being positively related to the number of striped bass removed. Cavallo et al. (2013) found that survival of juvenile Chinook salmon in the North Fork Mokelumne River within the Delta increased from < 80% to >99% following a first predator removal event, but decreased to pre-removal density following a second removal event, suggesting that a more sustained removal effort was necessary. Overall, this illustrates the potential benefits (though uncertain) to juvenile salmonid survival as a result of predator removal

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[15] Although the screen lengths analyzed were different to those proposed under the PA, the order of magnitude of the results would remain the same if modeling specific to the PA was undertaken.

efforts; however, uncertainty in the efficacy of localized reduction of predatory fishes at the NDD remains. Therefore, it is not clear that this measure will be effective in mitigating the potential adverse effect to juvenile salmonids from the NDD. Although it is uncertain that the measure would be effective, for purposes of this analysis, it is assumed that it would not be.

5.4.1.3.1.1.2 South Delta Exports

As described by NMFS (2009: 341-374), direct entrainment of juvenile winter-run Chinook salmon, spring-run Chinook salmon, and Central Valley steelhead includes a number of components contributing to loss. These include the following.

- SWP
    - Prescreen loss (from Clifton Court Forebay radial gates to primary louvers at the Skinner Fish Protection Facility): 75% loss
    - Louver efficiency: 25% loss
    - Collection, handling, trucking, and release: 2% loss
    - Post release: 10% loss
    - Total loss (combination of the above): 83.5%
- CVP
    - Prescreen loss (in front of trash racks and primary louvers): 15% loss
    - Louver efficiency: 53.2% loss
    - Collection, handling, trucking, and release: 2% loss
    - Post release: 10% loss
    - Total loss (combination of the above): 35.1%

The present analysis provides quantitative analyses of entrainment differences between NAA and PA, and a qualitative discussion of potential predation differences between NAA and PA. The above loss percentages are assumed not to differ between NAA and PA, so the differences are attributable to differences in export pumping. Clifton Court Forebay's configuration will change under the PA with the division into north and south cells (Section 3.2.5.1.2, *Clifton Court Forebay*), so that the potential active storage (12,050 acre feet; see page 14-8 in Appendix 3.B, *Conceptual Engineering Report, Volume 1*) for the proposed South Clifton Court Forebay would be somewhat less than the active storage under existing conditions (~14,700 acre feet, based on the difference in storage between maximum and minimum normal water surface elevations; see page 4-2 in Appendix 3.B, *Conceptual Engineering Report, Volume 1*). This could result in lower residence times for a given level of Banks pumping under the PA compared to NAA, which may result in less prescreen loss under the PA for a given level of Banks pumping. Gingras (1997: 16-17) found a significant negative relationship between export rate and prescreen loss for marked juvenile Chinook salmon in Clifton Court Forebay and reasoned that this presumably reflected the inverse relationship between export rate and residence time in the Forebay. Recent hydrodynamic studies have confirmed the inverse relationship between export pumping and transit time for passive particles across the Forebay (MacWilliams and Gross 2013), although specific relationships for juvenile salmonids are lacking. Given the lack of specific relationships between residence time and prescreen loss for juvenile salmonids, for this effects analysis it is assumed that there is no difference in prescreen loss between NAA and PA across Clifton Court Forebay attributable to Banks pumping and the reconfiguration of the Forebay under the PA.

Outside of Clifton Court Forebay, the other major difference in configuration of the SWP south Delta export facility under the PA will be the inclusion of a control structure in the Banks approach channel leading to the Skinner Fish Protective Facility. This control structure will consist of three channels, each with a radial gate[16]; all gates will either be fully closed (when export is occurring only from the NDD) or fully open (when export is occurring from only the south Delta export facilities or from both the NDD and south Delta). The change in configuration from a 250-foot-wide channel to a control structure with total width of around 170 feet consisting of three channels and dividing walls could alter the suitability of the approach channel habitat for predatory fishes. For example, if predatory fishes are able to exploit the hydrodynamics created by the concrete divisions between the channels, predation risk could increase under the PA. This risk cannot be quantified based on available information.

Following completion of PA construction and commencement of PA operations, studies will be undertaken as part of the Clifton Court Forebay Technical Team described in Section 3.2.5.1.3, Clifton Court Forebay Technical Team, to estimate the extent to which the reconfigured Clifton Court Forebay and associated changes to the south Delta export facilities change the prescreen loss of juvenile salmonids (i.e., from the Clifton Court Forebay radial gates to the primary louvers at the Skinner Fish Protective Facility) relative to the assumptions currently made for estimating loss and take per the NMFS (2009) BiOp (or the prevailing assumptions at the commencement of PA operations). These studies will consist of releases of tagged (acoustic or PIT) or otherwise marked juvenile salmonids, followed by recapture or detection in order to estimate survival in different parts of the salvage process, as has been done in previous studies (Gingras 1997; Clark et al. 2009). The results of these experiments will inform the need to change the loss multipliers used to estimate loss and take as a function of expanded salvage. Should the experiments indicate statistically significant differences between the PA loss multipliers and the prevailing multipliers used prior to the commencement of PA operations, and following regulatory agency approval, the new PA multipliers will from then on be applied to subsequent loss estimates that are used to estimate the level of incidental take in relation to the level of incidental take that has been authorized by NMFS/DFW for the PA in each water year. South Delta export pumping will be managed in real time, as currently occurs, in order to ensure

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[16] The drawings presented in the CER Volume 2 (dated April 1, 2015) that were included as Appendix 3.C of the working draft BA were incorrect in indicating a weir would be included in the control structure in the Banks approach channel. Such weirs would only be included in the water control structures in other parts of the new conveyance system, which would be in areas to which fish would not have access (other than the fish not successfully salvaged at the Skinner/Tracy facilities or screened by the NDD) and therefore would not affect losses as part of the salvage process.

that losses of listed juvenile salmonids remain below the authorized incidental take, which will have been set to a level that limits the potential for jeopardy for the species.

Construction activities in Clifton Court Forebay could interact with operations to affect the survival of juvenile salmonids, for example, by increasing the potential for prescreen loss, given that there is some evidence that anthropogenic noise can affect predation rates of fishes (Simpson et al. 2016). However, as noted in Section 5.2.5.2.1, *Salmonids*, the timing of in-water construction activities (June 1–November 30) would avoid the periods when juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead are most likely to be present in the south Delta. Thus, the interaction of operations with construction would be expected to affect only a limited portion of the juvenile salmonid populations, and any effect cannot be quantified because of the lack of specific information for how prescreen loss would differ as a result of construction noise, for example. It is also not possible to quantify the extent to which any equipment or structures left in the Forebay between in-water work periods (e.g., in winter/spring) would affect the prescreen loss of juvenile salmonids. It is possible that such equipment or structures could provide predator habitat and therefore increase predation risk.

5.4.1.3.1.1.2.1 Entrainment

5.4.1.3.1.1.2.1.1 Salvage-Density Method: Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, and Steelhead

The salvage-density method was used to assess differences in south Delta exports and resulting entrainment[17] during the periods of occurrence of juvenile salmonids in the Delta, based on historical salvage data. Details of the method, together with results by month and water year, are presented in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale,* Section 5D.1.1.2, *South Delta Exports*. Note that although this method provides an index of entrainment loss, it is most appropriately viewed comparatively, and functions primarily to illustrate south Delta export differences between scenarios. The method does not account for differences in salvage and entrainment loss that could occur because of other operational effects, e.g., changes in juvenile salmonid routing because of the NDD or the HOR gate.

The results of the salvage-density method showed that, based on modeled south Delta exports, mean entrainment loss at the south Delta export facilities would be lower under PA than NAA in all water year types for winter-run Chinook salmon, spring-run Chinook salmon, and steelhead (Table 5.4-5, Table 5.4-6, and Table 5.4-7). The differences between PA and NAA were greater in wetter water years, as a result of less south Delta export pumping facilitated by operation of the NDD. For winter-run Chinook salmon, the differences ranged from 16% less under PA at the SWP in critical years to 82% less under PA at the CVP in wet years (Table 5.4-5). For spring-run Chinook salmon, the differences ranged from 11% less under PA at the CVP in critical years to 92% less under PA at the CVP in wet years (Table 5.4-5). For steelhead, the differences ranged

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[17] As noted in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5D.1.1.2, *South Delta Exports*, there is uncertainty regarding the population-level significance of south Delta entrainment losses for salmonids (and green sturgeon). Regardless of the significance of this loss, this effects analysis provides relative differences between the NAA and PA.

from 1% less under PA at the SWP in critical years to 80% less under PA at the CVP in wet years (Table 5.4-5).

Table 5.4-5. Estimated Mean Entrainment Index (Number of Fish Lost, Based on Normalized Salvage Data) of Juvenile Winter-Run Chinook Salmon for NAA and PA Scenarios at the CVP/SWP Salvage Facilities, By Water Year Type

Water Year Type	State Water Project				Central Valley Project		
	NAA	PA	PA vs. NAA[1]		NAA	PA	PA vs. NAA[1]
Wet	10,629	3,531	-7,097 (-67%)		1,404	248	-1,156 (-82%)
Above Normal	5,995	3,073	-2,922 (-49%)		613	134	-479 (-78%)
Below Normal	5,655	3,434	-2,221 (-39%)		790	529	-261 (-33%)
Dry	3,327	2,775	-552 (-17%)		731	481	-250 (-34%)
Critical	917	772	-145 (-16%)		305	244	-62 (-20%)

Notes: [1] Negative values indicate lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

Table 5.4-6. Estimated Mean Entrainment Index (Number of Fish Lost, Based on Nonnormalized Salvage Data) of Juvenile Spring-Run Chinook Salmon for NAA and PA Scenarios at the CVP/SWP Salvage Facilities, By Water Year Type

Water Year Type	State Water Project				Central Valley Project		
	NAA	PA	PA vs. NAA[1]		NAA	PA	PA vs. NAA[1]
Wet	27,193	5,743	-21,449 (-79%)		13,600	1,125	-12,474 (-92%)
Above Normal	16,923	2,873	-14,049 (-83%)		5,176	1,035	-4,140 (-80%)
Below Normal	4,892	3,061	-1,831 (-37%)		853	642	-211 (-25%)
Dry	10,936	7,378	-3,557 (-33%)		2,271	1,655	-616 (-27%)
Critical	5,859	4,804	-1,055 (-18%)		1,991	1,777	-214 (-11%)

Notes: [1] Negative values indicate lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

Table 5.4-7. Estimated Mean Entrainment Index (Number of Fish Lost, Based on Nonnormalized Salvage Data) of Juvenile Steelhead for NAA and PA Scenarios at the CVP/SWP Salvage Facilities, By Water Year Type

Water Year Type	State Water Project				Central Valley Project		
	NAA	PA	PA vs. NAA[1]		NAA	PA	PA vs. NAA[1]
Wet	5,464	1,671	-3,792 (-69%)		1,045	212	-833 (-80%)
Above Normal	11,221	6,493	-4,729 (-42%)		1,834	585	-1,249 (-68%)
Below Normal	8,413	5,409	-3,004 (-36%)		2,337	1,595	-742 (-32%)
Dry	8,147	6,633	-1,513 (-19%)		1,625	1,057	-568 (-35%)
Critical	4,819	4,771	-48 (-1%)		838	597	-242 (-29%)

Notes: [1] Negative values indicate lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

The salvage-density method analysis was applied to steelhead and spring-run Chinook salmon without regard to the region of origin (i.e., Sacramento River vs. San Joaquin River basins) because this information is not known. It is not clear from these data to what extent the entrainment results could represent San Joaquin River basin steelhead and spring-run Chinook salmon. San Joaquin River basin steelhead and spring-run Chinook salmon may be more likely to enter the CVP export facility via the Delta Mendota Canal than enter Clifton Court Forebay because the CVP entrance is located on Old River upstream of the SWP intake at Clifton Court Forebay and therefore would be the first source of entrainment these fish would encounter, if migrating down Old River. Evidence for this hypothesis is provided by salvage data of coded-wire-tagged juvenile San Joaquin River spring-run Chinook salmon that were released in spring 2016 (Marcinkevage pers. comm.). A total of 165,000 spring-run juveniles were released on March 18 at Hills Ferry, with a total of 129 of these fish recorded in SWP and CVP salvage sampling between March 20 and April 6. Adjusting for the losses before salvage sampling (i.e., prescreen loss and louver efficiency; see 5.4.1.3.1.1.2 *South Delta Exports*) gives adjusted totals of 43 spring-run juveniles that otherwise would have been sampled at SWP and 304 spring-run juveniles that otherwise would have been sampled at CVP. During the period from March 20 to April 6, the total water exported was 56,341 acre feet by the SWP and 73,935 acre-feet by the CVP[18]. Thus, the salvage density of the released spring-run juveniles that were sampled, adjusted for losses, would be around 5.4 times greater for the CVP (0.00411 fish per acre-foot) compared to the SWP (0.00076 fish per acre-foot). Overall, this provides evidence that consideration of CVP exports is an appropriate indicator of the potential for entrainment differences between PA and NAA, as the density of San Joaquin River fish entrained at CVP is likely to be considerably greater than at SWP.

Results of differences in entrainment between the PA and NAA from the salvage density method are presented in Table 5.4-7 for each facility separately. The results indicate there is generally a greater difference between NAA and PA for the CVP than for the SWP. This suggests that entrainment of San Joaquin River basin steelhead could be proportionally less than for Sacramento River basin steelhead; this is particularly true when considering that these results do not account for the presence of the HOR gate, which would route many juvenile steelhead away from the south Delta export facilities. In contrast to steelhead, entrainment results for juvenile spring-run Chinook salmon based on the salvage-density method suggest that there would be less of a difference between PA and NAA at the CVP compared to the SWP in drier years (Table 5.4-6; although the differences were still appreciable), which may be somewhat indicative of results for spring-run Chinook salmon from the San Joaquin River basin; however, as with steelhead, these results do not account for the presence of the HOR gate, which would route away from the south Delta export facilities many juvenile spring-run Chinook salmon entering the Delta down the San Joaquin River.

5.4.1.3.1.1.2.1.2 Salvage Based on Zeug and Cavallo (2014): Winter-Run Chinook Salmon

As described previously, the salvage-density method is essentially a means of examining changes in south Delta exports weighted by historic salvage density to account for species timing between months; the method does not account for potential non-linear relationships between salvage (entrainment) and south Delta exports, nor does it account for other factors that may influence salvage, such as Delta channel flows that could influence the survival or migration routes that juvenile salmonids may take. Zeug and Cavallo (2014) recently demonstrated that

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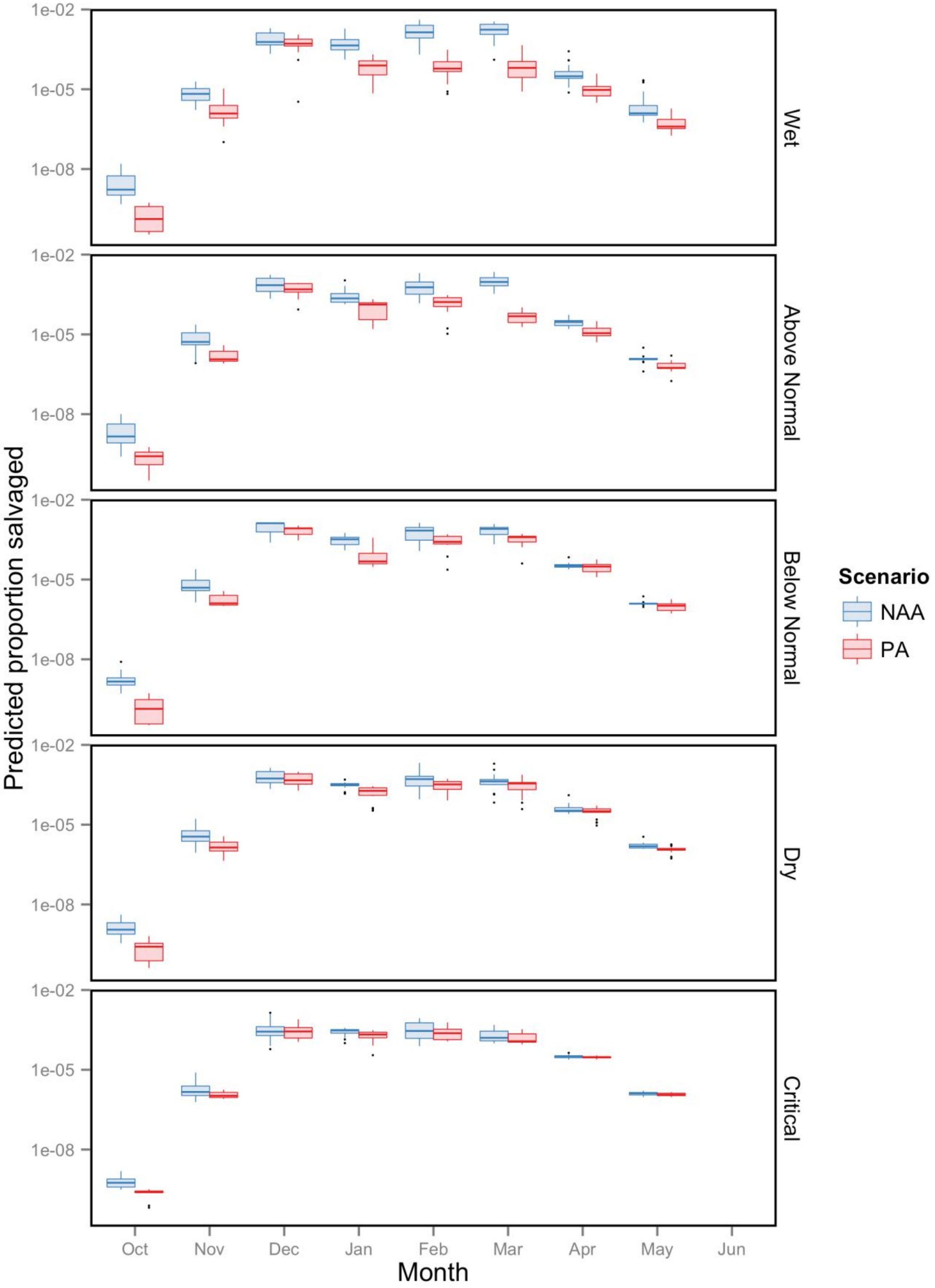
[18] http://www.dfg.ca.gov/delta/apps/salvage/, accessed July 3, 2016.

these other factors could be linked statistically to salvage of marked hatchery-reared juvenile Chinook salmon. The methods employed by Zeug and Cavallo (2014) were used to compare salvage between the NAA and PA scenarios (see methods description 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.D.1.1.2.2, *Salvage Based on Zeug and Cavallo (2014)*). Two operational factors influencing survival were included in the analysis. From the modeling, south Delta exports have a positive relationship with the probability of salvage and a positive relationship with count of fish salvaged, i.e., greater south Delta exports give a greater probability of salvage occurring, and more fish are salvaged when salvage occurs. Sacramento River flow downstream of the NDD has a positive relationship with the probability of zero salvage (possibly reflecting hydrodynamic influences in terms of lower probability of entering the interior Delta and therefore being salvaged) and a weak positive relationship with the count of fish that are salvaged (possibly reflecting the hydrodynamic influence of more flow giving better survival of the fish that do enter the interior Delta and are entrained by the export facilities, or more fish being cued to emigrate from the Delta). The analysis was conducted for winter-run Chinook salmon alone because marked spring-run Chinook salmon have only been salvaged in very low numbers and no studies of steelhead with marks specific to given release locations were available.

The analysis showed that in wet years salvage of juvenile winter-run Chinook salmon was predicted to be substantially higher under NAA relative to PA (Figure 5.4-3). These differences were particularly apparent in October and November (medians were 82-92% less under PA; although the proportion was very small in October, reflecting very low occurrence in this month; see Figure 5.D.42 in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*) and again from January through March (medians were 81–95% less under PA). In wet years, median salvage under PA ranged from 15% less than NAA in December to 92% less in October. In wetter years, more water is diverted from the NDD rather than the south Delta export facilities, reducing the chance that fish will be salvaged. A similar pattern of salvage was observed in above normal years, with median salvage under PA ranging from 31% less than NAA in December to 95% less than NAA in March. In below normal and dry years, considerably lower salvage under the PA was also evident in October, November, and January (80–94% lower median salvage under PA), but the differences were less in February–April (4–50% lower median salvage under PA) relative to wetter years (60–96% lower median salvage under PA). This may occur as exports shift from the north to the south delta and less water is exported. In critical years, differences in median salvage ranged from 1% higher under PA in December to 63% lower under PA in October.

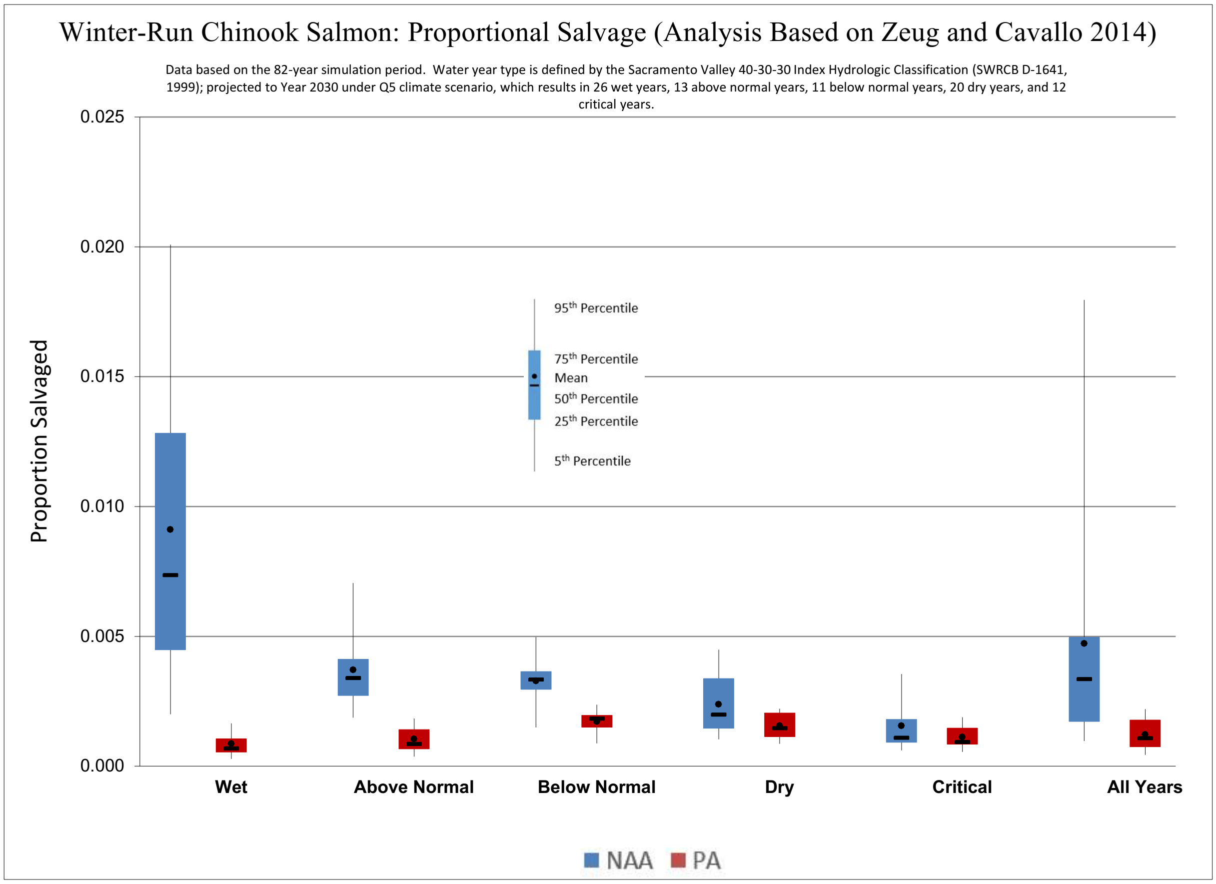
Annual estimates of proportional salvage for all 82 water years reflected the differences previously discussed for the monthly patterns: salvage was less under PA and the magnitude of the difference varied considerably between years (Figure 5.4-4 and Figure 5.4-5, Table 5.4-8), which again is related to the proportion of water diverted from the north delta. In wetter years when south Delta exports were low, less fish were estimated to be salvaged and the divergence in estimates between scenarios was greater.

There is considerable annual variability in the estimates of salvage. Non-parametric bootstrapping (i.e., generation of 500 annual salvage estimates for each scenario by randomly sampling from the original data, with replacement, and refitting the statistical model) revealed that the 95% confidence intervals for the NAA and PA scenarios overlapped in all years (Figure 5.4-6), partly as a result of extrapolation beyond the range of the data from which the model was developed. This illustrates that there is uncertainty in the magnitude of difference in salvage that may occur between NAA and PA, although the mean predictions were within the range of those observed in the data used to develop the relationships.



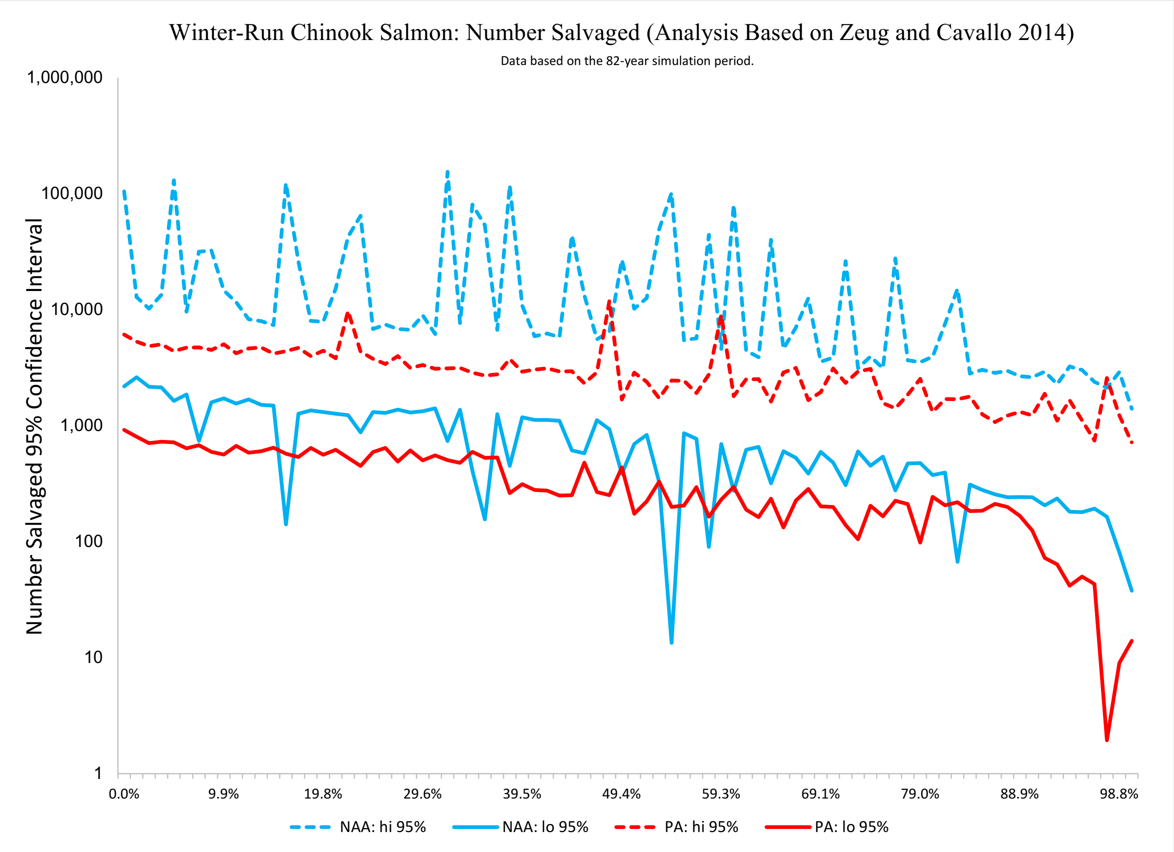
Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-3. Predicted Proportion of Annual Salvage of Juvenile Winter-Run Chinook Salmon in October-June, from the Analysis Based on Zeug and Cavallo (2014).



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-4. Box Plots of Annual Proportion of Juvenile Winter-Run Chinook Salmon Salvaged, Grouped by Water-Year Type, from the Analysis Based on Zeug and Cavallo (2014).

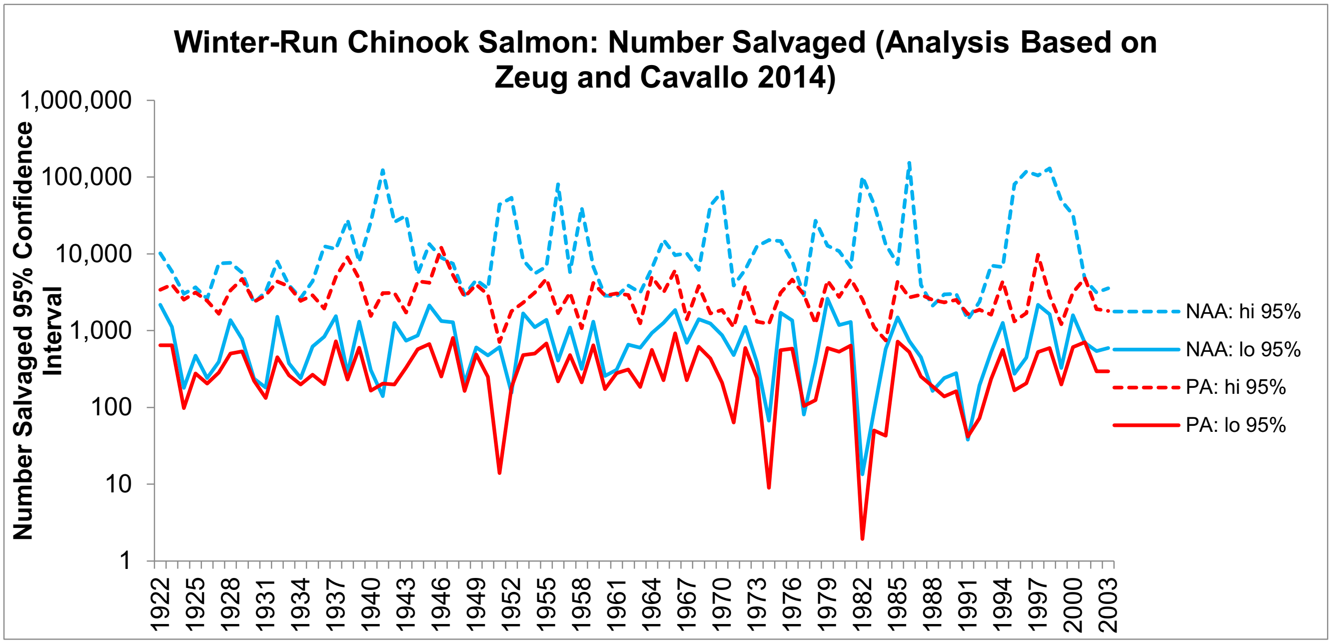


Note: Data are sorted by mean estimate, with only 95% confidence intervals shown. The plot is based on numbers of fish as opposed to proportions in order to avoid a negative logarithmic scale. All years assumed 1,000,000 fish were released.

Figure 5.4-5. Exceedance Plot of Annual Number of Juvenile Winter-Run Chinook Salmon Salvaged, from the Analysis Based on Zeug and Cavallo (2014).

Table 5.4-8. Mean Annual Proportion of Winter-Run Chinook Salmon Salvaged, By Water Year-Type, from the Analysis Based on Zeug and Cavallo (2014).

WY	Pulse protection flows		
	NAA	PA	PA vs. NAA
W	0.0091	0.0009	-0.0082 (-91%)
AN	0.0037	0.0010	-0.0027 (-72%)
BN	0.0033	0.0017	-0.0016 (-48%)
D	0.0024	0.0016	-0.0008 (-35%)
C	0.0016	0.0011	-0.0004 (-28%)



Note: The plot is based on numbers of fish as opposed to proportions in order to avoid a negative logarithmic scale. All years assumed 1,000,000 fish were released.

Figure 5.4-6. 95% Confidence Interval of Annual Number of Winter-Run Chinook Salmon Salvaged (From 1,000,000 Released), from the Analysis Based on Zeug and Cavallo (2014).

5.4.1.3.1.1.2.2 Predation

Appreciable losses of juvenile salmonids occurs because of predation in association with the south Delta export facilities (Gingras 1997; Clark et al. 2009). Less entrainment of juvenile salmonids, as estimated in the preceding sections with the salvage-density method and salvage estimates based on Zeug and Cavallo (2014), would be expected to result in less entrainment-related predation loss. To the extent that the localized reduction of predatory fishes, discussed further in Section 5.5.2, *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities*, reduces predator abundance in Clifton Court Forebay, predation risk to juvenile salmonids could be further reduced under the PA relative to the NAA. However, there is uncertainty in the efficacy of predatory fish reduction, given that previous efforts did not yield measurable changes in predator population size within the Forebay (Brown et al. 1996); for the purposes of this effects analysis it is not assumed to be effective.

5.4.1.3.1.1.3 Head of Old River Gate

The proposed HOR gate would have the potential to considerably increase the proportion of San Joaquin River basin-origin juvenile steelhead and spring-run Chinook salmon that remain in the main-stem San Joaquin River rather than entering Old River, as well as increasing their migration speed; these far-field effects of the HOR gate are discussed further in the analyses of channel velocity in Section 5.4.1.3.1.2.1.1, *Channel Velocity (DSM2-HYDRO),* and flow routing into channel junctions in Section 5.4.1.3.1.2.1.2.1, *Flow Routing into Channel Junctions*. This section focuses on potential near-field operational effects of the HOR gate, namely predation and blockage of upstream passage.

5.4.1.3.1.1.3.1 Predation

Studies of the rock barrier installed at the HOR in 2012 suggested the structure created eddies that could have resulted in enhanced predatory fish habitat and increased predation on juvenile salmonids (California Department of Water Resources 2015a); such adverse effects could also occur to juvenile steelhead and spring-run Chinook salmon from the San Joaquin River as a result of HOR gate operations when the gate is closed. Such effects arose because the barrier was not located immediately adjacent to the San Joaquin River, but slightly downstream in Old River. Given that the HOR gate could be operated in intermediate positions between fully closed and fully open (lying flat on the channel bed), there would be potential for the creation of hydrodynamic conditions providing opportunities for predators to ambush passing (possibly disoriented) juvenile steelhead and spring-run Chinook salmon. The extent to which any near-field predation at the HOR gate would offset the anticipated beneficial effects of a greater proportion of fish and flow remaining in the San Joaquin River is unclear, although the available data for fall-run juvenile Chinook salmon suggest that in general the presence of a barrier improves through-Delta survival (see review by Hankin et al. 2010 and comparison of 2012 [rock barrier] versus 2013 [no barrier] by Brandes and Buchanan 2016; however, see also comments by Anderson et al. [2012] with specific reference to the uncertainty in the effectiveness of the 2012 HOR rock barrier implementation in protecting out-migrating salmonid smolts).

5.4.1.3.1.1.3.2 Upstream Passage

Adult steelhead and spring-run Chinook salmon returning to natal tributaries in the San Joaquin River basin via Old River could experience migration delay when encountering the HOR gate during its October- June operational period since steelhead adults are present between December and February. The HOR gate would include a fish passage structure meeting NMFS and USFWS guidelines in order to allow passage of upstream migrating salmonids, including steelhead and Chinook salmon. The existing fall rock barrier includes a 30-foot-wide notch at elevation 2.3 feet NAVD, which is intended to allow passage of upstream-migrating salmonids. NMFS (2013a: 89) considered that this notch would result in minimal delay to upstream migrating steelhead, and presumably the same conclusion is reasonable for spring-run Chinook salmon. The fish passage structure for the PA's proposed gate also would be intended to minimize delay to upstream migrants, therefore minimizing the potential for adverse effects.

5.4.1.3.1.1.4 Delta Cross Channel

The principal effect of the DCC would be to influence the proportion of juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead entering the interior Delta, where survival is lower, during downstream migration from the Sacramento River basin. These effects are discussed further in Section 5.4.1.3.1.2.1.2, *Entry into Interior Delta*, in relation to far-field effects.

An additional potential effect of DCC operations is delayed migration of adult salmonids migrating upstream to the Sacramento River basin. NMFS (2009: 406) noted that adults destined for the Sacramento River basin may be blocked or delayed by the DCC gates if they have entered the Mokelumne River system and are downstream of the DCC gates. During the main period of winter-run and spring-run Chinook salmon upstream migration (winter/spring), there would be little to no difference in the number of days the gates would be open between NAA and PA (see Table 5.A.6-31 in Appendix 5.A, *CalSim II Modeling and Results*). The overlap of steelhead migration with the fall months means that they could encounter a greater frequency of the DCC gates being open under the PA because of several operational criteria[19] described in Section 5.A.5.1.5.2 of Appendix 5.A. The CalSim modeling showed that in September of ~20% of years, sufficient water was exported by the NDD that the 25,000-cfs threshold for closure of the DCC is not exceeded, whereas it is exceeded under the NAA in the same years and results in closure of the DCC more than under PA (see Table 5.A.6-31 in Appendix 5.A). Additionally, in October-November, reservoir releases later in the year under the NAA triggered the 7,500-cfs Sacramento River at Wilkins Slough threshold assumed to coincide with juvenile salmon migration into the Delta, which resulted in a greater number of days with DCC closed under NAA. Last, the DCC may also have been open more under the PA to maintain water quality conditions per D-1641 (Rock Slough salinity standard). These factors could result in a greater proportion of steelhead that are destined for the Sacramento River basin entering the central Delta and moving up the Mokelumne River system, therefore delaying migration somewhat, particularly if the DCC gates are subsequently closed.

The potential for delay of adult salmonids entering the central Delta and moving up the Mokelumne River system may be dependent on the duration of DCC openings. Assessing the

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[19] The same operational criteria are assumed for the NAA and PA.

duration of DCC openings in each month for the NAA and PA and the potential effects on upstream-migrating adult salmonids is complicated by overlaps of closure periods across months (e.g., DCC opening in one month, followed by closure in the subsequent month). The month of November perhaps illustrates best how the duration of DCC opening could differ between NAA and PA. Openings commencing in November occurred at a similar frequency under NAA (n = 25 openings over the 82-year CalSim period) and PA (n = 22 openings). Openings tended to be longer under the PA (mean = 14.0 days, median = 8 days, mode = 20 days) than the NAA (mean = 8.6 days, median = 6 days, mode = 3 days) (Figure 5.4-7). NMFS (2009: 406) suggested that adult salmonids that are migrating to the Sacramento River basin have the ability to drop back and swim around the DCC gates during intermittent openings to meet water quality standards or tidal operations. The lower frequency of intermittent openings under the PA for the example month of November suggests that there could be greater potential for delay to upstream-migrating adult steelhead returning to the Sacramento River basin than there would be under the NAA. A greater frequency of multi-day openings therefore could have some adverse effects on adult steelhead attempting to reach the Sacramento River through the DCC, by decreasing the attraction flows from the Sacramento River and delaying migration if the DCC gates were subsequently closed. The proportion of steelhead that could be affected by this mechanism is unknown, with the only data from which to make inferences regarding the proportion of upstream-migrating adult salmonids that could take the DCC pathway via the central Delta/Mokelumne River being for fall-run Chinook salmon. Stein and Cuetara (2004) found that of 66 adult fall-run Chinook salmon acoustically tagged and released in Suisun Marsh, 47 of these fish left the Delta in the Sacramento River at Hood. Of these 47 fish, 10 (21%) traveled via the interior Delta, including the DCC, and movement out of the DCC was always when a strong positive flow into the DCC was occurring. During Stein and Cuetara's (2004) study (October-November 2003), the DCC was open 100% of the time. This indicates that some portion of upstream-migrating adult salmonids, including steelhead, could be delayed by a greater frequency of multi-day opening and subsequent closure under the PA in some years. Further study would be required to ascertain the extent to which adult steelhead could find an alternative pathway through the Delta, or how long they may hold below the gates until they are reopened.

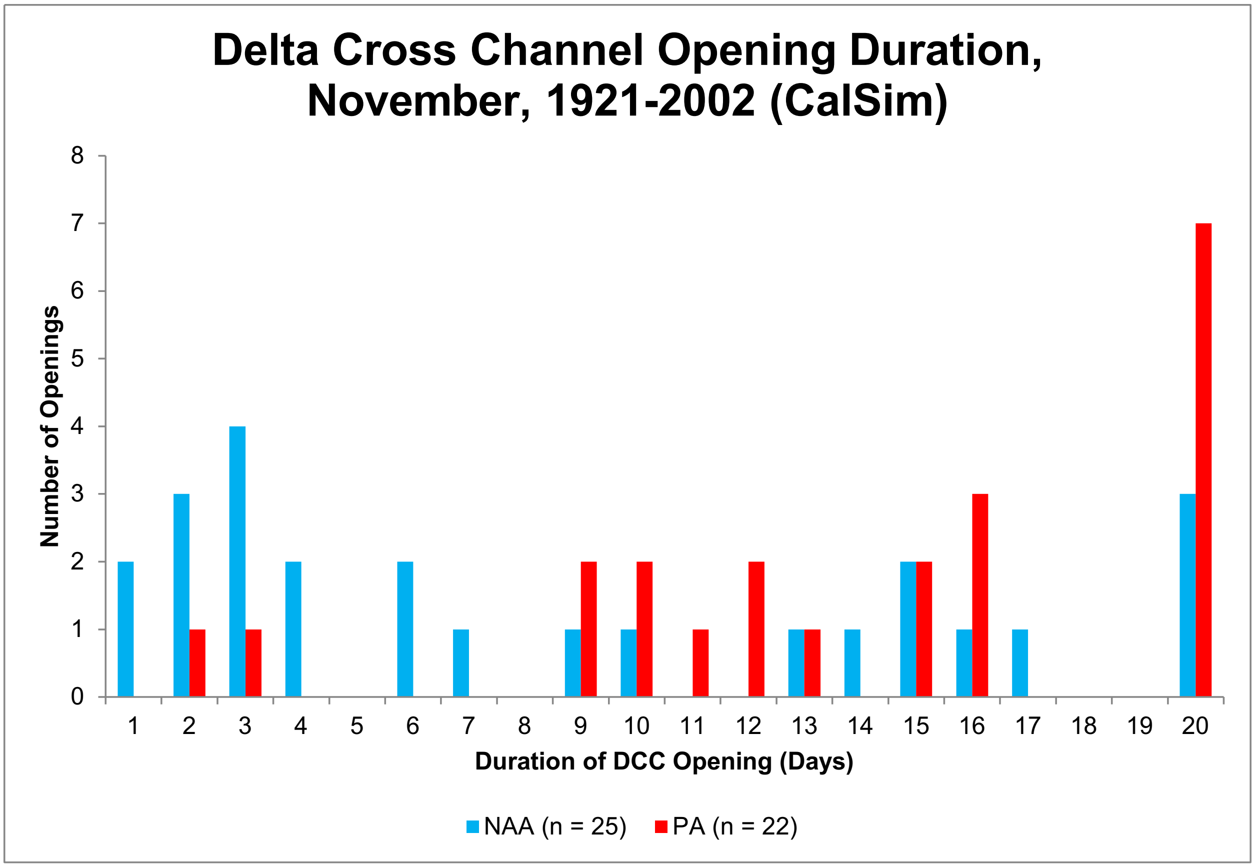

Figure 5.4-7. Duration of Delta Cross Channel Openings that Began in November, from CalSim Modeling of 1921-2002.

5.4.1.3.1.1.5 Suisun Marsh Facilities

5.4.1.3.1.1.5.1 Suisun Marsh Salinity Control Gates

The principal potential effect of the Suisun Marsh Salinity Control Gates (SMSCG) being closed up to 20 days per year from October through May is delay of upstream-migrating adult winter-run Chinook salmon, spring-run Chinook salmon, and steelhead that have entered Montezuma Slough from its westward end and are seeking to exit the slough at its eastward end. Vincik (2013) found some evidence that opening of the boat lock improved passage rates of acoustically tagged adult Chinook salmon, and that even with the gates up, ~30-40% of fish returned downstream. Adult salmonids that do not continue upstream past the SMSCG are expected to return downstream by backtracking through Montezuma Slough to Suisun Bay, and they likely find the alternative upstream route to their natal Central Valley streams through Suisun and Honker Bays (National Marine Fisheries Service 2009: 435). NMFS (2009: 436) noted that the effect of the SMSCG when closed are uncertain on adult salmonids, but suggested that if the ultimate destination of adult spring-run Chinook salmon and steelhead in natal tributaries is reliant on access provided by short-duration, high-streamflow events, delay in the Delta could affect reproductive viability. This would be less of an issue for winter-run Chinook salmon, which when in the Delta are typically several weeks or months away from spawning and use the mainstem Sacramento River, to which access would not be dependent on short-duration streamflow events. Results of the DSM2 modeling indicate that the flow through the SMSCG would be very similar under NAA and PA (see Table 5.B.5-29 in Appendix 5.B, *DSM2 Methods and Results*), indicating that operation of the gates would be similar under NAA and PA.

As described by NMFS (2009: 436), downstream migrating juvenile salmonids may also be affected by the operation of the SMSCG, given the overlap of operations with the occurrence of these species. NMFS (2009: 436; citations omitted) noted:

> As juvenile salmon and steelhead emigrate downstream, some fish will pass through Montezuma Slough as they travel towards the ocean. If the SMSCG are in operation, the gates will open and close twice each day with the tides. On the ebb tide, the gates are open and fish will pass downstream into Montezuma Slough without restriction. On the flood tide, the gates are closed and freshwater flow and the passage of juvenile fish will be restricted. Most juvenile listed salmonids in the western Delta entering San Francisco Bay are expected to be actively emigrating smolts. Smolts are likely taking advantage of the ebb tide to pass downstream, and, thus, the operation of the SMSCG is not expected to significantly impede their downstream movement in the estuary.

In addition to the lack of impediments to passage, NMFS (2009: 437; citations omitted) noted the following with respect to near-field predation effects:

> Salmonid smolt predation by striped bass and pikeminnow could be exacerbated by operation of the SMSCG. These predatory fish are known to congregate in areas where prey species can be easily ambushed. Pikeminnow are not typically major predators of juvenile salmonids, but both pikeminnow and striped bass are opportunistic predators that will take advantage of localized, unnatural circumstances. The SMSCG provides an enhanced opportunity for predation because fish passage is blocked or restricted when the structure is operating. However, DWR proposes to limit the operation of the SMSCG to only periods required for compliance with salinity control standards, and this operational frequency is expected to be 10-20 days per year. Therefore, the SMSCG will not provide the stable environment which favors the establishment of a local predatory fish population and the facility is not expected to support conditions for an unusually large population of striped bass and pikeminnow.

Operational criteria for the SMSCG would not change under the PA relative to NAA, and, as previously shown, operations modeling suggested that there would be little difference between NAA and PA in terms of SMSCG opening. Therefore, the potential for adverse near-field effects on downstream-migrating juvenile salmonids would be limited.

5.4.1.3.1.1.5.2 Roaring River Distribution System

As described by NMFS (2009: 437-438), the Roaring River Distribution System (RRDS)'s water intake (eight 60-inch-diameter culverts) is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain screen approach velocity of 0.2 ft/s (for Delta Smelt protection), so that juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead would be excluded from entrainment. Therefore effects from the RRDS would be discountable.

5.4.1.3.1.1.5.3 Morrow Island Distribution System

NMFS (2009: 438) considered it unlikely that juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead would be entrained by the three unscreened 48-inch culverts that form the Morrow Island Distribution System (MIDS) water intake, as a result of their larger size and better swimming ability relative to the size of fall-run Chinook salmon observed to have been entrained (<45 mm), and also because the location of the MIDS intake on Goodyear Slough is not on a migratory corridor for listed juvenile salmonids. Therefore effects from the MIDS would be discountable.

5.4.1.3.1.1.5.4 Goodyear Slough Outfall

NMFS (2009: 438) concluded that it would be unlikely that winter-run Chinook salmon, spring-run Chinook salmon, and steelhead would encounter or be negatively affected by the Goodyear Slough outfall given its location and design, which is intended to improve water circulation in Suisun Marsh and therefore was felt by NMFS (2009: 438) to likely be of benefit to juvenile salmonids by improving water quality and increasing foraging opportunities.

5.4.1.3.1.1.6 North Bay Aqueduct

Pumping rates at the North Bay Aqueduct Barker Slough Intake generally would be similar under the NAA and PA (see Table 5.B.5-35 in Appendix 5.B, *DSM2 Methods and Results*). Regardless of differences in the rate of pumping and any resulting differences in exposure to the intake under NAA and PA, the basic conclusions from NMFS (2009: 417) apply:

> [The] screens, which were designed to protect juvenile salmonids per NMFS criteria, should prevent entrainment and greatly minimize any impingement of fish against the screen itself. Furthermore, the location of the pumping plant on Barker Slough is substantially removed from the expected migrational corridors utilized by emigrating Chinook salmon and steelhead smolts in the North Delta system.

Therefore, there would be expected to be a minimal adverse effect from the North Bay Aqueduct intake on juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead from the Sacramento River basin.

5.4.1.3.1.1.7 Other Facilities

5.4.1.3.1.1.7.1 Contra Costa Canal Rock Slough Intake

The 1.75-mm-opening, 0.2 ft/s-approach-velocity fish screen installed at the Rock Slough intake is intended to prevent entrainment of listed fish, including juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead, into the Contra Costa Canal. However, the 4 mechanical rakes making up the screen cleaning system are unable to handle the large amount of aquatic vegetation that ends up on the fish screen (National Marine Fisheries Service 2015a: 2). This has resulted in a number of operational issues that have resulted in problems such as capture of adult salmon by rake heads (Seedall 2015) and operation of the fish screen only on ebb tides (National Marine Fisheries Service 2015b).This has led Reclamation to test alternative technology (a prototype rake) to improve vegetation removal, an action that NMFS (2015a: 4) concluded would improve fish protection (i.e., screen efficiency) by minimizing the chance a listed fish would be entrained or impinged on the fish screen. In addition, mechanical removal of aquatic weeds within Rock Slough in 2015 to facilitate testing of the new rake design was expected by NMFS (2015b: 4) to improve screen efficiency, reduce predation of juvenile salmonids by vegetation-associated predatory fishes, and reduce adult salmonid mortality during screen maintenance. As noted by NMFS (2015a: 4), Rock Slough is off the main migratory routes through the Delta for listed fish species, however, due to tidal action, salmon and steelhead occasionally stray into Rock Slough. Modeled pumping suggested that diversions under the PA generally would be similar to NAA, with the exception of April and May, when diversions were modeled to be greater under the PA (see Table 5.B.5-36 in Appendix 5.B, *DSM2 Methods and Results*). The overall diversions for the Rock Slough intake and the other CCWD intakes on Old River and Middle River do not differ greatly between NAA and PA, suggesting that Rock Slough may have been favored in the modeling of PA for operational reasons, e.g., Old and Middle River flow criteria, for example. Greater use of the Rock Slough intake would be likely to increase take of juvenile salmonids under the PA compared to NAA. However, resolution of the aforementioned issues regarding screen effectiveness would be expected to minimize the potential for any adverse effects.

5.4.1.3.1.1.7.2 Clifton Court Forebay Aquatic Weed Control Program

The application of copper-based herbicides in Clifton Court Forebay is intended to reduce the standing crop of invasive aquatic weeds, among which the dominant species is *Egeria densa*. As reviewed by NMFS (2009: 388-390), aquatic weed control with copper-based herbicides to treat *Egeria* and other aquatic weeds in Clifton Court Forebay has the potential to result in a variety of negative physiological effects on juvenile salmonids, ranging from sublethal effects such as diminished olfactory sensitivity (e.g., reduced ability to imprint on natal streams or to avoid chemical contaminants) to lethal effects. Winter-run Chinook salmon, spring-run Chinook salmon, and steelhead would be expected to be minimally exposed to such effects because their period of occurrence within Clifton Court Forebay is entirely or nearly entirely before the July/August timeframe for herbicide treatment. Entrainment of juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead into Clifton Court Forebay would be expected to be less under the PA than NAA in July-August (see Tables 5.D-21, 5.D-22, 5.D-23, 5.D.24, and 5.D-25 in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, for juvenile steelhead, for example), which would reduce the exposure of these species to any adverse effects of herbicide treatment compared to the situation under the NAA (although exposure would be expected to be minimal under both the NAA and PA scenarios).

Mechanical removal of aquatic weeds in Clifton Court Forebay would occur on an as needed basis and therefore could coincide with occurrence of juvenile winter-run Chinook salmon, spring-run Chinook salmon, and steelhead. In assessing the potential for adverse effects of the 2013-2017 Water Hyacinth Control Program in the Delta, NMFS (2013b: 11) concluded that mechanical removal could have negative effects to listed species but that these would be discountable because of several factors, including that mechanical removal would be limited to dense water hyacinth mats where listed salmonids are not likely to be present. Presumably within Clifton Court Forebay there would be greater potential for juvenile salmonids to encounter mechanical removal of water hyacinth, given that hyacinth and fish may follow similar pathways across the Forebay toward the intake channel and the trash racks. However, any potential adverse effects from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) would potentially be offset by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency at the Skinner Fish Delta Fish Protective Facility because of reduced smothering by weeds.

5.4.1.3.1.2 Far-Field Effects

5.4.1.3.1.2.1 Indirect Mortality Within the Delta

5.4.1.3.1.2.1.1 Channel Velocity (DSM2-HYDRO)

Delta channel flows have considerable importance for downstream migrating juvenile salmonids, as shown by studies in which through-Delta survival of Chinook salmon smolts positively correlated with flow (Newman 2003; Perry 2010) although one recent study by Zeug and Cavallo (2013) did not find evidence for effects of inflow on the probability of recovery of coded-wire-tagged Chinook salmon in ocean fisheries. Flow-related survival, in terms of the influence of downstream river (net) flow, may be more important in areas with largely unidirectional downstream flow and lesser tidal influence, as opposed to strong tidal influence, because tidal influence progressively becomes much greater with movement downstream. The Delta Passage Model, for example, does not include a net flow-survival relationship in the Sacramento River below Rio Vista, because such a relationship is not supported by existing data (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale,* Section 5.D.1.2.2, *Delta Passage Model*). Further evidence of possible greater importance of flow in riverine reaches (as opposed to tidal reaches) comes from the recent study of Michel et al. (2015), who found that survival of acoustically tagged juvenile late fall-run Chinook salmon from the upper Sacramento River to the Golden Gate Bridge was greatest in 2011, the highest flow year, and that survival in the other years (2007-2010) was lower and did not differ greatly; the overall pattern was driven by in-river (upstream of Delta) survival being considerably greater in 2011 than the other years, whereas through-Delta survival was similar in all five years.

The PA has the potential to both adversely and beneficially change channel flows in the Delta, through changes in north and south Delta export patterns in relation to the NAA. Although north Delta exports would reduce Sacramento River flows downstream of the NDD, this would allow greater south and central Delta channel flows because of less south Delta exports.

As described 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.D.1.2.1.1.1, *Velocity*, velocity generally is a superior variable than flow for examining potential effects on fish because its effects do not vary with channel size and velocity has a direct relationship with bioenergetics. However, for the present analysis, the summary is based only on velocity, without linkage to biological outcomes such as sustained fish swimming speed, and represents a somewhat new methodology in terms of assessing potential differences, having only recently been applied in Reclamation/DWR’s Biological Review for Endangered Species Act Compliance with the WY 2015 Drought Contingency Plan April through September Project

Description[20]. In addition, the behavior of juvenile salmonids, particularly with respect to selective tidal-stream transport (Delaney et al. 2014) means that simple differences in velocity may not translate into biological outcomes between scenarios and therefore indicates that there is uncertainty as to the significance of the velocity-based results to listed salmonids beyond general trends in differences. A comparison of hydrodynamic conditions in important Delta channels for the NAA and PA scenarios was undertaken based on 15-minute DSM2-HYDRO velocity outputs. Three velocity metrics were assessed: magnitude of channel velocity; magnitude of negative velocity; and proportion of time in each day that velocity was negative. Lower overall velocity, greater negative velocity, and a greater proportion of negative velocity are all indicators of potential adverse effects to juvenile salmonids, e.g., by delaying migration or causing advection into migration pathways with lower survival. As previously noted, the lack of an explicit biological outcome in the modeling means that there is some uncertainty in the biological significance of the results; other analyses used herein to assess effects, such as the Delta Passage Model and the analysis based on Perry (2010), provide more explicit context as to biological significance because differences in flow are converted to potential differences in survival. Note that the summary of velocity differences between NAA and PA does not account for real-time operations that would be done in order to limit potential operational effects by assessing flow conditions in the context of fish presence, e.g., by using monitoring data from at or upstream of the Delta periphery (e.g., Knights Landing on the Sacramento River or Mossdale on the San Joaquin River).

A comprehensive description of the results is presented 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.D.1.2.1.2, *Results*. In this section, the detailed information presented with text and graphs in Appendix 5.D is summarized in color-coded tables, which highlight differences in medians of 5% or greater between PA and NAA. These differences are plotted and described across the full range of variability of the data in Appendix 5.D.

With respect to overall velocity, operational differences between NAA and PA led to differences in channel velocity. Within the south Delta and San Joaquin River, the changes would be positive for migrating juvenile salmonids because channel velocity was generally greater under the PA (Table 5.4-9). In the San Joaquin River, this was caused by the closure of the HOR gate (assumed in the modeling to be open during days in October prior to the D-1641 San Joaquin River pulse, 100% closed during the pulse, 50% closed from January–June 15, and 100% open during the remaining months), and median channel 21 velocity downstream of the HOR was around 10–50% greater (0.02–0.08 ft/s greater). In Old River downstream of the south Delta export facilities, the differences were related to less south Delta exports; however, in April and May it was also apparent that in drier years median velocity was less positive under PA than NAA. Although the PA criteria are consistent with the OMR flows and San Joaquin I/E ratio requirements in the current BiOps, and south Delta export pumping is almost always lower (Appendix 5.A, *CALSIM Methods and Results*, Figures 5.A.6-27-1 to 5.A.6-27-19 and Table 5.A.6-27), in April and May the assumption of the HOR gate being 50% closed, combined with

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[20] Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/2015/biorev2_aprsep.pdf

differing modeling assumptions for south Delta exports[21], results in Old River channel velocity that was slightly lower under PA than NAA (although both had positive median velocity). Channel velocity in Old River upstream of the south Delta export facilities was less positive under the PA than NAA, reflecting less south Delta exports under the PA (i.e., the export facilities exert some hydrodynamic influence by increasing velocity toward them) and the HOR gate, which blocks flow from entering 50% of the time during January–June 15.

In the north Delta, less flow in the Sacramento River downstream of the NDD (channel 418) under the PA led to lower median channel velocity under the PA relative to NAA (Table 5.4-9). Reflecting the fact that greater diversion would occur in wetter years, the difference in median velocity for channel 418 ranged from 10–24% less under PA in wet years to 4–11% less in critical years, which equated to absolute differences of 0.23–0.57 ft/s in wet years to 0.04–0.15 ft/s in critical years. Sacramento River channels farther downstream (421 and 423, upstream and downstream of Georgiana Slough) had similar patterns of difference, but with lower magnitude of change, reflecting greater tidal influence; this was also evident in Sutter Slough (channel 379) and Steamboat Slough (channel 383) (Table 5.4-9), with the latter being farther downstream than the former.

Considering only negative velocity estimates, under the PA the median negative velocity in the San Joaquin River downstream of Old River was greater (closer to zero) than under NAA, with the relative difference decreasing as water years became drier (Table 5.4-10); there was little difference farther downstream near the confluence with the Mokelumne River, reflecting greater tidal influence. Negative velocity estimates in Old River downstream of the south Delta export facilities under the PA were either less than or similar to (defined as <5% difference in the medians) those under NAA, whereas in Old River upstream of the facilities, the negative velocities were greater (again reflecting less south Delta exports and the influence of the HOR gate, both of which would increase the influence of flood tides in this channel). In the north Delta, the estimates of negative velocity must be interpreted with caution because in many cases negative velocity occurred for only a very small proportion of time (particularly in the more upstream channels such as Sutter Slough and the Sacramento River downstream of the NDD and upstream of Georgiana Slough; see Table 5.4-11). For the situations where an appreciable proportion of velocity estimates were negative under both scenarios, (e.g., Steamboat Slough and the Sacramento River downstream of Georgiana Slough), median negative velocity under PA was similar to or more negative than median negative velocity under NAA. This is consistent with less Sacramento River flow because of the NDD, increasing the flood tide influence on velocity. The absolute differences in median negative velocity were not large, however; for example, in the Sacramento River downstream of Georgiana Slough, differences in the periods during which there was a greater proportion of negative velocity (typically drier years) generally were much less than 0.1 ft/s (Table 5.4-10).

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[21] To some extent the results reflect the fact that there were differences in the CalSim modeling between the San Luis rule curves assumed for the NAA and PA: the NAA was more conservative in terms of being well below criteria for April-May San Luis reservoir filling, whereas the PA assumed a different curve and was much closer to criteria in some instances. Additional discussion of the rule curve differences is provided in Appendix 5.A, *CALSIM Methods and Results*, Section 5.A.4.4.

The median daily proportion of negative velocity again illustrated the effect of the HOR gate in the San Joaquin River downstream of HOR, where the proportion under the PA generally was less than under NAA, although farther downstream near the confluence with the Mokelumne River the tidal influence resulted in little to no difference between PA and NAA (Table 5.4-11). The daily proportion of negative velocity in Old River downstream of the south Delta export facilities under PA was similar to or less than NAA, whereas upstream of the facilities, the greater tidal influence caused by the HOR gate and less south Delta exports led to an greater proportion of time with negative velocity. In the north Delta, as previously noted in the analysis of negative velocity, the farther upstream channels had little to no negative velocity much of the time (e.g., Sutter Slough and the Sacramento River downstream of the NDD) (Table 5.4-11). Of concern from the perspective of salmonids migrating down the Sacramento River was greater frequency of negative velocity in the Sacramento River downstream of Georgiana Slough under the PA relative to the NAA, with differences between medians ranging from little difference (<5%) in a number of water-year types/months to >110% more (0.09 in absolute difference) in March of below normal years.

Overall, the results of the analysis of channel velocity suggest the potential for adverse effects to migrating juvenile winter-run and spring-run Chinook salmon and juvenile steelhead migrating downstream through the north Delta from the Sacramento River basin caused by lower overall velocity, greater negative velocity, and a greater proportion of time with negative velocity, which may delay migration and result in greater repeated exposure to entry into migration routes with lower survival, particularly because of entry into Georgiana Slough (see also discussion of flow routing into channel junctions). Juvenile steelhead and spring-run Chinook salmon emigrating from the San Joaquin River basin would potentially benefit from the HOR gate, which would increase overall velocity and reduce negative velocity in the San Joaquin River, as well as reducing the daily proportion of negative velocity; these effects would be greatest farther upstream. Salmonids from both the Sacramento and San Joaquin River basins generally would potentially benefit from interior Delta channel velocity (e.g., Old River downstream of the south Delta export facilities) that would be somewhat more positive and less frequently negative. As previously noted, the summary of Delta hydrodynamic conditions based on DSM2 does not account for the results of coordinated monitoring and research that will be done under the Adaptive Management Program and real-time operations that would be done in order to limit potential operational effects to avoid jeopardy while maximizing water supplies, by assessing flow conditions in the context of fish presence, e.g., by using monitoring data from at or upstream of the Delta periphery (e.g., Knights Landing on the Sacramento River or Mossdale on the San Joaquin River).

Table 5.4-9. Median 15-minute Velocity in Important Delta Channels, from DSM2-HYDRO Modeling, with Green Shading Indicating PA is ≥ 5% More than NAA and Red Shading Indicating PA is ≥ 5% Less than NAA.

DSM2 Channel	Location	Water Year Type	December			January			February			March			April			May			June		
			NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
21	San Joaquin River downstream of HOR	W	0.263	0.264	0.001 (0%)	0.378	0.433	0.054 (14%)	0.473	0.533	0.060 (13%)	0.482	0.548	0.066 (14%)	0.428	0.493	0.065 (15%)	0.407	0.462	0.055 (13%)	0.330	0.355	0.025 (8%)
		AN	0.182	0.185	0.003 (2%)	0.239	0.295	0.056 (23%)	0.308	0.371	0.064 (21%)	0.295	0.368	0.073 (25%)	0.271	0.351	0.081 (30%)	0.254	0.331	0.078 (31%)	0.152	0.196	0.045 (30%)
		BN	0.115	0.119	0.004 (4%)	0.131	0.202	0.071 (54%)	0.265	0.318	0.053 (20%)	0.169	0.251	0.082 (49%)	0.199	0.286	0.087 (44%)	0.166	0.245	0.079 (47%)	0.097	0.118	0.022 (22%)
		D	0.087	0.089	0.002 (3%)	0.112	0.171	0.059 (52%)	0.167	0.223	0.057 (34%)	0.172	0.228	0.056 (32%)	0.167	0.234	0.067 (40%)	0.155	0.217	0.061 (39%)	0.090	0.110	0.020 (22%)
		C	0.085	0.086	0.001 (1%)	0.087	0.128	0.041 (47%)	0.120	0.167	0.048 (40%)	0.104	0.142	0.038 (37%)	0.099	0.134	0.035 (35%)	0.092	0.128	0.035 (38%)	0.076	0.083	0.008 (11%)
45	San Joaquin River near the confluence with the Mokelumne River	W	0.240	0.251	0.011 (4%)	0.432	0.488	0.056 (13%)	0.471	0.554	0.083 (18%)	0.452	0.550	0.098 (22%)	0.439	0.474	0.034 (8%)	0.394	0.430	0.036 (9%)	0.232	0.293	0.061 (27%)
		AN	0.140	0.155	0.015 (11%)	0.269	0.300	0.031 (11%)	0.334	0.368	0.034 (10%)	0.293	0.385	0.092 (31%)	0.298	0.324	0.026 (9%)	0.247	0.270	0.022 (9%)	0.142	0.171	0.030 (21%)
		BN	0.061	0.081	0.020 (34%)	0.131	0.191	0.060 (45%)	0.237	0.260	0.023 (10%)	0.168	0.197	0.029 (17%)	0.213	0.222	0.009 (4%)	0.172	0.186	0.014 (8%)	0.130	0.139	0.008 (6%)
		D	0.068	0.076	0.008 (11%)	0.118	0.149	0.031 (27%)	0.184	0.198	0.013 (7%)	0.192	0.203	0.011 (6%)	0.195	0.208	0.014 (7%)	0.158	0.172	0.014 (9%)	0.134	0.143	0.010 (7%)
		C	0.085	0.087	0.002 (2%)	0.092	0.111	0.020 (21%)	0.148	0.150	0.002 (1%)	0.152	0.161	0.010 (6%)	0.144	0.148	0.004 (3%)	0.122	0.126	0.004 (3%)	0.124	0.124	0.000 (0%)
94	Old River downstream of the south Delta export facilities	W	-0.250	-0.175	0.075 (30%)	0.004	0.227	0.224 (5831%)	0.036	0.448	0.412 (1138%)	0.052	0.505	0.454 (877%)	0.350	0.486	0.136 (39%)	0.296	0.453	0.157 (53%)	-0.110	0.170	0.279 (255%)
		AN	-0.358	-0.272	0.087 (24%)	-0.121	0.008	0.129 (107%)	-0.062	0.087	0.149 (240%)	-0.146	0.265	0.411 (282%)	0.189	0.230	0.041 (22%)	0.164	0.197	0.032 (20%)	-0.181	-0.061	0.120 (66%)
		BN	-0.446	-0.363	0.083 (19%)	-0.200	0.003	0.203 (101%)	-0.108	-0.051	0.057 (53%)	-0.171	-0.100	0.071 (42%)	0.109	0.061	-0.048 (-44%)	0.088	0.061	-0.027 (-30%)	-0.131	-0.077	0.054 (41%)
		D	-0.368	-0.321	0.046 (13%)	-0.213	-0.134	0.079 (37%)	-0.133	-0.086	0.047 (35%)	-0.097	-0.074	0.024 (24%)	0.067	0.047	-0.020 (-30%)	0.039	0.043	0.004 (11%)	-0.112	-0.043	0.069 (61%)
		C	-0.266	-0.222	0.044 (16%)	-0.214	-0.190	0.023 (11%)	-0.107	-0.108	0.000 (0%)	-0.019	-0.016	0.003 (16%)	0.056	0.034	-0.022 (-39%)	0.045	0.029	-0.015 (-35%)	0.035	0.052	0.017 (48%)
212	Old River upstream of the south Delta export facilities	W	0.682	0.701	0.018 (3%)	0.946	0.867	-0.079 (-8%)	1.120	1.036	-0.084 (-8%)	1.199	1.075	-0.124 (-10%)	1.171	1.074	-0.097 (-8%)	1.161	1.069	-0.093 (-8%)	0.666	0.621	-0.045 (-7%)
		AN	0.574	0.558	-0.016 (-3%)	0.705	0.578	-0.127 (-18%)	0.794	0.689	-0.105 (-13%)	0.818	0.754	-0.064 (-8%)	0.814	0.640	-0.174 (-21%)	0.805	0.612	-0.193 (-24%)	0.301	0.159	-0.142 (-47%)
		BN	0.493	0.465	-0.028 (-6%)	0.503	0.362	-0.141 (-28%)	0.713	0.555	-0.158 (-22%)	0.583	0.350	-0.234 (-40%)	0.657	0.387	-0.269 (-41%)	0.589	0.327	-0.262 (-44%)	0.132	0.047	-0.085 (-64%)
		D	0.445	0.428	-0.017 (-4%)	0.452	0.287	-0.165 (-36%)	0.541	0.378	-0.162 (-30%)	0.575	0.387	-0.188 (-33%)	0.584	0.363	-0.221 (-38%)	0.546	0.346	-0.200 (-37%)	0.113	0.037	-0.076 (-67%)
		C	0.418	0.394	-0.024 (-6%)	0.393	0.248	-0.145 (-37%)	0.467	0.300	-0.167 (-36%)	0.410	0.251	-0.159 (-39%)	0.378	0.235	-0.143 (-38%)	0.359	0.200	-0.160 (-44%)	0.009	-0.011	-0.020 (-229%)
365	Delta Cross Channel	W	0.016	0.016	0.000 (0%)	0.013	0.013	0.000 (1%)	0.014	0.014	0.000 (0%)	0.015	0.015	0.000 (1%)	0.016	0.016	0.000 (2%)	0.016	0.016	0.000 (2%)	0.422	0.471	0.049 (12%)
		AN	0.025	0.027	0.001 (6%)	0.014	0.014	0.000 (1%)	0.015	0.015	0.000 (1%)	0.015	0.015	0.000 (2%)	0.014	0.014	0.000 (2%)	0.013	0.013	0.000 (2%)	0.662	0.576	-0.087 (-13%)
		BN	0.036	0.037	0.001 (3%)	0.011	0.012	0.001 (5%)	0.013	0.013	0.000 (1%)	0.012	0.012	0.000 (1%)	0.012	0.013	0.000 (1%)	0.011	0.011	0.000 (2%)	0.667	0.613	-0.053 (-8%)
		D	0.043	0.043	0.000 (-1%)	0.011	0.011	0.000 (2%)	0.012	0.012	0.000 (0%)	0.013	0.013	0.000 (0%)	0.012	0.012	0.000 (0%)	0.010	0.011	0.000 (2%)	0.675	0.609	-0.065 (-10%)
		C	0.040	0.039	-0.001	0.010	0.010	0.000	0.011	0.011	0.000	0.010	0.011	0.000	0.010	0.010	0.000	0.008	0.009	0.000	0.535	0.518	-0.017

DSM2 Channel	Location	Water Year Type	December			January			February			March			April			May			June		
			NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
					(-1%)			(1%)			(0%)			(2%)			(0%)			(2%)			(-3%)
379	Sutter Slough	W	1.691	1.478	-0.214 (-13%)	2.573	2.270	-0.304 (-12%)	3.045	2.765	-0.280 (-9%)	2.536	2.208	-0.327 (-13%)	1.763	1.648	-0.116 (-7%)	1.687	1.543	-0.143 (-8%)	1.036	0.807	-0.229 (-22%)
		AN	1.101	1.012	-0.089 (-8%)	1.866	1.578	-0.288 (-15%)	2.564	2.305	-0.259 (-10%)	2.052	1.769	-0.283 (-14%)	1.345	1.270	-0.075 (-6%)	1.022	0.958	-0.065 (-6%)	0.799	0.656	-0.143 (-18%)
		BN	0.996	0.902	-0.094 (-9%)	1.079	1.015	-0.064 (-6%)	1.327	1.192	-0.134 (-10%)	1.146	0.992	-0.154 (-13%)	0.937	0.922	-0.015 (-2%)	0.856	0.832	-0.023 (-3%)	0.763	0.681	-0.082 (-11%)
		D	0.875	0.823	-0.052 (-6%)	1.008	0.939	-0.069 (-7%)	1.202	1.090	-0.112 (-9%)	1.236	1.052	-0.185 (-15%)	0.956	0.946	-0.010 (-1%)	0.821	0.799	-0.022 (-3%)	0.758	0.659	-0.099 (-13%)
		C	0.766	0.721	-0.046 (-6%)	0.932	0.892	-0.040 (-4%)	1.006	0.909	-0.097 (-10%)	0.846	0.805	-0.041 (-5%)	0.751	0.734	-0.017 (-2%)	0.649	0.607	-0.042 (-6%)	0.610	0.562	-0.048 (-8%)
383	Steamboat Slough	W	1.972	1.789	-0.183 (-9%)	2.932	2.617	-0.315 (-11%)	3.448	3.120	-0.328 (-10%)	2.868	2.495	-0.373 (-13%)	2.021	1.903	-0.118 (-6%)	1.888	1.742	-0.146 (-8%)	1.346	1.140	-0.206 (-15%)
		AN	1.394	1.313	-0.081 (-6%)	2.161	1.916	-0.245 (-11%)	2.937	2.632	-0.305 (-10%)	2.346	2.042	-0.304 (-13%)	1.581	1.538	-0.044 (-3%)	1.275	1.206	-0.070 (-5%)	1.026	0.930	-0.095 (-9%)
		BN	1.235	1.156	-0.079 (-6%)	1.362	1.276	-0.086 (-6%)	1.631	1.518	-0.113 (-7%)	1.397	1.239	-0.158 (-11%)	1.169	1.140	-0.030 (-3%)	1.089	1.062	-0.027 (-2%)	0.972	0.941	-0.031 (-3%)
		D	1.115	1.066	-0.049 (-4%)	1.272	1.196	-0.076 (-6%)	1.493	1.384	-0.109 (-7%)	1.483	1.307	-0.177 (-12%)	1.204	1.177	-0.027 (-2%)	1.032	1.012	-0.020 (-2%)	0.964	0.918	-0.046 (-5%)
		C	0.987	0.936	-0.051 (-5%)	1.175	1.121	-0.054 (-5%)	1.249	1.143	-0.106 (-8%)	1.083	1.019	-0.064 (-6%)	0.960	0.942	-0.018 (-2%)	0.816	0.808	-0.008 (-1%)	0.779	0.776	-0.003 (0%)
418	Sacramento River downstream of proposed NDD	W	2.224	1.901	-0.323 (-15%)	3.416	2.884	-0.532 (-16%)	4.052	3.484	-0.568 (-14%)	3.347	2.775	-0.571 (-17%)	2.305	2.070	-0.235 (-10%)	2.191	1.939	-0.252 (-12%)	1.524	1.162	-0.362 (-24%)
		AN	1.494	1.351	-0.143 (-10%)	2.473	2.019	-0.453 (-18%)	3.409	2.918	-0.491 (-14%)	2.700	2.240	-0.460 (-17%)	1.752	1.615	-0.137 (-8%)	1.343	1.225	-0.119 (-9%)	1.206	0.982	-0.224 (-19%)
		BN	1.365	1.219	-0.145 (-11%)	1.432	1.312	-0.120 (-8%)	1.744	1.538	-0.206 (-12%)	1.508	1.279	-0.229 (-15%)	1.240	1.186	-0.054 (-4%)	1.140	1.081	-0.060 (-5%)	1.157	1.017	-0.140 (-12%)
		D	1.222	1.131	-0.091 (-7%)	1.349	1.227	-0.122 (-9%)	1.594	1.411	-0.183 (-11%)	1.623	1.353	-0.269 (-17%)	1.265	1.218	-0.047 (-4%)	1.096	1.041	-0.055 (-5%)	1.149	0.992	-0.157 (-14%)
		C	1.081	0.993	-0.088 (-8%)	1.245	1.163	-0.082 (-7%)	1.333	1.182	-0.151 (-11%)	1.134	1.059	-0.075 (-7%)	1.019	0.977	-0.042 (-4%)	0.885	0.814	-0.071 (-8%)	0.928	0.826	-0.102 (-11%)
421	Sacramento River upstream of Georgiana Slough	W	1.858	1.672	-0.186 (-10%)	2.737	2.445	-0.292 (-11%)	3.191	2.903	-0.288 (-9%)	2.679	2.337	-0.342 (-13%)	1.897	1.773	-0.124 (-7%)	1.786	1.637	-0.149 (-8%)	1.407	1.115	-0.292 (-21%)
		AN	1.322	1.241	-0.081 (-6%)	2.031	1.773	-0.258 (-13%)	2.736	2.467	-0.269 (-10%)	2.210	1.921	-0.288 (-13%)	1.472	1.418	-0.055 (-4%)	1.154	1.074	-0.080 (-7%)	1.114	0.955	-0.159 (-14%)
		BN	1.194	1.113	-0.082 (-7%)	1.251	1.167	-0.084 (-7%)	1.501	1.374	-0.127 (-8%)	1.295	1.139	-0.156 (-12%)	1.076	1.053	-0.023 (-2%)	0.986	0.954	-0.032 (-3%)	1.067	0.980	-0.087 (-8%)
		D	1.087	1.040	-0.047 (-4%)	1.173	1.099	-0.073 (-6%)	1.372	1.263	-0.109 (-8%)	1.381	1.198	-0.183 (-13%)	1.103	1.084	-0.020 (-2%)	0.944	0.914	-0.030 (-3%)	1.058	0.955	-0.103 (-10%)
		C	0.956	0.902	-0.054 (-6%)	1.080	1.039	-0.041 (-4%)	1.147	1.053	-0.094 (-8%)	0.989	0.945	-0.045 (-5%)	0.885	0.867	-0.018 (-2%)	0.756	0.733	-0.024 (-3%)	0.852	0.814	-0.039 (-5%)
423	Sacramento River downstream of Georgiana Slough	W	1.713	1.578	-0.134 (-8%)	2.467	2.211	-0.256 (-10%)	2.857	2.593	-0.265 (-9%)	2.429	2.129	-0.300 (-12%)	1.755	1.670	-0.085 (-5%)	1.623	1.522	-0.102 (-6%)	1.147	0.975	-0.171 (-15%)
		AN	1.229	1.161	-0.067 (-5%)	1.857	1.680	-0.177 (-10%)	2.463	2.205	-0.259 (-11%)	2.015	1.764	-0.251 (-12%)	1.402	1.368	-0.034 (-2%)	1.127	1.072	-0.055 (-5%)	0.824	0.739	-0.086 (-10%)
		BN	1.063	0.993	-0.070 (-7%)	1.199	1.121	-0.077 (-6%)	1.458	1.359	-0.100 (-7%)	1.235	1.091	-0.144 (-12%)	1.020	0.998	-0.022 (-2%)	0.947	0.927	-0.020 (-2%)	0.767	0.743	-0.024 (-3%)
		D	0.949	0.903	-0.046 (-5%)	1.120	1.055	-0.065 (-6%)	1.328	1.228	-0.100 (-8%)	1.313	1.150	-0.162 (-12%)	1.058	1.032	-0.025 (-2%)	0.890	0.877	-0.013 (-2%)	0.759	0.723	-0.037 (-5%)
		C	0.829	0.784	-0.046 (-6%)	1.023	0.973	-0.050 (-5%)	1.095	0.999	-0.096 (-9%)	0.945	0.883	-0.062 (-7%)	0.824	0.810	-0.014 (-2%)	0.674	0.669	-0.005 (-1%)	0.596	0.594	-0.001 (0%)

Table 5.4-10. Median 15-minute Negative Velocity in Important Delta Channels, from DSM2-HYDRO Modeling, with Green Shading Indicating PA is ≥5% More than NAA and Red Shading Indicating PA is ≥5% Less than NAA.

DSM2 Channel	Location	Water Year Type	December			January			February			March			April			May			June		
			NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
21	San Joaquin River downstream of HOR	W	-0.298	-0.295	0.003 (1%)	-0.246	-0.194	0.052 (21%)	-0.182	-0.133	0.049 (27%)	-0.166	-0.121	0.045 (27%)	-0.154	-0.104	0.051 (33%)	-0.187	-0.124	0.063 (34%)	-0.222	-0.205	0.017 (7%)
		AN	-0.334	-0.332	0.002 (1%)	-0.284	-0.233	0.051 (18%)	-0.246	-0.187	0.059 (24%)	-0.225	-0.170	0.055 (25%)	-0.194	-0.132	0.062 (32%)	-0.215	-0.149	0.066 (31%)	-0.267	-0.249	0.017 (7%)
		BN	-0.321	-0.317	0.004 (1%)	-0.309	-0.251	0.058 (19%)	-0.281	-0.220	0.061 (22%)	-0.258	-0.198	0.060 (23%)	-0.229	-0.167	0.061 (27%)	-0.249	-0.190	0.059 (24%)	-0.299	-0.287	0.012 (4%)
		D	-0.333	-0.330	0.002 (1%)	-0.318	-0.259	0.059 (19%)	-0.306	-0.250	0.057 (18%)	-0.309	-0.254	0.054 (18%)	-0.277	-0.226	0.051 (18%)	-0.291	-0.239	0.052 (18%)	-0.312	-0.301	0.011 (4%)
		C	-0.338	-0.337	0.001 (0%)	-0.341	-0.294	0.047 (14%)	-0.317	-0.266	0.051 (16%)	-0.324	-0.282	0.042 (13%)	-0.327	-0.288	0.039 (12%)	-0.325	-0.284	0.041 (13%)	-0.322	-0.319	0.003 (1%)
45	San Joaquin River near the confluence with the Mokelumne River	W	-1.314	-1.307	0.008 (1%)	-1.223	-1.199	0.023 (2%)	-1.161	-1.118	0.043 (4%)	-1.196	-1.146	0.049 (4%)	-1.206	-1.188	0.018 (1%)	-1.231	-1.212	0.018 (1%)	-1.296	-1.264	0.032 (2%)
		AN	-1.343	-1.332	0.010 (1%)	-1.284	-1.268	0.016 (1%)	-1.255	-1.236	0.018 (1%)	-1.265	-1.219	0.045 (4%)	-1.285	-1.272	0.013 (1%)	-1.306	-1.297	0.010 (1%)	-1.340	-1.331	0.009 (1%)
		BN	-1.376	-1.364	0.012 (1%)	-1.341	-1.316	0.025 (2%)	-1.295	-1.283	0.012 (1%)	-1.321	-1.304	0.016 (1%)	-1.303	-1.297	0.005 (0%)	-1.316	-1.310	0.006 (0%)	-1.333	-1.330	0.003 (0%)
		D	-1.370	-1.365	0.005 (0%)	-1.348	-1.334	0.014 (1%)	-1.331	-1.321	0.010 (1%)	-1.323	-1.315	0.008 (1%)	-1.314	-1.310	0.004 (0%)	-1.328	-1.323	0.005 (0%)	-1.339	-1.336	0.003 (0%)
		C	-1.358	-1.355	0.002 (0%)	-1.351	-1.345	0.005 (0%)	-1.333	-1.329	0.004 (0%)	-1.337	-1.334	0.003 (0%)	-1.341	-1.339	0.002 (0%)	-1.336	-1.335	0.001 (0%)	-1.333	-1.334	0.000 (0%)
94	Old River downstream of the south Delta export facilities	W	-0.962	-0.953	0.009 (1%)	-0.895	-0.849	0.045 (5%)	-0.859	-0.775	0.084 (10%)	-0.873	-0.724	0.149 (17%)	-0.715	-0.706	0.009 (1%)	-0.733	-0.711	0.022 (3%)	-0.917	-0.815	0.102 (11%)
		AN	-0.977	-0.968	0.008 (1%)	-0.922	-0.884	0.038 (4%)	-0.910	-0.870	0.040 (4%)	-0.927	-0.812	0.115 (12%)	-0.821	-0.838	-0.017 (-2%)	-0.818	-0.834	-0.016 (-2%)	-0.963	-0.929	0.034 (4%)
		BN	-1.002	-0.996	0.006 (1%)	-0.956	-0.888	0.068 (7%)	-0.921	-0.889	0.031 (3%)	-0.940	-0.915	0.025 (3%)	-0.844	-0.877	-0.033 (-4%)	-0.843	-0.867	-0.024 (-3%)	-0.932	-0.923	0.009 (1%)
		D	-0.992	-0.987	0.006 (1%)	-0.965	-0.931	0.034 (4%)	-0.936	-0.919	0.017 (2%)	-0.929	-0.912	0.016 (2%)	-0.865	-0.882	-0.017 (-2%)	-0.851	-0.866	-0.014 (-2%)	-0.929	-0.917	0.012 (1%)
		C	-0.950	-0.952	-0.002 (0%)	-0.955	-0.943	0.012 (1%)	-0.916	-0.915	0.001 (0%)	-0.896	-0.905	-0.008 (-1%)	-0.888	-0.897	-0.009 (-1%)	-0.866	-0.878	-0.012 (-1%)	-0.898	-0.898	0.001 (0%)
212	Old River upstream of the south Delta export facilities	W	-0.451	-0.461	-0.010 (-2%)	-0.461	-0.698	-0.237 (-51%)	-0.377	-0.691	-0.314 (-83%)	-0.342	-0.661	-0.319 (-93%)	-0.418	-0.705	-0.288 (-69%)	-0.504	-0.766	-0.262 (-52%)	-0.261	-0.319	-0.058 (-22%)
		AN	-0.481	-0.465	0.016 (3%)	-0.531	-0.718	-0.187 (-35%)	-0.490	-0.678	-0.188 (-38%)	-0.431	-0.773	-0.342 (-79%)	-0.506	-0.767	-0.261 (-52%)	-0.550	-0.807	-0.257 (-47%)	-0.306	-0.348	-0.043 (-14%)
		BN	-0.433	-0.445	-0.012 (-3%)	-0.526	-0.761	-0.236 (-45%)	-0.501	-0.678	-0.177 (-35%)	-0.465	-0.675	-0.210 (-45%)	-0.548	-0.750	-0.202 (-37%)	-0.604	-0.798	-0.194 (-32%)	-0.369	-0.396	-0.027 (-7%)
		D	-0.472	-0.479	-0.008 (-2%)	-0.500	-0.699	-0.199 (-40%)	-0.544	-0.707	-0.163 (-30%)	-0.578	-0.723	-0.145 (-25%)	-0.620	-0.767	-0.147 (-24%)	-0.642	-0.793	-0.151 (-24%)	-0.400	-0.430	-0.030 (-8%)
		C	-0.591	-0.573	0.018 (3%)	-0.554	-0.700	-0.146 (-26%)	-0.596	-0.716	-0.121 (-20%)	-0.691	-0.797	-0.106 (-15%)	-0.735	-0.829	-0.094 (-13%)	-0.731	-0.830	-0.099 (-14%)	-0.473	-0.489	-0.016 (-3%)
365	Delta Cross Channel	W	-0.052	-0.052	0.000 (0%)	-0.050	-0.050	0.000 (0%)	-0.050	-0.049	0.000 (1%)	-0.051	-0.051	0.000 (1%)	-0.052	-0.052	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.056	-0.060	-0.004 (-7%)
		AN	-0.052	-0.052	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.052	-0.052	0.000 (1%)	-0.052	-0.052	0.000 (0%)	-0.053	-0.053	0.000 (0%)	-0.059	-0.061	-0.002 (-3%)
		BN	-0.053	-0.053	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.051	-0.051	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.057	-0.059	-0.002 (-3%)
		D	-0.054	-0.054	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.051	-0.052	0.000 (0%)	-0.052	-0.052	0.000 (0%)	-0.058	-0.060	-0.002 (-3%)

DSM2 Channel	Location	Water Year Type	December			January			February			March			April			May			June		
			NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
		C	-0.055	-0.055	0.000 (-1%)	-0.052	-0.052	0.000 (0%)	-0.051	-0.051	0.000 (0%)	-0.051	-0.051	0.000 (0%)	-0.051	-0.051	0.000 (0%)	-0.051	-0.051	0.000 (0%)	-0.099	-0.095	0.004 (4%)
379	Sutter Slough	W	-0.120	-0.127	-0.007 (-6%)	-0.077	-0.073	0.003 (5%)	-0.025	-0.022	0.003 (12%)	NA*	NA	NA	-0.111	-0.119	-0.008 (-7%)	-0.124	-0.122	0.002 (2%)	-0.147	-0.135	0.011 (8%)
		AN	-0.224	-0.209	0.015 (7%)	-0.099	-0.062	0.037 (37%)	-0.206	-0.177	0.029 (14%)	NA	-0.027	NA	-0.154	-0.150	0.003 (2%)	-0.140	-0.123	0.017 (12%)	-0.135	-0.104	0.032 (24%)
		BN	-0.218	-0.199	0.019 (9%)	-0.173	-0.162	0.010 (6%)	-0.295	-0.271	0.025 (8%)	-0.096	-0.094	0.002 (2%)	-0.154	-0.142	0.012 (8%)	-0.132	-0.136	-0.005 (-3%)	-0.139	-0.145	-0.005 (-4%)
		D	-0.194	-0.180	0.014 (7%)	-0.136	-0.128	0.008 (6%)	-0.153	-0.143	0.010 (7%)	-0.127	-0.115	0.013 (10%)	-0.172	-0.163	0.009 (5%)	-0.149	-0.136	0.013 (9%)	-0.143	-0.156	-0.013 (-9%)
		C	-0.231	-0.240	-0.010 (-4%)	-0.192	-0.121	0.071 (37%)	-0.149	-0.173	-0.024 (-16%)	-0.166	-0.145	0.021 (12%)	-0.146	-0.144	0.002 (2%)	-0.249	-0.248	0.001 (1%)	-0.222	-0.230	-0.008 (-3%)
383	Steamboat Slough	W	-0.404	-0.399	0.005 (1%)	-0.362	-0.364	-0.002 (-1%)	-0.185	-0.250	-0.065 (-35%)	-0.160	-0.347	-0.187 (-117%)	-0.372	-0.397	-0.025 (-7%)	-0.410	-0.438	-0.028 (-7%)	-0.550	-0.579	-0.029 (-5%)
		AN	-0.492	-0.516	-0.025 (-5%)	-0.345	-0.340	0.005 (2%)	-0.525	-0.461	0.064 (12%)	-0.246	-0.324	-0.078 (-32%)	-0.367	-0.393	-0.027 (-7%)	-0.431	-0.456	-0.025 (-6%)	-0.567	-0.594	-0.026 (-5%)
		BN	-0.484	-0.512	-0.028 (-6%)	-0.457	-0.470	-0.014 (-3%)	-0.419	-0.435	-0.015 (-4%)	-0.392	-0.419	-0.027 (-7%)	-0.434	-0.463	-0.029 (-7%)	-0.480	-0.490	-0.010 (-2%)	-0.578	-0.547	0.030 (5%)
		D	-0.541	-0.559	-0.018 (-3%)	-0.439	-0.474	-0.035 (-8%)	-0.376	-0.421	-0.045 (-12%)	-0.384	-0.409	-0.025 (-7%)	-0.471	-0.474	-0.003 (-1%)	-0.472	-0.476	-0.004 (-1%)	-0.582	-0.578	0.003 (1%)
		C	-0.625	-0.648	-0.023 (-4%)	-0.499	-0.494	0.005 (1%)	-0.419	-0.485	-0.066 (-16%)	-0.487	-0.516	-0.029 (-6%)	-0.503	-0.516	-0.014 (-3%)	-0.613	-0.621	-0.007 (-1%)	-0.691	-0.696	-0.005 (-1%)
418	Sacramento River downstream of proposed NDD	W	-0.120	-0.136	-0.017 (-14%)	-0.091	-0.092	-0.002 (-2%)	NA	-0.073	NA	NA	0.000	NA	-0.168	-0.160	0.008 (5%)	-0.145	-0.154	-0.008 (-6%)	-0.156	-0.175	-0.019 (-12%)
		AN	-0.250	-0.242	0.008 (3%)	-0.065	-0.064	0.001 (2%)	-0.265	-0.220	0.046 (17%)	NA	-0.036	NA	-0.200	-0.183	0.017 (8%)	-0.150	-0.140	0.010 (7%)	-0.202	-0.156	0.046 (23%)
		BN	-0.254	-0.231	0.023 (9%)	-0.187	-0.180	0.007 (4%)	-0.374	-0.359	0.015 (4%)	-0.126	-0.114	0.012 (9%)	-0.175	-0.178	-0.002 (-1%)	-0.150	-0.160	-0.010 (-7%)	-0.135	-0.135	0.000 (0%)
		D	-0.233	-0.200	0.032 (14%)	-0.141	-0.139	0.002 (1%)	-0.154	-0.149	0.005 (3%)	-0.115	-0.119	-0.004 (-3%)	-0.194	-0.182	0.012 (6%)	-0.168	-0.158	0.010 (6%)	-0.157	-0.152	0.005 (3%)
		C	-0.272	-0.266	0.006 (2%)	-0.224	-0.146	0.078 (35%)	-0.155	-0.188	-0.033 (-21%)	-0.183	-0.169	0.014 (8%)	-0.166	-0.162	0.004 (3%)	-0.285	-0.281	0.005 (2%)	-0.271	-0.263	0.009 (3%)
421	Sacramento River upstream of Georgiana Slough	W	-0.074	-0.080	-0.006 (-8%)	-0.061	-0.052	0.008 (14%)	NA	-0.104	NA	NA	-0.033	NA	-0.123	-0.123	0.001 (0%)	-0.111	-0.147	-0.036 (-33%)	-0.152	-0.158	-0.006 (-4%)
		AN	-0.190	-0.187	0.003 (2%)	-0.047	-0.084	-0.037 (-78%)	-0.179	-0.139	0.040 (22%)	NA	-0.058	NA	-0.156	-0.137	0.019 (12%)	-0.110	-0.142	-0.032 (-29%)	-0.186	-0.147	0.038 (21%)
		BN	-0.218	-0.179	0.038 (18%)	-0.141	-0.141	0.000 (0%)	-0.304	-0.278	0.025 (8%)	-0.088	-0.096	-0.008 (-9%)	-0.133	-0.161	-0.028 (-21%)	-0.115	-0.146	-0.031 (-27%)	-0.113	-0.133	-0.020 (-18%)
		D	-0.178	-0.161	0.017 (10%)	-0.103	-0.105	-0.002 (-2%)	-0.106	-0.118	-0.012 (-11%)	-0.077	-0.092	-0.014 (-18%)	-0.149	-0.157	-0.008 (-5%)	-0.125	-0.145	-0.020 (-16%)	-0.162	-0.142	0.020 (12%)
		C	-0.223	-0.223	0.000 (0%)	-0.163	-0.108	0.054 (33%)	-0.113	-0.152	-0.039 (-35%)	-0.134	-0.139	-0.004 (-3%)	-0.122	-0.139	-0.018 (-15%)	-0.219	-0.234	-0.015 (-7%)	-0.247	-0.256	-0.009 (-4%)
423	Sacramento River downstream of Georgiana Slough	W	-0.347	-0.343	0.005 (1%)	-0.310	-0.297	0.013 (4%)	-0.225	-0.217	0.008 (4%)	-0.144	-0.286	-0.142 (-98%)	-0.317	-0.338	-0.021 (-7%)	-0.356	-0.384	-0.028 (-8%)	-0.545	-0.580	-0.035 (-6%)
		AN	-0.448	-0.468	-0.020 (-4%)	-0.297	-0.285	0.012 (4%)	-0.467	-0.402	0.065 (14%)	-0.213	-0.268	-0.054 (-25%)	-0.312	-0.333	-0.021 (-7%)	-0.377	-0.403	-0.026 (-7%)	-0.576	-0.610	-0.034 (-6%)
		BN	-0.449	-0.479	-0.030 (-7%)	-0.396	-0.414	-0.017 (-4%)	-0.354	-0.372	-0.018 (-5%)	-0.329	-0.363	-0.034 (-10%)	-0.385	-0.412	-0.026 (-7%)	-0.434	-0.443	-0.008 (-2%)	-0.582	-0.585	-0.002 (0%)
		D	-0.505	-0.520	-0.015 (-3%)	-0.389	-0.426	-0.037 (-9%)	-0.329	-0.369	-0.039 (-12%)	-0.334	-0.348	-0.014 (-4%)	-0.417	-0.419	-0.002 (0%)	-0.430	-0.435	-0.005 (-1%)	-0.589	-0.600	-0.011 (-2%)
		C	-0.587	-0.608	-0.021	-0.438	-0.444	-0.006	-0.373	-0.432	-0.059	-0.435	-0.463	-0.028	-0.460	-0.472	-0.012	-0.566	-0.576	-0.010	-0.678	-0.682	-0.004

DSM2 Channel	Location	Water Year Type	December			January			February			March			April			May			June		
			NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
					(-4%)			(-1%)			(-16%)			(-6%)			(-3%)			(-2%)			(-1%)

Note: *NA denotes that there were no negative velocity estimates.

Table 5.4-11. Median Daily Proportion of Negative Velocity in Important Delta Channels, from DSM2-HYDRO Modeling, with Green Shading Indicating PA is ≥ 5% Less than NAA and Red Shading Indicating PA is ≥ 5% More than NAA.

DSM2 Channel	Location	Water Year Type	December			January			February			March			April			May			June		
			NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
21	San Joaquin River downstream of HOR	W	0.438	0.438	0.000 (0%)	0.365	0.250	-0.115 (-31%)	0.219	0.083	-0.135 (-62%)	0.167	0.063	-0.104 (-63%)	0.234	0.094	-0.141 (-60%)	0.292	0.135	-0.156 (-54%)	0.385	0.323	-0.063 (-16%)
		AN	0.469	0.458	-0.010 (-2%)	0.438	0.406	-0.031 (-7%)	0.406	0.333	-0.073 (-18%)	0.396	0.260	-0.135 (-34%)	0.396	0.292	-0.104 (-26%)	0.406	0.323	-0.083 (-21%)	0.448	0.438	-0.010 (-2%)
		BN	0.469	0.469	0.000 (0%)	0.458	0.427	-0.031 (-7%)	0.438	0.396	-0.042 (-10%)	0.438	0.396	-0.042 (-10%)	0.427	0.385	-0.042 (-10%)	0.438	0.396	-0.042 (-10%)	0.458	0.458	0.000 (0%)
		D	0.469	0.469	0.000 (0%)	0.458	0.438	-0.021 (-5%)	0.458	0.427	-0.031 (-7%)	0.458	0.438	-0.021 (-5%)	0.448	0.417	-0.031 (-7%)	0.448	0.427	-0.021 (-5%)	0.469	0.458	-0.010 (-2%)
		C	0.469	0.469	0.000 (0%)	0.469	0.448	-0.021 (-4%)	0.458	0.438	-0.021 (-5%)	0.458	0.448	-0.010 (-2%)	0.458	0.448	-0.010 (-2%)	0.458	0.448	-0.010 (-2%)	0.469	0.469	0.000 (0%)
45	San Joaquin River near the confluence with the Mokelumne River	W	0.479	0.479	0.000 (0%)	0.458	0.448	-0.010 (-2%)	0.448	0.438	-0.010 (-2%)	0.448	0.438	-0.010 (-2%)	0.448	0.438	-0.010 (-2%)	0.448	0.448	0.000 (0%)	0.469	0.469	0.000 (0%)
		AN	0.490	0.490	0.000 (0%)	0.469	0.469	0.000 (0%)	0.458	0.458	0.000 (0%)	0.458	0.448	-0.010 (-2%)	0.458	0.458	0.000 (0%)	0.469	0.469	0.000 (0%)	0.479	0.479	0.000 (0%)
		BN	0.500	0.490	-0.010 (-2%)	0.490	0.479	-0.010 (-2%)	0.479	0.479	0.000 (0%)	0.479	0.479	0.000 (0%)	0.469	0.469	0.000 (0%)	0.479	0.469	-0.010 (-2%)	0.479	0.479	0.000 (0%)
		D	0.500	0.490	-0.010 (-2%)	0.490	0.479	-0.010 (-2%)	0.479	0.479	0.000 (0%)	0.479	0.479	0.000 (0%)	0.469	0.469	0.000 (0%)	0.479	0.479	0.000 (0%)	0.479	0.479	0.000 (0%)
		C	0.490	0.490	0.000 (0%)	0.490	0.490	0.000 (0%)	0.479	0.479	0.000 (0%)	0.479	0.479	0.000 (0%)	0.479	0.479	0.000 (0%)	0.479	0.479	0.000 (0%)	0.479	0.479	0.000 (0%)
94	Old River downstream of the south Delta export facilities	W	0.583	0.573	-0.010 (-2%)	0.531	0.490	-0.042 (-8%)	0.531	0.448	-0.083 (-16%)	0.531	0.438	-0.094 (-18%)	0.448	0.438	-0.010 (-2%)	0.458	0.448	-0.010 (-2%)	0.531	0.479	-0.052 (-10%)
		AN	0.583	0.583	0.000 (0%)	0.531	0.510	-0.021 (-4%)	0.531	0.500	-0.031 (-6%)	0.542	0.469	-0.073 (-13%)	0.469	0.469	0.000 (0%)	0.469	0.469	0.000 (0%)	0.542	0.521	-0.021 (-4%)
		BN	0.667	0.604	-0.063 (-9%)	0.552	0.490	-0.063 (-11%)	0.521	0.521	0.000 (0%)	0.542	0.531	-0.010 (-2%)	0.479	0.490	0.010 (2%)	0.479	0.490	0.010 (2%)	0.531	0.521	-0.010 (-2%)
		D	0.594	0.583	-0.010 (-2%)	0.552	0.531	-0.021 (-4%)	0.531	0.531	0.000 (0%)	0.521	0.521	0.000 (0%)	0.490	0.500	0.010 (2%)	0.490	0.490	0.000 (0%)	0.521	0.510	-0.010 (-2%)
		C	0.542	0.542	0.000 (0%)	0.552	0.552	0.000 (0%)	0.521	0.521	0.000 (0%)	0.500	0.500	0.000 (0%)	0.490	0.490	0.000 (0%)	0.490	0.490	0.000 (0%)	0.490	0.490	0.000 (0%)
212	Old River upstream of the south Delta export facilities	W	0.344	0.354	0.010 (3%)	0.292	0.396	0.104 (36%)	0.125	0.354	0.229 (183%)	0.094	0.297	0.203 (217%)	0.177	0.365	0.188 (106%)	0.229	0.396	0.167 (73%)	0.188	0.385	0.198 (106%)
		AN	0.344	0.365	0.021 (6%)	0.365	0.427	0.063 (17%)	0.313	0.406	0.094 (30%)	0.271	0.417	0.146 (54%)	0.344	0.427	0.083 (24%)	0.365	0.438	0.073 (20%)	0.438	0.464	0.026 (6%)
		BN	0.333	0.365	0.031 (9%)	0.385	0.448	0.063 (16%)	0.365	0.427	0.063 (17%)	0.354	0.438	0.083 (24%)	0.375	0.438	0.063 (17%)	0.396	0.448	0.052 (13%)	0.469	0.490	0.021 (4%)
		D	0.375	0.375	0.000 (0%)	0.385	0.448	0.063 (16%)	0.385	0.448	0.063 (16%)	0.396	0.448	0.052 (13%)	0.406	0.448	0.042 (10%)	0.417	0.458	0.042 (10%)	0.479	0.500	0.021 (4%)
		C	0.396	0.406	0.010 (3%)	0.406	0.458	0.052 (13%)	0.396	0.448	0.052 (13%)	0.438	0.469	0.031 (7%)	0.438	0.469	0.031 (7%)	0.438	0.469	0.031 (7%)	0.500	0.500	0.000 (0%)
365	Delta Cross Channel	W	0.448	0.448	0.000 (0%)	0.427	0.427	0.000 (0%)	0.427	0.417	-0.010 (-2%)	0.427	0.427	0.000 (0%)	0.438	0.427	-0.010 (-2%)	0.427	0.427	0.000 (0%)	0.073	0.083	0.010 (14%)
		AN	0.458	0.458	0.000	0.448	0.448	0.000	0.438	0.438	0.000	0.438	0.438	0.000	0.448	0.448	0.000	0.458	0.458	0.000	0.031	0.063	0.031

DSM2 Channel	Location	Water Year Type	December			January			February			March			April			May			June		
			NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
					(0%)			(0%)			(0%)			(0%)			(0%)			(0%)			(100%)
		BN	0.458	0.448	-0.010 (-2%)	0.469	0.458	-0.010 (-2%)	0.458	0.458	0.000 (0%)	0.458	0.458	0.000 (0%)	0.458	0.458	0.000 (0%)	0.469	0.458	-0.010 (-2%)	0.042	0.063	0.021 (50%)
		D	0.458	0.458	0.000 (0%)	0.469	0.469	0.000 (0%)	0.458	0.458	0.000 (0%)	0.458	0.458	0.000 (0%)	0.458	0.458	0.000 (0%)	0.469	0.469	0.000 (0%)	0.042	0.073	0.031 (75%)
		C	0.458	0.458	0.000 (0%)	0.469	0.469	0.000 (0%)	0.469	0.469	0.000 (0%)	0.469	0.469	0.000 (0%)	0.469	0.469	0.000 (0%)	0.469	0.469	0.000 (0%)	0.146	0.156	0.010 (7%)
379	Sutter Slough	W	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)
		AN	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.083	0.063	-0.021 (-25%)
		BN	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.052	0.063	0.010 (20%)	0.104	0.083	-0.021 (-20%)
		D	0.000	0.063	0.063 (Inf.)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.052	0.052	0.000 (0%)	0.104	0.104	0.000 (0%)
		C	0.167	0.203	0.036 (22%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.021	0.021 (Inf.)	0.083	0.094	0.010 (13%)	0.167	0.188	0.021 (12%)	0.240	0.250	0.010 (4%)
383	Steamboat Slough	W	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.198	0.302	0.104 (53%)
		AN	0.125	0.167	0.042 (33%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.031	0.031 (Inf.)	0.188	0.229	0.042 (22%)	0.302	0.333	0.031 (10%)
		BN	0.167	0.229	0.063 (37%)	0.115	0.146	0.031 (27%)	0.000	0.094	0.094 (Inf.)	0.042	0.146	0.104 (250%)	0.219	0.250	0.031 (14%)	0.281	0.281	0.000 (0%)	0.313	0.313	0.000 (0%)
		D	0.260	0.281	0.021 (8%)	0.182	0.224	0.042 (23%)	0.021	0.125	0.104 (500%)	0.000	0.125	0.125 (Inf.)	0.224	0.229	0.005 (2%)	0.271	0.271	0.000 (0%)	0.313	0.323	0.010 (3%)
		C	0.333	0.344	0.010 (3%)	0.219	0.250	0.031 (14%)	0.146	0.214	0.068 (46%)	0.281	0.292	0.010 (4%)	0.302	0.302	0.000 (0%)	0.344	0.354	0.010 (3%)	0.375	0.375	0.000 (0%)
418	Sacramento River downstream of proposed NDD	W	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)
		AN	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)
		BN	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.031	0.052	0.021 (67%)	0.000	0.000	0.000 (0%)
		D	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.021	0.042	0.021 (100%)	0.000	0.000	0.000 (0%)
		C	0.141	0.156	0.016 (11%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.005	0.005 (Inf.)	0.073	0.083	0.010 (14%)	0.156	0.167	0.010 (7%)	0.130	0.135	0.005 (4%)
421	Sacramento River upstream of Georgiana Slough	W	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)
		AN	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.031	0.031 (Inf.)	0.000	0.000	0.000 (0%)
		BN	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.042	0.073	0.031 (75%)	0.000	0.000	0.000 (0%)
		D	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.021	0.073	0.052 (250%)	0.000	0.000	0.000 (0%)
		C	0.135	0.156	0.021 (15%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.052	0.052 (Inf.)	0.083	0.104	0.021 (25%)	0.167	0.167	0.000 (0%)	0.125	0.135	0.010 (8%)
423	Sacramento River downstream of Georgiana	W	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.281	0.333	0.052 (19%)
		AN	0.146	0.188	0.042 (29%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.000	0.000 (0%)	0.000	0.063	0.063 (Inf.)	0.208	0.250	0.042 (20%)	0.344	0.365	0.021 (6%)

DSM2 Channel	**Location**	**Water Year Type**	**December**				**January**				**February**				**March**				**April**				**May**				**June**		
			NAA	**PA**	**PA vs. NAA**		**NAA**	**PA**	**PA vs. NAA**		**NAA**	**PA**	**PA vs. NAA**		**NAA**	**PA**	**PA vs. NAA**		**NAA**	**PA**	**PA vs. NAA**		**NAA**	**PA**	**PA vs. NAA**		**NAA**	**PA**	**PA vs. NAA**
	Slough	BN	0.188	0.250	0.063 (33%)		0.135	0.167	0.031 (23%)		0.000	0.115	0.115 (Inf.)		0.083	0.177	0.094 (113%)		0.240	0.250	0.010 (4%)		0.292	0.292	0.000 (0%)		0.354	0.354	0.000 (0%)
		D	0.281	0.302	0.021 (7%)		0.198	0.240	0.042 (21%)		0.083	0.146	0.063 (75%)		0.000	0.146	0.146 (Inf.)		0.229	0.240	0.010 (5%)		0.281	0.281	0.000 (0%)		0.354	0.365	0.010 (3%)
		C	0.344	0.354	0.010 (3%)		0.240	0.260	0.021 (9%)		0.177	0.229	0.052 (29%)		0.292	0.292	0.000 (0%)		0.302	0.313	0.010 (3%)		0.354	0.354	0.000 (0%)		0.396	0.396	0.000 (0%)

5.4.1.3.1.2.1.2 Entry into Interior Delta

Juvenile salmonids may enter the interior Delta from the mainstem Sacramento and San Joaquin Rivers through junctions such as Georgiana Slough/Delta Cross Channel and the HOR. Survival through the interior Delta from the Sacramento River has been shown to be consistently appreciably lower than in the river mainstem (Perry et al. 2010, 2013; Brandes and McLain 2001; Singer et al. 2013), whereas some evidence supports higher main stem survival for the San Joaquin River (reviewed by Hankin et al. 2010) and other evidence does not (Buchanan et al. 2013, 2015[22]). Perry et al. (2013) found that, based on observed patterns for hatchery-origin late fall–run Chinook salmon, eliminating entry into the interior Delta through Georgiana Slough and the Delta Cross Channel would increase overall through-Delta survival by up to approximately one-third (10-35%); this represents an absolute increase in survival of 2-7%. The need to reduce entry into the interior Delta by juvenile salmonids was recognized in the NMFS (2009) BiOp, which requires that engineering solutions be investigated to lessen the issue; such solutions may include physical or nonphysical barriers.

The PA has the potential to result in changes in interior Delta entry on the Sacramento River and the San Joaquin River. Less flow in the Sacramento River (as would occur because of exports by the NDD) leads to a greater tidal influence at the Georgiana Slough/DCC junction (Perry et al. 2015) and a greater proportion of flow entering the junction (Cavallo et al. 2015); installation of a nonphysical barrier at the Georgiana Slough junction would aim to minimize the biological consequences of these changes in hydrodynamics by allowing flow to enter Georgiana Slough but preventing fish from entering the distributary 23. Installation of the HOR gate under the PA would greatly reduce entry into Old River from the San Joaquin River. These factors are discussed in this section.

5.4.1.3.1.2.1.2.1 Flow Routing Into Channel Junctions

Perspective on potential differences in juvenile salmonid entry into the interior Delta between modeled operations of the NAA and PA was provided by assessing differences in the proportion of flow entering important channel junctions from the Sacramento River and the San Joaquin River based on DSM2-HYDRO modeling (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale,* Section 5.D.1.2.1.1.2, *Flow Routing at Junctions*, for methods, with results in Section 5.D.1.2.1.2.2, *Flow Routing at Junctions*, of the same appendix). Assessment of the proportion of flow entering a junction generally is a reasonable proxy for the proportion of fish entering the junction (Cavallo et al. 2015). As noted previously in the analysis of velocity, the summary provided herein does not account for the results of the coordinated monitoring and research under the Adaptive Management Program and real-time operations that would be done

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[22] The study of Buchanan et al. (2015) occurred in 2012, when a rock barrier was in place at HOR, resulting in very few fish entering Old River (presumably through the barrier culverts), giving high uncertainty in the estimates of survival via the Old River route (which was not significantly different from survival in the San Joaquin River mainstem route). See also discussion by Anderson et al. (2012) for the Report of the 2012 Delta Science Program Independent Review Panel (IRP) on the Long-term Operations Opinions (LOO) Annual Review.

[23] Note that there is essentially no effect of south Delta exports on the proportion of flow (and fish) entering Georgiana Slough (Cavallo et al. 2015).

in order to limit potential operational effects to avoid jeopardy while maximizing water supplies, by assessing flow conditions in the context of fish presence, e.g., by using monitoring data from at or upstream of the Delta periphery (e.g., Knights Landing on the Sacramento River or Mossdale on the San Joaquin River).

For the Sacramento River, the junctions analyzed included Sutter and Steamboat Sloughs, for which less entry from the mainstem Sacramento River is actually a negative effect, as these are relatively high survival migration pathways that allow fish to avoid entry into the interior Delta (Perry et al. 2010; 2012), Georgiana Slough, and the DCC. The junctions off the mainstem San Joaquin River that were analyzed included the HOR, Turner Cut, Columbia Cut, Middle River, and mouth of Old River.

For the Sacramento River, the analysis of flow routing into channel junctions showed that at Sutter Slough, the most upstream junction, there generally would be little difference in proportion of flow entering the junction between NAA and PA, although in one case (December of critical years) the difference in median proportion was 5% less under PA (0.01 absolute difference) (Table 5.4-12). Slightly farther downstream at Steamboat Slough, there were more incidences of median proportion being >5% less under PA (0.01-0.02 less absolute difference in February and March of below normal and dry years). Differences in flow routing into the Delta Cross Channel in December to May are discountable because the gates are usually closed in these months[24], whereas there were negligible differences in June, when the gates are opened again (see summary of gate openings in Table 5.B.5-24 in Appendix 5.B, *DSM2 Methods and Results*). The proportion of flow entering Georgiana Slough under the PA was generally similar to (<5% difference) or somewhat greater than the proportion entering under NAA, with the largest difference between medians in March of dry years (11% more under the PA, or 0.04 in absolute terms).

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[24] However, in drought years temporary changes to DCC criteria could be made, as has occurred in recent years. See Section 3.7.1.2, *Recent Drought Management Actions*, in Chapter 3, *Description of the Proposed Action*, for further discussion.

Table 5.4-12. Median Daily Proportion of Flow Entering Important Delta Channels, from DSM2-HYDRO Modeling, with Green Shading Indicating PA is ≥5% Less than NAA and Red Shading Indicating PA is ≥5% More than NAA(Except for Sutter/Steamboat Sloughs, where Entry is Considered Beneficial and the Color Scheme is Reversed).

Junction	Water Year Type	December			January			February			March			April			May			June		
		NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
Sutter Slough (Entry is beneficial)	W	0.262	0.262	0.000 (0%)	0.264	0.263	-0.001 (0%)	0.267	0.265	-0.002 (-1%)	0.265	0.265	0.000 (0%)	0.263	0.263	0.000 (0%)	0.263	0.263	0.000 (0%)	0.219	0.193	-0.026 (-12%)
	AN	0.259	0.257	-0.002 (-1%)	0.261	0.261	0.000 (0%)	0.263	0.263	0.000 (0%)	0.262	0.263	0.001 (0%)	0.262	0.261	-0.001 (0%)	0.262	0.258	-0.004 (-2%)	0.181	0.174	-0.007 (-4%)
	BN	0.257	0.252	-0.005 (-2%)	0.259	0.258	-0.001 (0%)	0.261	0.261	0.000 (0%)	0.260	0.259	-0.001 (0%)	0.261	0.259	-0.002 (-1%)	0.240	0.238	-0.002 (-1%)	0.175	0.181	0.006 (3%)
	D	0.227	0.219	-0.008 (-4%)	0.256	0.254	-0.002 (-1%)	0.260	0.259	-0.001 (0%)	0.260	0.259	-0.001 (0%)	0.259	0.259	0.000 (0%)	0.242	0.239	-0.003 (-1%)	0.173	0.174	0.001 (1%)
	C	0.195	0.185	-0.010 (-5%)	0.254	0.247	-0.007 (-3%)	0.259	0.256	-0.003 (-1%)	0.249	0.239	-0.010 (-4%)	0.230	0.225	-0.005 (-2%)	0.199	0.195	-0.004 (-2%)	0.151	0.152	0.001 (1%)
Steamboat Slough (Entry is beneficial)	W	0.254	0.242	-0.012 (-5%)	0.278	0.272	-0.006 (-2%)	0.291	0.284	-0.007 (-2%)	0.277	0.270	-0.007 (-3%)	0.257	0.253	-0.004 (-2%)	0.252	0.249	-0.003 (-1%)	0.182	0.180	-0.002 (-1%)
	AN	0.207	0.203	-0.004 (-2%)	0.259	0.248	-0.011 (-4%)	0.279	0.272	-0.007 (-3%)	0.263	0.257	-0.006 (-2%)	0.238	0.229	-0.009 (-4%)	0.202	0.203	0.001 (0%)	0.164	0.169	0.005 (3%)
	BN	0.200	0.193	-0.007 (-4%)	0.213	0.209	-0.004 (-2%)	0.238	0.220	-0.018 (-8%)	0.218	0.205	-0.013 (-6%)	0.196	0.196	0.000 (0%)	0.192	0.194	0.002 (1%)	0.164	0.168	0.004 (2%)
	D	0.192	0.190	-0.002 (-1%)	0.199	0.197	-0.002 (-1%)	0.222	0.210	-0.012 (-5%)	0.232	0.212	-0.020 (-9%)	0.197	0.198	0.001 (1%)	0.192	0.194	0.002 (1%)	0.163	0.169	0.006 (4%)
	C	0.192	0.193	0.001 (1%)	0.198	0.196	-0.002 (-1%)	0.203	0.199	-0.004 (-2%)	0.193	0.194	0.001 (1%)	0.190	0.191	0.001 (1%)	0.191	0.193	0.002 (1%)	0.180	0.183	0.003 (2%)
Delta Cross Channel (Entry is adverse)	W	0.006	0.007	0.001 (17%)	0.004	0.004	0.000 (0%)	0.003	0.003	0.000 (0%)	0.004	0.004	0.000 (0%)	0.005	0.006	0.001 (20%)	0.006	0.006	0.000 (0%)	0.386	0.379	-0.007 (-2%)
	AN	0.009	0.010	0.001 (11%)	0.005	0.006	0.001 (20%)	0.004	0.004	0.000 (0%)	0.005	0.006	0.001 (20%)	0.007	0.008	0.001 (14%)	0.010	0.011	0.001 (10%)	0.432	0.426	-0.006 (-1%)
	BN	0.009	0.010	0.001 (11%)	0.009	0.009	0.000 (0%)	0.007	0.008	0.001 (14%)	0.008	0.009	0.001 (13%)	0.010	0.010	0.000 (0%)	0.011	0.011	0.000 (0%)	0.437	0.430	-0.007 (-2%)
	D	0.011	0.011	0.000 (0%)	0.010	0.010	0.000 (0%)	0.008	0.009	0.001 (13%)	0.008	0.009	0.001 (13%)	0.010	0.010	0.000 (0%)	0.011	0.011	0.000 (0%)	0.442	0.429	-0.013 (-3%)
	C	0.013	0.013	0.000 (0%)	0.010	0.010	0.000 (0%)	0.009	0.010	0.001 (11%)	0.011	0.011	0.000 (0%)	0.011	0.011	0.000 (0%)	0.012	0.013	0.001 (8%)	0.389	0.379	-0.010 (-3%)
Georgiana Slough (Entry is adverse)	W	0.314	0.342	0.028 (9%)	0.293	0.295	0.002 (1%)	0.291	0.292	0.001 (0%)	0.292	0.293	0.001 (0%)	0.302	0.304	0.002 (1%)	0.307	0.311	0.004 (1%)	0.396	0.393	-0.003 (-1%)
	AN	0.395	0.401	0.006 (2%)	0.304	0.327	0.023 (8%)	0.292	0.293	0.001 (0%)	0.299	0.302	0.003 (1%)	0.336	0.360	0.024 (7%)	0.417	0.405	-0.012 (-3%)	0.420	0.402	-0.018 (-4%)
	BN	0.411	0.418	0.007 (2%)	0.396	0.400	0.004 (1%)	0.339	0.379	0.040 (12%)	0.391	0.417	0.026 (7%)	0.424	0.416	-0.008 (-2%)	0.433	0.422	-0.011 (-3%)	0.414	0.412	-0.002 (0%)
	D	0.415	0.419	0.004 (1%)	0.421	0.423	0.002 (0%)	0.382	0.400	0.018 (5%)	0.366	0.406	0.040 (11%)	0.416	0.411	-0.005 (-1%)	0.432	0.423	-0.009 (-2%)	0.415	0.403	-0.012 (-3%)
	C	0.387	0.384	-0.003 (-1%)	0.412	0.428	0.016 (4%)	0.418	0.416	-0.002 (0%)	0.431	0.429	-0.002 (0%)	0.440	0.434	-0.006 (-1%)	0.404	0.397	-0.007 (-2%)	0.363	0.347	-0.016 (-4%)
Head of Old River (Entry is adverse)	W	0.649	0.642	-0.007 (-1%)	0.580	0.322	-0.258 (-44%)	0.537	0.282	-0.255 (-47%)	0.534	0.323	-0.211 (-40%)	0.525	0.259	-0.266 (-51%)	0.527	0.259	-0.268 (-51%)	0.515	0.497	-0.018 (-3%)
	AN	0.663	0.661	-0.002 (0%)	0.616	0.349	-0.267 (-43%)	0.577	0.280	-0.297 (-51%)	0.560	0.264	-0.296 (-53%)	0.529	0.253	-0.276 (-52%)	0.537	0.252	-0.285 (-53%)	0.530	0.474	-0.056 (-11%)
	BN	0.679	0.667	-0.012 (-2%)	0.635	0.342	-0.293 (-46%)	0.602	0.353	-0.249 (-41%)	0.611	0.289	-0.322 (-53%)	0.559	0.264	-0.295 (-53%)	0.581	0.279	-0.302 (-52%)	0.504	0.412	-0.092 (-18%)
	D	0.667	0.662	-0.005 (-1%)	0.647	0.362	-0.285 (-44%)	0.634	0.371	-0.263 (-41%)	0.629	0.385	-0.244 (-39%)	0.597	0.322	-0.275 (-46%)	0.602	0.335	-0.267 (-44%)	0.467	0.377	-0.090 (-19%)

Junction	Water Year Type	December			January			February			March			April			May			June		
		NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
	C	0.642	0.639	-0.003 (0%)	0.638	0.405	-0.233 (-37%)	0.622	0.383	-0.239 (-38%)	0.594	0.398	-0.196 (-33%)	0.567	0.393	-0.174 (-31%)	0.580	0.383	-0.197 (-34%)	0.367	0.307	-0.060 (-16%)
Turner Cut (Entry is adverse)	W	0.176	0.173	-0.003 (-2%)	0.176	0.181	0.005 (3%)	0.191	0.187	-0.004 (-2%)	0.197	0.190	-0.007 (-4%)	0.180	0.189	0.009 (5%)	0.177	0.187	0.010 (6%)	0.190	0.183	-0.007 (-4%)
	AN	0.171	0.169	-0.002 (-1%)	0.167	0.174	0.007 (4%)	0.175	0.185	0.010 (6%)	0.182	0.185	0.003 (2%)	0.170	0.188	0.018 (11%)	0.167	0.186	0.019 (11%)	0.173	0.173	0.000 (0%)
	BN	0.177	0.172	-0.005 (-3%)	0.165	0.168	0.003 (2%)	0.169	0.181	0.012 (7%)	0.169	0.181	0.012 (7%)	0.164	0.182	0.018 (11%)	0.161	0.176	0.015 (9%)	0.163	0.164	0.001 (1%)
	D	0.168	0.167	-0.001 (-1%)	0.164	0.170	0.006 (4%)	0.161	0.170	0.009 (6%)	0.159	0.168	0.009 (6%)	0.157	0.170	0.013 (8%)	0.157	0.168	0.011 (7%)	0.160	0.160	0.000 (0%)
	C	0.161	0.161	0.000 (0%)	0.161	0.167	0.006 (4%)	0.158	0.166	0.008 (5%)	0.152	0.159	0.007 (5%)	0.150	0.157	0.007 (5%)	0.151	0.158	0.007 (5%)	0.153	0.153	0.000 (0%)
Columbia Cut (Entry is adverse)	W	0.169	0.166	-0.003 (-2%)	0.166	0.163	-0.003 (-2%)	0.171	0.161	-0.010 (-6%)	0.173	0.157	-0.016 (-9%)	0.155	0.157	0.002 (1%)	0.155	0.157	0.002 (1%)	0.169	0.161	-0.008 (-5%)
	AN	0.166	0.164	-0.002 (-1%)	0.161	0.162	0.001 (1%)	0.165	0.165	0.000 (0%)	0.166	0.158	-0.008 (-5%)	0.153	0.160	0.007 (5%)	0.151	0.159	0.008 (5%)	0.164	0.161	-0.003 (-2%)
	BN	0.171	0.167	-0.004 (-2%)	0.160	0.158	-0.002 (-1%)	0.162	0.165	0.003 (2%)	0.161	0.164	0.003 (2%)	0.151	0.160	0.009 (6%)	0.149	0.158	0.009 (6%)	0.157	0.156	-0.001 (-1%)
	D	0.164	0.163	-0.001 (-1%)	0.159	0.161	0.002 (1%)	0.156	0.160	0.004 (3%)	0.153	0.158	0.005 (3%)	0.149	0.156	0.007 (5%)	0.148	0.154	0.006 (4%)	0.154	0.152	-0.002 (-1%)
	C	0.158	0.157	-0.001 (-1%)	0.157	0.160	0.003 (2%)	0.152	0.158	0.006 (4%)	0.147	0.151	0.004 (3%)	0.144	0.148	0.004 (3%)	0.144	0.149	0.005 (3%)	0.147	0.147	0.000 (0%)
Middle River (Entry is adverse)	W	0.189	0.186	-0.003 (-2%)	0.183	0.178	-0.005 (-3%)	0.185	0.174	-0.011 (-6%)	0.184	0.168	-0.016 (-9%)	0.167	0.168	0.001 (1%)	0.169	0.169	0.000 (0%)	0.186	0.176	-0.010 (-5%)
	AN	0.190	0.187	-0.003 (-2%)	0.180	0.178	-0.002 (-1%)	0.182	0.180	-0.002 (-1%)	0.183	0.173	-0.010 (-5%)	0.170	0.175	0.005 (3%)	0.170	0.174	0.004 (2%)	0.183	0.180	-0.003 (-2%)
	BN	0.194	0.189	-0.005 (-3%)	0.182	0.175	-0.007 (-4%)	0.180	0.180	0.000 (0%)	0.181	0.179	-0.002 (-1%)	0.171	0.176	0.005 (3%)	0.170	0.175	0.005 (3%)	0.178	0.177	-0.001 (-1%)
	D	0.188	0.186	-0.002 (-1%)	0.181	0.180	-0.001 (-1%)	0.179	0.178	-0.001 (-1%)	0.177	0.178	0.001 (1%)	0.171	0.175	0.004 (2%)	0.170	0.174	0.004 (2%)	0.176	0.175	-0.001 (-1%)
	C	0.180	0.180	0.000 (0%)	0.179	0.179	0.000 (0%)	0.175	0.176	0.001 (1%)	0.171	0.172	0.001 (1%)	0.169	0.172	0.003 (2%)	0.169	0.172	0.003 (2%)	0.170	0.170	0.000 (0%)
Mouth of Old River (Entry is adverse)	W	0.178	0.174	-0.004 (-2%)	0.177	0.172	-0.005 (-3%)	0.181	0.170	-0.011 (-6%)	0.177	0.164	-0.013 (-7%)	0.162	0.161	-0.001 (-1%)	0.163	0.161	-0.002 (-1%)	0.174	0.167	-0.007 (-4%)
	AN	0.174	0.172	-0.002 (-1%)	0.173	0.171	-0.002 (-1%)	0.175	0.172	-0.003 (-2%)	0.173	0.164	-0.009 (-5%)	0.159	0.162	0.003 (2%)	0.159	0.161	0.002 (1%)	0.171	0.169	-0.002 (-1%)
	BN	0.177	0.173	-0.004 (-2%)	0.168	0.164	-0.004 (-2%)	0.169	0.169	0.000 (0%)	0.165	0.164	-0.001 (-1%)	0.158	0.162	0.004 (3%)	0.158	0.161	0.003 (2%)	0.167	0.167	0.000 (0%)
	D	0.171	0.170	-0.001 (-1%)	0.167	0.166	-0.001 (-1%)	0.165	0.165	0.000 (0%)	0.162	0.163	0.001 (1%)	0.158	0.161	0.003 (2%)	0.158	0.160	0.002 (1%)	0.166	0.164	-0.002 (-1%)
	C	0.166	0.165	-0.001 (-1%)	0.166	0.166	0.000 (0%)	0.163	0.163	0.000 (0%)	0.157	0.159	0.002 (1%)	0.155	0.156	0.001 (1%)	0.156	0.158	0.002 (1%)	0.161	0.161	0.000 (0%)

For the San Joaquin River, the assumption of 50% closure of the PA's HOR gate from January to June 15, subject to RTO adjustments, led to appreciably less flow (~30-50%) entering Old River under the PA compared to NAA (Table 5.4-12). For Turner Cut, the next downstream junction, the proportion of flow entering the junction generally was greater under PA than NAA (median by water year type up to 11% greater, or 0.02 in absolute value), reflecting more flow remaining in the river main stem because of the HOR gate; this is consistent with the observations of Cavallo et al. (2015), who estimated (based on DSM2-HYDRO modeling) that more fish would enter the HOR with higher flow—for the PA, the flow that otherwise would have gone into Old River progresses to Turner Cut, thus producing a similar effect at that location. With movement downstream to other junctions, differences in flow routing into the junctions between NAA and PA were less which, as noted by Cavallo et al. (2015) reflects greater tidal influence; where lower proportions of flow entered the junctions under PA, this probably reflected less south Delta export pumping than NAA.

Overall, the analysis suggested that juvenile salmonids migrating down the Sacramento River would have somewhat greater potential to enter the interior Delta through Georgiana Slough, potentially resulting in adverse effects from the relatively low survival probability in that migration route. Minimization of this adverse effect would be undertaken with the installation of a nonphysical barrier at the Georgiana Slough junction (discussed in the next section). As previously noted, the summary of Delta hydrodynamic conditions based on DSM2 does not account for real-time operations that would be done in order to limit potential operational effects, by assessing flow conditions in the context of fish presence. Juvenile salmonids migrating down the San Joaquin River would, based on flow routing, potentially benefit from a HOR gate, which would considerably reduce entry into Old River and therefore reduce entrainment at the south Delta export facilities. Effects of the HOR gate in terms of near-field effects were discussed in Section 5.4.1.3.1.1.3, *Head of Old River Gate*.

5.4.1.3.1.2.1.2.2 Nonphysical Fish Barrier at Georgiana Slough

Installation of a nonphysical fish barrier at the Georgiana Slough junction would aim to minimize the potential for increased entry of fish into the junction caused by hydrodynamic changes because of the NDD, as described above. The probability of entry into Georgiana Slough is positively related to the location of the critical streakline, which is the streamwise division of flow vectors between the Sacramento River and Georgiana Slough (Perry et al. 2014). Occurrence of juvenile salmonids on the Sacramento River side of the critical streakline reduces the probability of entry into Georgiana Slough, so nonphysical barriers are installed such that their position increases the probability of juvenile salmonids remaining on the Sacramento River side of the critical streakline. The two types of nonphysical barrier with greatest potential for use at this junction are the Bioacoustic Fish Fence (BAFF) and Floating Fish Guidance Structure (FFGS); both have been tested at this location. A BAFF consists of acoustic deterrence stimuli broadcast from loudspeakers and contained within a bubble curtain that is illuminated with strobe lights (to allow the fish to orient away from the sound stimulus better). A BAFF was tested at Georgiana Slough in 2011 and 2012, using acoustically tagged juvenile salmonids. It was found that BAFF operations in 2011 reduced entry of late fall-run Chinook salmon into Georgiana Slough from 22.1% (0.221) to 7.4% (0.074), a reduction of around two thirds, and that operations in 2012 reduced entry of late fall-run Chinook salmon from 24.2% (0.242) to 11.8% (0.118), or a reduction of approximately half, with a similar reduction for steelhead (26.4% to 11.6%) (see summary by California Department of Water Resources 2015b: 3-11 to 3-

14). There is therefore potential to minimize adverse effects of hydrodynamic effects of the PA, given that the analysis of flow routing into Georgiana Slough based on DSM2-HYDRO data suggested potential increases in median proportional flow entry of up to 11-12% (see Table 5.4-12 in Section 5.4.1.3.1.2.1.2.1, *Flow Routing into Channel Junctions)* and some of the results of the through-Delta survival analyses show lower potential survival under the PA because of flow-survival relationships (see Section 5.4.1.3.1.2.1.3, *Through-Delta Survival*). Perry et al. (2013) illustrated that through-Delta survival of acoustically tagged juvenile late fall-run Chinook salmon could proportionally increase by 10-35% if interior Delta entry was eliminated, based on data for five of six releases they examined. This suggests that if an NPB reduced the probability of juvenile Chinook salmon taking the interior Delta pathway through Georgiana Slough by 50% (the lower of the two overall BAFF effectiveness estimates from 2011 and 2012), this could result in ~5-17% greater through-Delta survival.

However, it is important to consider several important limitations of the BAFF testing. First, the tested Chinook salmon were larger individuals (e.g., 110-140-mm fork length in 2011), which may result in better swimming ability and effectiveness of the BAFF relative to the smaller sizes of winter-run and spring-run Chinook salmon that would encounter the BAFF. Second, all fish were hatchery-raised, and therefore may have behaved differently than wild fish would in relation to a BAFF. Last, river flow in 2011 was very high, resulting in largely unidirectional, downstream flow, which could have improved BAFF effectiveness; however, the more variable flow conditions in 2012, including periods of reverse flow, illustrated that the BAFF has potential to be effective across a variety of environmental conditions if an engineering solution is desired.

In contrast to the BAFF, the FFGS tested at Georgiana Slough in 2014 showed limited effectiveness. At intermediate discharge (200-400 m^3/s; ~7,000-14,000 cfs), juvenile Chinook salmon entry into Georgiana Slough was five percentage points lower when the FFGS was turned on[25] (19.1% on; 23.9% off) (Romine et al. 2016). At higher discharge (>400 m^3/s), entry into Georgiana Slough was higher when the FFGS was turned on (19.3% on; 9.7% off), and at lower discharge (0-200 m^3/s) entry into Georgiana Slough was lower when the FFGS was turned on (43.7% on; 47.3% off). Overall entry into Georgiana Slough was 22% with the FFGS turned on, and 23% with the FFGS turned off. The results of the FFGS effectiveness study, coupled with the complex hydrodynamics of the Sacramento River-Georgiana Slough junction, suggest that dynamic deployment of an FFGS should be considered (Romine et al. 2016). For example, the greater entry into Georgiana Slough at higher flows could have been caused by turbulence around the structure, which could be decreased by angling the FFGS more toward shore at higher flows. Intermediate orientations, angles, lengths, and depths of FFGS could have resulted in different results. Overall, the results of the 2014 FFGS study suggest that this technology was less effective than the BAFF.

Effects of nonphysical barrier construction and near-field predation are discussed in Section 5.5.3, *Georgiana Slough Nonphysical Fish Barrier*.

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[25] In this study, “on” = FFGS angled towards the river channel to guide downstream-migrating juvenile Chinook salmon to the Sacramento River side of the critical streakline, “off” = FFGS angled parallel to the river bank in order to minimize any potential guiding effects (i.e., to provide a contrast to the “turned on” position).

5.4.1.3.1.2.1.3 Through-Delta Survival

Various analytical tools were used to provide greater biological context for the previously described operations-related differences in Delta hydrodynamics between the NAA and PA. These included the Delta Passage Model; analyses based on Newman (2003) and Perry (2010); the winter-run Chinook salmon life cycle models, IOS and OBAN; and the SalSim Through-Delta Survival Function. This section describes the principal results of these analyses. The tools were all focused on Chinook salmon, but the inferences from the results may be applicable to juvenile steelhead, given that there are similarities between Chinook salmon and steelhead with respect to at least some features of their Delta ecology (e.g., losses in Clifton Court Forebay [Gingras 1997; Clark et al. 2009] and relative loss by migration pathways through the Delta [Singer et al. 2013]) and their migration timing overlaps that of the listed juvenile Chinook salmon.

5.4.1.3.1.2.1.3.1 Delta Passage Model: Winter-Run and Sacramento River Basin Spring-Run Chinook Salmon

The Delta Passage Model (DPM) integrates operational effects of the NAA and PA that could influence survival of migrating juvenile winter-run and Sacramento River basin spring-run Chinook salmon through the Delta: differences in channel flows (flow-survival relationships), differences in routing based on flow proportions (e.g., entry into the interior Delta, where survival is lower), and differences in south Delta exports (export-survival relationships). Details of the DPM analysis are provided 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.D.1.2.2, *Delta Passage Model*. As with all such modeling tools, the DPM does not account for the results of the coordinated monitoring and research under the Adaptive Management Program and real-time operational adjustments that would occur in relation to fish presence, for example. The analysis was not applied to San Joaquin River basin spring-run Chinook salmon because the results for San Joaquin River fall-run Chinook salmon illustrate that the DPM results are influenced by proposed PA operations that are very different than those that have been observed in reality and upon which the modeled relationships are based (see Appendix 5.E., *Essential Fish Habitat*, Section 5.E.5.3.1.2.1.2.1, *Indirect Mortality within the Delta*). Instead, the SalSim through-Delta survival function was applied for estimating potential San Joaquin River basin spring-run Chinook salmon through-Delta survival (see Section 5.4.1.3.1.2.1.3.5, *SalSim Through-Delta Survival Function: San Joaquin River Basin Spring-Run Chinook Salmon*).

For winter-run Chinook salmon, the DPM results suggested that total through-Delta survival would be similar or lower under the PA than the NAA (Figure 5.4-8 and Figure 5.4-9). Mean total through-Delta survival under the PA ranged from 0.24 in critical years to 0.43 in wet years, with a range of 2% less than NAA in wet and above normal years to 7% less in dry years (Table 5.4-13). Mean survival down the mainstem Sacramento River route under the PA ranged from 0.26 in critical years to 0.46 in wet years, and the difference from NAA ranged from 4% less in critical years to 8% less in below normal and dry years, reflecting the influence of less river flow downstream of the NDD under the PA. As would be expected given that both scenarios assumed a notched Fremont Weir, Yolo Bypass entry was very similar between NAA and PA scenarios, and survival was identical (because the random draws from the route-specific survival distribution [Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of*

Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale, Section 5.D.1.2.2.2.5.4, *Route-Specific Survival*] were the same for NAA and PA). A slightly lower (1-2%) proportion of fish entered Sutter and Steamboat Sloughs under the PA compared to NAA (reflecting the flow routing into junctions; see Table 5.4-12 in Section 5.4.1.3.1.2.1.2.1, *Flow Routing into Channel Junctions*), and the difference in mean survival for this route between PA and NAA was similar to that of the mainstem Sacramento River, reflecting the similar flow-survival relationships in the relevant reaches (see Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.1.2.2.2.5.5, *Flow-Dependent Survival*). A slightly greater (1-2%[26]) proportion of fish used the interior Delta migration route under the PA compared to NAA (again reflecting the flow routing into junctions; see Table 5.4-12- in Section 5.4.1.3.1.2.1.2.1, *Flow Routing into Channel Junctions*), and mean survival in this route was appreciably greater (19-28%) in wet and above normal years, which reflected appreciably less south Delta exports under the PA[27].

Seventy-five randomized iterations of the DPM allowed 95% confidence intervals to be calculated for the annual estimates of through-Delta survival (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale,* Section 5.D.1.2.2.4, *Randomization to Illustrate Uncertainty*); of the 81 years in the simulation, the PA and NAA had non-overlapping confidence intervals in 10 years and all were lower under the PA (Figure 5.4-10). Of the 10 years, 3 were wet years (12% of all wet years), 1 was an above normal year (8% of all above normal years), 2 were below normal years (18% of all below normal years), 4 were dry years (20% of all dry years), and none were critical years. This suggests that the magnitudes of difference observed from the DPM would be most likely to be statistically detectable in below normal or dry years, although it is acknowledged that the DPM incorporates flow-survival and other relationships from a variety of studies and its measures of uncertainty are drawn from these relationships[28]; an integrated field study of through-Delta survival during PA implementation

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[26] To provide perspective on the actual number of fish that the 1-2% entering the interior Delta would represent, estimates of the number of juveniles entering the Delta are necessary. Such numbers are calculated on an annual basis by NMFS for the purposes of calculating allowable incidental take of winter-run Chinook salmon. NMFS estimated that between c. 124,500 and 3,739,000 juvenile winter-run Chinook salmon entered the Delta annually over the past decade (data from the NMFS [2014] Floating Fish Guidance Structure BiOp, plus updates for 2015 based on the 2016 NMFS letter to Reclamation estimating the JPE [Available: http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/winter-run_juvenile_production_estimate__jpe__-_january_28__2016.pdf, accessed March 11, 2016]).

[27] In addition, the DPM's export-survival relationship does not calculate absolute survival, but a ratio of survival in the interior Delta to survival in reach Sac3 (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.1.2.2.2.5.6, *Export-Dependent Survival*), and in wetter years the difference in survival in reach Sac3 between NAA and PA begins to level off as the flow-survival relationship begins to asymptote (Figure 5.D-45 in Appendix 5.D), so that less south Delta exports have a greater effect on survival at greater Sacramento River flows.

[28] As noted in the independent review panel report for the working draft BA, it is possible that the true annual values could lie near the bottom boundary of the confidence interval for PA and near the top boundary of the confidence interval for NAA (Simenstad et al. 2016). This would result in greater differences than suggested by the comparison of annual mean values. By the same rationale, it is also possible that the true annual values could lie near the top boundary of the confidence intervals for both PA and NAA, in which case the differences would be more similar to the differences between means.

would not necessarily have similar uncertainty in survival estimates. In addition, the operations modeling included a wider range of conditions than occurred during the field studies upon which the DPM model relationships were based, which contributes to the uncertainty. To provide insight into the conditions leading to years with non-overlapping confidence intervals, mean flow into reach Sac 3 (Sacramento River downstream of Georgiana Slough)[29] and south Delta exports, both weighted by proportion of the population entering the Delta, were plotted in relation to years with overlapping confidence intervals. This illustrated that years with non-overlapping confidence intervals were found in the range of weighted mean Sacramento River flow into reach Sac3 of ~7,000-12,500 cfs for NAA and ~5,500-10,000 cfs for PA (Figure 5.4-11). This corresponds closely with weighted mean flows in below normal years (NAA: 7,826 cfs; PA: 6,687 cfs) and dry years (NAA: 7,116 cfs; PA: 6,048 cfs), which is logical given that these had the greatest differences in survival (Table 5.4-13). In years with less flow, there are greater constraints on north Delta exports, whereas in wetter years, the rate of change in survival per unit of river flow decreases (Figure 5.D-45 in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*). Therefore, there would be the greatest potential for adverse effects in below normal and dry years. As previously stated this analysis does not account for the results of the coordinated monitoring and research under the Adaptive Management Program and real-time operational adjustments that would be made in response to fish presence, which would seek to maximize water supplies while limiting potential adverse effects as appropriate to avoid jeopardy.

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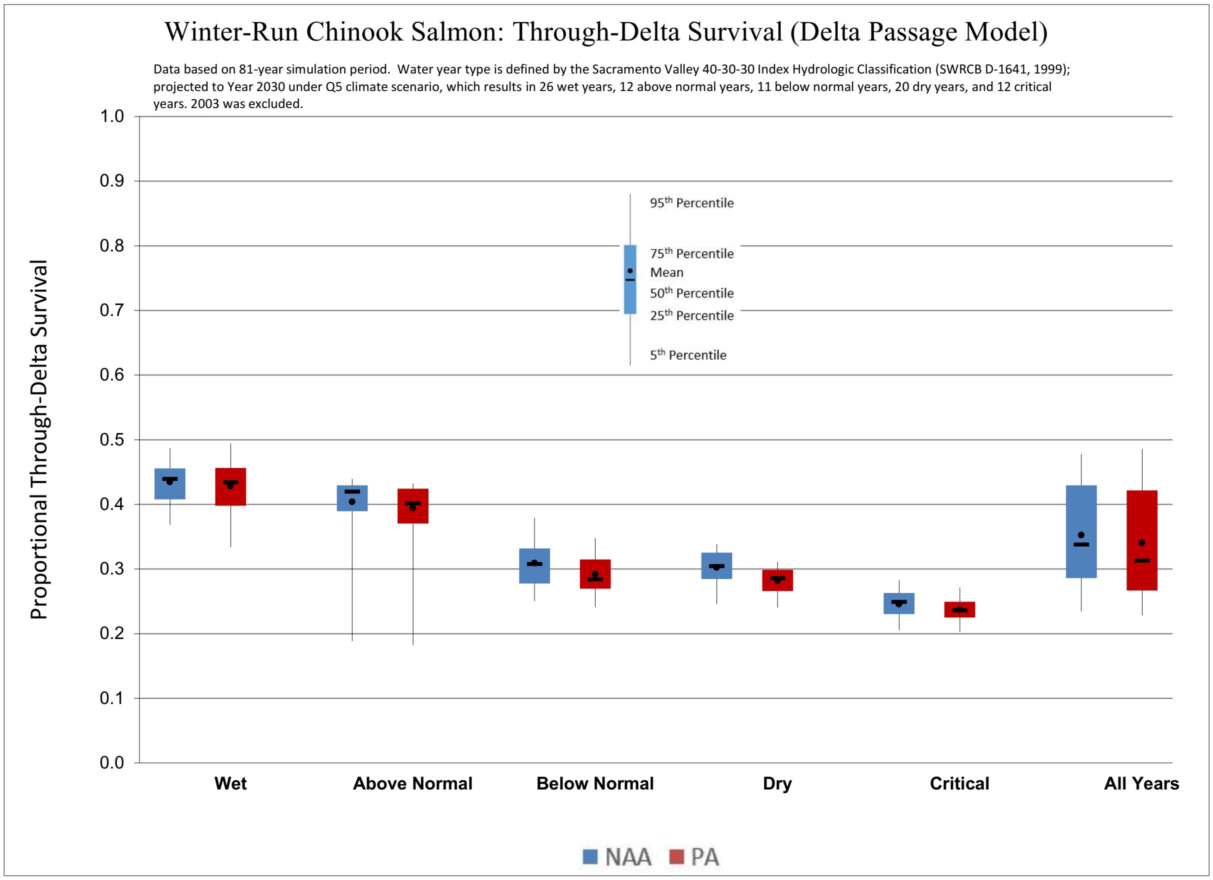
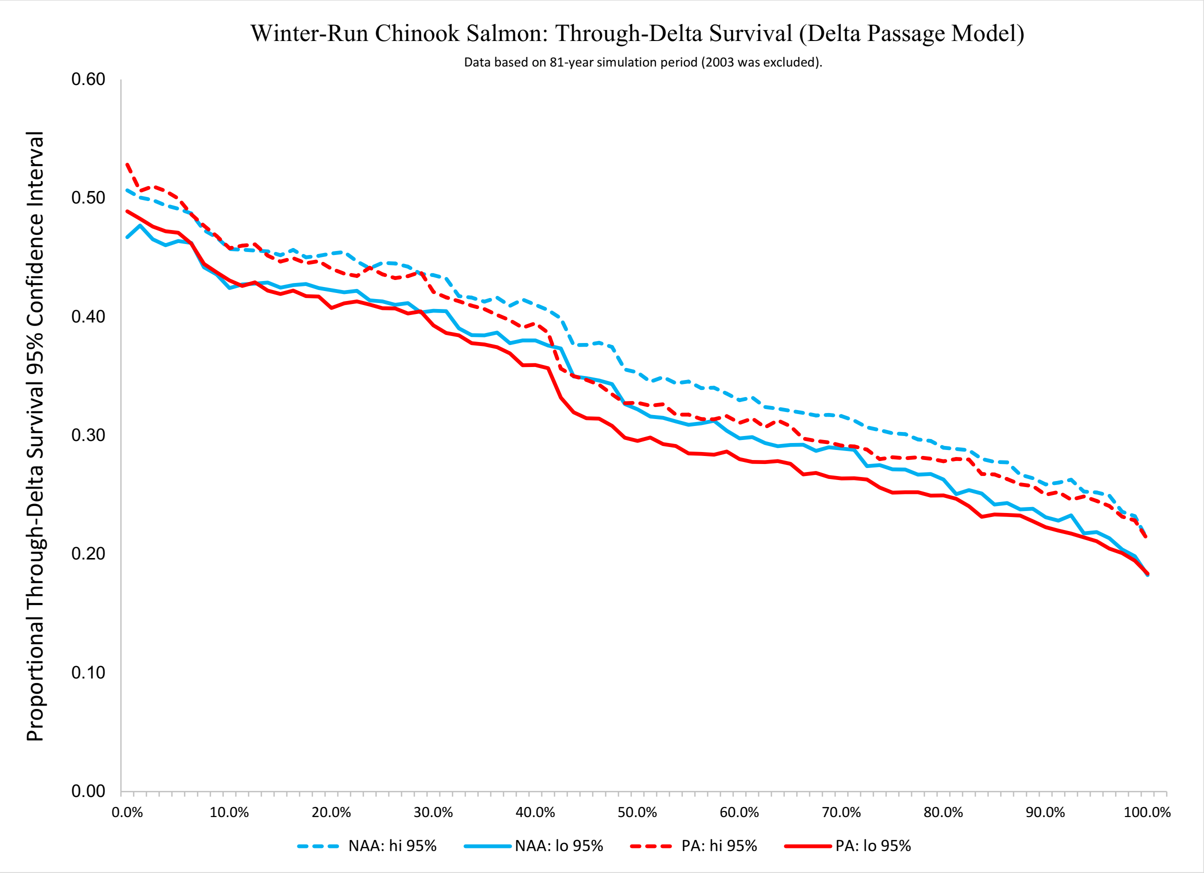
[29] This reach was chosen because it is the basis for the Sacramento River flow-survival relationships in the DPM, from Perry (2010).



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-8. Box Plots of Winter-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model, Grouped by Water Year Type.



Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

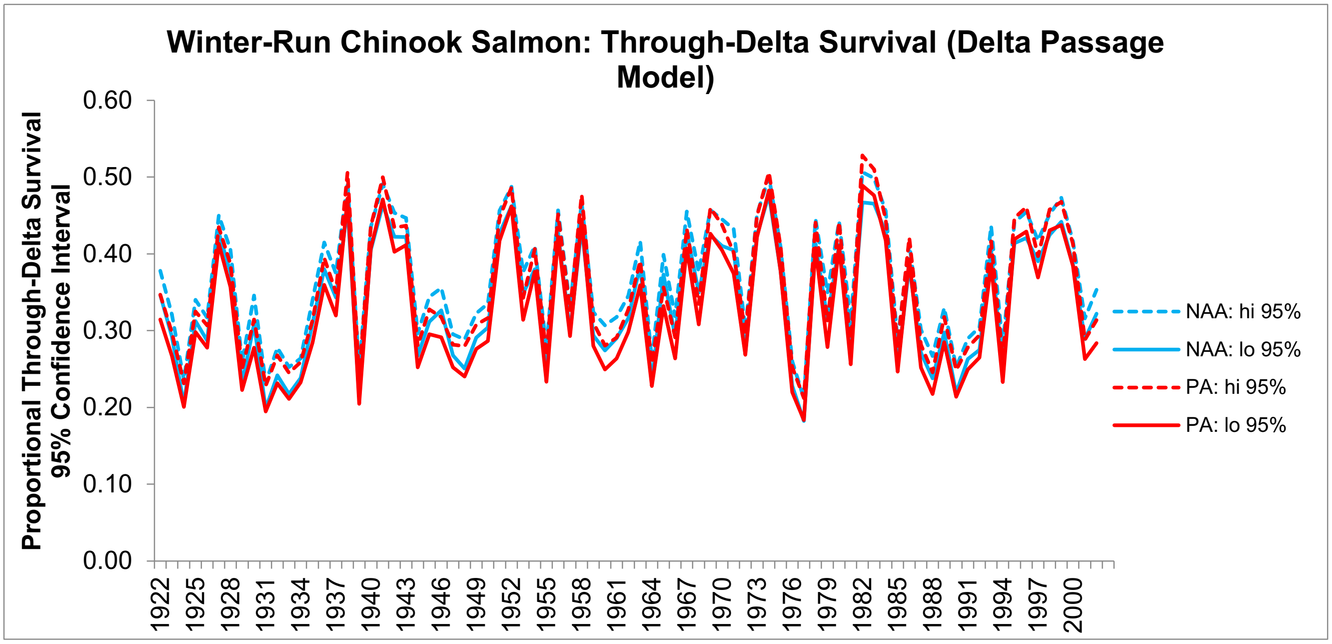
Figure 5.4-9. Exceedance Plot of Winter-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model.

Table 5.4-13. Delta Passage Model: Winter-Run Chinook Salmon Mean Through-Delta (Total) Survival, Mainstem Sacramento River survival, and Proportion Using and Surviving Other Migration Routes.

WY	Total Survival			Mainstem Sacramento River Survival			Yolo Bypass					
							Proportion Using Route			Survival		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.43	0.43	-0.01 (-2%)	0.48	0.46	-0.02 (-5%)	0.22	0.22	0.00 (1%)	0.47	0.47	0.00 (0%)
AN	0.40	0.39	-0.01 (-2%)	0.44	0.42	-0.02 (-6%)	0.16	0.17	0.00 (1%)	0.47	0.47	0.00 (0%)
BN	0.31	0.29	-0.02 (-6%)	0.34	0.31	-0.03 (-8%)	0.06	0.06	0.00 (2%)	0.47	0.47	0.00 (0%)
D	0.30	0.28	-0.02 (-7%)	0.33	0.30	-0.03 (-8%)	0.06	0.06	0.00 (2%)	0.47	0.47	0.00 (0%)
C	0.25	0.24	-0.01 (-4%)	0.27	0.26	-0.01 (-4%)	0.03	0.03	0.00 (0%)	0.47	0.47	0.00 (0%)

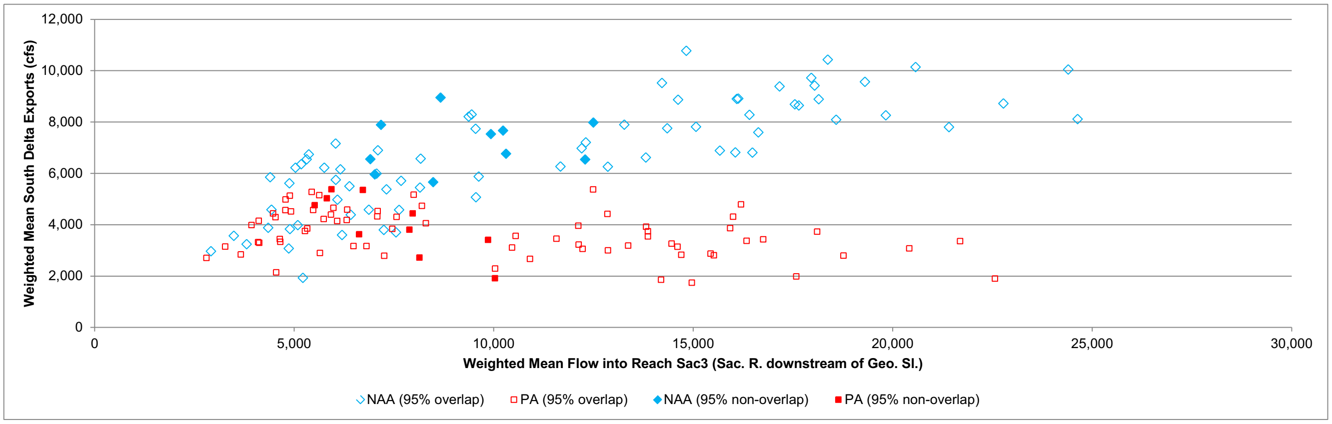
WY	Sutter/Steamboat Sloughs						Interior Delta (Via Georgiana Slough/DCC)					
	Proportion Using Route			Survival			Proportion Using Route			Survival		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.29	0.28	-0.01 (-2%)	0.52	0.50	-0.02 (-4%)	0.26	0.26	0.00 (2%)	0.18	0.23	0.05 (28%)
AN	0.30	0.29	-0.01 (-2%)	0.49	0.46	-0.02 (-5%)	0.26	0.27	0.01 (2%)	0.17	0.20	0.03 (19%)
BN	0.31	0.30	-0.01 (-2%)	0.38	0.35	-0.03 (-7%)	0.27	0.28	0.01 (2%)	0.14	0.15	0.01 (5%)
D	0.30	0.30	-0.01 (-2%)	0.37	0.34	-0.03 (-8%)	0.27	0.28	0.01 (2%)	0.14	0.14	0.00 (0%)
C	0.29	0.29	0.00 (-1%)	0.31	0.30	-0.01 (-4%)	0.29	0.29	0.00 (1%)	0.13	0.12	0.00 (-1%)

Note: Survival in Sutter/Steamboat Sloughs and Interior Delta routes includes survival in the Sacramento River prior to entering the channel junctions.



Note: Lines indicate 95% confidence intervals from the 75 iterations of the DPM.

Figure 5.4-10. Time Series of 95% Confidence Interval Annual Juvenile Winter-Run Chinook Salmon Through-Delta Survival Estimated from the Delta Passage Model.



Note: 95% overlap and non-overlap refers to years with overlapping and non-overlapping confidence intervals from DPM.

Figure 5.4-11. Delta Passage Model: Annual mean Sacramento River Flow into Reach Sac3 (Downstream of Georgiana Slough) and South Delta Exports, Weighted by Proportional Entry into the Delta of Winter-Run Chinook Salmon, Classified into Years of Overlapping and Non-overlapping Through-Delta Survival 95% Confidence Intervals.

For spring-run Chinook salmon, the DPM results suggested that through-Delta survival under the PA would be similar to or lower than the NAA (Figure 5.4-12 and Figure 5.4-13), with the differences being less than those for winter-run Chinook salmon. Mean total through-Delta survival under the PA ranged from 0.22 in critical years to 0.42 in wet years, with a range of 1% less than NAA in wet and critical years to 4% less in dry years (Table 5.4-14). Mean survival down the mainstem Sacramento River route under the PA ranged from 0.23 in critical years to 0.44 in wet years, and the difference from NAA ranged from 1% less in critical years to 5% less in above normal and dry years, reflecting the influence of less river flow downstream of the NDD under the PA. Yolo Bypass entry was similar between NAA and PA scenarios (both assumed a notched weir), and survival was identical (because the random draws from the route-specific survival distribution [Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale,* Section 5.D.1.2.2.2.5.4, *Route-Specific Survival*] were the same for NAA and PA). A slightly lower (0-2%) proportion of fish entered Sutter and Steamboat Sloughs under the PA compared to NAA (reflecting the flow routing into junctions; see Table 5.4-12 in Section 5.4.1.3.1.2.1.2.1, *Flow Routing into Channel Junctions*), and the difference in mean survival for this route between PA and NAA was similar to that of the mainstem Sacramento River, reflecting the similar flow-survival relationships in the relevant reaches (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.1.2.2.2.5, *Flow-Dependent Survival*). A similar or slightly greater (1-2%) proportion of fish used the interior Delta migration route under the PA compared to NAA (again reflecting the flow routing into junctions; see Table 5.4-12 in Section 5.4.1.3.1.2.1.2.1, *Flow Routing into Channel Junctions*), and mean survival in this route was greater (11–19%) in wet and above normal years, which reflected appreciably less south Delta exports under the PA.

As noted for winter-run Chinook salmon, seventy-five randomized iterations of the DPM allowed 95% confidence intervals to be calculated for the annual estimates of through-Delta survival (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale,* Section 5.D.1.2.2.4, *Randomization to Illustrate Uncertainty*). The 95% confidence intervals for NAA and PA overlapped in all years (Figure 5.4-14), illustrating that the magnitude of differences may be difficult to detect statistically if field studies were undertaken during PA implementation to assess effects[30]. The spring-run Chinook salmon DPM results suggested small differences in survival under the PA compared to NAA, whereas the analysis based on Newman (2003) (discussed in the next section) suggested that differences in survival would be largely undetectable (despite the Delta same entry timing being used for both). This reflects model differences (with further discussion being provided for the analysis based on Newman [2003] in the next section): in the DPM, the benefits of less south Delta exports under the PA are only experienced by the proportion of the population entering the interior Delta (0.25-0.30 take this route), whereas for the analysis based on Newman (2003), the effect of exports is applied to the

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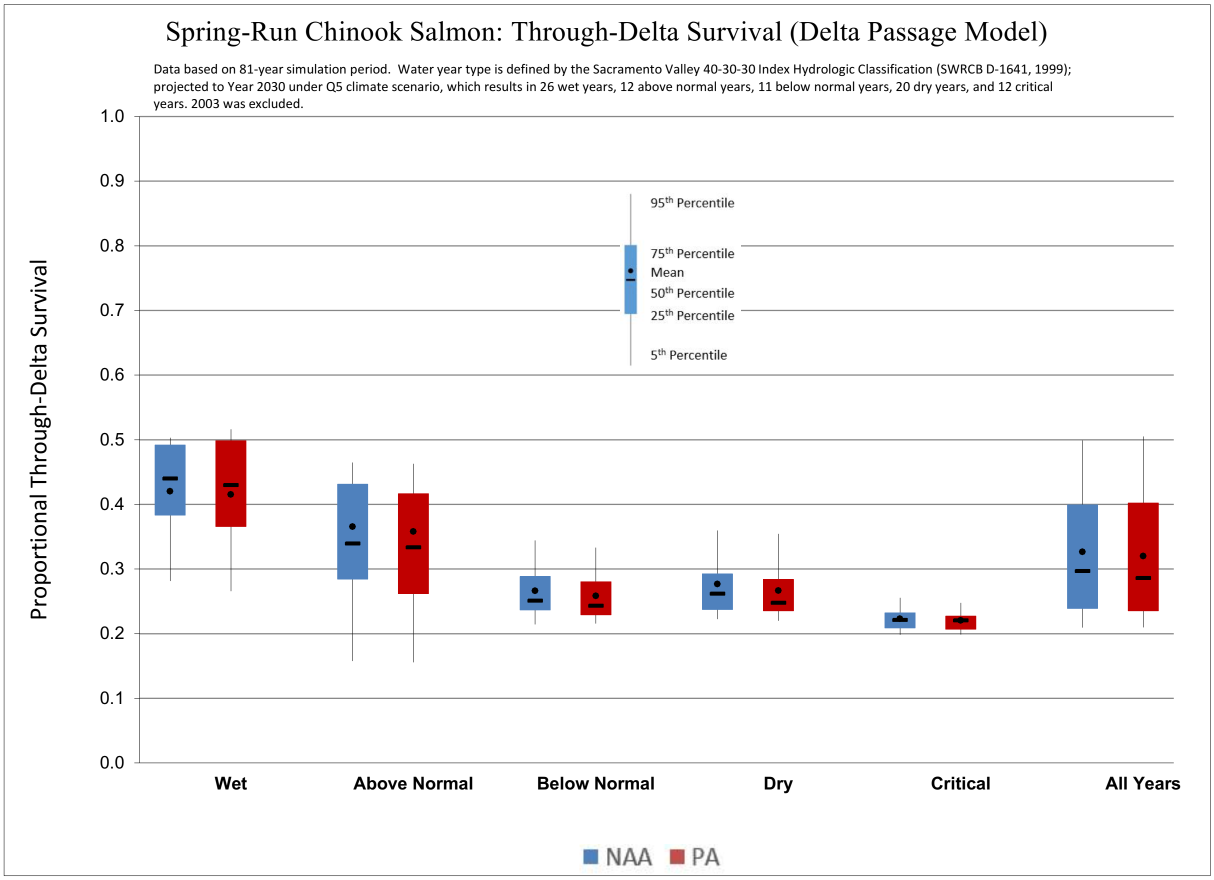
[30] As noted for winter-run Chinook salmon, it is acknowledged that the DPM incorporates flow-survival and other relationships from a variety of studies and its measures of uncertainty are drawn from these relationships; an integrated field study of through-Delta survival during PA implementation would not necessarily have similar uncertainty in survival estimates.

entire population; and in the DPM, the export-survival effect is weaker than the flow-survival effect (Model Demonstration results 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.D.1.2.2.5.2.3, *Model Demonstration*) and is calculated as a ratio of survival in reach Sac3 (which is lower because of the NDD), whereas as discussed in the following section, in the analysis based on Newman (2003) the export-survival effect is similar in magnitude to the flow-survival effect—the "offsetting" of south and north Delta exports results in similar survival under PA and NAA for the analysis based on Newman (2003). Further discussion of these issues and the Sacramento River flow and south Delta exports during the spring-run Chinook salmon migration period used for the DPM are provided in the analysis based on Newman (2003), which is found in the next section. Overall, the DPM results suggested the potential for a small negative effect on spring-run Chinook salmon juveniles from the PA but, as previously stated for winter-run Chinook salmon, this analysis does not account for the results of the coordinated monitoring and research under the Adaptive Management Program and real-time operational adjustments that would be made in response to fish presence, which would seek to maximize water supplies while limiting potential adverse effects as appropriate to avoid jeopardy.

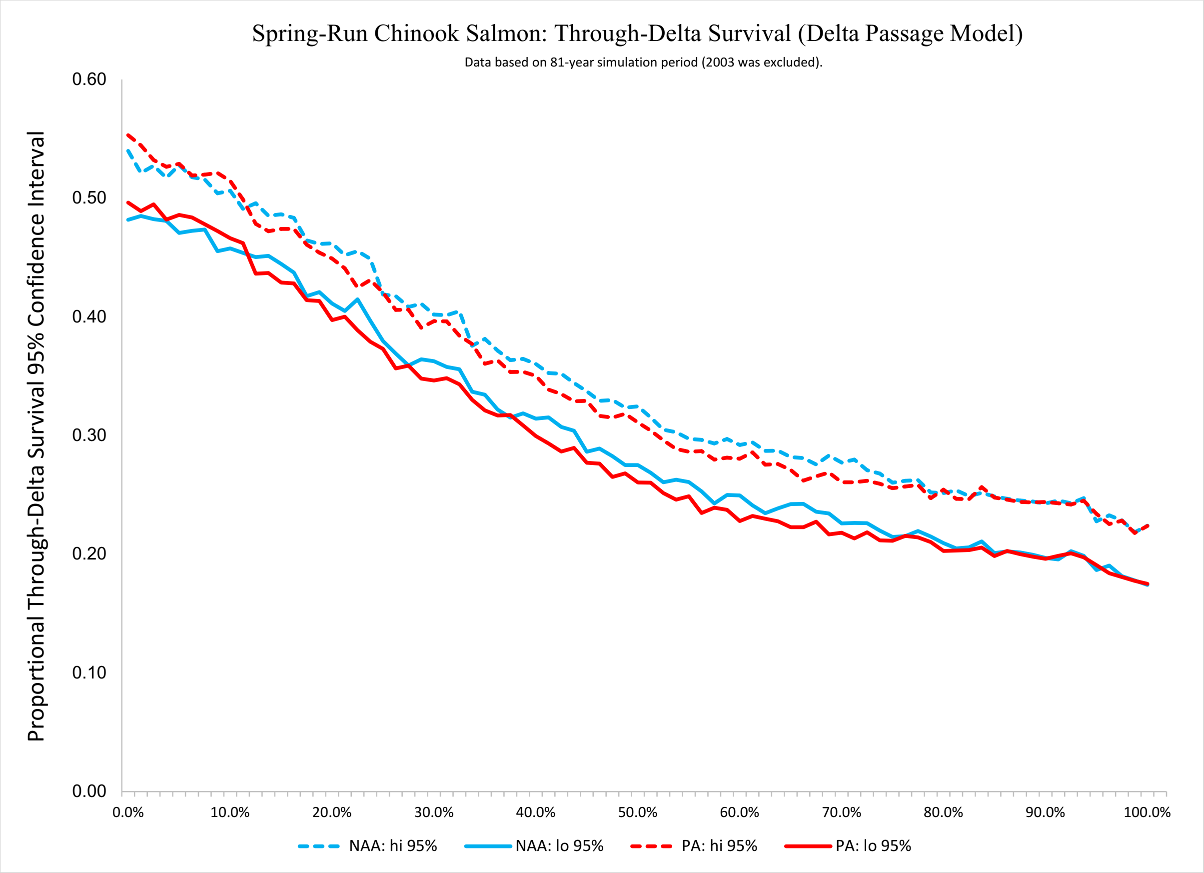
Table 5.4-14. Delta Passage Model: Spring-Run Chinook Salmon Mean Through-Delta (Total) Survival, Mainstem Sacramento River survival, and Proportion Using and Surviving Other Migration Routes.

WY	Total Survival			Mainstem Sacramento River Survival			Yolo Bypass					
							Proportion Using Route			Survival		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.42	0.42	0.00 (-1%)	0.46	0.44	-0.02 (-4%)	0.19	0.19	0.00 (1%)	0.47	0.47	0.00 (0%)
AN	0.37	0.36	-0.01 (-2%)	0.39	0.37	-0.02 (-5%)	0.13	0.14	0.01 (5%)	0.47	0.47	0.00 (0%)
BN	0.27	0.26	-0.01 (-3%)	0.29	0.28	-0.01 (-4%)	0.04	0.04	0.00 (-2%)	0.47	0.47	0.00 (0%)
D	0.28	0.27	-0.01 (-4%)	0.30	0.28	-0.01 (-5%)	0.05	0.05	0.00 (-1%)	0.47	0.47	0.00 (0%)
C	0.22	0.22	0.00 (-1%)	0.24	0.23	0.00 (-1%)	0.03	0.03	0.00 (-2%)	0.47	0.47	0.00 (0%)
WY	Sutter/Steamboat Sloughs						Interior Delta (Via Georgiana Slough/DCC)					
	Proportion Using Route			Survival			Proportion Using Route			Survival		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.29	0.28	0.00 (-1%)	0.50	0.48	-0.02 (-4%)	0.26	0.26	0.00 (1%)	0.21	0.25	0.04 (19%)
AN	0.29	0.29	-0.01 (-2%)	0.43	0.41	-0.02 (-4%)	0.27	0.27	0.00 (1%)	0.19	0.21	0.02 (11%)
BN	0.30	0.30	0.00 (-1%)	0.32	0.31	-0.01 (-4%)	0.28	0.28	0.00 (1%)	0.15	0.15	0.00 (2%)
D	0.30	0.29	0.00 (-1%)	0.34	0.32	-0.01 (-4%)	0.28	0.28	0.00 (1%)	0.15	0.15	0.00 (1%)
C	0.28	0.28	0.00 (0%)	0.28	0.27	0.00 (-1%)	0.30	0.30	0.00 (0%)	0.13	0.13	0.00 (1%)
Note: Survival in Sutter/Steamboat Sloughs and Interior Delta routes includes survival in the Sacramento River prior to entering the channel junctions.												



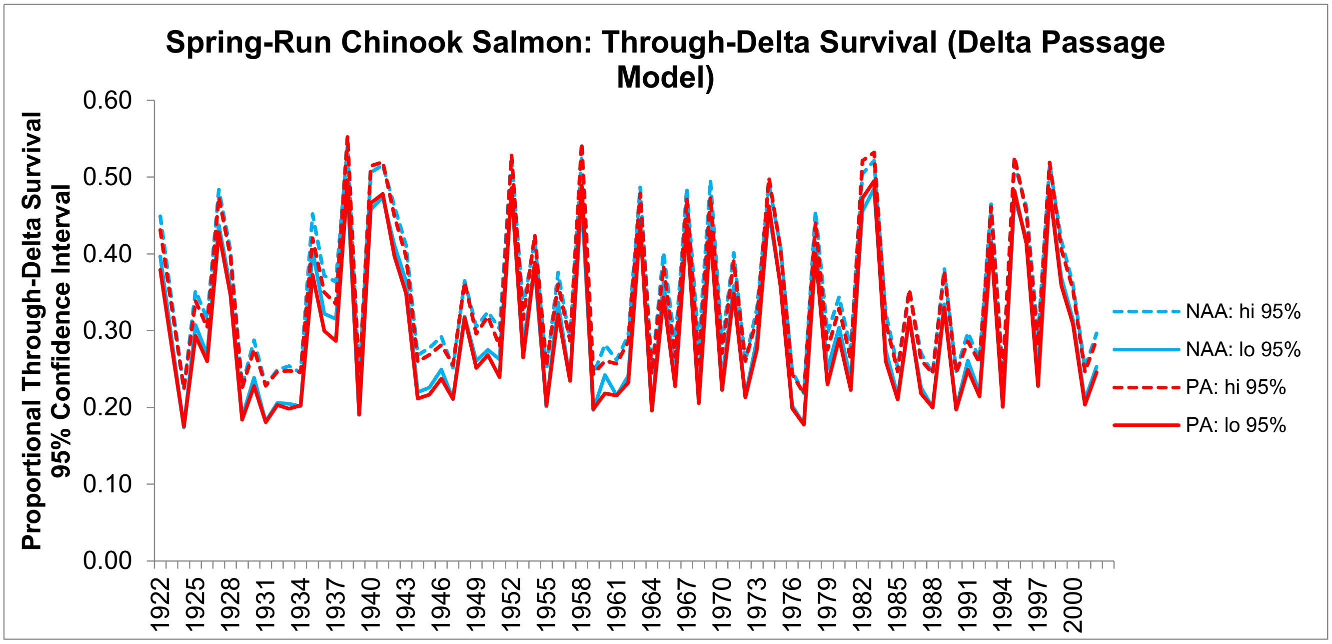
Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-12. Box Plots of Spring-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model, Grouped by Water Year Type.



Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 5.4-13. Exceedance Plot of Spring-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Delta Passage Model.



Note: Lines indicate 95% confidence intervals from the 75 iterations of the DPM.

Figure 5.4-14. Time Series of 95% Confidence Interval Annual Juvenile Spring-Run Chinook Salmon Through-Delta Estimated from the Delta Passage Model.

5.4.1.3.1.2.1.3.2 Analysis Based on Newman (2003): Sacramento River Spring-Run Chinook Salmon

In addition to the DPM, an analysis based on Newman (2003) was undertaken to assess the potential effects of the PA on juvenile spring-run Chinook salmon migrating through the Delta from the Sacramento River basin. The method is described further 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.D.1.2.3, *Analysis Based on Newman (2003)*, but essentially allows estimation of through-Delta survival as a function of river flow (Sacramento River below the NDD, to capture flow-survival effects), south Delta exports, and other covariates, including salinity, turbidity, DCC position, and water temperature. As noted in Appendix 5.D, the analysis does not include winter-run Chinook salmon because the data used by Newman (2003) were derived from studies of smolts released during the main fall-run/spring-run Chinook salmon migration period, which is after the main winter-run migration period, and the method requires water temperature data. Note that the analysis based on Newman (2003) does not include representation of near-field mortality effects from the NDD (e.g., predation or impingement at the NDD), but instead focuses on far-field effects.

The results of the analysis based on Newman (2003) suggested that difference in overall mean survival between the NAA and PA for spring-run Chinook salmon would be very small across all water year types (Figure 5.4-15, Figure 5.4-16, Figure 5.4-17). When examined by NDD bypass flow level, the minor differences between NAA and PA were also apparent (Table 5.4-15)[31].

The results are driven by several factors. The timing of spring-run Chinook salmon entry into the Delta was assumed to be the same as that used for the DPM, for which entry occurs during spring (March–May), with a pronounced unimodal peak in April (Figure 5.D-42 in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*). During April under the PA, south Delta exports and Sacramento River flow downstream of the NDD are similar in their absolute differences from the NAA (Table 5.4-16; for additional south Delta exports information, see also Figures 5.A.6-27-1 to 5.A.6-27-6, Figures 5.A.6-27-7 to 5.A.6-27-19, and Table 5.A.6-27 in Appendix 5.A, *CalSim II Modeling and Results*). In other words, less Sacramento River flow downstream of the NDD is offset by less south Delta exports. The analysis based on Newman (2003) includes a rate of change in juvenile Chinook salmon survival per unit of flow that is similar for the Sacramento River and south Delta exports (see Figure 5.D-61 in Appendix 5.D), so that a similar change in Sacramento River flows (less) and exports (less) results in similar survival, as the analysis showed.[32] As noted in the previous section describing the DPM results, this results in differences in the results compared to DPM results, for which survival under PA was slightly lower than under NAA.

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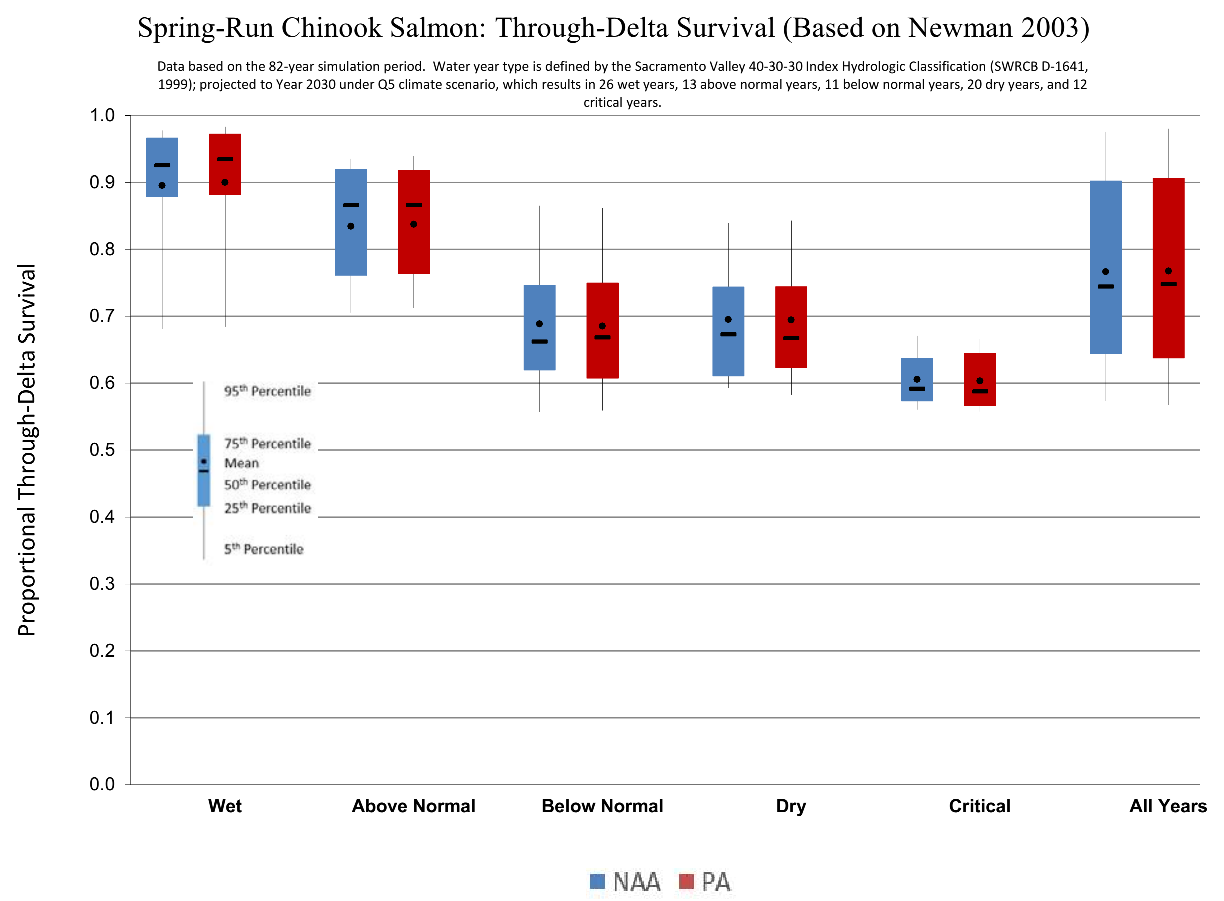
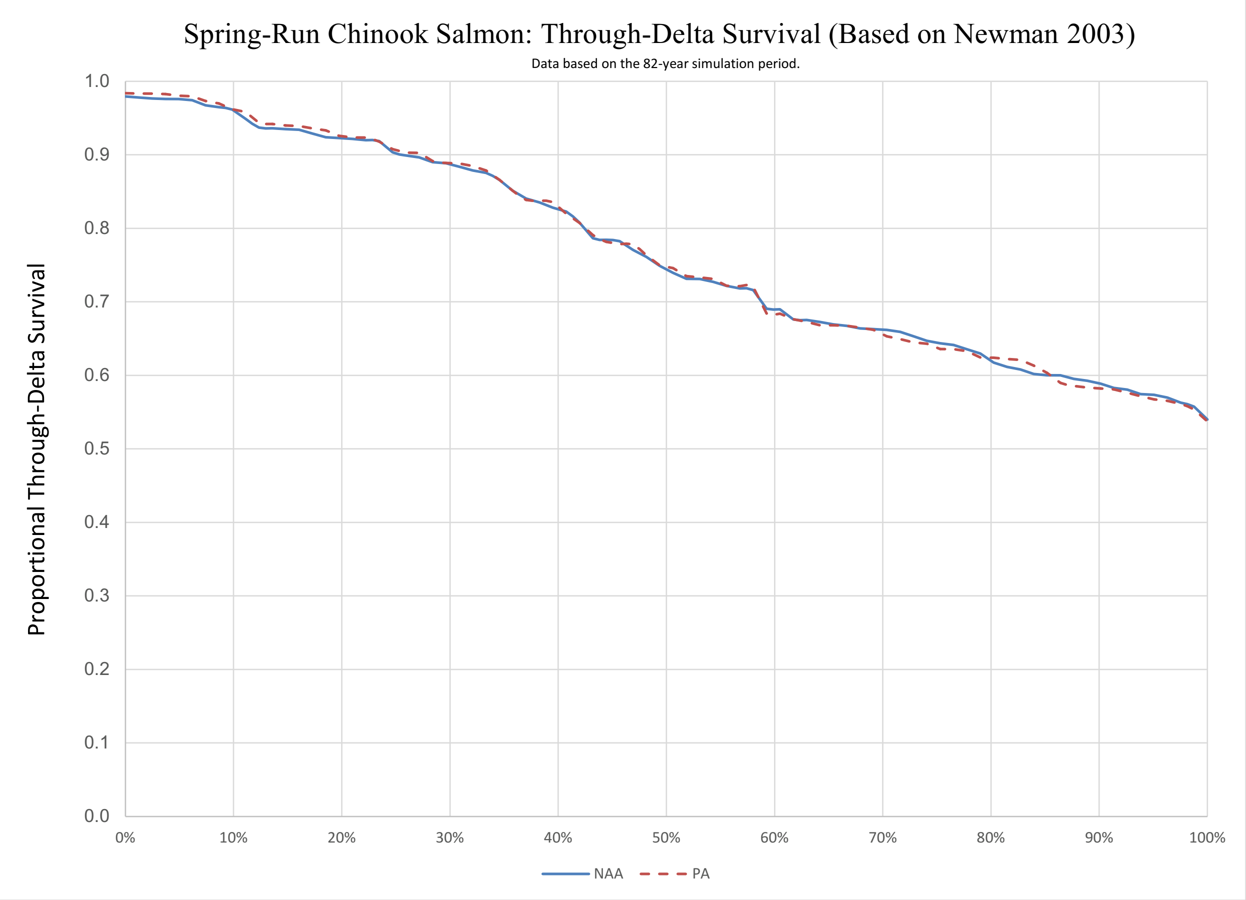
[31] Based on agency request, an unweighted version of these data is presented in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.1.2.3.3, *Results* (Table 5.D-46), which again shows the similarity between NAA and PA.

[32] The relative effect of south Delta exports and Sacramento River flow downstream of the NDD are illustrated in Figure 5.D-64 in Appendix 5.D, Section 5.D.1.2.3, *Analysis Based on Newman (2003).*



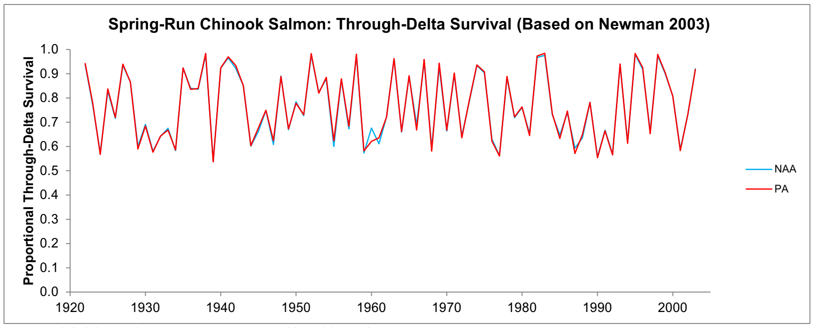
Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-15. Box Plots of Spring-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Analysis Based on Newman (2003), Grouped by Water Year Type.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-16. Exceedance Plot of Spring-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Analysis Based on Newman (2003).



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-17. Time Series of Spring-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Analysis Based on Newman (2003).

Table 5.4-15. Mean Annual Spring-Run Chinook Salmon Weighted Annual Through-Delta Survival Estimated from the Analysis Based on Newman (2003), Divided into Each NDD Bypass Flow Level.

WY	Pulse protection flows			Level 1 bypass flows			Level 2 bypass flows			Level 3 bypass flows			Total		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.00	0.00	0.00 (0%)	0.00	0.00	0.00 (2%)	0.04	0.04	0.00 (1%)	0.85	0.85	0.00 (0%)	0.90	0.90	0.00 (0%)
AN	0.00	0.00	0.00 (1%)	0.01	0.01	0.00 (0%)	0.06	0.06	0.00 (2%)	0.77	0.77	0.00 (0%)	0.83	0.84	0.00 (0%)
BN	0.00	0.00	0.00 (0%)	0.25	0.24	0.00 (-1%)	0.31	0.31	0.00 (0%)	0.13	0.13	0.00 (-1%)	0.69	0.69	0.00 (0%)
D	0.00	0.00	0.00 (-1%)	0.21	0.21	0.00 (0%)	0.39	0.39	0.00 (0%)	0.09	0.09	0.00 (0%)	0.69	0.69	0.00 (0%)
C	0.01	0.01	0.00 (-1%)	0.51	0.50	0.00 (-1%)	0.09	0.09	0.00 (1%)	0.00	0.00	0.00 (0%)	0.61	0.60	0.00 (0%)

Table 5.4-16. Mean South Delta Exports and Sacramento River Flow Downstream of the NDD in March-May, by Water-Year Type.

WY	South Delta Exports									Sacramento River Flow Downstream of the NDD (Bypass Flows)								
	March			April			May			March			April			May		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	9,461	1,706	-7,755 (-82%)	2,977	395	-2,582 (-87%)	3,378	570	-2,808 (-83%)	47,988	40,145	-7,844 (-16%)	34,998	32,406	-2,592 (-7%)	29,839	26,747	-3,092 (-10%)
AN	7,826	902	-6,924 (-88%)	1,801	369	-1,432 (-80%)	1,720	411	-1,309 (-76%)	40,801	34,100	-6,700 (-16%)	24,080	22,944	-1,136 (-5%)	16,711	15,444	-1,266 (-8%)
BN	6,089	3,825	-2,264 (-37%)	1,774	1,340	-435 (-24%)	1,624	1,034	-590 (-36%)	18,542	15,051	-3,492 (-19%)	14,076	13,607	-469 (-3%)	12,460	12,027	-433 (-3%_
D	4,868	3,619	-1,249 (-26%)	2,052	1,493	-559 (-27%)	2,054	1,337	-717 (-35%)	21,284	17,259	-4,025 (-19%)	14,895	14,348	-547 (-4%)	11,633	11,382	-251 (-2%_
C	2,701	2,139	-561 (-21%)	1,430	1,267	-163 (-11%)	1,415	1,207	-208 (-15%)	12,529	11,683	-846 (-7%)	10,290	10,144	-147 (-1%)	8,214	8,031	-184 (-2%)

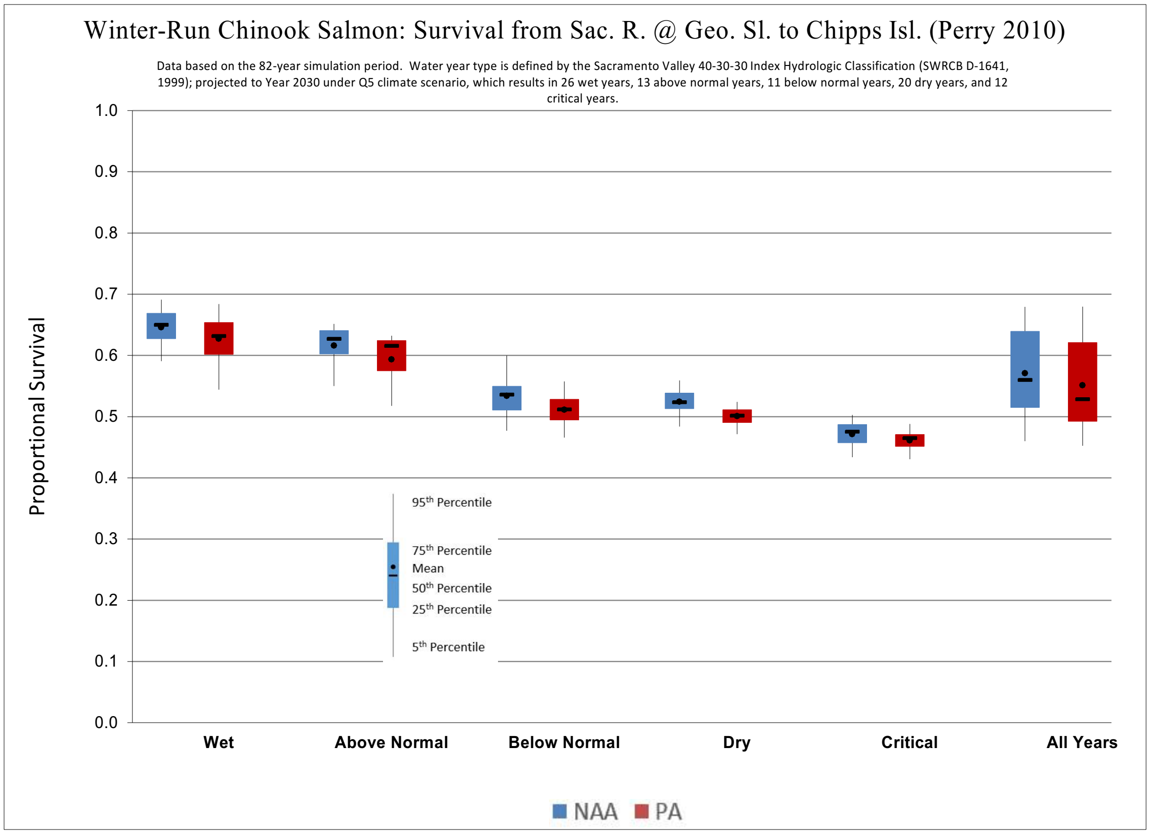
5.4.1.3.1.2.1.3.3 Analysis Based on Perry (2010): Winter-Run and Sacramento River Basin Spring-Run Chinook Salmon

In addition to the DPM and the analysis based on Newman (2003), which both allow consideration of the through-Delta juvenile Chinook salmon survival changes in relation to the far-field effects of both north and south Delta exports simultaneously, a focused analysis based on Perry (2010) was undertaken to focus solely on the potential flow-survival effects of the PA's proposed NDD on juvenile winter-run and spring-run Chinook salmon survival, particularly with respect to Sacramento River flows bypassing the NDD (i.e., pulse protection flows and level 1-3 bypass flows). The method is described further 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.D.1.2.4, and allows estimation of through-Delta survival from the Sacramento River at Georgiana Slough to Chipps Island, based on the implementation of the Perry (2010) flow-survival relationship from the DPM. The analysis based on Perry (2010) does not include representation of near-field mortality effects from the NDD (e.g., predation or impingement at the NDD), but instead focuses on far-field effects.

The results of the analysis based on Perry (2010) suggested that annual through-Delta survival in the Sacramento River from Georgiana Slough to Chipps Island would be similar or slightly lower, depending on water year type and pulse protection flow, under the PA relative to the NAA for both juvenile winter-run Chinook salmon (Figure 5.4-18 and Figure 5.4-19; Table 5.4-17; see also Figure 5.D-71 in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*) and juvenile spring-run Chinook salmon (Figure 5.4-20 and Figure 5.4-21; Table 5.4-18; see also Figure 5.D-77 in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*). As would be expected, for winter-run Chinook salmon the relative difference between NAA and PA scenarios in weighted survival generally was greater with the progression from pulse protection flows (0–2% relative difference), to level 1 bypass flows (2–5% relative difference), to level 2 bypass flows (3-7% relative difference), to level 3 bypass flows (2–12%) (Table 5.4-17). For winter-run Chinook salmon, the greatest differences in overall survival (4–5% less under PA) were in above normal, below normal, and dry years, a pattern that generally was also true for spring-run Chinook salmon (Table 5.4-18). However, the relative differences between NAA and PA for through-Delta survival of spring-run Chinook salmon (1–3% less under the PA, depending on water year type) were less than for winter-run (2–5% less under the PA).

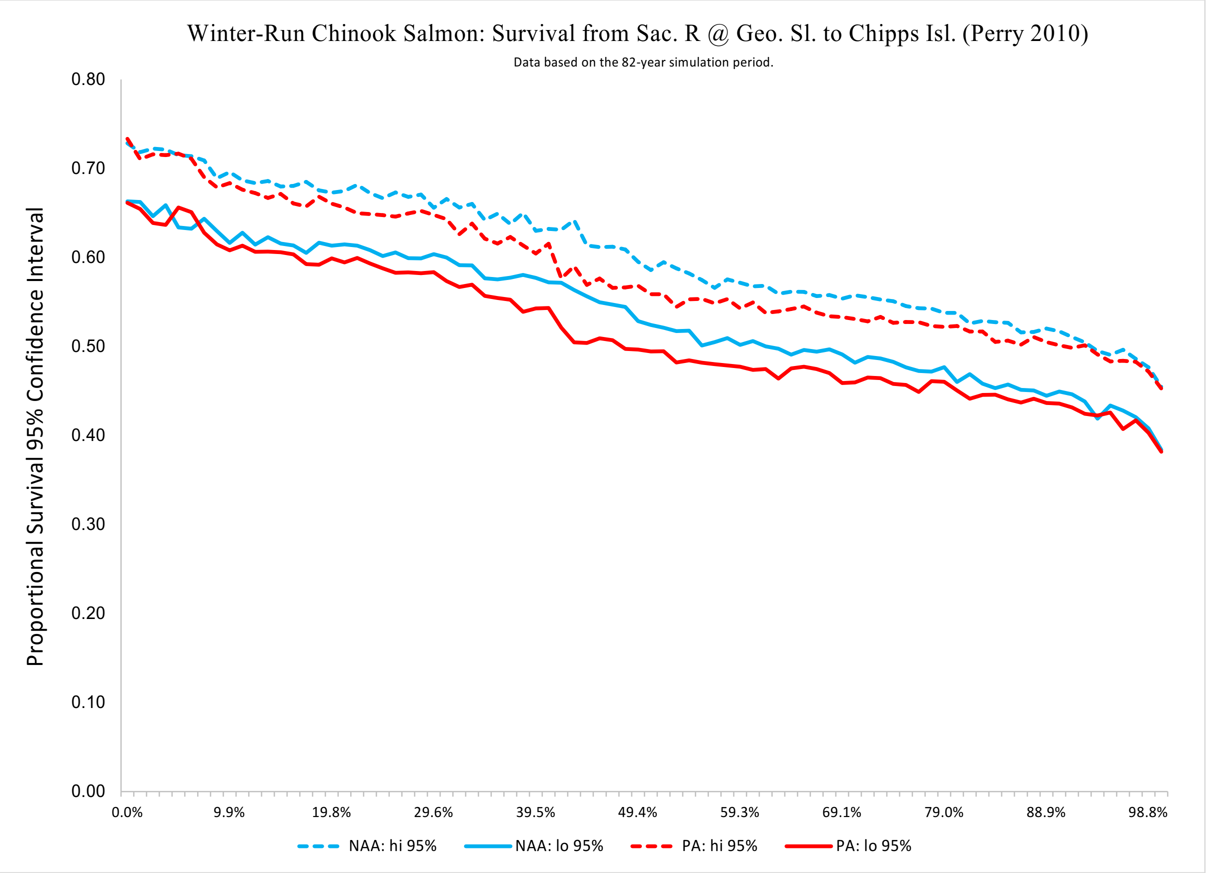
Note that there is appreciable variability in the underlying relationship between Sacramento River flow and survival, as represented in the analysis based on Perry (2010) (Figure 5.D-65 in Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*). Plots of annual estimated weighted survival and 95% confidence intervals presented in Appendix 5.D show considerable overlap in the estimate for the NAA and PA scenarios: for both winter-run and spring-run Chinook salmon, the estimates of weighted survival for pulse-protection flows, level 1-3 bypass flows, and overall survival overlap in all pairs of NAA and PA scenarios across the 82 years that were included in the analysis (see Figures 5.D-66 to 5.D-70 and Figures 5.D-72 to 5.D-76 in Appendix 5.D). This suggests that although the results discussed above show potentially less survival under the PA relative to the NAA, it might be challenging to statistically detect this small magnitude of difference during PA monitoring, for example.

Given that the analyses described above were for fixed winter-run and spring-run Chinook salmon entry distributions, it also was of interest to examine the differences in juvenile Chinook salmon survival based on Perry (2010) when assuming an equal daily weighting for entry distribution during December-June, the main juvenile Chinook salmon Delta entry period (Table 5.4-19). Although the entry distribution to the Delta was assumed to be the same on each day (i.e., equal daily weighting), the patterns from this analysis were similar to those observed for winter-run and spring-run Chinook salmon: lower survival under the PA relative to NAA (Figure 5.4-22 and Figure 5.4-23), with the relative differences between PA and NAA increasing with the movement from pulse protection flows (0–2%), to level 1 bypass flows (1–4%), to level 2 bypass flows (2–4%), to level 3 bypass flows (3–6%). In addition, the 95% confidence intervals for through-Delta survival estimates under all flow levels overlapped in every year between the NAA and PA scenarios (see Figures 5.D-78 to 5.D-82 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.D.1.2.4.3, *Results*), again suggesting that it might be challenging to statistically detect the small magnitude of the PA effect during monitoring of implementation.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-18. Box Plots of Juvenile Winter-Run Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010), Grouped by Water Year Type.



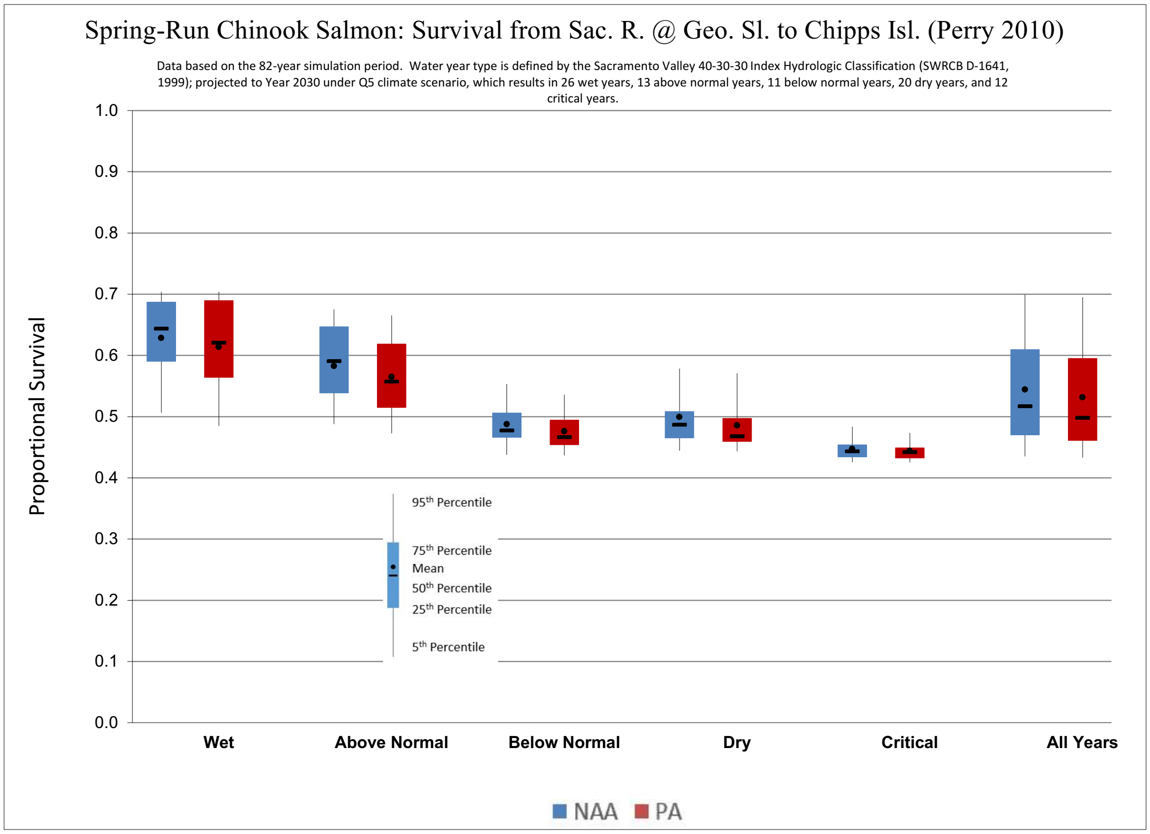
Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 5.4-19. Exceedance Plot of Juvenile Winter-Run Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010).

Table 5.4-17. Mean Annual Juvenile Winter-Run Chinook Salmon Weighted Survival from the Sacramento River at Georgiana Slough to Chipps Island By Water Year Type, Estimated from the Analysis Based on Perry (2010), Divided into Each NDD Bypass Flow Level.

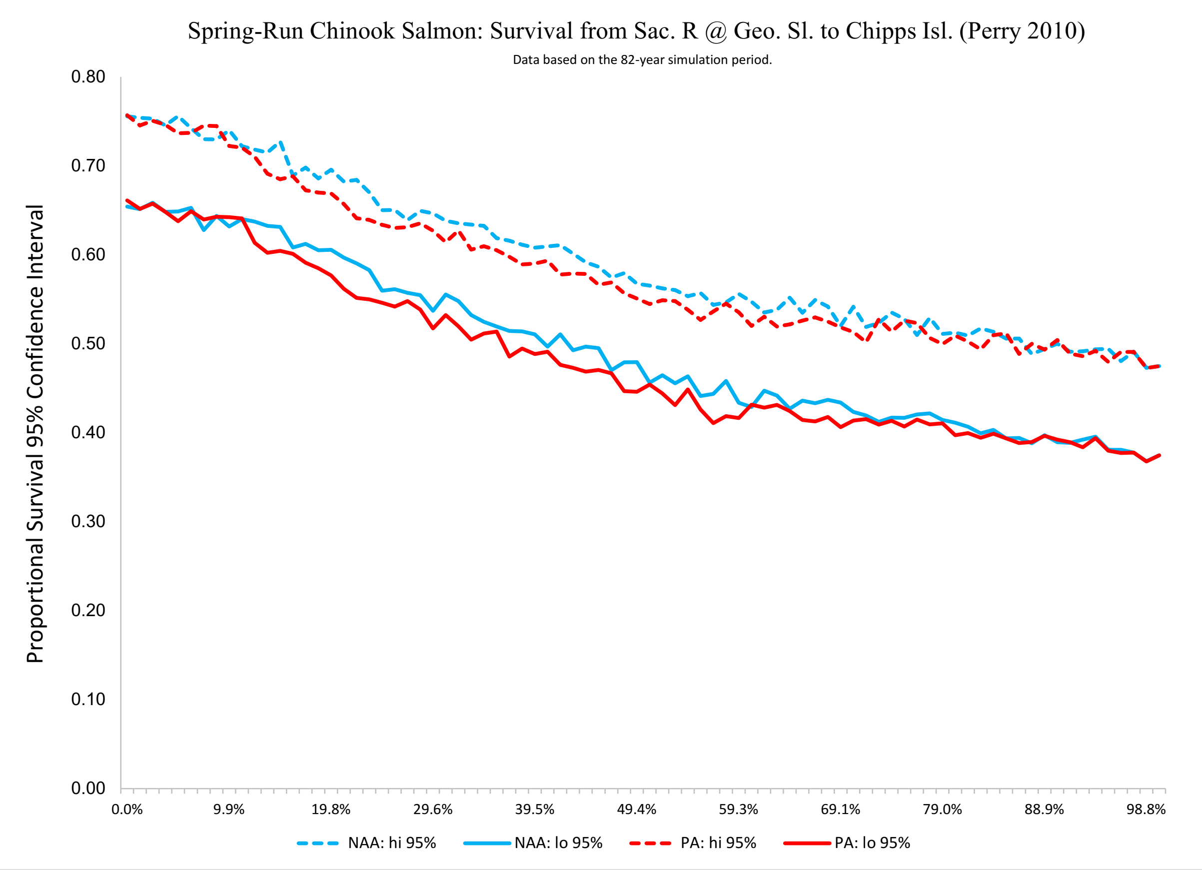
WY	Pulse protection flows			Level 1 bypass flows			Level 2 bypass flows			Level 3 bypass flows			Total		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.05	0.05	0.00 (0%)	0.16	0.15	-0.01 (-5%)	0.08	0.08	0.00 (-5%)	0.35	0.34	-0.01 (-2%)	0.65	0.63	-0.02 (-3%)
AN	0.04	0.04	0.00 (-1%)	0.20	0.19	-0.01 (-3%)	0.09	0.09	0.00 (-3%)	0.29	0.27	-0.01 (-5%)	0.62	0.59	-0.02 (-4%)
BN	0.04	0.04	0.00 (-1%)	0.29	0.28	-0.01 (-3%)	0.15	0.14	-0.01 (-6%)	0.05	0.05	0.00 (-10%)	0.53	0.51	-0.02 (-4%)
D	0.03	0.03	0.00 (-2%)	0.35	0.34	-0.01 (-4%)	0.12	0.11	-0.01 (-7%)	0.03	0.02	0.00 (-12%)	0.52	0.50	-0.02 (-5%)
C	0.03	0.03	0.00 (-1%)	0.41	0.40	-0.01 (-2%)	0.03	0.03	0.00 (-4%)	NA	NA	NA	0.47	0.46	-0.01 (-2%)

Note: Survival for a given flow level is weighted by the proportion of the juvenile population occurring during that flow level. NA indicates there were no level 3 bypass flows in critical years.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-20. Box Plots of Juvenile Spring-Run Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010), Grouped by Water Year Type.



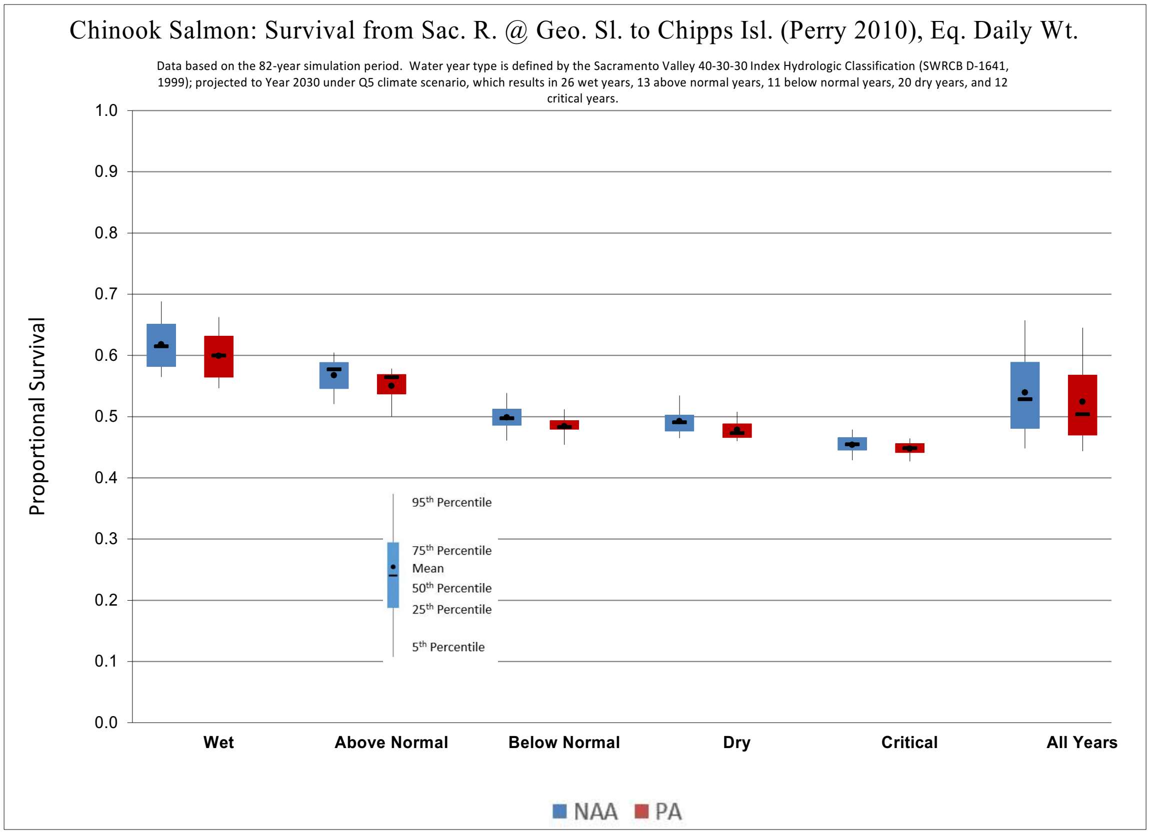
Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 5.4-21. Exceedance Plot of Juvenile Spring-Run Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010).

Table 5.4-18. Mean Annual Juvenile Spring-Run Chinook Salmon Weighted Survival from the Sacramento River at Georgiana Slough to Chipps Island By Water Year Type, Estimated from the Analysis Based on Perry (2010), Divided into Each NDD Bypass Flow Level.

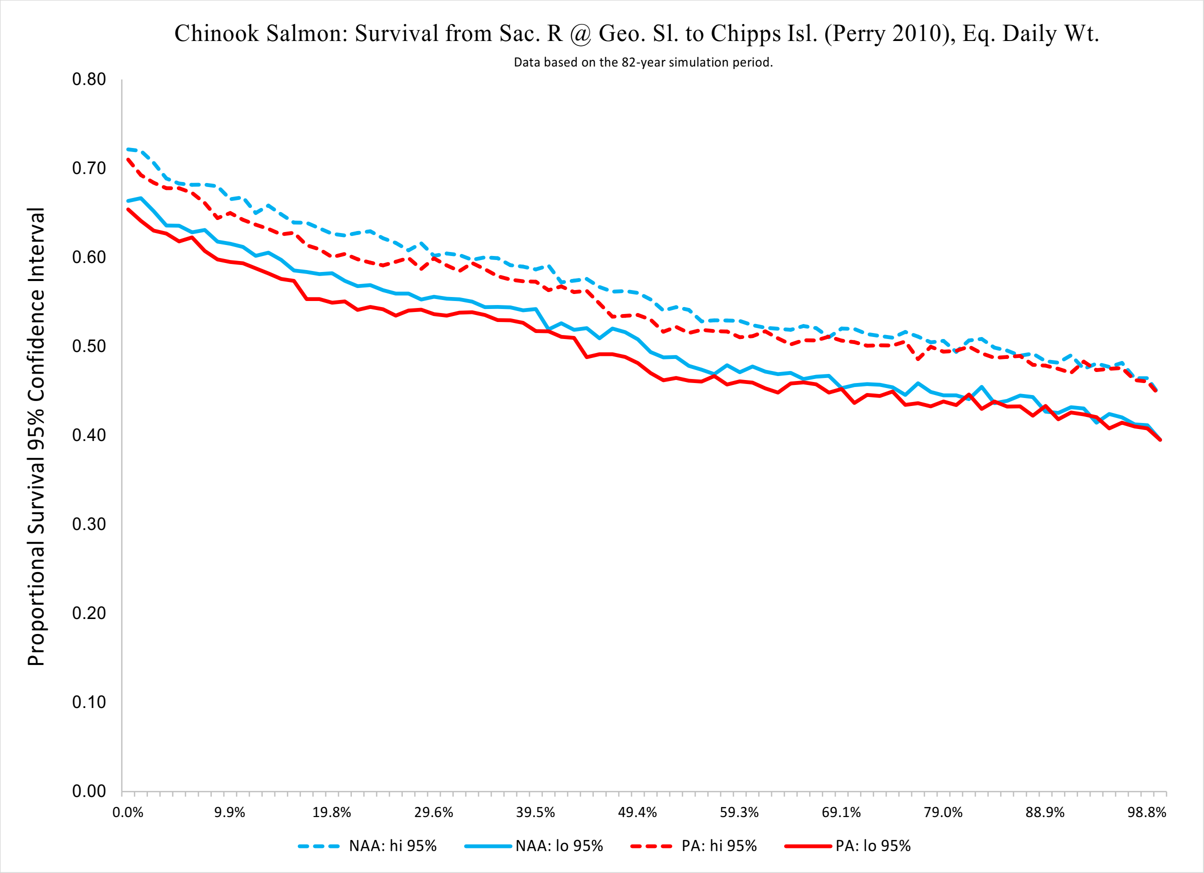
WY	Pulse protection flows			Level 1 bypass flows			Level 2 bypass flows			Level 3 bypass flows			Total		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.04	0.04	0.00 (0%)	0.12	0.12	0.00 (-4%)	0.06	0.06	0.00 (-3%)	0.39	0.38	-0.01 (-3%)	0.62	0.60	-0.02 (-3%)
AN	0.03	0.03	0.00 (-1%)	0.15	0.15	0.00 (-3%)	0.07	0.07	0.00 (-2%)	0.32	0.31	-0.01 (-4%)	0.57	0.55	-0.02 (-3%)
BN	0.03	0.03	0.00 (0%)	0.25	0.24	-0.01 (-2%)	0.16	0.16	-0.01 (-4%)	0.06	0.05	0.00 (-5%)	0.50	0.48	-0.01 (-3%)
D	0.02	0.02	0.00 (-1%)	0.27	0.27	-0.01 (-3%)	0.16	0.15	0.00 (-3%)	0.04	0.04	0.00 (-6%)	0.49	0.48	-0.01 (-3%)
C	0.02	0.02	0.00 (-2%)	0.39	0.39	-0.01 (-1%)	0.04	0.04	0.00 (-2%)	NA	NA	NA	0.45	0.45	-0.01 (-1%)

Note: Survival for a given flow level is weighted by the proportion of the juvenile population occurring during that flow level. NA indicates there were no level 3 bypass flows in critical years.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-22. Box Plots of Juvenile Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010), Grouped by Water Year Type, Assuming Equal Daily Weighting from December to June.



Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 5.4-23. Exceedance Plot of Juvenile Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010), Assuming Equal Daily Weighting from December to June.

Table 5.4-19. Mean Annual Juvenile Chinook Salmon Weighted Survival from the Sacramento River at Georgiana Slough to Chipps Island By Water Year Type, Estimated from the Analysis Based on Perry (2010), Divided into Each NDD Bypass Flow Level, Assuming Equal Daily Weighting from December to June.

WY	Pulse protection flows			Level 1 bypass flows			Level 2 bypass flows			Level 3 bypass flows			Total		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
W	0.04	0.04	0.00 (0%)	0.12	0.12	0.00 (-4%)	0.06	0.06	0.00 (-3%)	0.39	0.38	-0.01 (-3%)	0.62	0.60	-0.02 (-3%)
AN	0.03	0.03	0.00 (-1%)	0.15	0.15	0.00 (-3%)	0.07	0.07	0.00 (-2%)	0.32	0.31	-0.01 (-4%)	0.57	0.55	-0.02 (-3%)
BN	0.03	0.03	0.00 (0%)	0.25	0.24	-0.01 (-2%)	0.16	0.16	-0.01 (-4%)	0.06	0.05	0.00 (-5%)	0.50	0.48	-0.01 (-3%)
D	0.02	0.02	0.00 (-1%)	0.27	0.27	-0.01 (-3%)	0.16	0.15	0.00 (-3%)	0.04	0.04	0.00 (-6%)	0.49	0.48	-0.01 (-3%)
C	0.02	0.02	0.00 (-2%)	0.39	0.39	-0.01 (-1%)	0.04	0.04	0.00 (-2%)	NA	NA	NA	0.45	0.45	-0.01 (-1%)

Note: Survival for a given flow level is weighted by the proportion of the juvenile population occurring during that flow level. NA indicates there were no level 3 bypass flows in critical years.

5.4.1.3.1.2.1.3.4 Life Cycle Models (IOS and OBAN): Winter-run Chinook Salmon

The winter-run Chinook salmon life cycle models IOS and OBAN were also run to provide perspective on potential PA effects with respect to both in-Delta and upstream conditions. Methods and results are presented 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.D.3, *Life Cycle Models*. In both models, ocean conditions were assumed not to differ between the NAA and PA, in order to focus the analysis on potential PA effects.

As described in Section 5.4.2, *Upstream Hydrologic Changes*, upstream differences in environmental stressors between the NAA and PA were found to be small, so the main driver of differences in escapement between NAA and PA was differences in Delta survival. IOS's in-Delta component is the DPM, although with one important difference from the DPM results previously discussed in Section 5.4.1.3.1.2.1.3.1, *Delta Passage Model: Winter-Run and Spring-Run Chinook Salmon*: Delta entry in IOS consists of a unimodal peak, the timing of which depends on upstream fry/egg rearing, in contrast to the fixed nature of Delta entry for the standalone DPM; the unimodal peak generally occurs between the bimodal peaks from the fixed entry distribution (Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.3.1.1.5, *Delta Passage*). Whereas the DPM results showed that the 95% confidence intervals of annual through-Delta survival estimates for NAA and PA did not overlap in 10 of 81 years, the through-Delta survival confidence intervals overlapped in all but one year for IOS. This may have reflected a greater proportion of the through-Delta migration occurring earlier in the migration season for IOS, when NDD bypass flow restrictions would have been greater, with the result that there was greater overlap in survival estimates between NAA and PA for IOS compared to DPM.

In IOS, as with the DPM, in-Delta channel flow-survival relationships tend to have a greater effect on survival than the export-survival effect, as discussed in Section 5.4.1.3.1.2.1.3, *Through-Delta Survival,* for spring-run Chinook salmon. In contrast, OBAN's through-Delta survival component includes Yolo Bypass inundation (which was assumed the same for NAA and PA, based on both scenarios having a notched Fremont Weir) and south Delta exports, which would be appreciably less under the PA than NAA. In order to represent potential adverse effects of the NDD on through-Delta survival in OBAN, sensitivity analyses of additional mortality (1%, 5%, 10%, and 50%) were applied to the estimates of survival derived from Yolo Bypass inundation and south Delta exports. The OBAN results demonstrated that early ocean survival and the spreading of effects between age 3 and age 4 maturing adults has a significant buffering effect on through-Delta survival effects[33], so that estimates of escapement between sensitivity analysis scenarios did not directly reflect proportional differences in through-Delta survival. The sensitivity analysis results suggested that at 5% additional mortality because of the NDD, the number of years having greater than 50% probability of *equal or greater* escapement under the

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[33] As discussed further 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.D.3.2.8, *Results*, OBAN includes a lower bound on escapement to avoid numerical instability, which also contributed to less than expected differences between sensitivity analysis scenarios when escapement was low.

PA relative to the NAA would be the same as the number of years having less than 50% probability of *lower* escapement under the PA relative to the NAA. In simpler terms, 5% additional mortality because of the NDD[34] would cancel out the gains from south Delta export reductions under the PA, judged from the probability of having escapement equal to or less than NAA.

In contrast to OBAN, which suggested that the benefits of less south Delta exports could offset additional mortality from the NDD, the IOS escapement estimates suggested that lower through-Delta survival would result in increasing divergence of PA and NAA escapement estimates, resulting in a median 25% lower escapement for the PA over the 81 years simulated. However, the variability in through-Delta survival estimates across the 75 randomized iterations of IOS meant that as median escapement diverged, so too did the 95% confidence intervals, so that the escapement confidence intervals for the PA and NAA overlapped in all years; in the years with greatest differences in escapement between PA and NAA, the 95% confidence intervals spread over two orders of magnitude. This likely reflects the uncertainty in the underlying model parameters (e.g., flow-survival and export-survival relationships), as well extrapolation beyond the range of the data upon which the model parameters were based. OBAN was similar to IOS in that the differences in escapement between NAA and PA scenarios usually were within 90% probability intervals[35]. For both life cycle models, the uncertainty in the relationships between environmental parameters and fish survival, coupled with extrapolation beyond the data from which the relationships were established, gave wide variation in the range of escapement estimates.

5.4.1.3.1.2.1.3.5 SalSim Through-Delta Survival Function: San Joaquin River Basin Spring-Run Chinook Salmon

Through-Delta survival for spring-run Chinook salmon from the San Joaquin River basin was estimated using the survival function from the Juvenile Delta Module of the Salmon Simulator (SalSim; AD Consultants 2014). Whereas SalSim is a standalone life cycle modeling tool, the coefficients of the survival function from its Delta Module were used in a spreadsheet to compare potential survival differences between NAA and PA. The details of the method as applied for fall-run Chinook salmon are described in the *SalSim Through-Delta Survival Function: Fall-Run Chinook Salmon* subsection of Appendix 5.E., *Essential Fish Habitat*, Section 5.E.5.3.1.2.1.2.1, *Indirect Mortality within the Delta*. The DPM timing for spring-run Chinook salmon entering the Delta from the Sacramento River basin was assumed for this analysis to be representative of the timing for entry of San Joaquin River spring-run Chinook salmon.

The results of the analysis based on the SalSim through-Delta survival function suggested that the through-Delta survival of San Joaquin River spring-run Chinook salmon under the PA would be greater under the PA than NAA (Figure 5.4-24 and Figure 5.4-25, and Table 5.4-20;). This is the result of the implementation of the HOR gate, which was modeled to be 50% closed during the main period of spring-run Chinook salmon migration, with the result that flow into the

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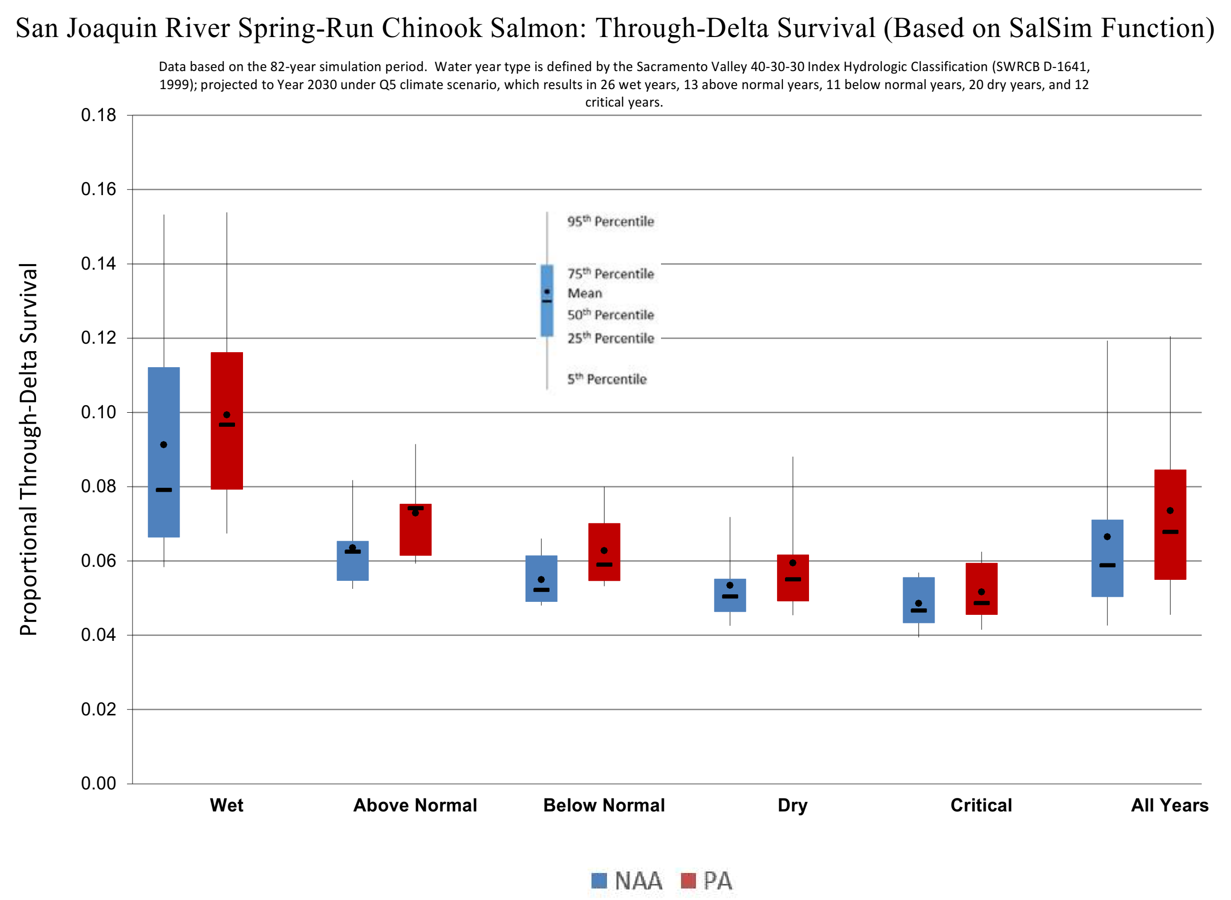
[34] That is, (PA Delta survival)*0.95 (i.e., 5% lower Delta survival)

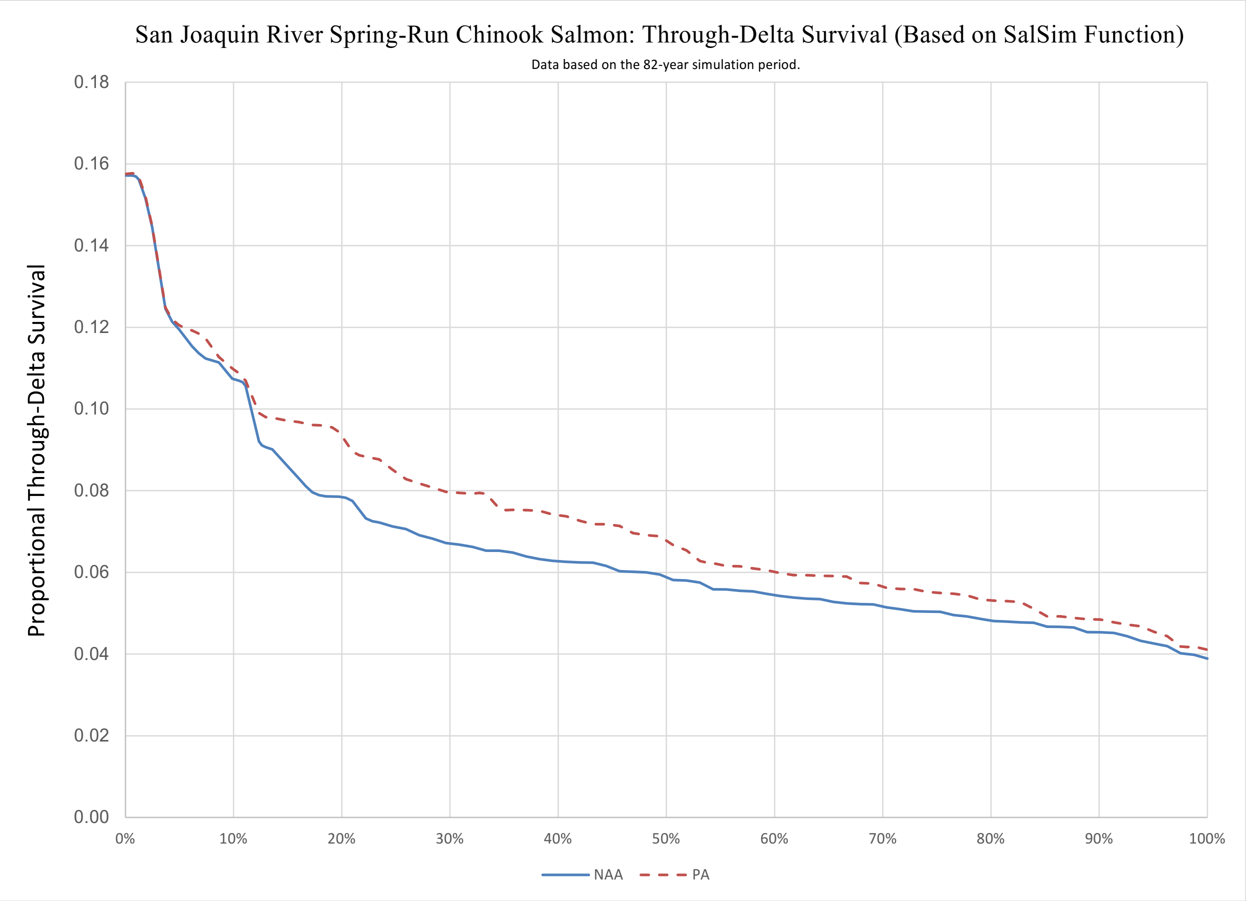
[35] The exception was one year in which the PA with 50.0% additional NDD mortality had lower escapement than the NAA, and the percentage difference did not include zero within the 90% probability interval.

Stockton Deepwater Ship Channel is considerably greater under the PA (Table 5.4-20). The relative differences in survival between NAA and PA were greatest in intermediate water-year types (above normal, below normal, and dry), as a result of two factors. First, the HOR gate would not be closed when Vernalis flow is greater than 10,000 cfs; this results in the top 5% of survival estimates being identical between NAA and PA (Figure 5.4-25.), which limits the overall differences in wet years. Second, in critical years when flows are very low and water temperature would be high, the rate of change in survival is considerably less than with more flow and lower temperature, as shown in the flatness of the flow-survival curve in Appendix 5.E, *Essential Fish Habitat*. Overall, the analysis based on the SalSim Juvenile Delta Module survival function suggested that the PA would likely have a positive effect on San Joaquin River spring-run Chinook salmon in the Delta.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-24. Box Plots of San Joaquin River Spring-Run Chinook Salmon Smolt Annual Through-Delta Survival Estimated from the Juvenile Delta Module Survival Function of SalSim, Grouped by Water Year Type.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-25. Exceedance Plot of San Joaquin River Spring-Run Chinook Salmon Smolt Annual Through-Delta Survival Estimated from the Juvenile Delta Module Survival Function of SalSim.

Table 5.4-20. Mean Annual San Joaquin River Spring-Run Chinook Salmon Smolt Annual Through-Delta Survival Estimated from the Juvenile Delta Module Survival Function of SalSim, Together with Weighted-Mean Flow into the Stockton Deepwater Ship Channel, Grouped by Water Year Type.

Water Year Type	Through-Delta Survival Probability				Flow into Stockton Deepwater Ship Channel (cfs) Weighted by Proportion of Fish Entering the Delta		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
W	0.091	0.099	0.008 (9%)		4,568	5,380	811 (18%)
AN	0.064	0.073	0.009 (15%)		2,305	3,386	1,081 (47%)
BN	0.055	0.063	0.008 (14%)		1,471	2,456	986 (67%)
D	0.053	0.059	0.006 (11%)		1,124	1,883	759 (68%)
C	0.049	0.052	0.003 (6%)		483	929	446 (92%)

5.4.1.3.1.2.2 Habitat Suitability

5.4.1.3.1.2.2.1 Bench Inundation

Channel margin habitat in the Delta, and in much of the Sacramento/San Joaquin Rivers in general, has been considerably reduced because of the construction of levees and the armoring of their banks with riprap (Williams 2009). This has reduced the extent of high-value rearing habitat for rearing Chinook salmon juveniles, for such shallow-water habitat provides refuge from unfavorable hydraulic conditions and predation, as well as foraging habitat. Although the benefits of such habitat are most often associated with smaller, rearing individuals (McLain and Castillo 2009; H.T. Harvey & Associates with PRBO Conservation Science 2011), good quality channel margin habitat also functions as holding areas during downstream migration (Burau et al. 2007; Zajanc et al. 2013), thereby improving connectivity between higher value habitats along the migration route. Whereas, historically, riverbank protection from erosion was undertaken with riprap alone, in recent years there has been an emphasis from DWR and USACE to install bank protection that incorporates riparian and wetland benches, as well as other habitat features, to restore habitat function (HT Harvey and PRBO Conservation Science 2011). These benches are shallow areas along the channel margins that have relatively gentle slopes (e.g., 10:1 instead of the customary 3:1) and are designed to be wetted or flooded during certain parts of the year to provide habitat for listed species of fish and other species. Wetland benches are at lower elevations where more frequent wetting and inundation may be expected, and riparian benches occupy higher portions of the slope where inundation is restricted to high-flow events. These benches were planted and often secured with riprap or other materials.

5.4.1.3.1.2.2.1.1 Operational Effects

Several levee improvements projects along the Sacramento River have been implemented by the USACE and others, and have included the restoration of benches intended to be inundated under specific flows during certain months to provide suitable habitat for listed species of fish. Restored benches in the north Delta could potentially be affected by the PA because of changes in water level; for example, less water in the Sacramento River below the NDD could result in riparian benches being inundated less frequently. This possibility was examined by calculating bench inundation indices for juvenile Chinook salmon (see detailed method description 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.D.1.3.1, *Bench Inundation*). These indices range from 0 (no availability of bench habitat) to 1 (water depth on the bench is optimal for juvenile Chinook salmon all of the time). The analysis was undertaken for a number of riparian and wetland benches in five geographic locations within the north Delta, by linking bench elevation data to DSM2-HYDRO-simulated water surface elevation.

The bench inundation analysis suggested that the effects of changes in water surface elevation caused by PA operations would vary by location and bench type (Table 5.4-21). As noted above, wetland benches are located at lower elevation than riparian benches and are intended to be inundated much of the time; this results in relatively high bench inundation indices in all water year types, and makes them less susceptible to differences in water levels that could be caused by the NDD, as reflected by the small differences between NAA and PA in all locations and water year types. In the Sacramento River above the NDD, the wetland bench inundation indices were greater in drier than wetter years, reflecting the water depth becoming shallower and therefore moving toward the optimum for juvenile Chinook salmon (i.e., 2.2-2.5 feet; see Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.1.3.1, *Bench Inundation*).

In contrast to wetland benches, riparian benches are at higher elevations and are intended to be inundated only for portions of winter/spring. Riparian bench inundation indices were higher in wetter years and smaller in drier years, particularly in spring (Table 5.4-21). Although there were some large *relative* differences in bench inundation indices between NAA and PA (e.g., ~40–90% lower under PA in below normal to critical years in the Sacramento River below the NDD to Sutter/Steamboat sloughs), these differences occurred in drier years when there was little habitat value under either PA or NAA. The greatest differences during the periods when the riparian benches would provide more than minimal habitat value (assumed here, based on best professional judgement, to be a bench inundation index > 0.05[36]) were:

- 29% lower riparian bench inundation index under PA in the Sacramento River from Sutter Steamboat sloughs to Rio Vista in spring of above normal years;
- 24% lower riparian bench inundation index under PA in the Sacramento River below the NDD to Sutter/Steamboat sloughs in spring of above normal years
- 19% lower riparian bench inundation index under PA in Sutter/Steamboat Sloughs in spring of wet years.

Channel margin enhancement would be implemented to offset these deficits, as described in the following section.

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[36] A bench inundation index of 0.05 equates to optimal depth (suitability = 1) 5% of the time within a season (with no other inundation occurring); or equates to poor depth (suitability = 0.05) 100% of the time within a season; or in reality, equates to a combination of time and depth between these ranges. The choice of an index of 0.05 was based on best professional judgement of an index demarcating little value to no value from some value.

Table 5.4-21. Mean Bench Inundation Index by Location, Bench Type, Water Year Type, and Season, for NAA and PA.

Location	Bench Type (Total Length)	Water Year Type	Winter (December-February)				Spring (March-June)		
			NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
Cache Slough	Riparian (2,950 ft)	W	0.011	0.010	-0.001 (-6%)		0.003	0.003	0.000 (-9%)
		AN	0.004	0.004	0.000 (-6%)		0.001	0.001	0.000 (-8%)
		BN	0.003	0.003	0.000 (-4%)		0.000	0.000	0.000 (-7%)
		D	0.002	0.002	0.000 (-8%)		0.000	0.000	0.000 (-6%)
		C	0.002	0.002	0.000 (-4%)		0.000	0.000	0.000 (-4%)
	Wetland (3,992 ft)	W	0.232	0.229	-0.003 (-1%)		0.189	0.186	-0.003 (-2%)
		AN	0.202	0.199	-0.003 (-2%)		0.158	0.157	-0.001 (-1%)
		BN	0.181	0.178	-0.002 (-1%)		0.135	0.134	-0.001 (-1%)
		D	0.176	0.173	-0.003 (-2%)		0.139	0.138	-0.001 (-1%)
		C	0.158	0.157	-0.002 (-1%)		0.132	0.132	0.000 (0%)
Sacramento River above NDD	Riparian (18,521 ft)	W	0.170	0.186	0.016 (9%)		0.186	0.180	-0.007 (-4%)
		AN	0.162	0.169	0.007 (4%)		0.105	0.103	-0.001 (-1%)
		BN	0.100	0.100	0.000 (0%)		0.015	0.009	-0.005 (-35%)
		D	0.111	0.112	0.000 (0%)		0.023	0.017	-0.006 (-28%)
		C	0.038	0.038	0.000 (0%)		0.004	0.003	-0.001 (-27%)
	Wetland (3,766 ft)	W	0.360	0.364	0.004 (1%)		0.398	0.412	0.014 (3%)
		AN	0.398	0.396	-0.002 (-1%)		0.471	0.470	0.000 (0%)
		BN	0.447	0.450	0.003 (1%)		0.493	0.492	-0.001 (0%)
		D	0.424	0.429	0.005 (1%)		0.489	0.489	0.000 (0%)
		C	0.475	0.466	-0.009 (-2%)		0.393	0.391	-0.002 (-1%)
Sacramento River below NDD to Sutter/Steamboat Sl.	Riparian (3,037 ft)	W	0.247	0.227	-0.020 (-8%)		0.180	0.142	-0.039 (-21%)
		AN	0.210	0.175	-0.035 (-17%)		0.084	0.064	-0.020 (-24%)
		BN	0.116	0.098	-0.018 (-15%)		0.002	0.000	-0.002 (-77%)
		D	0.144	0.123	-0.020 (-14%)		0.008	0.005	-0.003 (-40%)
		C	0.041	0.036	-0.004 (-11%)		0.000	0.000	0.000 (0%*)
	Wetland (3,115 ft)	W	0.318	0.331	0.013 (4%)		0.357	0.343	-0.014 (-4%)
		AN	0.319	0.322	0.003 (1%)		0.289	0.280	-0.009 (-3%)
		BN	0.281	0.276	-0.006 (-2%)		0.203	0.192	-0.011 (-5%)
		D	0.281	0.278	-0.003 (-1%)		0.212	0.199	-0.014 (-6%)
		C	0.226	0.221	-0.005 (-2%)		0.171	0.168	-0.003 (-2%)
Sacramento River from Sutter/Steamboat Sl. to Rio Vista	Riparian (1,685 ft)	W	0.257	0.219	-0.039 (-15%)		0.171	0.126	-0.045 (-26%)
		AN	0.206	0.159	-0.047 (-23%)		0.075	0.053	-0.022 (-29%)
		BN	0.118	0.092	-0.025 (-22%)		0.002	0.000	-0.001 (-75%)
		D	0.146	0.115	-0.031 (-21%)		0.006	0.004	-0.003 (-43%)
		C	0.044	0.036	-0.008 (-18%)		0.000	0.000	0.000 (0%**)
	Wetland (2,430 ft)	W	0.410	0.421	0.011 (3%)		0.437	0.420	-0.017 (-4%)
		AN	0.412	0.409	-0.003 (-1%)		0.362	0.350	-0.013 (-3%)
		BN	0.361	0.354	-0.007 (-2%)		0.265	0.254	-0.012 (-4%)
		D	0.365	0.360	-0.005 (-1%)		0.276	0.262	-0.014 (-5%)
		C	0.295	0.290	-0.005 (-2%)		0.230	0.226	-0.003 (-1%)

Location	Bench Type (Total Length)	Water Year Type	Winter (December-February)				Spring (March-June)		
			NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
Sutter/Steamboat Sloughs	Riparian (5,235 ft)	W	0.262	0.233	-0.028 (-11%)		0.196	0.159	-0.037 (-19%)
		AN	0.220	0.186	-0.034 (-15%)		0.103	0.085	-0.018 (-17%)
		BN	0.138	0.117	-0.020 (-15%)		0.024	0.021	-0.003 (-12%)
		D	0.160	0.135	-0.025 (-16%)		0.030	0.026	-0.004 (-14%)
		C	0.066	0.059	-0.007 (-11%)		0.019	0.018	-0.001 (-4%)
	Wetland (2,670 ft)	W	0.515	0.528	0.014 (3%)		0.562	0.548	-0.014 (-2%)
		AN	0.528	0.526	-0.001 (0%)		0.499	0.486	-0.013 (-3%)
		BN	0.488	0.482	-0.006 (-1%)		0.401	0.387	-0.014 (-3%)
		D	0.487	0.483	-0.004 (-1%)		0.414	0.397	-0.017 (-4%)
		C	0.420	0.415	-0.005 (-1%)		0.356	0.352	-0.004 (-1%)

Notes: *Value was changed from -92% because absolute change was extremely small. **Value was changed from -80% because absolute change was extremely small.

5.4.1.3.1.2.2.1.2 Channel Margin Enhancement

As described above, PA operations have the potential to reduce riparian bench inundation, which would reduce habitat suitability for juvenile Chinook salmon from the Sacramento River basin. Channel margin enhancement would be undertaken in order to mitigate for deficits created by PA operations. Channel margin enhancement would be coordinated with NMFS, would occur at sites currently containing poor habitat, and would accommodate the range of water stage elevations necessary to provide appropriate water depth and other habitat features for juvenile Chinook salmon. Additional discussion of channel margin enhancement is provided in Section 5.5.1, *Tidal, Channel Margin, and Riparian Habitat Protection and Restoration*.

5.4.1.3.1.2.2.2 Water Temperature (DSM2-QUAL)

Kimmerer (2004: 19-20) noted that the water temperature in the San Francisco Estuary depends mainly on air temperature, and that even in the Delta the relationship between air and water temperature is only slightly affected by freshwater inflow. He further noted that at Freeport high inflow reduces water temperature on cool days, presumably because water reaches the Delta before its temperature equilibrates with air temperature; at Antioch low inflow increases water temperature on cool days, probably because of the moderating effect of warmer estuarine water moving farther upstream. USFWS (2008: 194) suggested, based on Kimmerer (2004) that water temperatures at Freeport can be cooled up to about 3°C by high Sacramento River flows, but only by very high river flows that cannot be sustained by CVP/SWP operations. In general, flow-related effects on Delta water temperature are expected to be minor (Wagner *et al.* 2011). However, operational changes under the PA with respect to less south Delta export pumping and less Sacramento River inflow because of the proposed NDD mean that it is prudent to investigate whether water temperature is expected to differ between the NAA and the PA, and if so, why. DSM2-QUAL modeling was undertaken to examine water temperature differences between NAA and PA scenarios at four locations, in response to requests from NMFS and USFWS for locations with biological relevance to listed fishes based on likely occurrence: Sacramento River at Rio Vista, San Joaquin River at Prisoners Point, Stockton Deep Water Ship Channel, and San Joaquin River at Brandt Bridge. Detailed methods are presented in Attachment 5.B.A.4 of Appendix 5.B, *DSM2 Methods and Results,* and results are presented in Section 5.B.5 of that appendix. In general, DSM2-QUAL modeling suggested that there would be only very slight differences in water temperature between NAA and PA. For the Sacramento River at Rio Vista, water temperature differences were most apparent during July to November (see, for example, the temperature exceedance plots in Appendix 5.B, *DSM2 Methods and Results*, Section 5.B.5: Figure 5.B.5.40-1). This period is essentially outside the main juvenile migration period for juvenile spring-run Chinook salmon and steelhead, but may overlap with early (November) occurrence of juvenile winter-run Chinook salmon in the Delta. However, the results suggest small differences in mean temperature may be small even when they are visually apparent, e.g., in November, the greatest difference between NAA and PA scenarios was at the 20% exceedance level, and was ~0.3°C greater under the PA (Appendix 5.B, *DSM2 Methods and Results*, Section 5.B.5: Figure 5.B.5.40-1); such differences may not be of biological significance, whereas a difference of 0.5-1°C would be of more importance. The timing of differences between NAA and PA scenarios could overlap with steelhead upstream migration, but again, the slight differences suggest little effect of the PA in relation to the NAA.

The water temperature results on the San Joaquin River have relevance for San Joaquin River steelhead and spring-run Chinook salmon migrating through the Delta from the San Joaquin River basin. Differences between the NAA and PA scenarios varied by location. At Brandt Bridge, the most upstream station examined (river km 72, i.e., just below the Old River divergence), there was little to no difference in temperature between NAA and PA (see exceedance plots in Appendix 5.B, *DSM2 Methods and Results*, Section 5.B.5: Figure 5.B.5.42-1), as would be expected given that the main source of water is the San Joaquin River under both scenarios. At the Stockton Deep Water Ship Channel, differences were apparent from January to June, which may reflect a greater proportion of warmer San Joaquin River water under the PA as a combined result of the presence of the HOR gate and less south Delta exports. The greatest differences occurred in the cold months of January and February, which suggests that there would be little issue for juvenile or adult steelhead and spring-run Chinook salmon from the San Joaquin River basin at this time because water temperatures are not limiting in these months, whereas slightly higher water temperatures during April-June could result in less suitable habitat conditions for juvenile steelhead, given that temperatures above 15-17°C are above optimal (Moyle et al. 2008). There would be less of an issue for juvenile spring-run Chinook salmon, for which temperatures above 19-20°C are above optimal (Moyle et al. 2008). At Prisoners Point, similar patterns to the Stockton Deep Water Ship Channel were evident for January to April, whereas in May and June, there was little difference between the NAA and PA, which is more similar to the pattern at Rio Vista and reflects general warming and a lesser influence of operations on water temperature with movement downstream. Overall, there appears to be the potential for a small negative effect of greater water temperature on steelhead juveniles, because of slightly higher spring water temperature in the San Joaquin River at the Stockton Deep Water Ship Channel. However, this may have little biological effect on steelhead because of the small magnitude of temperature differences between the PA and NAA scenarios and the high frequency of May and June temperatures that exceed the optimal temperature range for both the PA and NAA, indicating temperatures would be above optimal under both scenarios. As previously noted, in general it is expected that air temperature is the main driver on water temperature in the Delta, as shown by detailed temperature modeling that does not include the effects of flow and has higher correspondence with observed temperatures than DSM2-QUAL estimates (Wagner *et al.* 2011)

5.4.1.3.1.2.2.3 Selenium

The increase in the proportion of San Joaquin River water entering the Delta because of less south Delta exports under the PA would be expected to increase the selenium concentration in Delta water. However, the analyses of potential effects on trophic level 3 species, which are representative of juvenile salmonids, showed essentially no difference between PA and NAA scenarios in particulate, invertebrate, or whole-body estimates of selenium concentration (see Appendix 5.F, *Selenium Analysis*). Therefore, the PA is not likely to increase exposure of salmonids to selenium toxicity.

Olfactory Cues for Upstream Migration

Attraction flows and the importance of olfactory cues to adult Chinook salmon were well described by Marston et al. (2012):

> Chinook salmon rely primarily on olfactory cues to successfully migrate through the Delta's maze of waterways to home back to their natal river (Groves et al.

> 1968; Mesick 2001). Juvenile salmon imprint by acquiring a series of chemical waypoints at every major confluence that enables them to relocate their river of origin (Quinn 1997 ; Williams 2006).

Marston et al. (2012) used recoveries of coded-wire tags from hatchery-origin Chinook salmon to estimate stray rates of adults. Fish released further upstream in-river had considerably lower straying rates than fish released downstream (including in San Francisco Bay) presumably because the fish released downstream had imprinted on fewer waypoints. For the Sacramento River, the stray rate for fish released upstream of the confluence of the Sacramento and San Joaquin Rivers was very low (average 0.1%, range 0 to 6.7%; Marston et al. 2012 [Methods Appendix:10])—If this rate is representative of wild populations spawned upstream, then it suggests a very low rate of straying for fish emigrating from natal tributaries in the Sacramento River basin with the existing flows through the Delta. As noted by Marston et al. (2012:18), Quinn (1997) suggested that background levels of straying for hatchery-origin salmon are 2 to 5%, although few studies have been conducted on wild-origin Chinook salmon; one such study for wild-origin Mokelumne River Chinook salmon—albeit a population with appreciable hatchery influence—reported a stray rate of over 7% (Williams 2006).

Sacramento River flows downstream of the proposed NDD generally would be lower under PA operations relative to NAA, with differences between water-year types because of differences in the relative proportion of water being exported from the NDD and south Delta export facilities. As assessed by DSM2-QUAL fingerprinting analysis, the average percentage of Sacramento River–origin water at Collinsville, where the Sacramento and San Joaquin Rivers converge in the west Delta, was estimated to be always slightly lower under PA than NAA (Table 5.4-22). However, during the fall/winter/spring periods of interest for upstream migrating salmonids, Sacramento River water formed the majority of water in the confluence area, and differences between scenarios were within the 20% change in olfactory cues that adult sockeye salmon detected and behaviorally responded to (Fretwell 1989). Therefore, it is concluded that there would be little potential for an effect from changes in olfactory cues for upstream migrating adults salmonids from the Sacramento River basin.

Less use of the south Delta export facilities under the PA would result in a greater amount of San Joaquin River reaching the confluence area (Table 5.4-23), which may increase the olfactory cues available for upstream migrating adult salmonids from the San Joaquin River basin, including steelhead and spring-run Chinook salmon. As shown by Marston et al. (2012), relatively small changes in the ratio of south Delta exports to San Joaquin River inflow may affect the straying rate of upstream migrating adult fall-run Chinook salmon[37]. The several-fold increase in San Joaquin River flow reaching the confluence area under the PA (Table 5.4-23) has the potential to improve homing of adult salmonids, including steelhead and spring-run Chinook salmon, to the San Joaquin River basin.

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[37] There is uncertainty in the relative or combined importance of San Joaquin River flow and south Delta exports explaining straying rates better (Marston et al. 2012); as noted by Marston et al. (2012), statistically speaking, the results of their analysis suggested San Joaquin River flows were more important than south Delta exports (with the latter not being statistically significant at $P < 0.05$), but because little if any pulse flow leaves the Delta when south Delta exports are elevated, exports in combination with pulse flow may be of importance.

Table 5.4-22. Mean Percentage of Water at Collinsville Originating in the Sacramento River, from DSM2-QUAL Fingerprinting.

Month	**Wet**				**Above Normal**				**Below Normal**				Dry				Critical		
	NAA	**PA**	**PA vs. NAA**		**NAA**	**PA**	**PA vs. NAA**		**NAA**	**PA**	**PA vs. NAA**		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
Jan	71.8	71.4	0 (0%)		71.7	70.5	-1 (-2%)		72.8	70.7	-2 (-3%)		72.3	69.4	-3 (-4%)		71.9	71.3	-1 (-1%)
Feb	65.4	59.1	-6 (-11%)		74.4	69.2	-5 (-8%)		80.6	76.2	-4 (-6%)		81.0	78.7	-2 (-3%)		80.1	78.6	-1 (-2%)
Mar	69.2	58.9	-10 (-17%)		77.6	69.1	-9 (-12%)		83.4	76.6	-7 (-9%)		82.1	76.9	-5 (-7%)		80.7	78.4	-2 (-3%)
Apr	70.7	63.0	-8 (-12%)		79.0	70.0	-9 (-13%)		81.9	76.5	-5 (-7%)		81.4	77.5	-4 (-5%)		77.0	75.4	-2 (-2%)
May	73.8	67.3	-6 (-10%)		75.2	68.4	-7 (-10%)		74.5	70.7	-4 (-5%)		73.9	71.8	-2 (-3%)		68.4	66.8	-2 (-2%)
Jun	71.7	60.2	-11 (-19%)		67.4	60.1	-7 (-12%)		67.2	64.0	-3 (-5%)		68.7	66.0	-3 (-4%)		60.4	59.0	-1 (-2%)
Jul	74.3	59.8	-14 (-24%)		75.8	63.2	-13 (-20%)		73.1	63.7	-9 (-15%)		62.3	57.7	-5 (-8%)		54.3	52.3	-2 (-4%)
Aug	67.0	56.3	-11 (-19%)		71.3	62.9	-8 (-13%)		68.5	61.0	-7 (-12%)		60.3	55.4	-5 (-9%)		51.2	48.6	-3 (-5%)
Sep	88.9	83.6	-5 (-6%)		79.8	76.6	-3 (-4%)		58.5	51.0	-8 (-15%)		53.6	48.7	-5 (-10%)		48.9	46.8	-2 (-4%)
Oct	86.6	80.9	-6 (-7%)		76.1	75.0	-1 (-1%)		53.4	56.9	4 (6%)		50.1	54.7	5 (8%)		42.8	46.5	4 (8%)
Nov	86.0	73.7	-12 (-17%)		76.5	70.1	-6 (-9%)		57.6	57.9	0 (0%)		56.4	57.9	1 (3%)		41.4	43.9	3 (6%)
Dec	77.1	70.7	-6 (-9%)		75.5	69.3	-6 (-9%)		67.7	65.0	-3 (-4%)		67.6	65.6	-2 (-3%)		59.4	57.5	-2 (-3%)

Table 5.4-23. Mean Percentage of Water at Collinsville Originating in the San Joaquin River, from DSM2-QUAL Fingerprinting.

Month	**Wet**				**Above Normal**				**Below Normal**				Dry				Critical		
	NAA	**PA**	**PA vs. NAA**		**NAA**	**PA**	**PA vs. NAA**		**NAA**	**PA**	**PA vs. NAA**		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
Jan	1.3	3.4	2.1 (63%)		0.1	0.8	0.7 (92%)		0.2	0.5	0.3 (68%)		0.4	1.2	0.7 (63%)		0.2	0.2	0.0 (24%)
Feb	2.1	5.5	3.4 (62%)		1.0	3.0	2.0 (67%)		0.5	2.8	2.3 (83%)		0.3	1.2	0.9 (79%)		0.1	0.3	0.2 (66%)
Mar	4.1	11.4	7.3 (64%)		1.9	6.8	4.9 (72%)		1.4	5.0	3.7 (72%)		0.9	2.7	1.8 (67%)		0.3	1.0	0.7 (71%)
Apr	8.5	15.6	7.0 (45%)		4.2	11.7	7.5 (64%)		2.0	6.0	4.1 (67%)		1.6	3.9	2.4 (61%)		0.6	1.7	1.2 (68%)
May	13.6	19.8	6.3 (32%)		10.0	16.6	6.6 (40%)		5.7	9.7	4.1 (42%)		3.7	6.5	2.8 (43%)		0.9	2.3	1.4 (60%)
Jun	11.3	21.4	10.0 (47%)		8.5	15.1	6.7 (44%)		4.9	8.5	3.6 (43%)		3.3	6.0	2.7 (45%)		1.1	2.4	1.3 (55%)
Jul	5.5	14.5	8.9 (62%)		2.0	6.3	4.3 (68%)		1.3	3.4	2.1 (62%)		0.9	2.4	1.5 (62%)		0.6	1.5	0.9 (58%)
Aug	1.8	6.3	4.5 (71%)		0.2	1.6	1.4 (85%)		0.2	0.9	0.7 (80%)		0.2	0.8	0.6 (75%)		0.2	0.6	0.4 (61%)
Sep	0.2	1.9	1.6 (89%)		0.0	0.5	0.4 (91%)		0.0	0.3	0.3 (86%)		0.1	0.3	0.2 (76%)		0.1	0.3	0.1 (58%)
Oct	0.1	3.1	3.0 (96%)		0.0	0.7	0.7 (98%)		0.0	0.3	0.3 (94%)		0.0	0.2	0.2 (85%)		0.1	0.1	0.1 (53%)
Nov	0.6	9.6	9.0 (94%)		0.1	3.9	3.8 (98%)		0.1	1.2	1.1 (95%)		0.1	0.7	0.6 (89%)		0.1	0.4	0.2 (59%)
Dec	0.8	5.1	4.3 (84%)		0.1	3.2	3.1 (98%)		0.1	0.7	0.6 (89%)		0.2	0.6	0.5 (71%)		0.2	0.3	0.1 (39%)

5.4.1.3.1.2.2.4 Microcystis

The toxic blue-green alga *Microcystis* has been shown to have negative effects on the aquatic foodweb of the Delta (Brooks et al. 2012), principally in the south Delta and the middle to upper portions of the west/central Delta near locations such as Collinsville, Antioch, and Franks Tract (Lehman et al. 2010). *Microcystis* blooms generally occur from June to October, when water temperature is at least 19°C (Lehman et al. 2013). Lehman et al. (2013) suggested that streamflow is probably the most important factor maintaining *Microcystis* blooms, with longer residence times allowing the slow-growing colonies to accumulate into blooms. The summer/fall timing of *Microcystis* generally would be expected to avoid the period of occurrence of juvenile and adult winter-run and spring-run Chinook salmon and juvenile steelhead. *Microcystis* could, however, coincide with the occurrence of upstream-migrating adult steelhead, particularly those returning to the San Joaquin River basin that pass through the channels in the south Delta, where *Microcystis* is often abundant (Lehman et al. 2013). Quantitative analyses presented in detail for Delta Smelt in Section 6.1.3.5.5, *Microcystis*, showed that, based on analysis of flow in the lower San Joaquin River, conditions may be less favorable for *Microcystis* under the PA because of less south Delta exports and greater San Joaquin River flow past Jersey Point (QWEST). However, there are portions of the south Delta where residence time would be greater under the PA, which could give greater potential for *Microcystis* occurrence under the PA, although there has been no detailed study of *Microcystis* occurrence specifically in relation to residence time. Adult steelhead may be migrating through the Delta toward natal tributaries somewhat rapidly and without feeding, so the potential for ingestion of contaminated prey over longer periods would be limited; there is evidence that ingestion of prey contaminated by *Microcystis* can have effects on fish within the Delta (Lehman et al. 2010). Laboratory exposure of yearling rainbow trout to water containing *Microcystis* cell concentrations representative of bloom conditions did not give lethal effects or evidence of liver damage, suggesting that there is negligible entry of toxins through the gills or skin (Tencalla et al. 1994); however, it is possible for the toxins to enter fish guts passively during swimming (De Magalthaes et al. 2001, as cited by Lehman et al. 2010). Overall, this analysis suggests that the potential for negative effects to steelhead from changes in *Microcystis* under the PA relative to the NAA is insignificant. Under the assumption that the migration timing of San Joaquin River spring-run Chinook salmon is similar to that of Sacramento River basin spring-run, this suggests that most individuals would occur in the Delta during winter/spring and therefore would avoid the season of *Microcystis* occurrence. However, yearling juveniles migrating downstream could occur in the fall and therefore have some overlap with *Microcystis*. The risk to yearling San Joaquin River spring-run Chinook salmon associated with the mixed effects of the PA on *Microcystis*, including potential greater occurrence of *Microcystis* in some areas, is uncertain. As described in Section 6.1.3.5.5.5.2 *Population-Level Effects* for Delta Smelt, there is potential to mitigate effects on *Microcystis* through preferential south Delta export pumping: the modeling currently assumes that in the summer months (July–September), the first 3,000 cfs of exports would be from the south Delta, with any additional allowable exports able to be diverted from either the north or the south Delta; it would be possible to shift to additional south Delta pumping as opposed to north Delta pumping in order to reduce water residence time, for example. Subsequent monitoring will confirm to what extent the yearling life history trait occurs for San Joaquin River basin spring-run Chinook salmon.

5.4.1.3.2 Green Sturgeon

5.4.1.3.2.1 Near-Field Effects

5.4.1.3.2.1.1 North Delta Exports

5.4.1.3.2.1.1.1 Entrainment

Green sturgeon eggs, embryos, and larvae occur farther upstream in the Sacramento River than the proposed location of the NDD (Israel and Klimley 2008). Therefore, these life stages would not be entrained by the NDD. NMFS (2009: 119) noted that the lack of a significant proportion of juveniles below 200 mm in length in salvage samples at the south Delta export facilities indicates that juveniles likely hold in the mainstem Sacramento River upstream of the Delta before moving downstream. This would mean that juvenile green sturgeon would be effectively screened, given the 1.75-mm openings in the NDD screens.

5.4.1.3.2.1.1.2 Impingement and Screen Contact

Green sturgeon are demersal (i.e., tend to occupy the bottom of the channel), and therefore less likely to occur near vertical, on-bank fish screens that are off the river bottom, as proposed for the NDD. Preliminary studies at the UC Davis Fish Treadmill facility found that juvenile green sturgeon frequently contacted the fish screen but survival was high and the fish were not injured, with screen contact rate being unrelated to water velocity or time of day (Swanson et al. 2004b). Recent studies with a V-shaped screen in a test flume confirmed that contact with screens was frequent, and in this case screen contact was increased with increasing water velocity and was greater by day than by night (Poletto et al. 2014). There is therefore a potential for adverse effects from screen contact (e.g., injury), although impingement was rarely observed in laboratory studies.

5.4.1.3.2.1.1.3 Predation

NMFS (2009: 350) suggested that predation on juvenile green sturgeon during occurrence in Clifton Court Forebay would be minimal, given their size and protective scutes, but noted that this has never been experimentally verified. If true, the potential for predation at the NDD would be expected to be insignificant because the size and protective scutes of green sturgeon occurring near the NDD and the predators would be similar to that found in Clifton Court Forebay. However, there is uncertainty in the potential and extent of predation of juvenile green sturgeon at the NDD.

5.4.1.3.2.1.2 South Delta Exports

As noted for salmonids in Section 5.4.1.3.1.1.2, *South Delta Exports*, direct entrainment by the south Delta export facilities includes a number of components contributing to loss, including prescreen loss; louver efficiency; collection, handling, trucking, and release; and post-release mortality. However, specific loss estimates for these components generally are unknown for green sturgeon (National Marine Fisheries Service 2009: 341-374). Consistent with the analysis for salmonids, the present analysis for green sturgeon provides quantitative analyses of entrainment differences between NAA and PA, and a qualitative discussion of potential predation differences between NAA and PA. The various components of salvage loss (prescreen loss, etc.) are assumed not to differ between NAA and PA (other than qualitative discussion of potential prescreen loss differences in Clifton Court Forebay), so the differences between NAA and PA are attributable to differences in export pumping.

5.4.1.3.2.1.2.1 Entrainment

5.4.1.3.2.1.2.2 Salvage-Density Method

The salvage-density method was used to assess differences in south Delta exports and resulting entrainment during the periods of occurrence of juvenile green sturgeon in the Delta, based on historical salvage data. Details of the method, together with results by month and water year, are presented 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.D.1.1.2, *South Delta Exports*. As noted previously for juvenile salmonids, although this method provides an index of entrainment, it is most appropriately viewed comparatively, and functions primarily to illustrate south Delta export differences between scenarios. The method does not account for differences in salvage that could occur because of other operational effects, e.g., changes in juvenile sturgeon routing because of the NDD or the HOR gate.

The results of the salvage-density method showed that, based on modeled south Delta exports, mean salvage of juvenile green sturgeon at the south Delta export facilities would be lower under PA than NAA in all water year types that salvage had historically occurred (Table 5.4-24); during the historic period providing the salvage-density data for the analysis (1996-2008), there was no observed salvage of green sturgeon in above normal years (CVP), below normal years (CVP/SWP), and critical years (SWP), so this meant the density in these months was zero and therefore there were no differences between the NAA and PA scenarios in salvage estimate. The differences between PA and NAA were greater in wetter water years, as a result of less south Delta export pumping facilitated by operation of the NDD. The differences between scenarios ranged from 0% in the aforementioned periods when no salvage occurred historically, to 65% less under PA at the SWP in wet years (Table 5.4-24).

Table 5.4-24. Estimated Mean Entrainment Index (Number of Fish Salvaged, Based on Nonnormalized Salvage Data) of Juvenile Green Sturgeon for NAA and PA Scenarios at the CVP/SWP Salvage Facilities, By Water Year Type

Water Year Type	State Water Project				Central Valley Project		
	NAA	PA	PA vs. NAA[1]		NAA	PA	PA vs. NAA[1]
Wet	109	38	-71 (-65%)		69	28	-41 (-60%)
Above Normal	12	7	-5 (-41%)		0	0	0 (0%)
Below Normal	0	0	0 (0%)		0	0	0 (0%)
Dry	22	19	-3 (-13%)		51	24	-27 (-53%)
Critical	0	0	0 (0%)		7	5	-1 (-17%)

Notes: [1]Negative values indicate lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

5.4.1.3.2.1.2.3 Predation

As previously noted for the NDD, NMFS (2009: 350) suggested that predation on juvenile green sturgeon during occurrence in Clifton Court Forebay would be minimal, given their size and protective scutes, but noted that this has never been experimentally verified. Therefore, reductions in entrainment under the PA would not be expected to lead to anything more than a minimal reduction in entrainment-related predation at the south Delta export facilities. Localized reduction in predatory fishes (Section 5.5.2, *Localized Reduction of Predatory Fishes to*

Minimize Predator Density at North and South Delta Export Facilities) may decrease predatory fish density in Clifton Court Forebay, but given that there is uncertainty in the feasibility of doing so (based on previous studies; Brown et al. 1996) and NMFS's (2009: 350) suggestion that predation is minimal, the action would also be expected to provide no more than a minimal benefit to green sturgeon; the uncertainty in the measure's effectiveness means that for this BA, no effectiveness is assumed.

5.4.1.3.2.1.3 Head of Old River Gate

5.4.1.3.2.1.3.1 Predation

In contrast to juvenile salmonids, for which predation near previously implemented barriers at the HOR has been observed, there is no such information about predation risk near the HOR gate for green sturgeon. Following the logic of NMFS (2009: 350), which suggested that there may be minimal predation in Clifton Court Forebay because of the size of juvenile green sturgeon and their protective body scutes, there may be minimal risk to juvenile green sturgeon from predation at the HOR gate; however, as noted by NMFS (2009: 350) for Clifton Court Forebay, this has not verified experimentally, and the potential for predation of green sturgeon at the head of Old River gate is uncertain.

5.4.1.3.2.1.3.2 Upstream Passage

Passage of green sturgeon at the vertical slot fishway proposed for the HOR gate under the PA would be expected to be limited, as the structure is designed primarily for adult salmonid passage, whereas sturgeon have different requirements for successful passage (Webber et al. 2007). Therefore, green sturgeon intending to migrate to the San Joaquin River main stem from Old River could be confined to Old River until the HOR gate opened again. For the spring operations, this would be an adverse effect relative to the NAA, for which a rock barrier is not always installed. In the fall, operations of the HOR gate again could block passage of green sturgeon intending to move into the San Joaquin River from Old River; however, although the existing fall rock barrier has a 30-foot-wide notch at elevation 2.3 feet NAVD, the demersal nature of green sturgeon means that passage is unlikely under the NAA, based on NMFS' (2013a: 82) observation of passage being unlikely over the weir crests of other temporary barrier in the south Delta. Therefore, during the fall RTO of the HOR gate, passage impediment of green sturgeon in the south Delta would be insignificantly different from the NAA.

5.4.1.3.2.1.4 Delta Cross Channel

Given that the main period of upstream migration of adult green sturgeon is in the winter/spring, it is expected that the DCC gates would be closed and therefore any adult green sturgeon bound for the upper Sacramento River that encounter the gates would need to migrate back down the Mokelumne River and ascend an alternative Delta channel leading to the main stem Sacramento River. Any such delays in migration would be the same under the NAA and PA, given the same operational criteria during this time period (see Table 5.A.6-31 in Appendix 5.A, *CalSim II Modeling and Results*). NMFS (2009: 408) noted that there is little information available regarding juvenile green sturgeon movements in the lower Sacramento River and Delta waterways, and although there is newer available information since the assessment of NMFS (2009)—i.e., the summary by Klimley et al. (2015) of juvenile movements; see Section 5.4.1.3.2.2.1 *Indirect Mortality Within the Delta*—it remains unknown how vulnerable juvenile green sturgeon are to diversion into the DCC or their risk from predation in the Delta. The monthly number of days that the DCC gates would be open generally would be expected to be similar between NAA and PA throughout most of the year, except during fall, as discussed for salmonids. Therefore, differences between NAA and PA in effects on juvenile green sturgeon, which reside in the Delta for several years, are likely to be limited.

5.4.1.3.2.1.5 Suisun Marsh Facilities

5.4.1.3.2.1.5.1 Suisun Marsh Salinity Control Gates

As described by NMFS (2009: 435-436), little is known about adult green sturgeon upstream passage at the SMSCG, with existing studies suggesting that use of Suisun and Honker Bays was greater than Montezuma Slough where the SMSCG are located. NMFS (2009: 435-436) suggested that adult green sturgeon would have the opportunity to pass the SMSCG through the boat locks or gates (when open), as adult salmonids do, but that they could be delayed. However, any delays would not affect access to spawning habitat in the upper Sacramento River because adult green sturgeon tend to spawn in deeper water (Poytress et al. 2015) that would not be affected by temporary changes in flow; in addition, previous concerns from NMFS (2009: 436) regarding delays potentially affecting timing of arrival at Red Bluff Diversion Dam (where passage was previously restricted) no longer apply because of the decommissioning of the RBDD. The potential for predation near the SMSCG that was previously discussed for juvenile salmonids would be of minimal concern for juvenile green sturgeon because they are relatively large and unlikely prey for striped bass and Sacramento pikeminnow (National Marine Fisheries Service 2009: 439). In addition, as noted by NMFS (2009: 436), the multi-year estuarine residence of juvenile green sturgeon often includes long periods of localized, non-directional movement interspersed with occasional long-distance movements (Kelley et al. 2007); such movements are unlikely to be negatively affected by periodic delays of a few hours to a few days at the SMSCG. As discussed for salmonids, operational criteria for the SMSCG would not change under the PA relative to NAA, and operations modeling suggested that there would be little difference between NAA and PA in terms of SMSCG opening (see Table 5.B.5-29 in Appendix 5.B, *DSM2 Methods and Results*). Therefore any effects on green sturgeon from the SMSCG would be similar under NAA and PA.

5.4.1.3.2.1.5.2 Roaring River Distribution System

As previously described for juvenile salmonids, the low screen velocity at the RRDS intake culverts combined with a small screen mesh size are expected to successfully prevent green sturgeon from being entrained (National Marine Fisheries Service 2009: 437).

5.4.1.3.2.1.5.3 Morrow Island Distribution System

NMFS (2009: 438) noted that the MIDS is not on a migratory corridor for green sturgeon and that no green sturgeon had been entrained during DWR studies at the location in 2004-2006. However, seine surveys in Goodyear Slough did collect one juvenile white sturgeon in 2005-2006 (Enos et al. 2007), indicating that sturgeons can be present in the area. Overall, NMFS (2009: 438) considered it unlikely that green sturgeon would be entrained by the MIDS. Any entrainment that does occur would be expected to be similar between NAA and PA, as operations would not differ.

5.4.1.3.2.1.5.4 Goodyear Slough Outfall

NMFS (2009: 438) concluded that it would be unlikely that green sturgeon would encounter or be negatively affected by the Goodyear Slough outfall given its location and design, which is intended to improve water circulation in Suisun Marsh and therefore was felt by NMFS (2009: 438) to likely be of benefit to green sturgeon by improving water quality and increasing foraging opportunities.

5.4.1.3.2.1.6 North Bay Aqueduct

As described for salmonids, pumping rates at the North Bay Aqueduct Barker Slough Intake generally would be similar under the NAA and PA (see Table 5.B.5-35 in Appendix 5.B, *DSM2 Methods and Results*). In addition, NMFS (2009: 417) noted that green sturgeon are expected to be fully screened by the positive barrier screen in place at the pumping facility.

5.4.1.3.2.1.7 Other Facilities

5.4.1.3.2.1.7.1 Contra Costa Canal Rock Slough Intake

As described for salmonids, greater use of the Rock Slough intake under the PA than NAA could increase the potential for adverse effects to green sturgeon; however, resolution of screening effectiveness issues (new rake technology to eliminate aquatic weed problems) would be expected to limit any potential effects.

5.4.1.3.2.1.7.2 Clifton Court Forebay Aquatic Weed Control Program

As noted for salmonids, green sturgeon that occur in Clifton Court Forebay during application of copper-based herbicides would have the potential to be adversely affected from sublethal or lethal effects, although the potential for exposure to such effects would be limited to relatively few days during which chemical treatments would be applied. Mechanical removal of aquatic weeds such as water hyacinth may be unlikely to affect green sturgeon given their demersal position in the water column, which could limit the potential for direct injury from contact with cutting blades, for example.

5.4.1.3.2.2 Far-Field Effects

5.4.1.3.2.2.1 Indirect Mortality Within the Delta

In contrast to juvenile salmonids that are often moving relatively rapidly through the Delta toward the ocean and for which studies have shown that through-Delta survival can be linked to channel flows and south Delta exports, impacts to juvenile and sub-adult green sturgeon from such factors are less clear. As noted by NMFS (2009: 386), juvenile green sturgeon spend 1 to 3 years rearing in the Delta environment before transitioning to their marine life history stage; during this Delta rearing phase, fish are free to migrate throughout the Delta. Entrainment by the net negative export flows in the central and southern delta may cause fish to be pulled into the southern Delta waterways in an unnatural proportion to their normal movements, and acoustic tracking studies have provided more detailed information on the movements of this lifestage in the Delta. Thirty-two juvenile green sturgeon (30–53-cm fork length) fitted with acoustic tags were released at Santa Clara Shoals in the lower San Joaquin River near Fishermans Cut (Klimley et al. 2015). Over the nine-and-a-half-month life of the tags, these juvenile green sturgeon exhibited six behavioral patterns: 1) remained in the Delta, 2) moved into the Carquinez Strait, 3) migrated into San Pablo Bay, 4) moved into San Pablo Bay but returned to the Delta, 5) migrated through the estuary and likely left through the mouth of the bay, and 6) left the estuary only to later return. Thirty of the 32 tagged individuals were detected in the Central Delta, where they were released. Individuals stayed within this region on average 90.6 days and 44.3% of the time. The juveniles also stayed within the East Delta and the region between the East and Central Delta (see Figure 3 of Klimley et al. 2015). Fourteen individuals spent an average of 26.7 days and 28% of the time in the East Delta, and 16 juveniles spent 34.1 days and 31.0% of the time in the Central Delta. The next most inhabited regions were San Pablo Bay (15 individuals spent 26.0 days and 12.0% of their time) and around the Richmond Bridge (14 individuals spent 34.1 days and 13.4% of their time). As many as seven juveniles were detected near the Golden Gate Bridge, where they were present an average of 23.2 days and 9.9% of total days. Overall, these observations suggest the potential for both wide-ranging movements as well as residency in relatively small geographic areas for appreciable periods of time (multiple weeks). As described for juvenile salmonids in the summary of Delta hydrodynamics based on DSM2-HYDRO (Section 5.4.1.3.1.2.1.1, *Channel Velocity (DSM-HYDRO)* and Section 5.4.1.3.1.2.1.2.1, *Flow Routing Into Channel Junctions*, under the PA, channel velocity and flow routing into interior Delta channels generally would be expected to be improved in the south Delta because of less south Delta exports relative to NAA.

5.4.1.3.2.2.2 Habitat Effects

5.4.1.3.2.2.2.1 Delta Outflow

The reproductive success of white sturgeon, as judged by the year-class index of downstream trawl captures, is greatest in wet and above-normal water years when spring flows are high (Kohlhorst et al. 1991; Fish 2010). No similar studies have been conducted for green sturgeon because similar indices of year-class strength are not available. The mechanism behind the importance of higher flows for white sturgeon is not known and may involve both upstream and downstream (Delta) factors. Hypotheses for the mechanism underlying flow effects include higher flows facilitating young white sturgeon dispersal downstream, providing increased freshwater rearing habitat, increasing spawning activity cued by higher upstream flows, increasing nutrient loading into nursery areas, or increasing downstream migration rate and survival through reduced exposure time to predators (U.S. Fish and Wildlife Service 1995; Israel pers. comm.). Higher spring flows also benefit incubating eggs (U.S. Fish and Wildlife Service 1995). Coutant (2004) hypothesized that large recruitment events only happen during years when high spring and early summer outflows occur. This hypothesis was subsequently tested and found to be supported on the Columbia River by van der Leeuw et al. (2006).

As noted by Fish (2010), white sturgeon year-class indices correlate with Delta outflows, which are currently correlated with Delta inflows, at various periods. As described above, it is unclear if year-class strength for white sturgeon is explained best by Delta outflow, Delta inflow, both inflow and outflow, or flow-related changes in upstream areas. NMFS hypothesizes that relationships between white sturgeon year class index and Delta outflow may also be applicable to green sturgeon; year class indices for green sturgeon do not exist to examine these relationships directly.

NMFS provided linear regression relationships between white sturgeon year class indices and Delta outflow for two outflow averaging periods (April/May and March-July) (Marcinkevage pers. comm.). Although the raw data of white sturgeon year class index and Delta outflow suggest that nonlinear regression may be appropriate (Figure 5.4-26), there was no difference in explanatory power between linear and quadratic regressions for either averaging period[38], so the simpler, linear regression approach recommended by NMFS was used. Predicted means and 95% prediction intervals were calculated using PROC GLM and PROC PLM in SAS/STAT software, Version 9.4 of the SAS System for Windows.[39]

The analysis suggested that there would be very little difference in white sturgeon year-class index between NAA and PA with respect to either the April-May (Figure 5.4-29 and Figure 5.4-28) or the March-July (Figure 5.4-29 and Figure 5.4-30) Delta outflow averaging periods. Any differences were small, especially in relation to the magnitude of the 95% prediction intervals around the estimates (Figure 5.4-31 and Figure 5.4-31). Therefore, if white sturgeon is found to be a suitable surrogate species for green sturgeon with respect to Delta outflow, and Delta outflow is found to be a key mechanism affecting year class index, then the modeling results suggest that there would be essentially no difference between NAA and PA for green sturgeon with respect to effects from Delta outflow. This is because PA operations currently include provisions to ensure that Delta outflow in the spring is nearly equal to Delta outflow under NAA (see discussion in Appendix 5.A, *CALSIM Methods and Results*, Section 5.A.5.2.4.3)[40]. As explained previously, this analysis does not account for the results of the research and monitoring under the Adaptive Management Program and real time operational adjustments.

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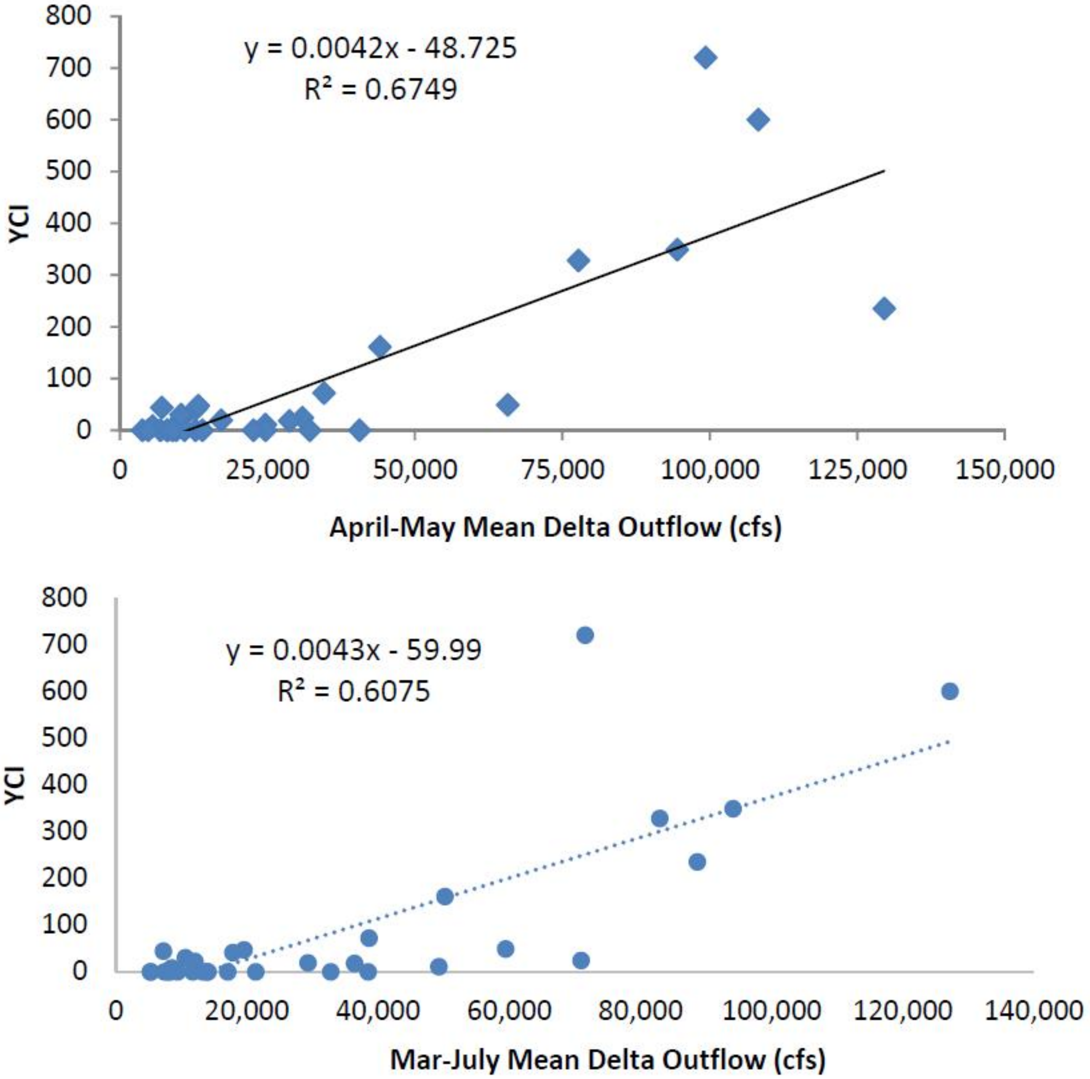
[38] Akaike's information criterion corrected for small sample sizes [AIC_C] was less than two units different for both comparisons of linear vs. quadratic regressions.

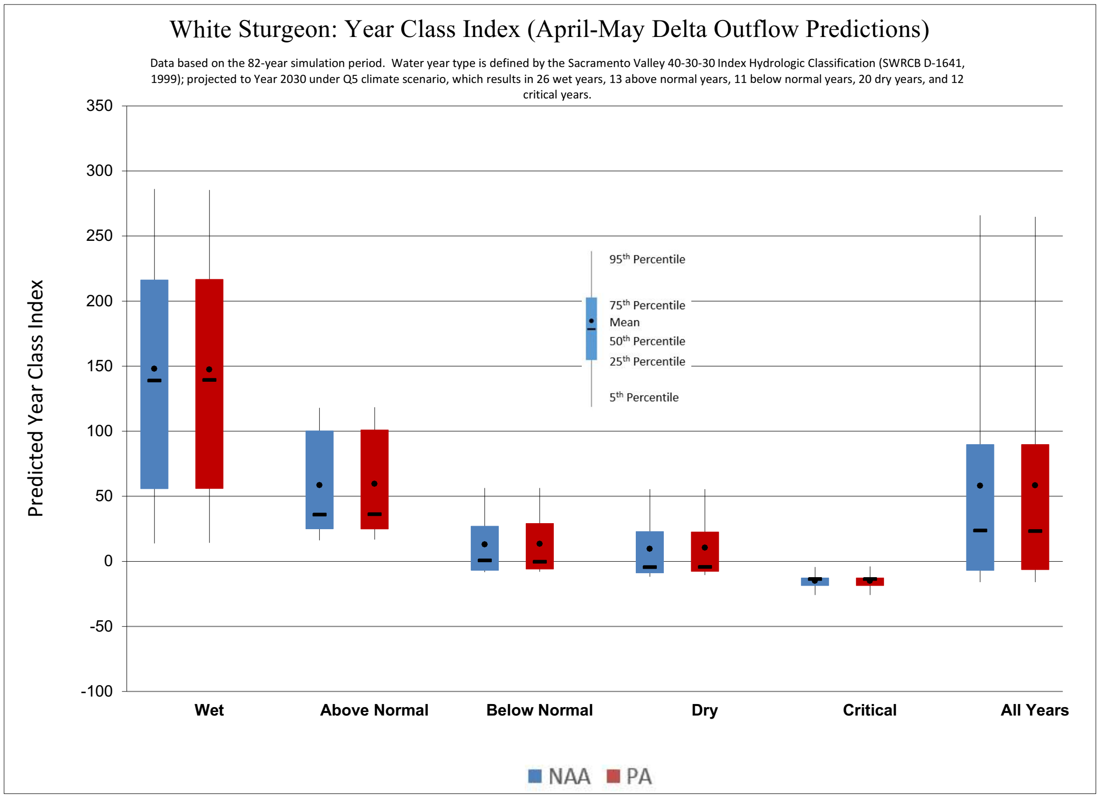
[39] Copyright 2002-2010, SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA

[40] As previously noted for analyses in Section 5.4.1.3.1.2.1.3.1 *Delta Passage Model: Winter-Run and Sacramento River Basin Spring-Run Chinook Salmon*, the independent review panel report for the working draft BA suggested that it is possible that the true annual values could lie near the bottom boundary of the prediction interval for PA and near the top boundary of the prediction interval for NAA (Simenstad et al. 2016). This would result in greater differences than suggested by the comparison of annual mean values. By the same rationale, it is also possible that the true annual values could lie near the top boundary of the confidence intervals for both PA and NAA, in which case the differences would be more similar to the differences between means.



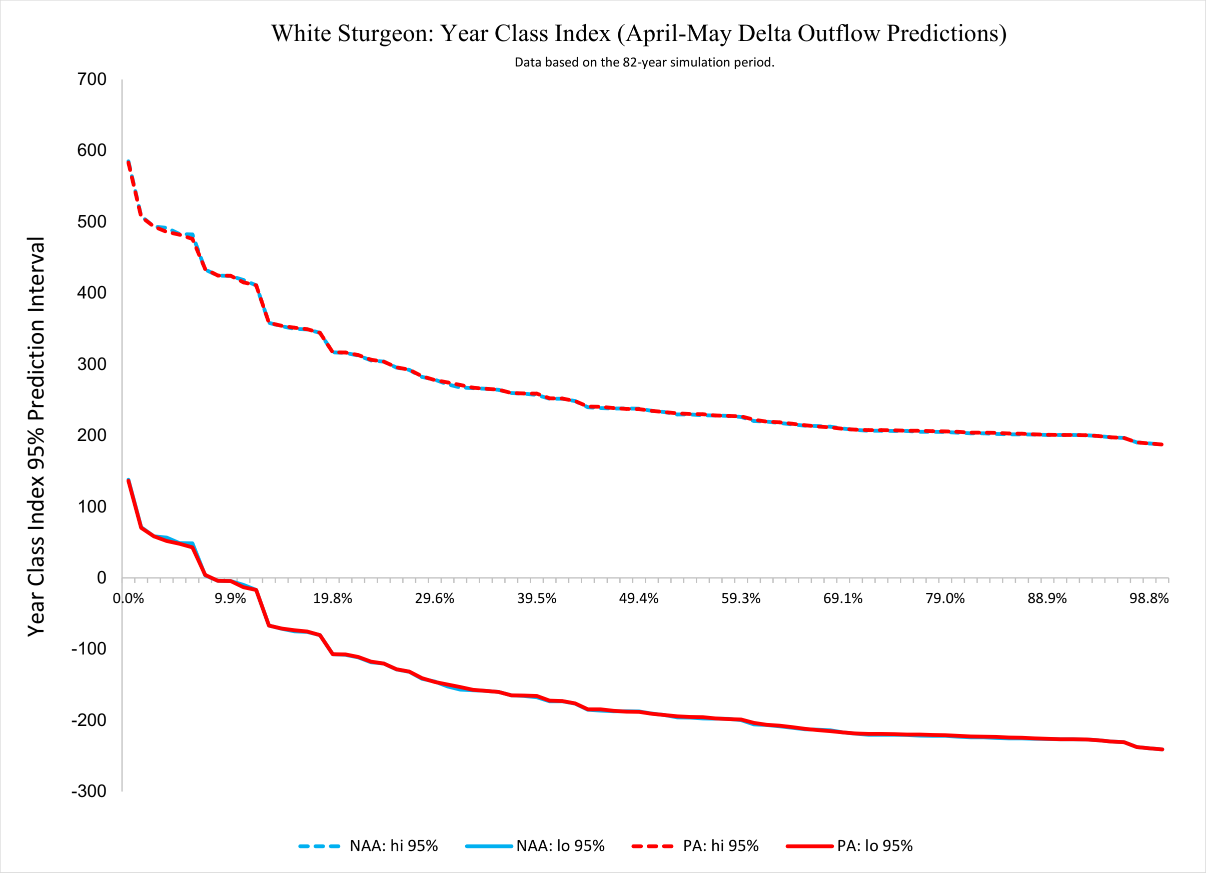
Source: Marcinkevage (pers. comm.)

Figure 5.4-26. White Sturgeon Year-Class Index (YCI) for 1980-2011 as function of Mean April-May Delta Outflow (Upper Panel) and Mean March-July Delta Outflow (Lower Panel).



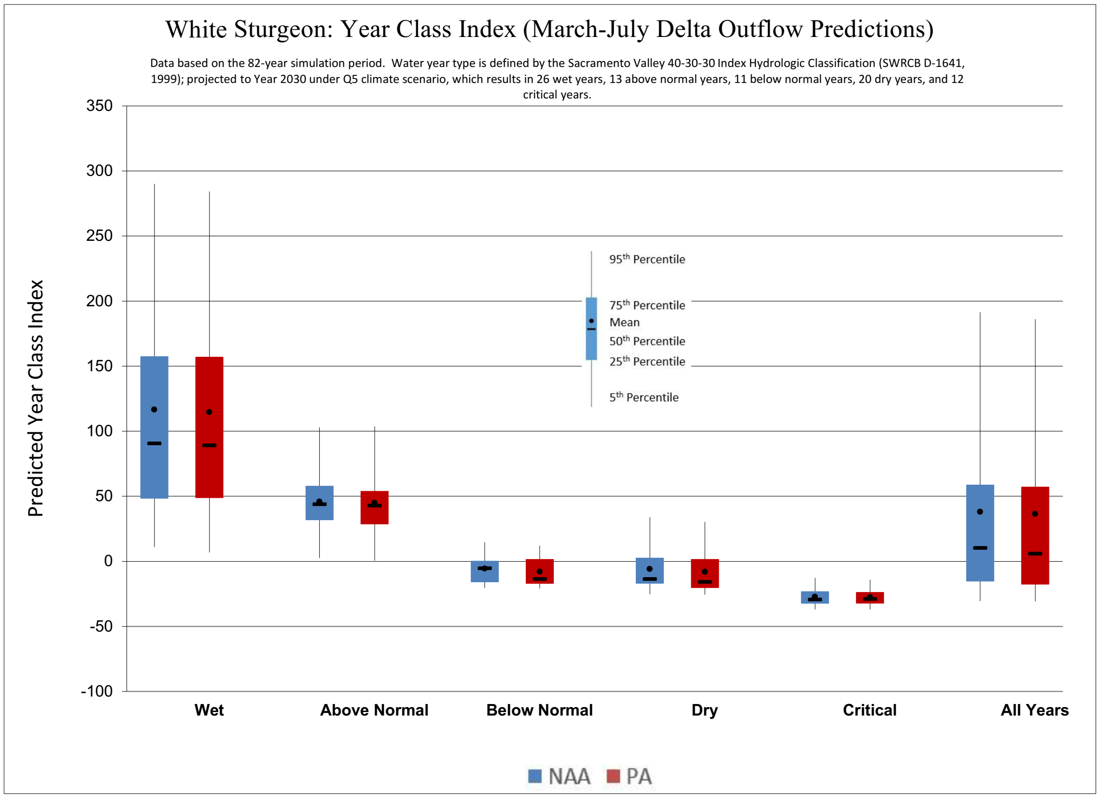
Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-27. Box Plots of White Sturgeon Year Class Index from the Mean April-May Delta Outflow Regression, Grouped by Water Year Type.



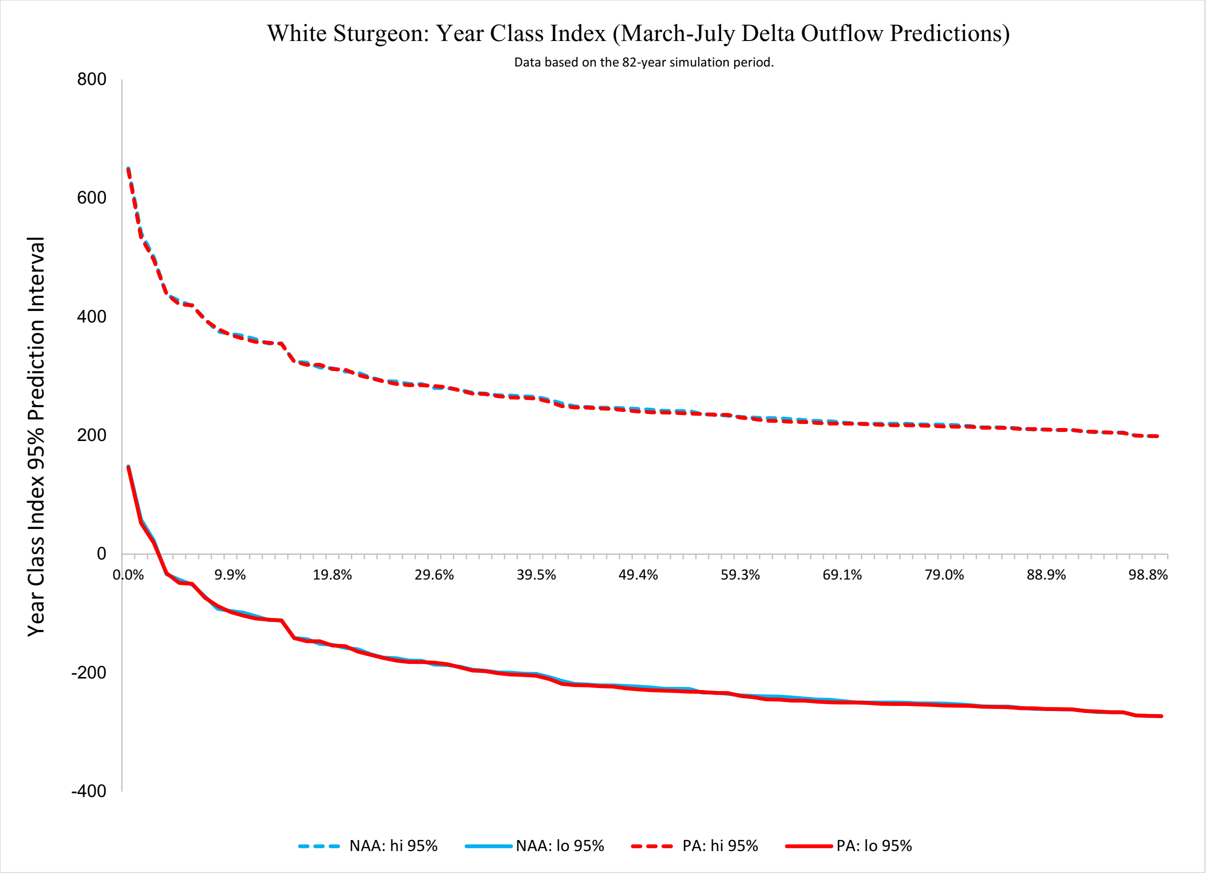
Note: Data are sorted by mean estimate, with only 95% prediction intervals shown.

Figure 5.4-28. Exceedance Plot of White Sturgeon Year Class Index from the Mean April-May Delta Outflow Regression.



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-29. Box Plots of White Sturgeon Year Class Index from the Mean March-July Delta Outflow Regression, Grouped by Water Year Type.



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown.

Figure 5.4-30. Exceedance Plot of White Sturgeon Year Class Index from the Mean March-July Delta Outflow Regression.

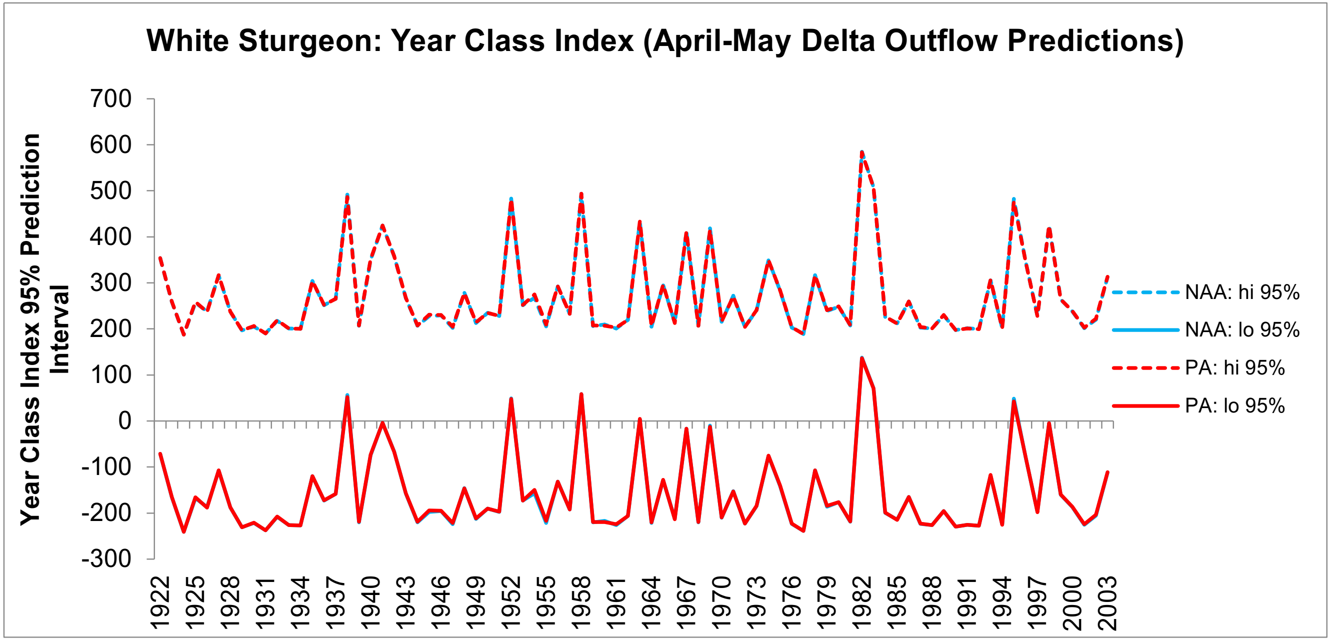


Figure 5.4-31. Time Series of 95% Prediction Interval Annual White Sturgeon Year Class Index, Estimated from the Mean April-May Delta Outflow Regression.

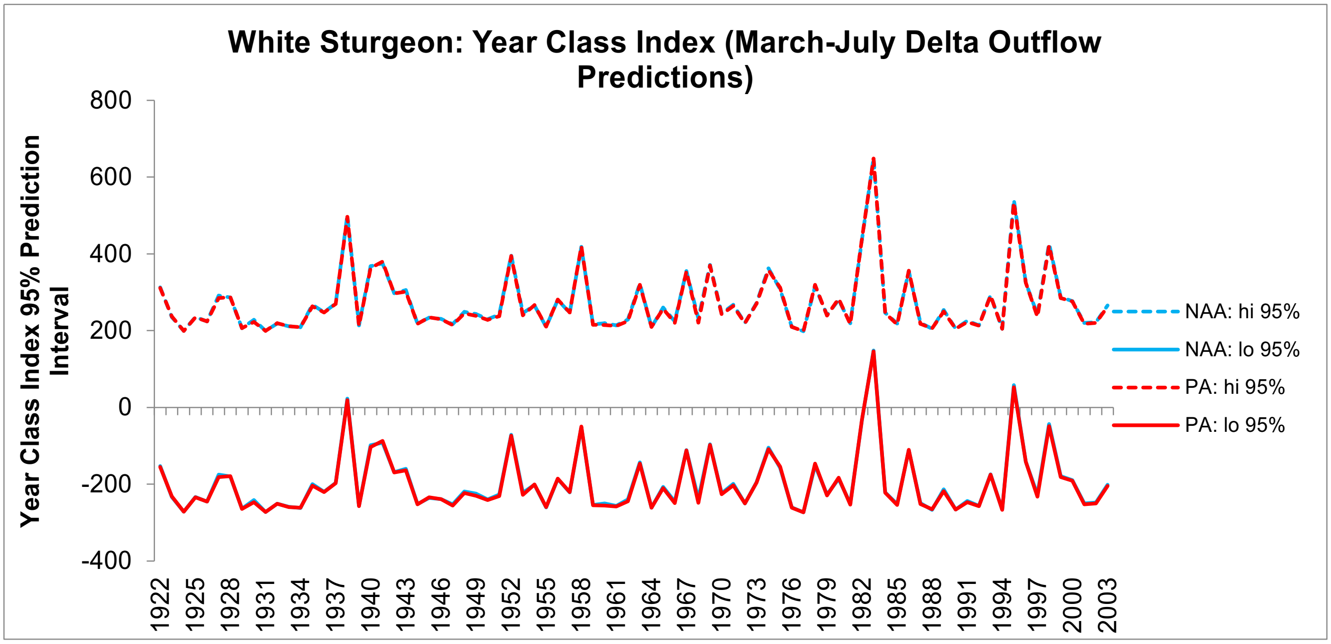


Figure 5.4-32. Time Series of 95% Prediction Interval Annual White Sturgeon Year Class Index, Estimated from the Mean March-July Delta Outflow Regression.

5.4.1.3.2.2.2.2 Selenium

As previously discussed for salmonids, the increase in the proportion of San Joaquin River water entering the Delta because of less south Delta exports under the PA would be expected to increase the selenium concentration in Delta water. A detailed analysis of the potential for effects is provided in Appendix 5.F, *Selenium Analysis*. The analysis presented therein concluded the following:

- Based on the selenium analysis for reproductive effects in green sturgeon (the most sensitive life-stage), no risks to individual green sturgeon or populations are predicted at two locations (Sacramento River upstream of Delta Cross Channel and San Joaquin River near San Andreas Landing).

- Risks to green sturgeon (individuals and populations) at the Old River at Clifton Court Forebay Radial Gates (West Canal) location are considered possible but unlikely (i.e., all dietary concentrations are below the benchmark of 8.2 mg/kg; although there are some exceedances of the whole-body benchmark of 3.3 mg/kg, there are no predicted exceedances of the 5 mg/kg benchmark).

- Modeled green sturgeon whole-body concentrations at the two western Delta locations may present a risk to sturgeon (i.e., all whole-body concentrations exceeded the 3.3 mg/kg threshold and 50 to 70 percent of whole-body concentrations exceeded the less conservative 5 mg/kg threshold). The 3.3 mg/kg threshold is an EC_{05} and the 5 mg/kg threshold is an EC_{10}, which suggests a small percentage of individuals may experience reproductive effects that could translate into a small population effect (under both the NAA and PA). However, it is important to note that there is very little predicted difference under the PA in comparison to the NAA.

- Possible risks identified for green sturgeon would be most likely to occur during dry or critical years.

5.4.1.3.2.2.2.3 Microcystis

As described for salmonids in Section 5.4.1.3.1.2.2.5, *Microcystis*, the PA could have mixed effects on the occurrence of *Microcystis* principally in the south Delta as a result of flow and residence time changes caused by less south Delta export pumping. Juvenile green sturgeon occur in the Delta year-round and therefore could be exposed to *Microcystis* or prey items containing *Microcystis*. The potential effects are uncertain because no studies have been made of *Microcystis* on green sturgeon, although there is evidence for Delta fish species being adversely affected by consumption of *Microcystis*-contaminated food (Lehman et al. 2010; Acuna et al. 2012). During workshops convened in August 2013 to discuss potential effects of the previously proposed BDCP, agency biologists felt that the high mobility of sturgeon juveniles (and adults) would allow movement away from adverse conditions caused by *Microcystis*, although this opinion was made with low certainty.

5.4.1.4 Assess Risk to Individuals

5.4.1.4.1 Salmonids

5.4.1.4.1.1 Risk to Salmonids from Near-Field Effects

5.4.1.4.1.1.1 Risk to Salmonids from North Delta Exports

As described in Section 5.4.1.2.1.4 *Exposure to North Delta Exports*, juvenile salmonids emigrating from the Sacramento River basin could be exposed to the near-field effects of the NDD, with the only individuals not passing through this reach being the proportion of the population entering the Yolo Bypass (estimated to be an average of ~8% in dry and critical water years and ~16% in wet and above normal years for winter-run and spring-run Chinook salmon; Table 5.4-2, Roberts et al. 2013, Acierto et al. 2014). As described in Section 5.4.1.3.1.1.1, the main near-field effects of the NDD on juvenile salmonids may include screen contact (resulting in risk of injury), long screen passage times (increasing the risk of screen contact or predation), and predation (giving risk of mortality). These effects pose some risk to juvenile salmonids, although there is uncertainty in the extent of the risk. As noted in in Section 5.4.1.3.1.1.1.3, indicators of the risk of predation vary between the lower estimates suggested by previous bioenergetics modeling (e.g., 0.3% for winter-run Chinook salmon) to higher estimates (5%) from the study conducted at the GCID fish screen (Vogel 2008b), although in neither case did these estimates consider the baseline rate of predation that might occur without the NDD. Juvenile salmonids from the San Joaquin basin would not be exposed to near-field effects of the NDD. Risk would be minimized by real-time operational adjustments to reduce north Delta exports to coincide with expected or observed pulses of juvenile salmonids into the Delta, as well by screen design (e.g., low approach velocity, small screen opening size per fish agency criteria, on-bank design; see Section 5.4.1.3.1.1.1 *North Delta Exports* and Section 3.2.2 *Fish Screen Design* in Chapter 3, *Description of the Proposed Action*).

5.4.1.4.1.1.2 Risk to Salmonids from South Delta Exports

As described in Section 5.4.1.2.1.5 *Exposure to South Delta Exports*, exposure to entrainment and associated predation at the south Delta exports would be expected to be greater for juvenile steelhead and spring-run Chinook salmon emigrating from the San Joaquin River basin, than for the ~10-30% entering the interior Delta through Georgiana Slough or the Delta Cross Channel that could subsequently move towards the south Delta. As illustrated in Section 5.4.1.3.1.1.2, the near-field effects of the south Delta export facilities present a risk from mortality by entrainment, either through associated predation (e.g., prescreen loss) or other effects (passing through screening louvers); this results in survival of entrained fish being less than 17% at the SWP and ~65% at the CVP. On the basis of less south Delta export pumping under the PA than NAA, analyses presented in Section 5.4.1.3.1.1.2 demonstrate that there is potential for less risk to juvenile salmonids from south Delta entrainment and associated predation under the PA than NAA, particularly in wetter years when a greater proportion of overall export pumping would be undertaken by the NDD under the PA. Since implementation of the NMFS (2009) BiOp, the risk to juvenile salmonids has been limited by export and OMR restrictions. These restrictions have limited loss of juvenile winter-run Chinook salmon entering the Delta to 1.4% to 66% of the permitted incidental take, equating to ~0.03% to 1.3% of the juvenile population entering the Delta (Islam et al. 2015). This loss, and the risk to juvenile Chinook salmon as a result, would be expected to be lower under the PA than the NAA. Analogous estimates of the percentage of other runs of juvenile salmonids lost at the south Delta export facilities are not made[41], but regardless, the loss would be expected to be less under the PA than NAA

For juvenile steelhead and spring-run Chinook salmon from the San Joaquin River basin, the risk of entrainment and associated predation at the south Delta export facilities would be expected to be further reduced under the PA by the operation of the HOR gate.

5.4.1.4.1.1.3 Risk to Salmonids from Head of Old River Gate

As described in Section 5.4.1.2.1.6 *Exposure to Head of Old River Gate Operations*, only juvenile and adult steelhead and spring-run Chinook salmon from the San Joaquin River basin would be expected to be exposed to HOR gate operations. As described in Section 5.4.1.3.1.1.3.1 *Predation*, there is risk to juvenile salmonids from near-field predation at the barrier. This risk is the result of predation that could occur close to the gate when closed, e.g., because of predatory fishes associating with the gate's in-water structure or capitalizing on longer residence times of juvenile salmonids caused by hydrodynamic eddies created by the position of the gate in Old River downstream of the junction (as shown for the 2012 rock barrier; Figure 5.4-33). Enhanced predation could also occur when the gate is open, if predators are able to use the structure as ambush habitat to attack juvenile salmonids passing close to structure near the channel bottom. In addition, the presence of a gate would be expected to guide juvenile salmonids toward a high-predation area in the scour hole in the San Joaquin River just downstream of the HOR. Based on data assessing the effects of the 2012 rock barrier on acoustically tagged juvenile Chinook salmon, the risk of predation at the junction can be high, as an estimated 39% of juveniles were preyed upon (DWR 2015a). In contrast, only 10% of juveniles were preyed upon in 2011 when no barrier was present. However, flows were much higher in 2011 and 2012, which led to considerably faster travel times through the HOR area in 2011 and possibly led to a lower risk of predation in that year. In addition, the density of predatory fishes at the junction was much lower in 2011 (possibly because of greater flow reducing habitat suitability). As described in Section 5.4.1.3.1.1.3.1 *Predation*, the extent to which the risk from any near-field predation at the HOR gate would offset the anticipated beneficial effects of a greater proportion of fish and flow remaining in the San Joaquin River is unclear, although the available data for fall-run juvenile Chinook salmon suggest that in general the presence of a barrier improves through-Delta survival (Hankin et al. 2010, Brandes and Buchanan 2016; however, see Anderson et al. 2012).

As described in Section 5.4.1.3.1.1.3.2 *Upstream Passage*, the HOR gate has the potential to delay upstream-migrating adult steelhead and spring-run Chinook salmon when closed. However, it is expected that there would be no risk to adults from the gate because of the provision of a fish passage structure meeting NMFS and USFWS guidelines in order to allow passage of upstream migrating salmonids, including steelhead and Chinook salmon.

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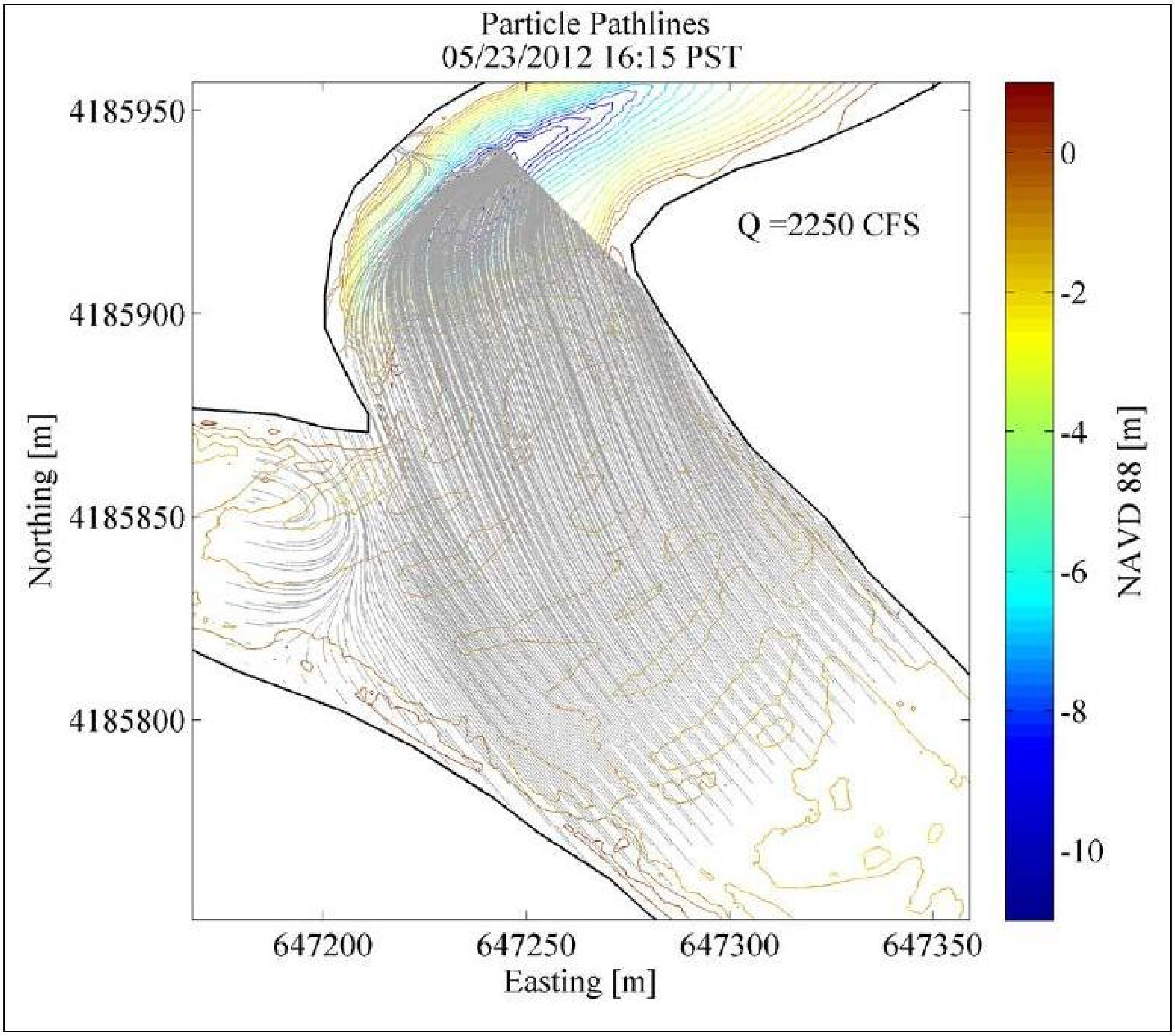
[41] The partial exception being estimates of the loss of hatchery-reared late fall-run Chinook salmon that are surrogates for the small percentage of Sacramento River basin spring-run Chinook salmon entering the Delta as yearlings.



Source: DWR (2015a). Note: The rock barrier is not shown in the diagram, but was just to the left (downstream) of the apparent eddy at the Head of Old River.

Figure 5.4-33. Two-Dimensional Near-Surface Particle Pathlines Estimated from Data Collected with a Side-Looking Acoustic Doppler Current Profiler at the Head of Old River, 5/23/2012, 1615 PST, with River Discharge in the San Joaquin River near Lathrop (Q) of 2,250 cfs.

5.4.1.4.1.1.4 Risk to Salmonids from Delta Cross Channel

As described in Section 5.4.1.2.1.7 *Exposure to Delta Cross Channel*, most juvenile salmonids approaching the DCC from the Sacramento River basin would encounter the DCC gates in the closed position, whereas primarily adult spring-run Chinook salmon and steelhead could encounter the gates in a mixture of open and closed configurations because of the seasonality of their upstream migrations. Section 5.4.1.3.1.1.4 illustrated that only for the adult steelhead migration period would the operations of the DCC potentially differ between the NAA and PA, and that there could be potential for greater delay under the PA in some years because of a greater frequency of multi-day opening and subsequent closure. The extent to which this would constitute a risk to steelhead adults is unknown without further study of the extent to which adult steelhead could find an alternative pathway through the Delta, or how long they may hold below the gates until they are reopened.

5.4.1.4.1.1.5 Risk to Salmonids from Suisun Marsh Facilities

As described in Section 5.4.1.2.1.8 *Exposure to Suisun Marsh Facilities*, the October–May operational period of the SMSCG coincides with the upstream and downstream migration periods of listed Central Valley salmonids, with the full extent of exposure depending on entry into Montezuma Slough. Salmonids could also encounter the RRDS in Montezuma Slough, but would be less likely to be exposed to the MIDS and the Goodyear Slough outfall. As described in Section 5.4.1.3.1.1.5.1, adult salmonids are at risk of delay if encountering closed SMSCG but could backtrack around the structure. The proportion of individuals that would do so is not known, and as described by NMFS (2009: 436) delays to spring-run Chinook salmon and steelhead could result in greater effects than to winter-run Chinook salmon, because spring-run and steelhead may be more reliant on short-term high flow events in smaller tributaries to access spawning habitat in these tributaries. With respect to juvenile salmonids migrating downstream, near-field predation and passage obstruction for migrants are not expected to cause considerable risk at the SMSCG (NMFS 2009L 436-437), and in any case there would be little difference in the number of days that the SMSCG would be operated between the PA and the NAA (see Table 5.B.5-29 in Appendix 5.B, DSM2 Methods and Results). The risk to juvenile salmonids at the RRDS because of the screened intakes would be insignificant (see Section 5.4.1.3.1.1.5.2 *Roaring River Distribution System*).

5.4.1.4.1.1.6 Risk to Salmonids from North Bay Aqueduct

As described in Section 5.4.1.2.1.9 *Exposure to North Bay Aqueduct*, listed salmonids could occur in the vicinity of the NBA's Barker Slough pumping plant, but as assessed in Section 5.4.1.3.1.1.6 *North Bay Aqueduct*, the screens at the facility are designed to protect juvenile salmonids per NMFS criteria. In addition, the location of the facility is well off the typical migration corridor of juvenile salmonids (NMFS 2009: 417). These factors indicate that the risk to listed salmonids from the NBA intake is insignificant.

5.4.1.4.1.1.7 Risk to Salmonids from Other Facilities

5.4.1.4.1.1.7.1 Risk to Salmonids from Contra Costa Canal Rock Slough Intake

As noted in Section 5.4.1.2.1.10.1, juvenile salmonids are present in the south Delta near the Rock Slough intake in winter/spring, and adult salmonids can also occur in the area. As described in Section 5.4.1.3.1.1.7.1 *Contra Costa Canal Rock Slough Intake*, there have been recent fouling issues with the fish screens at the Rock Slough intake, with a new mechanical rake system being tested to resolve these issues. DSM2 modeling suggested that PA pumping at the Rock Slough intake generally would be expected to be similar to the NAA, with the exception of April and May, when diversions were modeled to be greater under the PA (see Table 5.B.5-36 in Appendix 5.B, DSM2 Methods and Results). Resolution of the screening issue described above is expected to improve screen efficiency, reduce predation of juvenile salmonids by vegetation-associated predatory fishes, and reduce adult salmonid mortality during screen maintenance (NMFS 2015b: 4). This, coupled with the intake's location off the main migratory route (NMFS 2015a: 4), suggests that the risk to listed salmonids from the Rock Slough intake therefore would be insignificant.

5.4.1.4.1.1.7.2 Risk to Salmonids from Clifton Court Forebay Aquatic Weed Control Program

As noted in Section 5.4.1.2.1.10.2, exposure to the July/August herbicide application within Clifton Court Forebay would be expected to be minimal for listed salmonids because of their temporal occurrence within the Delta, whereas exposure to mechanical removal could occur as it would be done on an as-needed basis. The species response analysis (Section 5.4.1.3.1.1.7.2) showed that the small amount of entrainment that could occur in July/August would be expected to be less under the PA than the NAA. Mechanical removal could pose some risk to juvenile salmonids in Clifton Court Forebay from injury because of contact with cutting blades, but the reduction in aquatic weeds in the Forebay may provide an offsetting benefit and reduction in risk of predation by vegetation-associated fishes. Overall, the risk to salmonids from the Clifton Court Forebay Aquatic Weed Control Program is concluded to be insignificant.

5.4.1.4.1.2 Risk to Salmonids from Far-Field Effects

5.4.1.4.1.2.1 Risk to Salmonids from Indirect Mortality Within the Delta

As described in Section 5.4.1.3.1.2.1 *Indirect Mortality Within the Delta*, the PA has the potential to change important factors that influence survival of juvenile salmonids in the Delta, namely channel velocity and flow routing into the interior Delta. In the north Delta, the risk to juvenile salmonids generally would be expected to increase because of less flow leading to lower survival, as a result of flow-survival relationships (see Section 5.4.1.3.1.2.1.3 *Through-Delta Survival*) and a slightly greater percentage of flow entering the interior Delta at Georgiana Slough (see Section 5.4.1.3.1.2.1.2 *Entry into Interior Delta*). As described in Section 5.4.1.4.1.1.1 *Risk to Salmonids from North Delta Exports*, these potential effects would be of risk to all juvenile salmonids passing the NDD from the Sacramento River basin, which would constitute all the juveniles entering the Delta via the Sacramento River, but would exclude juveniles entering the Delta via the Yolo Bypass (~8-16% depending on water-year type). The risk to juvenile salmonids entering the Delta from the Sacramento River basin would be minimized by operational criteria and coordinated monitoring and research under the Adaptive Management Program, and real-time operational adjustments that would be made in response to fish presence, which would seek to maximize water supplies while limiting potential adverse effects as appropriate to avoid jeopardy. In addition, installation of a nonphysical fish barrier at the Georgiana Slough junction would minimize the potential for increased entry of fish into the junction caused by hydrodynamic changes because of the NDD, which would lessen the risk of individual fish entering the low-survival interior Delta. As described in Section 5.4.1.3.1.2.1.2.2 *Nonphysical Fish Barrier at Georgiana Slough*, pilot studies of barrier effectiveness have suggested that a BAFF has more potential than an FFGS at this location, with the BAFF reducing entry of acoustically tagged test Chinook salmon into Georgiana Slough by half or more.

For juvenile salmonids from the San Joaquin River basin, risks to individuals related to through-Delta survival generally would be expected to be lower under the PA than NAA as a result of less south Delta exports and the HOR gate (previously discussed in Section 5.4.1.4.1.1.3 *Risk to Salmonids from Head of Old River Gate*). As described in Section 5.4.1.3.1.2.1.3.5 *SalSim Through-Delta Survival Function: San Joaquin River Basin Spring-Run Chinook Salmon*, there could be appreciably greater through-Delta survival for juvenile San Joaquin River spring-run Chinook salmon under the PA, for example.

It is important to note that the risks to individuals from indirect mortality within the Delta are based mostly on the conclusions of studies related to larger juveniles, generally at least smolt-sized (e.g., the DPM is focused on fish of 70 mm and greater; see Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.D.1.2.2, *Delta Passage Model*). Smaller juveniles also migrate through the Delta (Miller et al. 2010), but quantitative data such as flow-survival relationships from which to draw conclusions regarding the risk to these juveniles do not exist. It is possible that these small juveniles would also experience far-field risk from PA operations, although it is unclear whether this risk would be greater or less than the risk for larger juveniles.

5.4.1.4.1.2.2 Risk to Salmonids from Changes in Habitat Suitability

Of the potential changes in habitat suitability that could occur because of the PA that were analyzed in Section 5.4.1.3.1.1.2.2 *Habitat Suitability*, there is discountable risk to salmonids from differences between PA and NAA in water temperature, selenium, olfactory cues, and *Microcystis*. The main potential risk to salmonids is less restored bench inundation for Sacramento River basins because of the far-field effects of the NDD, as described in Section 5.4.1.3.1.2.2.1.1 *Operational Effects*, which could result in less available habitat for rearing or resting during migration. This risk, which is estimated to result in up to ~20-30% less restored riparian bench habitat availability in some years at these restored bench locations, would be compensated for by restoration of channel margin habitat, as described in Section 3.4.4 *Fish Species Conservation* of Chapter, *Description of the Proposed Action*.

5.4.1.4.2 Green Sturgeon

5.4.1.4.2.1 Risk to Green Sturgeon from Near-Field Effects

5.4.1.4.2.1.1 Risk to Green Sturgeon from North Delta Exports

The near-field effects of the NDD create a potential risk to juvenile green sturgeon, which are present year-round in the Delta (see Section 5.4.1.2.2 *Exposure to North Delta Exports*). As described in Section 5.4.1.3.2.1.1, there is potential for adverse effects (e.g., injury) from screen contact should juvenile green sturgeons occur off the river bottom and encounter the screens, although laboratory studies did not find screen contact to result in injury (Swanson et al. 2004b). The extent of this risk is uncertain, whereas the risk of entrainment is none because of the size of the juveniles compared to the 1.75-mm screen openings. The risk of predation at the NDD may be low because of the size and protective scutes of green sturgeon, based on the analysis conducted for risk of predation in Clifton Court Forebay (NMFS 2009: 350), although this is uncertain.

5.4.1.4.2.1.2 Risk to Green Sturgeon from South Delta Exports

As described in Section 5.4.1.3.2.1.2, *South Delta Exports*, entrainment of green sturgeon can occur at the south Delta export facilities, with salvage efficiency generally not known. There has been little salvage of green sturgeon in recent years: between January 1, 2009, and June 20, 2016, for example, 12 green sturgeon were salvaged at the Skinner facility (all in 2011) and 6 green sturgeon were salvaged at the Tracy facility (2 in 2011, 4 in 2016)[42]. It is unknown what

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[42] http://www.dfg.ca.gov/delta/apps/salvage/SalvageExportChart.aspx?Species=3&SampleDate=6%2f2%2f2016&Facility=1, accessed June 23, 2016.

percentage of the green sturgeon population this represents, so that the overall risk is uncertain. As shown in Section 5.4.1.3.2.1.2.2 *Salvage-Density Method*, the risk to green sturgeon from south Delta entrainment under the PA generally would be expected to be less than for the NAA as result of less south Delta export pumping under the PA, with the salvage-density method suggesting the potential for 60-65% less entrainment in wet years, with less difference in drier years, as a result of little observed historical salvage in drier years. As previously noted in Section 5.4.1.3.2.1.2.5 *Predation*, NMFS's (2009: 350) suggestion that predation on juvenile green sturgeon during occurrence in Clifton Court Forebay is minimal—given juvenile green sturgeon size relative to predators, and their protective scutes—means that reductions in risk of entrainment under the PA would possibly lead to an insignificant change in risk of entrainment-related predation at the south Delta export facilities.

5.4.1.4.2.1.3 Risk to Green Sturgeon from Head of Old River Gate

As described in Section 5.4.1.2.2.5 *Exposure to Head of Old River Gate Operations*, some green sturgeon could occur in the vicinity of the HOR gate and be exposed to operational effects, although captures by anglers in the vicinity of that area are relatively low compared to other areas (see Section 5.4.1.2.2.4 *Spatial Occurrence*). As described in Section 5.4.1.3.2.1.3.1 *Predation*, there is uncertainty in the extent to which there could be predation risk to juvenile green sturgeon near the HOR gate. The risk of delay from passage at the HOR gate's vertical slot fishway, in contrast, is likely for any individuals migrating upstream through Old River to reach the San Joaquin River during spring (Section 5.4.1.3.2.1.3.2 *Upstream Passage*). Based on capture reports from the sturgeon report card, this risk may be limited to relatively few individuals (Table 5.4-4). These individuals therefore would be at risk of being negatively affected by the PA relative to the NAA, given that a rock barrier is not always installed in spring under the NAA. During the fall RTO of the HOR gate, the risk of passage impediment of green sturgeon in the south Delta would be insignificant, because of the installation of a rock barrier under the NAA, which is also likely to create passage delays.

5.4.1.4.2.1.4 Risk to Green Sturgeon from Delta Cross Channel

As described in Section 5.4.1.3.2.1.5 *Delta Cross Channel*, the upstream migration period of adult green sturgeon coincides with the winter/spring closure period for the DCC under both the NAA and PA, so that adult green sturgeon bound for the upper Sacramento River that encounter the closed DCC gates would need to migrate back down the Mokelumne River and ascend an alternative Delta channel leading to the main stem Sacramento River; any such delays in migration would be the same under the NAA and PA and therefore there would be no difference in the risk to green sturgeon adults from the DCC. It is unknown how vulnerable juvenile green sturgeon are to diversion into the DCC or their risk from predation in the Delta, but given that the monthly number of days that the DCC gates would be open generally would be expected to be similar between NAA and PA throughout most of the year, except during fall, as discussed for salmonids in Section 5.4.1.3.1.1.4, the differences in between NAA and PA are likely to be insignificant.

5.4.1.4.2.1.5 Risk to Green Sturgeon from Suisun Marsh Facilities

As described in Section 5.4.1.3.2.1.5 *Suisun Marsh Facilities*, screening at the RRDS intake, the low likelihood of entrainment by the unscreened MIDS, and the possible beneficial effects of the Goodyear Slough outfall indicate that the risk to green sturgeon from these three facilities is insignificant. In addition, although there may be greater potential of effects to green sturgeon from operations of the SMSCG than from the other Suisun Marsh facilities, the risk may also be insignificant. This is because delays to upstream adult migration would not affect access to deep spawning habitat in the upper Sacramento River—such habitat being available regardless of temporary changes in flow, unlike some spawning habitat for steelhead and spring-run Chinook salmon in smaller tributaries, for example—and any delays to juvenile green sturgeon would not be expected to adversely affect their long periods of localized, non-directional movements and occasional long-distance movements. In addition, the difference in operations between NAA and PA would be minimal, so the difference in risk between NAA and PA would be insignificant.

5.4.1.4.2.1.6 Risk to Green Sturgeon from North Bay Aqueduct

The similar pumping rates for NAA and PA and full screening of the North Bay Aqueduct Barker Slough Intake indicate that the risk to green sturgeon from this facility would be insignificant (Section 5.4.1.3.2.1.6 *North Bay Aqueduct*).

5.4.1.4.2.1.7 Risk to Green Sturgeon from Other Facilities

5.4.1.4.2.1.7.1 Risk to Green Sturgeon from Contra Costa Canal Rock Slough Intake

Although Rock Slough is not part of designated critical habitat for green sturgeon, individuals could still occur in that location and be exposed to the Rock Slough intake (Section 5.4.1.2.2.9.1 *Contra Costa Canal Rock Slough Intake*). Although pumping may be somewhat greater under the PA than NAA, resolution of the screening effectiveness issues would result in insignificant risk to green sturgeon from the Rock Slough intake.

5.4.1.4.2.1.7.2 Risk to Green Sturgeon from Clifton Court Forebay Aquatic Weed Control Program

Year-round potential occurrence of green sturgeon juveniles and sub-adults in Clifton Court Forebay means that there could be exposure to both chemical and mechanical elements of the weed control program (Section 5.4.1.2.2.9.2 *Clifton Court Forebay Aquatic Weed Control Program*). The risk from chemical treatments would be limited to a few days, whereas the risk from as-required mechanical removal may be limited because of the demersal position of sturgeons that could limit the potential for injury (Section 5.4.1.3.2.1.7.2). NMFS (2009: 390-391) noted that few green sturgeon would be expected to be exposed to herbicide application in Clifton Court Forebay, but indicated that the relative percentage of the population this would represent is unknown. NMFS (2009: 391) likewise noted that the number of green sturgeon that reside in the Forebay at any given time is unknown, with this uncertainty complicating the assessment of both population and individual exposure risks; NMFS (2009: 391) suggested that this area of green sturgeon life history needs further resolution to make an accurate assessment. A summary of recent studies of the movements of 33 acoustically tagged juvenile green sturgeon in the Delta did not indicate that any individuals moved to Clifton Court Forebay (Klimley et al. 2015). It is uncertain the extent to which the movements of these 33 fish is representative of the population as a whole, but if representative, this would indicate that the risk to green sturgeon from the weed control program is discountable as the probability of occurrence of green sturgeon in the Forebay would be very low, and the probability of encountering a weed control action while in the Forebay would also be very low.

5.4.1.4.2.2 Risk to Green Sturgeon from Far-Field Effects

5.4.1.4.2.2.1 Risk to Green Sturgeon from Indirect Mortality Within the Delta

As described in the discussion presented in Section 5.4.1.3.2.2.1 *Indirect Mortality Within the Delta*, the risk to green sturgeon from indirect mortality in the Delta is less clear than for juvenile salmonids. Because juvenile green sturgeon can range widely throughout the Delta, the risks from changes in north Delta hydrodynamics because of the NDD or in the south Delta because of less south Delta exports under the PA are uncertain.

5.4.1.4.2.2.2 Risk to Green Sturgeon from Habitat Effects

As described in Section 5.4.1.3.2.2.2 *Habitat Effects*, potential habitat effects on green sturgeon from the PA include changes in Delta outflow, selenium exposure, and *Microcystis* exposure. Under the assumption that green sturgeon could respond in a similar manner to Delta outflow as white sturgeon, the analysis presented in Section 5.4.1.3.2.2.1 *Delta Outflow* demonstrated that the risk to green sturgeon from PA operations relative to the NAA would be insignificant, as there would be very little difference in the surrogate white sturgeon year-class index between NAA and PA with respect to either the April-May or the March-July outflow averaging periods.

As described in Section 5.4.1.3.2.2.2.2 *Selenium*, the increased proportion of San Joaquin River water entering the Delta because of less south Delta exports under the PA would not be expected to result in any risk to green sturgeon individuals or populations in the Sacramento River upstream of DCC and San Joaquin River near San Andreas Landing, i.e., the north and central Delta. There would be potential risks at Old River at Clifton Court Forebay Radial Gates (West Canal), i.e., the south Delta, and in the west Delta, although with little difference between NAA and PA. Risks would be most likely to occur in dry or critical years.

The risk to green sturgeon associated with the mixed effects of the PA on *Microcystis*, including potential greater occurrence in some areas, is uncertain (Section 5.4.1.3.2.2.2.3). The considerable mobility of green sturgeon (Klimley et al. 2015) suggests that they could move away from affected areas, although this is uncertain. As described in Section 6.1.3.5.5.5.2 *Population-Level Effects* for Delta Smelt, there is potential to mitigate effects on *Microcystis* through preferential south Delta export pumping: the modeling currently assumes that in the summer months (July–September), the first 3,000 cfs of exports would be from the south Delta, with any additional allowable exports able to be diverted from either the north or the south Delta; it would be possible to shift to additional south Delta pumping as opposed to north Delta pumping in order to reduce water residence time, for example. This would reduce the difference in the risk of south Delta entrainment between the NAA and PA (see Section 5.4.1.4.2.1.2 *Risk to Green Sturgeon from South Delta Exports*).

5.4.1.5 Effects of the Action on Designated Critical Habitat

5.4.1.5.1 Salmonids

5.4.1.5.1.1 North Delta Exports

The principal effects of NDD operations on critical habitat for listed salmonids would be near-field and far-field effects on juvenile salmonids in the north Delta. As described previously in Section 5.4.1.3.1.1.1, *North Delta Exports*, the near-field effects include potential for impingement, screen contact, long passage times, and predation at the NDD. Design and operational criteria of the NDD would minimize the potential for adverse effects on the downstream access (winter-run Chinook salmon) and freshwater migration corridor/estuarine areas (spring-run Chinook salmon and steelhead) PBFs of critical habitat. These design and operational features of the NDD include frequent screen cleaning and approach and sweeping velocity criteria providing protection to minimize screen surface impingement of juvenile Chinook salmon and steelhead. The smooth screen surface also would serve to reduce the risk of abrasion and scale loss for any fish that does come into contact with the screens. Operational criteria would also minimize potential for far-field effects to these PBFs with respect to through-Delta survival, by having bypass flow criteria that adjust NDD exports downward coincident with juvenile salmonid entry into the Delta (Section 3.3.3.1, *North Delta Diversion*); as described in Section 5.4.1.3.1.2.1, *Indirect Mortality Within the Delta*, potential changes in channel velocity and entry into the interior Delta through Georgiana Slough/DCC could affect critical habitat, with the Georgiana Slough nonphysical fish barrier intended to be designed and installed to minimize these potential effects. As discussed in Section 5.4.1.3.1.2.1.2.2 *Nonphysical Fish Barrier at Georgiana Slough*, if an NPB reduced the probability of juvenile Chinook salmon taking the interior Delta pathway through Georgiana Slough by 50%, this could result in ~5-17% greater through-Delta survival based on the elasticity analysis by Perry et al. (2013); this could minimize the effects to the PBFs of concern in the Delta because of hydrodynamic effects on entry into the interior Delta or flow-survival effects.

As described in Section 5.4.1.3.1.2.2.1, *Bench Inundation*, NDD operations have the potential to reduce access to riparian bench areas, which could reduce riparian habitat and downstream access PBF for winter-run Chinook salmon and the estuarine areas PBF for spring-run Chinook salmon and steelhead. Compensation for this potential effect would be provided by channel margin enhancement of areas currently including poor habitat (see Section 3.4, *Conservation Measures*). NMFS (2009: 385-386) noted that the effects of the SWP/CVP on the rearing qualities of the Delta are related to the removal or reduction of potential forage species from the Delta environment (e.g., by entrainment of salmonid invertebrate prey or entrainment of the invertebrate's phytoplankton prey), which affects the estuarine areas PBF, for example. As described in the analysis of entrainment of food web materials by the NDD for Delta Smelt (see Section 6.1.3.5.4, *Entrainment of Food Web Materials*), it is estimated that the NDD would seldom entrain more than 5% of the Delta's standing stock of phytoplankton in any given month; there also would be less entrainment of phytoplankton at the south Delta export facilities (discussed below), as well as in situ production within the Delta (downstream of the NDD), that could offset the effects of entrainment at the NDD.

5.4.1.5.1.2 South Delta Exports

Reductions in south Delta exports under the PA compared to NAA have a potential to beneficially affect the estuarine areas PBF of critical habitat for spring-run Chinook salmon and Central Valley steelhead in the central and south Delta[43]. The risk of entrainment would be lower, as illustrated by the salvage-density analysis (see Section 5.4.1.3.1.1.2.1.1, *Salvage-Density Method: Winter-Run Chinook Salmon, Spring-Run Chinook Salmon, and Steelhead*), and hydrodynamic conditions would be expected to be more favorable because of reduced south Delta exports (see Section 5.4.1.3.1.2.1, *Indirect Mortality Within the Delta*). Reduced south

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[43] Critical habitat for winter-run Chinook salmon in the Delta is limited to the main stem Sacramento River, which is essentially unaffected by south Delta export operations (Cavallo et al. 2015).

Delta exports would increase the olfactory cues available for adult steelhead returning to the San Joaquin River basin (see Section 5.4.1.3.1.2.2.4, *Olfactory Cues for Upstream Migration*), thus improving the critical habitat for this life stage in the Delta. Although the PA would have a potential to reduce adverse effects on south Delta and interior Delta critical habitat, to the extent that the south Delta export facilities remain in use and have effects on water movement, there is a potential for adverse effects on critical habitat. Additionally, reduced Delta exports could increase the concentration of selenium in the Delta, but the risk to critical habitat for juvenile salmonids would be low, as indicated by the quantitative analyses previously discussed (see Section 5.4.1.3.1.2.2.3, *Selenium*). Any differences in *Microcystis* occurrence between the NAA and PA would be unlikely to affect the estuarine area PBF for adult steelhead, as discussed in Section 5.4.1.3.1.2.2.5, *Microcystis*.

5.4.1.5.1.3 Head of Old River Gate Operations

In conjunction with reduced south Delta exports, HOR gate operations have a potential to beneficially affect the estuarine area PBF for juvenile steelhead emigrating from the San Joaquin River basin by keeping flow in the mainstem San Joaquin River and reducing the proportion of fish moving into Old River. However, as described in Section 5.4.1.3.1.1.3.1, *Predation*, the extent to which any near-field predation at the HOR gate would offset the anticipated beneficial effects of a greater proportion of fish and flow remaining in the San Joaquin River is unclear, although the available data for juvenile Chinook salmon suggest that in general the presence of a barrier improves through-Delta survival (see review by Hankin et al. 2010 and comparison of 2012 [rock barrier] versus 2013 [no barrier] by Brandes and Buchanan 2016; however, see also comments by Anderson et al. [2012] with specific reference to the uncertainty in the effectiveness of the 2012 HOR rock barrier implementation in protecting out-migrating salmonid smolts).Upstream passage for adult steelhead would be provided with a fish passage structure, so the risk of adverse effects on the estuarine areas PBF for this life stage would be small (see Section 5.4.1.3.1.1.3, *Head of Old River Gate*).

5.4.1.5.1.4 Delta Cross Channel

As discussed by NMFS (2009: 410), for both winter-run and spring-run Chinook salmon, designated critical habitat lies adjacent to the location of the DCC gates. In the case of designated critical habitat for the winter-run Chinook salmon (58 FR 33212) the DCC is specifically not included because the biological opinions issued by NMFS in 1992 and 1993 concerning winter-run Chinook salmon included measures on the operations of the gates that were designed to exclude winter-run Chinook salmon from the channel and the waters of the Central Delta. For spring-run Chinook salmon, designated critical habitat (70 FR 52488) includes the DCC from its point of origin on the Sacramento River to its terminus at Snodgrass Slough, including the location of the gates. Designated critical habitat for Central Valley steelhead includes most of the Delta and its waterways; however, the DCC waterway was not included in the text or maps of the Federal Register notice as being part of the Delta waters designated as critical habitat. Nevertheless, actions of the DCC gates affect the critical habitat PBFs designated for the spring-run Chinook salmon and CV steelhead populations. Primarily, DCC gate operations interfere with the performance of the Sacramento River as a migratory corridor for spring-run Chinook salmon and Central Valley steelhead by preventing access downstream from the spawning grounds to San Francisco Bay and the Pacific Ocean. Fish entrained into the DCC and the Mokelumne River systems are at a greater risk of mortality than their counterparts who have remained in the mainstem of the Sacramento River. The operations of the gates permit fish to enter habitat and waterways they would not normally have access to with substantially higher predation risks than the migratory corridor available in the Sacramento River channel. Operations of the gates have a direct effect on the entrainment rate and hence the functioning of the Sacramento River as a migratory corridor.

However, during the downstream migration period of listed juvenile salmonids, the DCC gates would be closed, operational criteria not differing between NAA and PA during winter/spring. As described in Section 5.4.1.3.1.1.4, *Delta Cross Channel*, there may be minor differences between NAA and PA in terms of the number of days that the DCC is open during the adult steelhead upstream migration period in fall, but given that the differences between NAA and PA in the number of days open generally were not considerable, and adult salmonids that are migrating to the Sacramento River basin have the ability to swim around the DCC gates using other Delta channels (National Marine Fisheries Service 2009: 406). As such, DCC operations are not expected to result in adverse effects on adult steelhead critical habitat.

5.4.1.5.1.5 Suisun Marsh Facilities

As described in Chapter 3, Section 3.3.2.5, *Operational Criteria for the Suisun Marsh Facilities*, there are no proposed changes to operations of the Suisun Marsh facilities under the PA, in relation to what would occur under the NAA, so that effects of the PA on critical habitat would be expected to be similar to the effects under the NAA. This is described for each facility in the following sections.

5.4.1.5.1.5.1 Suisun Marsh Salinity Control Gates

As described by NMFS (2009: 437), Montezuma Slough is designated critical habitat for endangered winter-run Chinook salmon, with PBFs of designated critical habitat including water quality and quantity, foraging habitat, natural cover including large substrate and aquatic vegetation, and migratory corridors free of obstructions. As discussed in Section 5.4.1.3.1.1.5.1, *Suisun Marsh Salinity Control Gates*, fish passage could be affected by the operation of the SMSCG, with the gates potentially delaying upstream-migrating adult salmonids that have entered Montezuma Slough and are seeking to exit the slough at its eastward end. Adult salmonids that do not continue upstream past the SMSCG are expected to return downstream by backtracking through Montezuma Slough to Suisun Bay, and they likely find the alternative upstream route to their natal Central Valley streams through Suisun and Honker Bays (National Marine Fisheries Service 2009: 435). The tidally-operated gates are also expected to influence water currents and tidal circulation periodically during the 10 to 20 days of annual operation. However, these changes in water flow will be limited to the flood portion of the tidal cycle and will generally be limited to a few days during each periodic operational episode. Overall, the short-term changes to tidal flow patterns in Montezuma Slough due to operation of the SMSCG are not expected to significantly change habitat availability or suitability for rearing of listed anadromous salmonids (National Marine Fisheries Service 2009: 437).

5.4.1.5.1.5.2 Roaring River Distribution System

As discussed in the previous section, Montezuma Slough is designated critical habitat for endangered winter-run Chinook salmon. As described by NMFS (2009: 438), the operation of the RRDS may affect some PBFs of designated critical habitat. Fish passage and the migration corridor will not be affected, because the RRDS intakes are properly screened. However, water withdrawals at RRDS could influence flow, water quality, and food resources. The water surface elevation and water circulation at this location on Montezuma Slough is dominated by tides. The diversion is also tidally-operated by filling the intake pond at the RRDS during high tide. Since high tide conditions raise the water surface elevation throughout Montezuma Slough, water withdrawals at the RRDS intake do not reduce the quantity of available habitat and are not expected to negatively affect the condition of estuarine habitat for listed salmonids in Montezuma Slough (National Marine Fisheries Service 2009: 438).

5.4.1.5.1.5.3 Morrow Island Distribution System

Goodyear Slough, the location of the Morrow Island Distribution System, is not designated critical habitat for winter-run Chinook salmon, spring-run Chinook salmon, or Central Valley steelhead.

5.4.1.5.1.5.4 Goodyear Slough Outfall

As previously noted, Goodyear Slough, the location of the Goodyear Slough Outfall, is not designated critical habitat for winter-run Chinook salmon, spring-run Chinook salmon, or Central Valley steelhead.

5.4.1.5.1.5.5 North Bay Aqueduct

The following account of the potential effects on critical habitat because of the NBA was adapted from that of NMFS (2009: 418). The location of the Barker Slough Pumping Plant lies within the regional waterways designated as critical habitat for both spring-run Chinook salmon and Central Valley steelhead. The Federal Register (September 2, 2005, 70 FR 52488) identifies the upstream tidal limits of Cache Slough and Prospect Slough, as well as Miner Slough and the Yolo Bypass within the Sacramento Delta Hydrologic Unit 5510 as critical habitat. Barker Slough and Lindsey Slough are interconnected with the Cache Slough complex of waterways and were not specifically excluded as critical habitat, as was the Sacramento DWSC. Designated critical habitat for winter-run Chinook salmon is more ambiguous, as only the Sacramento River was named as critical habitat (58 FR 33212) and not any of the tributaries or side channels and sloughs associated with the north Delta system.

As described by NMFS (2009: 418), the footprint of the Barker Slough Pumping Plant is relatively small and located approximately 7 to 10 miles upstream from Cache Slough on Barker Slough. Barker Slough is a dead-end Slough without any significant sources of inflow. It does not physically block a migratory corridor, nor does it occur in habitat that appears to be utilized extensively by Chinook salmon or steelhead, based on monitoring surveys. The primary effects of the NBA and the Barker Slough Pumping Plant are related to the entrainment of water from the Cache Slough complex of waterways. The entrainment of water from these waterways can redirect or delay listed salmonids present in those waterways. This can affect the PBF concerned with the preservation of the functionality of the migratory corridors for listed salmonids. However the effect the Barker Slough Pumping on this PBF is believed to be insignificant due to the relatively small magnitude of the diversion (National Marine Fisheries Service 2009: 418). As shown in the analysis described in Section 5.4.1.3.1.1.6, *North Bay Aqueduct*, there would be expected to be little difference in pumping between NAA and PA.

5.4.1.5.1.6 Other Facilities

5.4.1.5.1.6.1 Contra Costa Canal Rock Slough Intake

Rock Slough is not part of designated critical habitat for winter-run Chinook salmon, spring-run Chinook salmon, or Central Valley steelhead.

5.4.1.5.1.6.2 Clifton Court Forebay Aquatic Weed Control Program

Clifton Court Forebay is not part of the designated critical habitat for winter-run Chinook salmon, spring-run Chinook salmon, or Central Valley steelhead and thus actions taken within the Forebay itself do not affect PBFs in the Delta for rearing habitat or migratory corridors (National Marine Fisheries Service 2009: 391). Chemical treatments for aquatic weeds would occur with the radial gates closed, so no herbicide would exit the forebay into the south Delta. After the exposure period, residual herbicide would be pulled into the California Aqueduct via the pumps when the radial gates are opened to let in fresh water from the Delta (National Marine Fisheries Service 2009: 391). The flushing of the forebay with external Delta water should reduce any remaining herbicide to insignificant levels and move the treated water volume into the aqueduct system of the SWP, and therefore there should be no discernable effects on designated critical habitat outside the forebay (National Marine Fisheries Service 2009: 391).

5.4.1.5.2 Green Sturgeon

5.4.1.5.2.1 North Delta Exports

As described in Section 5.4.1.3.2.1, *Near-Field Effects*, the potential for near-field effects (entrainment, impingement, and predation) on green sturgeon from the NDD is small. Therefore, the effects on designated green sturgeon critical habitat PBFs such as migratory corridor in the Sacramento River is small. As discussed for listed salmonid critical habitat in Section 5.4.1.5.1.1, *North Delta Exports*, direct entrainment of forage base items (e.g., zooplankton and phytoplankton) by water diversions has the potential to adversely affect critical habitat for green sturgeon. However, as demonstrated in the analysis of entrainment of food web materials by the NDD for Delta Smelt (see Section 6.1.3.5.4, *Entrainment of Food Web Materials*), it is estimated that the NDD would seldom entrain more than 5% of the Delta's standing stock of phytoplankton in any given month; there also would be less entrainment of phytoplankton at the south Delta export facilities under the PA, as well as in situ production within the Delta (downstream of the NDD), that could offset the effects of entrainment at the NDD.

5.4.1.5.2.2 South Delta Exports

As described by NMFS (2009: 386), impacts to the migratory corridor function of juvenile and sub-adult green sturgeon critical habitat from south Delta exports are less clear than for juvenile salmonids because green sturgeon spend 1 to 3 years rearing in the Delta environment before transitioning to their marine life history stage. During this Delta rearing phase, green sturgeon are free to migrate throughout the Delta. Net negative export flows in the central and southern delta may cause fish to be entrained into the southern Delta waterways, which is not typical of their normal movements. Should this be the case, then the PA would be expected to have a lesser effect in this regard compared to the NAA, as indicated by results of the salvage-density analysis (see Section 5.4.1.3.2.1.2.2, *Salvage-Density Method*) and analysis of hydrodynamic conditions (see Section 5.4.1.3.2.2.1, *Indirect Mortality Within the Delta*). Reduced Delta exports would increase the concentration of selenium in the Delta, although this is not expected to have substantial effects on green sturgeon (see Section 5.4.1.3.2.2.2.2, *Selenium*). As discussed in Section 5.4.1.3.2.2.2.3, *Microcystis*, south Delta operations could influence the potential for occurrence of *Microcystis* under the PA, with greater flow and lower residence time compared to NAA in the lower San Joaquin River, but greater residence time in portions of the south Delta. These flow changes are not expected to adversely affect green sturgeon critical habitat because the PBF for water flow refers to Sacramento River for attraction of upstream migrants, which would not be affected by south Delta exports, and the PBF for water quality (principally temperature, salinity, and dissolved oxygen) would not be greatly altered by the PA (see water temperature analysis in Section 5.4.1.3.1.2.2.2, *Water Temperature (DSM2-QUAL)*; see summaries of salinity [electrical conductivity] in Appendix 5.B, *DSM2 Methods and Results*; see qualitative discussion of dissolved oxygen effects of Alternative 4A on pp. 4.3.4-19 to 4.3.4-22 in the Bay Delta Conservation Plan/California WaterFix RDEIR/SDEIS, available at http://baydeltaconservationplan.com/RDEIRS/4_New_Alternatives.pdf).

5.4.1.5.2.3 Head of Old River Gate Operations

Operations of the HOR gate would have the potential to affect the migratory corridor PBF of green sturgeon critical habitat. As described in Section 5.4.1.3.2.1.3.2, *Upstream Passage*, the proposed vertical slot fishway designed for adult salmonids could confine green sturgeon to Old River until the gate was opened again. Under the NAA, a physical (rock) barrier is not always installed at HOR during the spring upstream migration period of green sturgeon, so this would represent a temporary effect on the migration PBF for green sturgeon critical habitat. In addition, it is possible that near-field predation effects could occur to smaller juvenile green sturgeon at the HOR gate, therefore potentially affecting the migratory corridor PBF.

5.4.1.5.2.4 Delta Cross Channel

The DCC is included in designated critical habitat for green sturgeon. As described in Section 5.4.1.3.2.1.4, *Delta Cross Channel*, the DCC gates would be expected to be closed during the upstream migration period of adult green sturgeon, therefore affecting the migratory corridor PBF of critical habitat; however, this would not differ between NAA and PA. As noted in the analysis by NMFS (2009: 408), the extent to which the DCC affects juvenile green sturgeon is uncertain, given their long residence time in the Delta. Although the DCC gates could be open more often under the PA than NAA, the differences are not considerable and so any differences in critical habitat effects would be insignificant, in light of juvenile green sturgeon spending several years in the Delta.

5.4.1.5.2.5 Suisun Marsh Facilities

As described in Chapter 3, Section 3.3.2.5, *Operational Criteria for the Suisun Marsh Facilities*, and as noted previously for listed salmonids, there are no proposed changes to operations of the Suisun Marsh facilities under the PA, in relation to what would occur under the NAA, so that effects of the PA on critical habitat would be expected to be similar to the effects under the NAA. This is described for each facility in the following sections.

5.4.1.5.2.5.1 Suisun Marsh Salinity Control Gates

The SMSCG are located on Montezuma Slough, which is designated critical habitat for green sturgeon. The specific PBFs of proposed critical habitat for the Southern DPS of green sturgeon in estuarine areas include food resources, water flow, water quality, migratory corridor, water depth, and sediment quality. As discussed in Section 5.4.1.3.2.1.5.1, *Suisun Marsh Salinity Control Gates*, fish passage will be affected by the operation of the SMSCG, although operations under the NAA and PA would be very similar. The tidally-operated gates are also expected to influence water currents and tidal circulation periodically during the up to 20 days of annual operation. However, as noted by NMFS (2009: 437), these changes in water flow will be limited to the flood portion of the tidal cycle and will generally be limited to a few days during each periodic operational episode. Overall, the short-term changes to tidal flow patterns in Montezuma Slough due to operation of the SMSCG would result in insignificant changes to habitat availability or suitability for rearing of green sturgeon, and the effects of the NAA and PA would be similar.

5.4.1.5.2.5.2 Roaring River Distribution System

As discussed in the previous section, Montezuma Slough, the location of the RRDS, is designated critical habitat for green sturgeon. As discussed by NMFS (2009: 437-438), the operation of the RRDS may affect some PBFs of critical habitat. Fish passage and the migration corridor will not be affected, because the RRDS intakes are properly screened. However, water withdrawals at RRDS could influence flow, water quality, and food resources. The water surface elevation and water circulation at this location on Montezuma Slough is dominated by tides. The diversion is also tidally-operated by filling the intake pond at the RRDS during high tide. Because high tide conditions raise the water surface elevation throughout Montezuma Slough, water withdrawals at the RRDS intake do not reduce the quantity of available habitat and are not expected to negatively affect the condition of estuarine habitat for green sturgeon in Montezuma Slough (National Marine Fisheries Service 2009: 437-438); any effects would be similar between NAA and PA.

5.4.1.5.2.5.3 Morrow Island Distribution System

Goodyear Slough, the location of the MIDS, is designated as critical habitat for green sturgeon. As described by NMFS (2009: 438), the slough is subject to tidal influence and the MIDS intake is also tidally operated. High tide conditions raise the water surface elevation throughout the area and, thus, the withdrawal of water at MIDS during high tide does not reduce the volume of aquatic habitat in the marsh. Low water intake velocities minimize the loss of aquatic organisms to entrainment. Overall, the quality of habitat, foraging of prey organisms by juvenile sturgeon, and the other specific PBFs for green sturgeon critical habitat are not likely to be negatively affected by the operation of MIDS, with any effects being similar between NAA and PA.

5.4.1.5.2.5.4 Goodyear Slough Outfall

As noted by NMFS (2009: 438), improved water circulation from operation of the Goodyear Slough Outfall likely benefits juvenile green sturgeon in Suisun Marsh by improving water quality and increasing foraging opportunities. Therefore, the PBFs of critical habitat for green sturgeon are not likely to be negatively affected by the operation of the Goodyear Slough Outfall (National Marine Fisheries Service 2009: 438), and any effects would be similar between NAA and PA.

5.4.1.5.2.6 North Bay Aqueduct

As described by NMFS (2009: 418), the footprint of the Barker Slough Pumping Plant is relatively small and located approximately 7 to 10 miles upstream from Cache Slough on Barker Slough, which is part of designated critical habitat for green sturgeon. Barker Slough is a dead-end slough without any significant sources of inflow. It does not physically block a migratory corridor, nor does it occur in habitat that appears to be utilized extensively by green sturgeon based on the monitoring surveys mentioned previously. The primary effects of the NBA and the

Barker Slough Pumping Plant are related to the entrainment of water from the Cache Slough complex of waterways. The entrainment of water from these waterways can affect the PBF concerned with preservation of the functionality of the migratory corridors for green sturgeon. However the effect the Barker Slough Pumping on this PBF is believed to be insignificant because of the relatively small magnitude of the diversion (National Marine Fisheries Service 2009: 418), and there would be relatively little difference in diversions between the NAA and PA (see Table 5.B.5-35 in Appendix 5.B, *DSM2 Methods and Results*).

5.4.1.5.2.7 Other Facilities

5.4.1.5.2.7.1 Contra Costa Canal Rock Slough Intake

Rock Slough is not part of designated critical habitat for green sturgeon.

5.4.1.5.2.7.2 Clifton Court Forebay Aquatic Weed Control Program

Critical habitat for green sturgeon does not include Clifton Court Forebay. As previously described for salmonids, application of herbicides would be done in such a way that critical habitat outside the Forebay would not be affected.

5.4.2 Upstream Hydrologic Changes

For purposes of this analysis, “upstream” refers to waterways upstream of the legal Delta where flows, reservoir storage, and water temperatures and, as a result, listed fish species or critical habitat for such species may be affected by implementation of the PA. Therefore, this section assesses potential effects on listed aquatic species and critical habitat in the American River and Sacramento River upstream of the Delta. The potential effects on listed aquatic species and critical habitat in the Delta resulting from the proposed action (PA) are described in Section 5.4.1, *Proposed Delta Exports and Related Hydrodynamics*.

A preliminary screening analysis was conducted using model outputs of exceedance plots and mean reservoir storage, monthly flows, and water temperatures, where available, in the Trinity, Sacramento, American, San Joaquin, and Stanislaus Rivers and Clear Creek to determine whether modeled flows, storage, and water temperatures in any of these waterways would be clearly not affected by the PA and, therefore, no further analyses of effects on listed aquatic species or critical habitat for such species would be necessary in the waterway.

Results of this preliminary analysis indicated that there would be no effect of the PA on operations in the Trinity, San Joaquin, and Stanislaus Rivers and on Clear Creek (Appendix 5.C, *Upstream Water Temperature Methods and Results*). Accordingly, it was concluded that these areas are not part of the Action area (Chapter 4, *Action Area and Environmental Baseline*). As such, the following listed species or their critical habitat in these waterways are not evaluated in this effects analysis.

- Trinity River: Southern Oregon/Northern California Coastal coho salmon.
- San Joaquin River upstream of the Delta: California Central Valley (CCV) steelhead distinct population segment (DPS), Central Valley spring-run Chinook salmon.
- Stanislaus River: CCV steelhead DPS.

- Clear Creek: Central Valley spring-run Chinook salmon, CCV steelhead DPS.

This preliminary analysis indicates that there is the potential for changes in reservoir operations, instream flows, and water temperatures in the Sacramento River and American River. Therefore, the analysis of potential effects in each of these rivers is described in detail here.

5.4.2.1 Sacramento River

5.4.2.1.1 Deconstruct the Action

The PA could cause changes in cold-water pool storage in Shasta Reservoir and in operations of Shasta Dam, which could cause changes to instream flows and water temperatures in the Sacramento River. Changes under the PA in the magnitude, duration, frequency, timing, and rate of change of flows in the Sacramento River can all affect habitat characteristics of the life stages of winter- and spring- run Chinook salmon, steelhead, and green sturgeon that are present.

For spawning, egg incubation, and alevins, this analysis evaluates flow-related effects on weighted usable area (WUA) of spawning habitat, redd dewatering, and redd scour. Changes in flow rates can affect the amount of WUA of spawning habitat, which is characterized by velocity, depth, and substrate type (U.S. Fish and Wildlife Service 2003b, 2005a, 2006). Redd dewatering occurs when flows are reduced while eggs and alevins are still in the gravel after a spawning event (U.S. Fish and Wildlife Service 2006). Redd scour and entombment can occur when flood flows are of a high enough magnitude to mobilize the gravel, although attempts are made to spread out flood control releases when possible.

For fry and juveniles, this analysis evaluates flow-related effects on WUA of rearing habitat and juvenile stranding. Changes in flow rates can affect the amount of WUA of rearing habitat, which is characterized by velocity, depth, and substrate type (U.S. Fish and Wildlife Service 2005b). Juvenile stranding can occur when flows are reduced rapidly and individuals are unable to escape an area that becomes isolated from the main channel or dewatered, often leading to mortality (U.S. Fish and Wildlife Service 2006). Appendix 5.D, *Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*,[44] provides detail on the methods used to evaluate flow effects of the PA.

As cold-water species, salmonids and sturgeon are sensitive to water temperatures. Changes to water temperatures may influence the suitability of habitat for each life stage present in the Sacramento River and can lead to sublethal impairments that include reduced growth, inhibited smoltification, altered migration, disease, and ultimately death. Appendix 5.D provides detail on the methods used to evaluate water temperature effects of the PA.

5.4.2.1.2 Assess Species Exposure

The species in the Sacramento River upstream of the Delta that could be affected by implementation of the PA include winter-run and spring-run Chinook salmon, CCV steelhead, and green sturgeon.

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[44] For brevity, this appendix is cited as Appendix 5.D throughout.

5.4.2.1.2.1 Winter-Run Chinook Salmon

Implementation of the PA has the potential to expose winter-run Chinook salmon to different flows and water temperatures than those predicted to occur under the NAA throughout their presence in the Sacramento River upstream of the Delta. Table 5.4-25 presents the timing of the upstream presence of each life stage for winter-run Chinook salmon in the Sacramento River upstream of the Delta. The months included in this table (and in tables for other races and species of fish presented below) represent the periods during which the majority (more than approximately 90%) of fish in a life stage are present.

Table 5.4-25. Temporal Occurrence of Winter-Run Chinook Salmon by Life Stage, Sacramento River Upstream of the Delta.

Life Stage	J	F	M	A	M	J	J	A	S	O	N	D
Spawning, egg incubation, and alevins[1]				░	▓	■	■	■	■	░		
Fry and Juvenile rearing[2]							▓	▓	▓	▓	▓	
Juvenile emigration[3]	░	░	░				░	▓	■	■	▓	▓
Adult immigration[4]	▓	■	■	■	▓	░	░	░				░
Adult holding[5]	░	▓	▓	■	■	■	▓	░				
	■	High			▓	Med			░	Low		

Sources: [1] Vogel and Marine 1991; [2] Gaines and Martin 2002; [3] Vogel and Marine 1991; Poytress et al. 2014; [4] National Marine Fisheries Service 1997, Hallock and Fisher 1985, specific to Red Bluff Diversion Dam; [5] Inferred based on immigration and spawning timing

Winter-run Chinook salmon spawn in the Sacramento River and eggs and alevins are in the gravel primarily between April and October with a peak during June through September. Based on CDFW aerial redd surveys from 2003 through 2014, the vast majority (99.3%) of winter-run Chinook salmon spawning between 2003 and 2014 occurred upstream of Airport Road Bridge (RM 284; Table 5.4-26).

Table 5.4-26. Spatial Distribution of Spawning Redds in the Sacramento River Based on Aerial Redd Surveys, Winter-Run Chinook Salmon, 2003–2014 (Source: CDFW)

Reach	Mean Annual Percent of Total Redds Sighted
Keswick Dam to ACID Dam	45.0
ACID Dam to Highway 44 Bridge	42.1
Highway 44 Bridge to Airport Road Bridge	12.2
Airport Road Bridge to Balls Ferry Bridge	0.3
Balls Ferry Bridge to Battle Creek	0.1
Battle Creek to Jelly's Ferry Bridge	0.1
Jelly's Ferry Bridge to Bend Bridge	0.1
Bend Bridge to Red Bluff Diversion Dam	0.0
Downstream of Red Bluff Diversion Dam	0.1

ACID = Anderson-Cottonwood Irrigation District

Juvenile winter-run Chinook salmon rear in the Sacramento River primarily between July and November. Fry and juvenile rearing occurs from Keswick Dam to the Delta. Many juveniles apparently rear in the Sacramento River below Red Bluff Diversion Dam for several months before they reach the Delta (Williams 2006). Juveniles begin moving downstream towards the ocean beginning in July and continue until March, with a peak migration period of September and October observed at Red Bluff Diversion Dam. The peak of winter run juvenile emigration at Knights Landing is November through February, although this is not reflected in Table 5.4-25.

Adult winter-run Chinook salmon migrate upstream primarily during December through August, with a peak during February through April. Adults then hold from approximately January through August until they spawn, with a peak holding period of April through June. Some adults have been shown to stray into the Colusa Basin Drain from the Sacramento River: for example, around 300 individuals (5% of the adult population) entered the Drain in 2012 (NMFS 2015c: 80) and were lost to the population because there is no pathway to return to the river; this situation will be largely remedied with construction and operation of a picket weir fence (NMFS 2015c). Adult salmonids, including winter-run Chinook, can also stray into the Colusa Basin Drain when flows are sufficiently high to allow passage via the Tule Canal and Knights Landing Ridge Cut from the south; replacement of the existing Wallace Weir with a permanent operable structure and fish rescue facility are planned to reduce losses of winter-run Chinook by this mechanism[45].

5.4.2.1.2.2 Spring-Run Chinook Salmon

Implementation of the PA has the potential to expose spring-run Chinook salmon to different flows and water temperatures than those predicted to occur under the NAA throughout their presence in the Sacramento River upstream of the Delta. Table 5.4-27 presents the timing of the upstream presence of each life stage for spring-run Chinook salmon in the Sacramento River upstream of the Delta.

Table 5.4-27. Temporal Occurrence of Spring-Run Chinook Salmon by Life Stage, Sacramento River Upstream of the Delta.

Life Stage	J	F	M	A	M	J	J	A	S	O	N	D
Spawning, egg incubation, and alevins[1]								▨	■	■	▨	░
Fry and Juvenile rearing[2]	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	■	■
Juvenile emigration[3]	▨	░	▨	■	▨					■	■	■
Adult immigration[4]			▨	▨	■	■	▨	▨	░			
Adult holding[5]				▨	■	■	■	■	░			

■ High ▨ Med ░ Low

Sources: [1] Moyle 2002; CDFW aerial redd surveys; [2] Snider and Titus 2000; Poytress et al 2014; [3] California Department of Fish and Game 1998, Snider and Titus 2000; Poytress et al 2014; specific to Red Bluff Diversion Dam;[4] Yoshiyama et al. 1998, Moyle 2002; [5] Inferred based on timing of adjacent life stages

Spring-run Chinook salmon may spawn in the Sacramento River between RBDD and Keswick Dam in very low densities with only a total of 449 redds documented from 2001 through 2014 (average 35/year; range= 0-105; no data available for 2009 or 2011) in CDFW aerial redd surveys. Eggs and alevins remain in the gravel primarily between August and December, with a peak between September and October. The vast majority (more than 91%) of spawning between 2003 and 2014 occurred upstream of Battle Creek (River Mile 272; Table 5.4-28).

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[45] http://resources.ca.gov/docs/ecorestore/projects/Wallace_Weir_Modification.pdf

Table 5.4-28. Spatial Distribution of Spawning Redds in the Sacramento River Based on Aerial Redd Surveys, Spring-Run Chinook Salmon, 2003–2014 (Source: CDFW)

Reach	Mean Annual Percent of Total Redds Sighted
Keswick Dam to ACID Dam	12.4
ACID Dam to Highway 44 Bridge	32.8
Highway 44 Bridge to Airport Road Bridge	27.7
Airport Road Bridge to Balls Ferry Bridge	10.9
Balls Ferry Bridge to Battle Creek	7.3
Battle Creek to Jelly's Ferry Bridge	1.5
Jelly's Ferry Bridge to Bend Bridge	2.6
Bend Bridge to Red Bluff Diversion Dam	0.8
Downstream of Red Bluff Diversion Dam	4.1

ACID = Anderson-Cottonwood Irrigation District

Juvenile spring-run Chinook salmon rear in the Sacramento River year-round, with a peak between November and December. Fry and juvenile rearing occur from Keswick to the Delta. Juveniles begin moving downstream towards the ocean beginning in October and continue until May, with peak migration periods of April and October through December. The peak of spring run juvenile emigration at Knights Landing is February through May (Snider and Titus 2000), although this is not reflected in Table 5.4-27.

Adult spring-run Chinook salmon migrate upstream primarily as early as March with a peak between May and June. Temperatures in the mainstem and Delta are likely too warm for migrating salmon by summer, although holding spring-run Chinook likely hold and move throughout the upper Sacramento once they have ascended the river. Adults display these behaviors from approximately April through September until they spawn in September. It is uncertain how late into summer spring-run Chinook salmon migrate into the Sacramento River. On tributaries, typically spring-run Chinook salmon cannot ascend to cooler water later than May or early June. On the Feather River, hatchery spring run Chinook salmon are identified as fish entering the ladder no later than June. While Red Bluff Diversion Dam once blocked spring-run Chinook passage and significantly delay migration of spring run Chinook such that they passed throughout the summer, this broad migration pattern is likely not natural given spring-run Chinook migration patterns from Northern Valley tributaries and the Feather River.

5.4.2.1.2.3 California Central Valley Steelhead

Implementation of the PA has the potential to expose CCV steelhead to different flows and water temperatures than those predicted to occur under the NAA throughout their presence in the Sacramento River upstream of the Delta. Table 5.4-29 presents the timing of the upstream presence of each life stage for steelhead in the Sacramento River upstream of the Delta.

Table 5.4-29. Temporal Occurrence of California Central Valley Steelhead by Life Stage, Sacramento River Upstream of the Delta.

Life Stage	J	F	M	A	M	J	J	A	S	O	N	D
Spawning, egg incubation, and alevins[1]	▒	▒	▒	▒							▒	▒
Kelt emigration[2]		▒	▒	▒	▒							
Juvenile rearing[3]	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
Smolt emigration[3,4]	■	■	■	▒	▒	▒					░	░
Adult immigration[5]	░	░	░					▒	■	■	■	▒
Adult holding[6]									▒	▒	▒	
	■	High			▒	Med			░	Low		

Sources:; [1] Reclamation 2008; [2] inferred from spawning period; [3] Gaines and Martin 2002; [4] Does not include migrant parr; [5] CDFW unpublished counts at RBDD 1966–1994; [6] Inferred from adjacent life stages

CCV steelhead may spawn in the Sacramento River and eggs and alevins remain in the gravel primarily between December and May. Recent steelhead monitoring data are scarce for the Upper Sacramento River system but numbers are considered low, and there is a strong resident component to the population (referred to as rainbow trout) that interacts with and produces both resident and anadromous offspring. Little is known about steelhead spawning locations in the Sacramento River, although it was assumed for this analysis that, because of constraints on water temperature and other habitat features, individuals spawn between Keswick Dam and Red Bluff Diversion Dam, where nearly all Chinook salmon spawn. After spawning, steelhead adults either die or kelts emigrate back to the ocean between February and May.

Juvenile steelhead rear for 1 to 3 years in the Sacramento River from Keswick Dam to the Delta. Therefore, individuals are present in the river throughout the year. Smolts begin migrating downstream towards the ocean beginning in November and continue until June, with a peak migration period of January through March.

Adult CCV steelhead migrate upstream during August and March with a peak between September and November. Adults then hold from September through November until they spawn.

5.4.2.1.2.4 Green Sturgeon

Implementation of the PA has the potential to expose green sturgeon to different flows and water temperatures than those predicted to occur under the NAA throughout their presence in the Sacramento River upstream of the Delta. Table 5.4-30 presents the timing of the upstream presence of each life stage for green sturgeon in the Sacramento River upstream of the Delta.

Table 5.4-30. Temporal Occurrence of Green Sturgeon by Life Stage, Sacramento River Upstream of the Delta

Life Stage	J	F	M	A	M	J	J	A	S	O	N	D
Spawning, egg incubation[1]			░	■	■	■	░					
Pre- and post-spawn adult holding[2]		░	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Post-spawn emigration[3]	▨			▨	▨	▨	▨	▨	▨	▨	▨	▨
Larval to juvenile rearing and emigration[4]	░	░	░	░	▨	■	■	▨	▨	░	░	░
Adult immigration[5]		░	▨	▨	▨	▨						

	■	High	▨	Med	░	Low

Sources: [1]; Poytress et al. 2009, 2010, 2011, 2012; [2] Israel and Klimley 2008; [3] Heublein et al. 2009; [4] National Marine Fisheries Service 2009; Poytress et al. 2014; [5] Reclamation 2008

Green sturgeon spawn and eggs incubate in the Sacramento River upstream of Hamilton City (RM 200) to as far upstream as Ink's Creek confluence (RM 281) and possibly up to the Cow Creek confluence (RM 280) (Brown 2007; Poytress et al. 2013) between March and July, with a peak between April and June. Larvae and juveniles rear and migrate year-round in much of the spawning reach and downstream. Therefore, individuals are present in this reach of the river throughout the year.

Adult green sturgeon migrate upstream primarily during February and June. Adults hold near spawning reaches beginning in February until they spawn and then after spawning until December. Post-spawning emigration occurs between April and January of the following year.

5.4.2.1.3 Assess Species Response to the Proposed Action

5.4.2.1.3.1 Winter-Run Chinook Salmon

5.4.2.1.3.1.1 Spawning, Egg Incubation, and Alevins

5.4.2.1.3.1.1.1 Flow-Related Effects

Estimated mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at the Keswick Dam to Red Bluff locations during the April through October spawning and egg incubation period, with peak occurrence during July through September, for winter-run Chinook salmon (Table 5.4-25). Changes in flow can affect the instream area available for spawning and egg incubation, along with the quality of the habitat, and can result in dewatering or scour of the redds. Shasta Reservoir storage volume at the end of May can influence flow rates below the dam during much of the winter-run salmon spawning and egg incubation period. Mean Shasta May storage volume under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A*, CALSIM Methods and Results,* Table 5.A.6-3). During the majority of months and water year types of the winter-run spawning period, the PA would result in insignificant changes (less than 5% difference) in mean flow in the Sacramento River at the Keswick Dam to Red Bluff locations (Appendix 5.A*, CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35). However, at both locations, flows under the PA would be 5% to 7% higher than the NAA during May of dry years and June of all water year types except wet years, and would be up to 17% higher in October of below normal and dry years. Flows under the PA would be 5% to 11% lower than the NAA in September of all except wet water year types, October of wet years, and August of below normal water years. The flow reductions in August and September occur within the peak winter-run spawning period (July through September). The results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.1.3.1.1.1.1 Spawning WUA

Spawning weighted usable area (WUA) provides a metric of spawning habitat availability that accounts for the spawning requirements of the fish with respect to water depth, flow velocity, and substrate. Spawning WUA for winter-run Chinook salmon was determined by USFWS (2003a, 2006) for a range of flows in three segments of the Sacramento River between Keswick Dam and the Battle Creek confluence (Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*). Segment 4 stretches 8 miles from Battle Creek to the confluence with Cow Creek; Segment 5 reaches 16 miles from Cow Creek to the A.C.I.D. Dam; and Segment 6 covers 2 miles from A.C.I.D. Dam to Keswick Dam. The Cow Creek confluence is about midway between the Airport Road Bridge and Balls Ferry and, therefore, based on CDFW aerial survey results (Table 5.4-26), 45% of winter-run Chinook salmon redds occur within Segment 6 and most of the remainder are found within Segment 5. To estimate changes in spawning WUA that would result from the PA, the flow-versus-spawning habitat WUA relationship developed for each of these segments was used with mean monthly CALSIM II flow estimates for the midpoint of each segment under the PA and the NAA during the winter-run spawning and egg incubation period. Further information on the WUA analysis methods is provided in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*.

Differences in winter-run spawning WUA under the PA and NAA were examined using exceedance plots of monthly mean WUA for the winter-run spawning period in each of the river segments for each water year type and all water year types combined. The exceedance curves for the PA generally match those of the NAA for all water year types in all three segments (Figure 5.4-30–Figure 5.4-51).

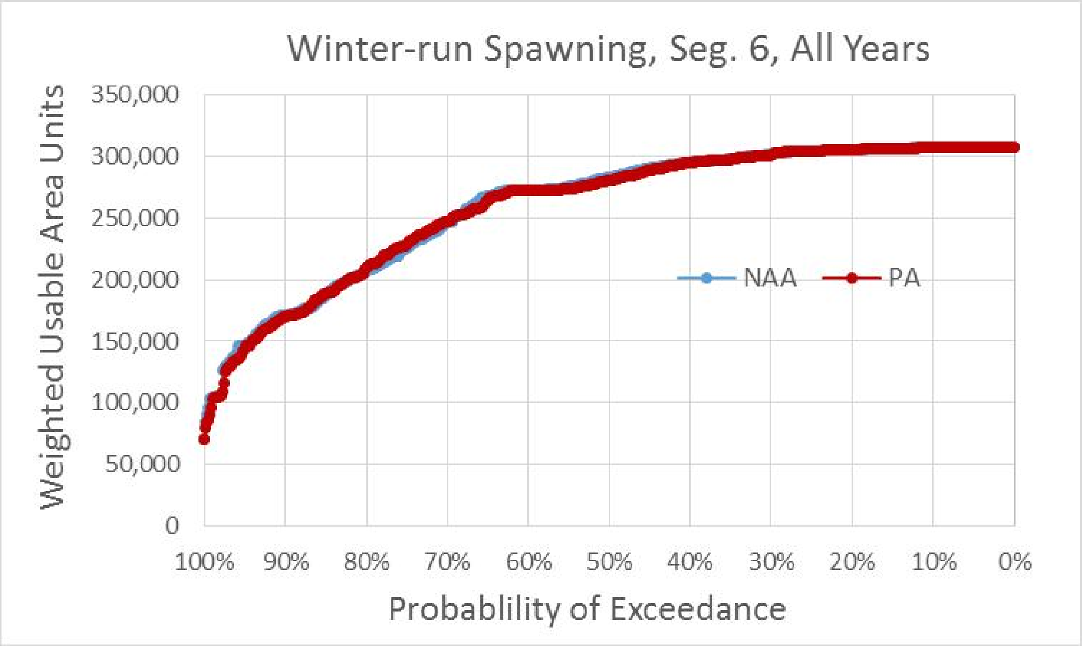

Figure 5.4-34. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

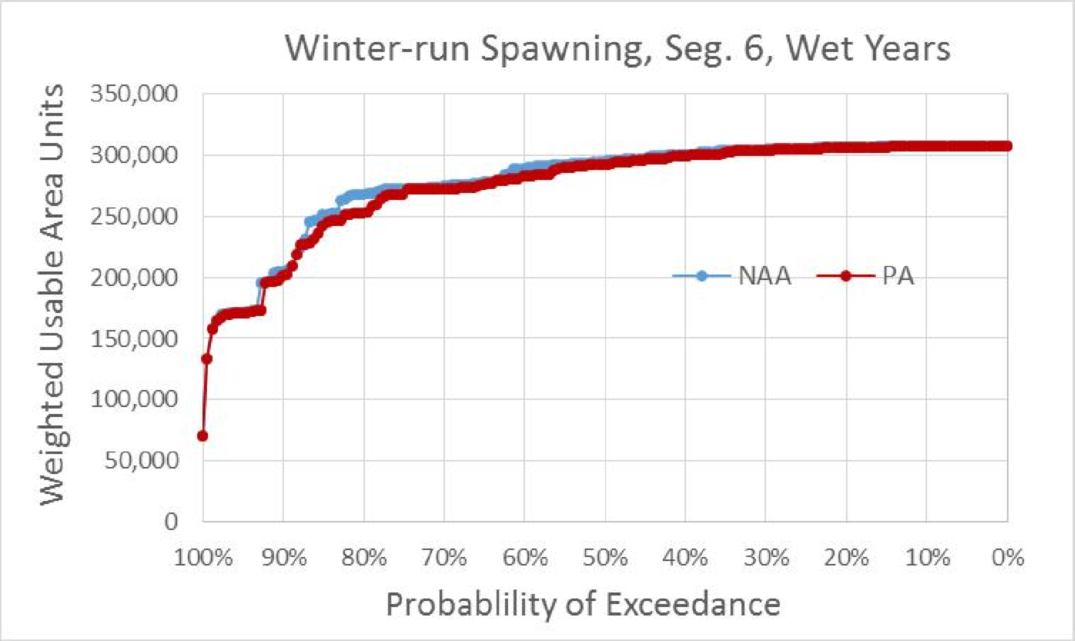

Figure 5.4-35. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

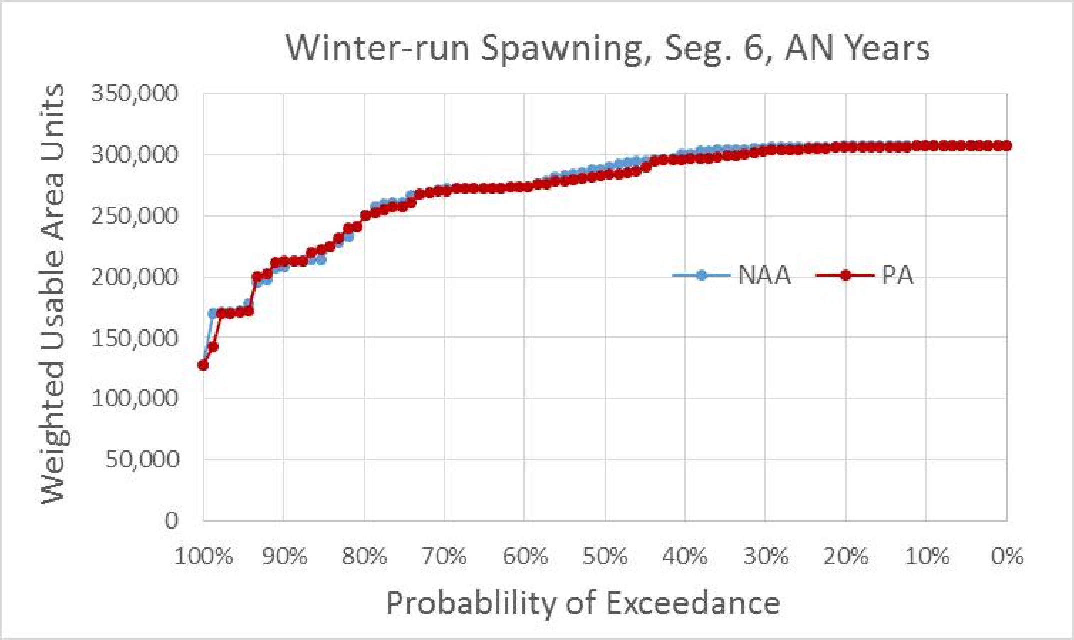

Figure 5.4-36. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

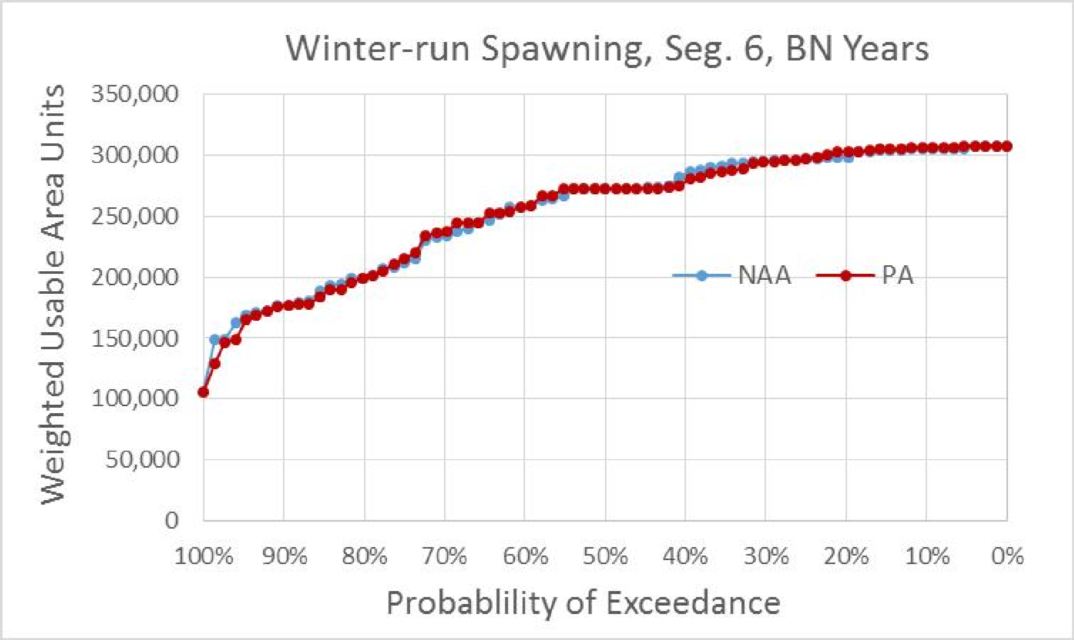

Figure 5.4-37. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

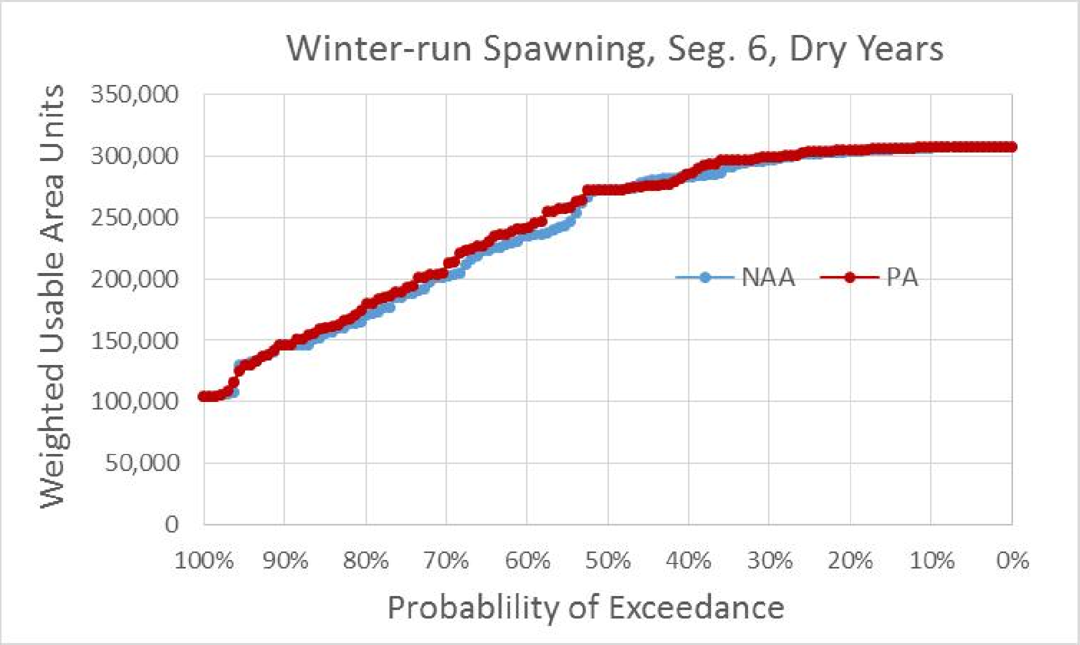

Figure 5.4-38. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

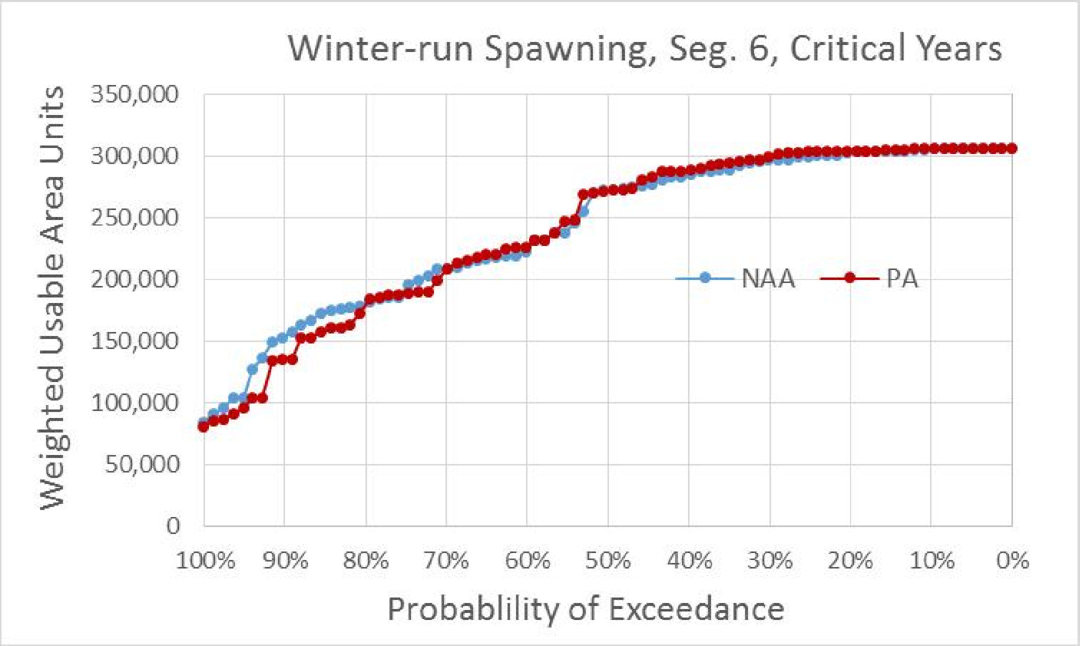

Figure 5.4-39. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

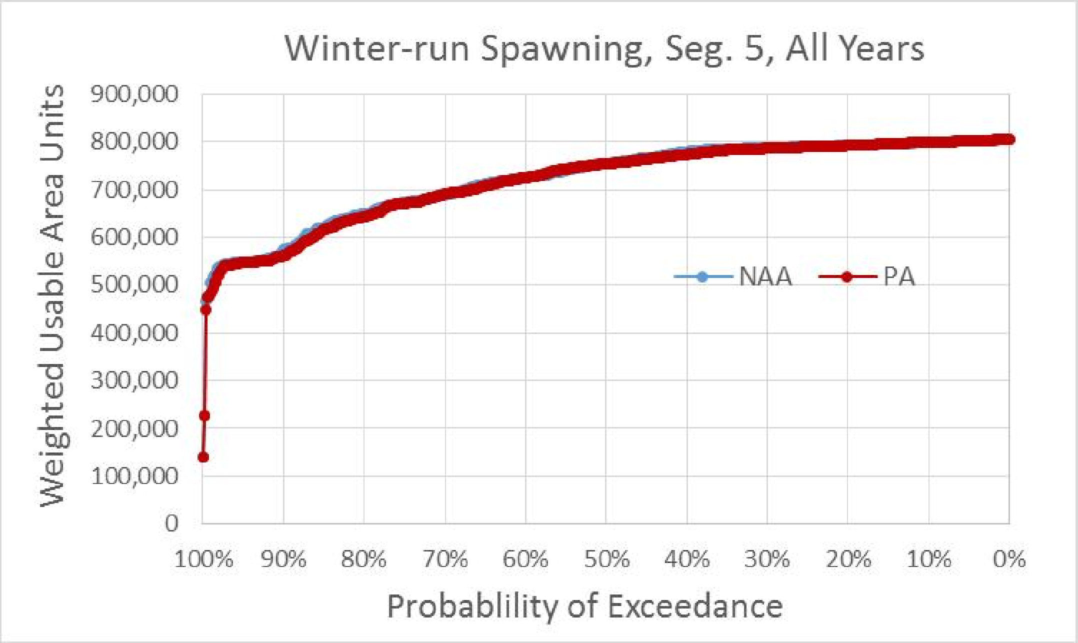

Figure 5.4-40. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

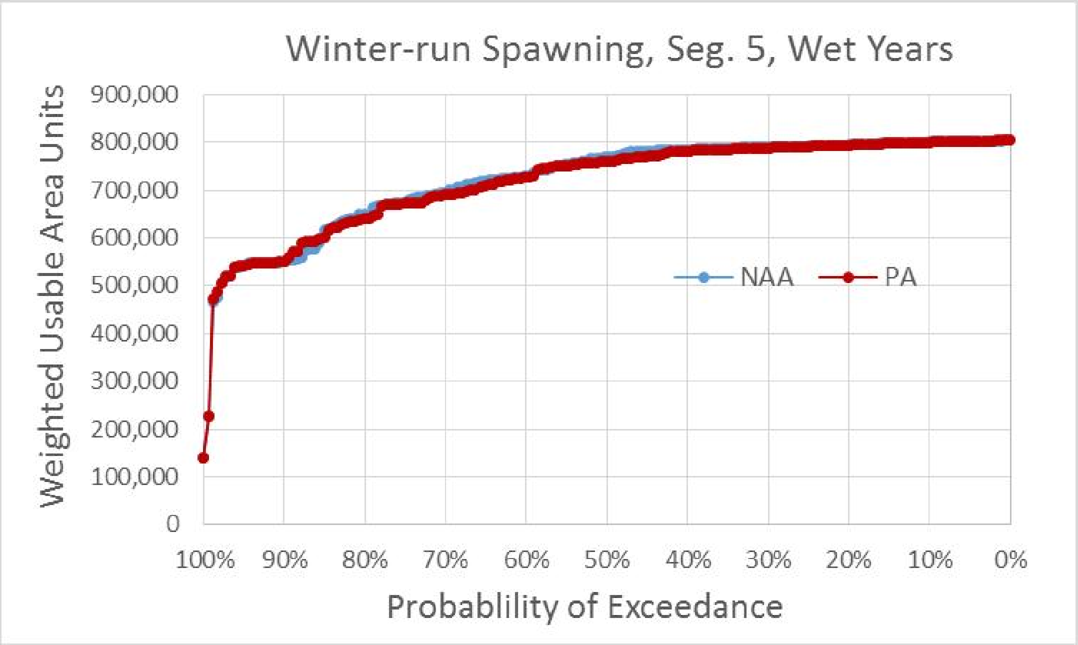

Figure 5.4-41. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

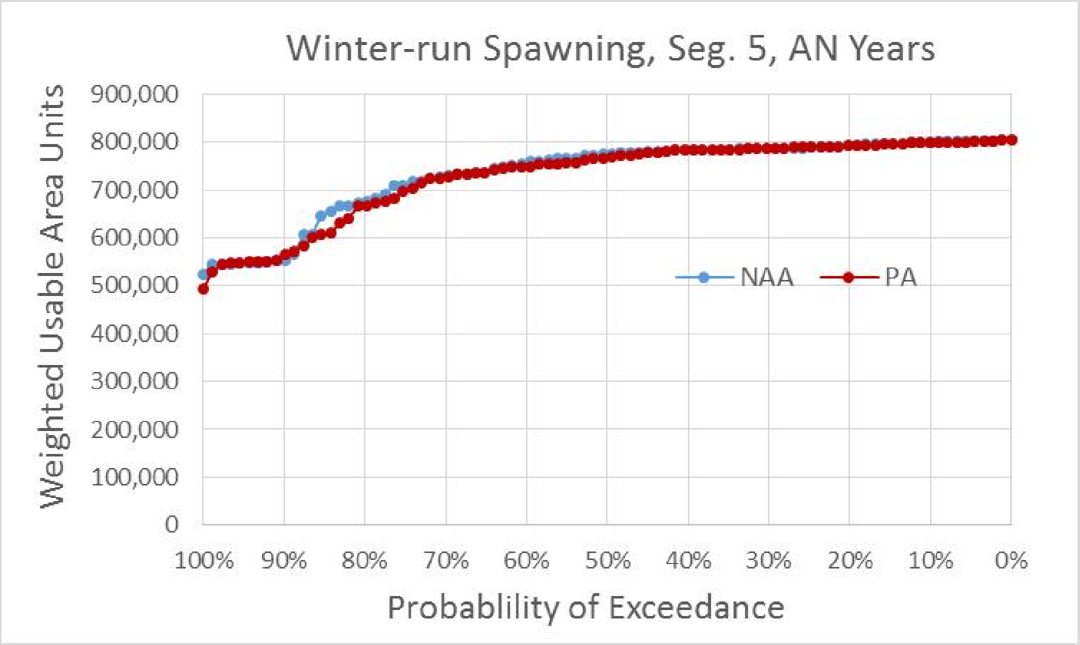

Figure 5.4-42. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

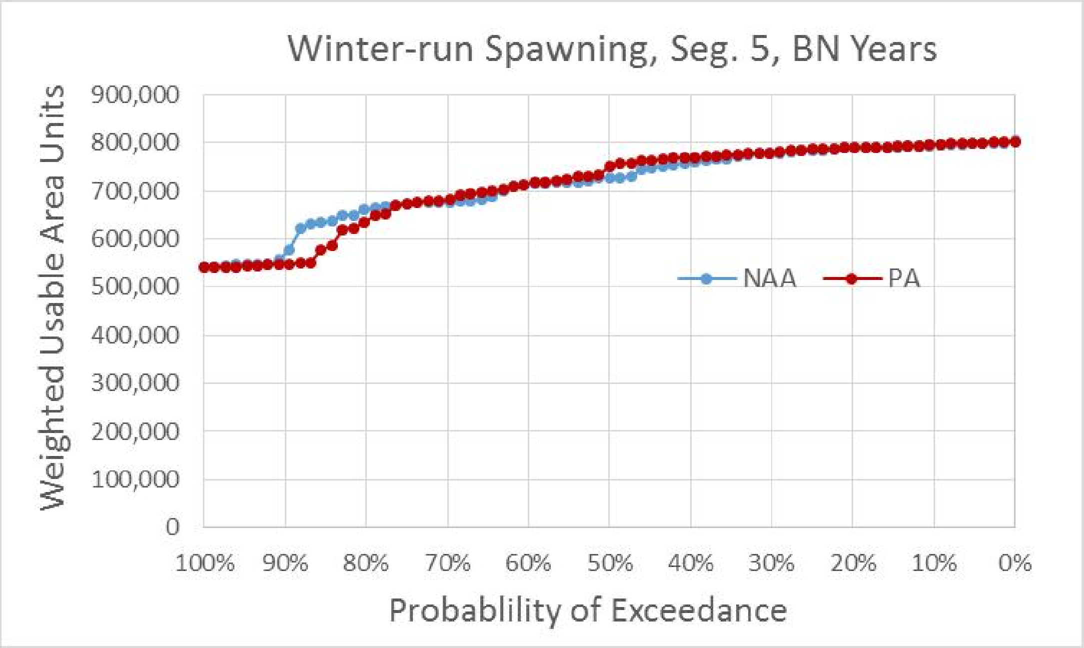

Figure 5.4-43. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

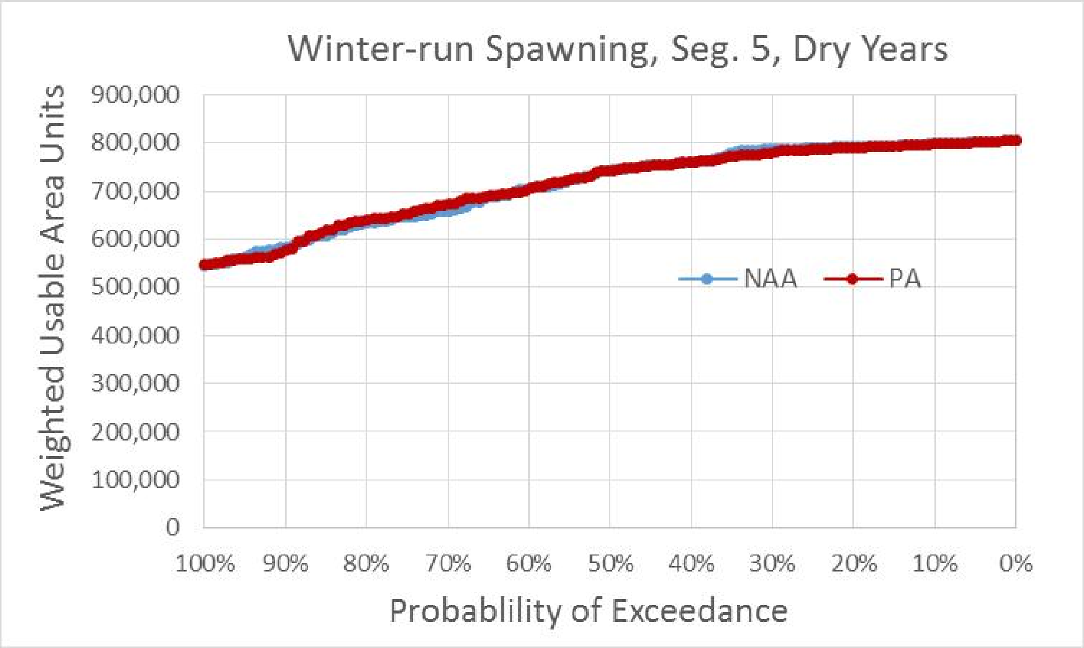

Figure 5.4-44. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

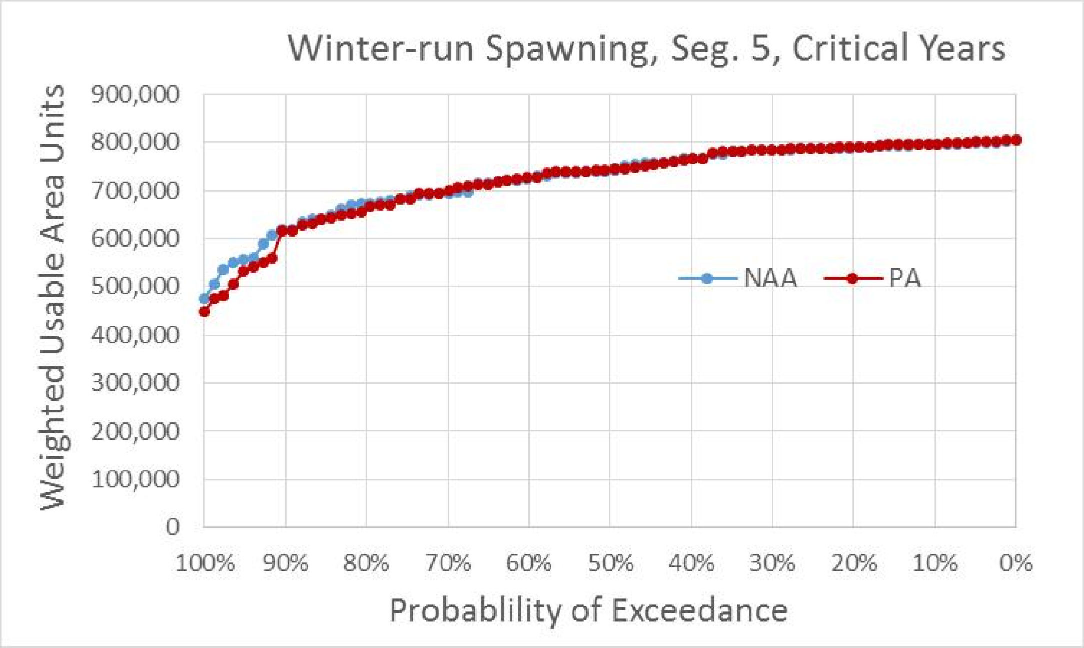

Figure 5.4-45. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

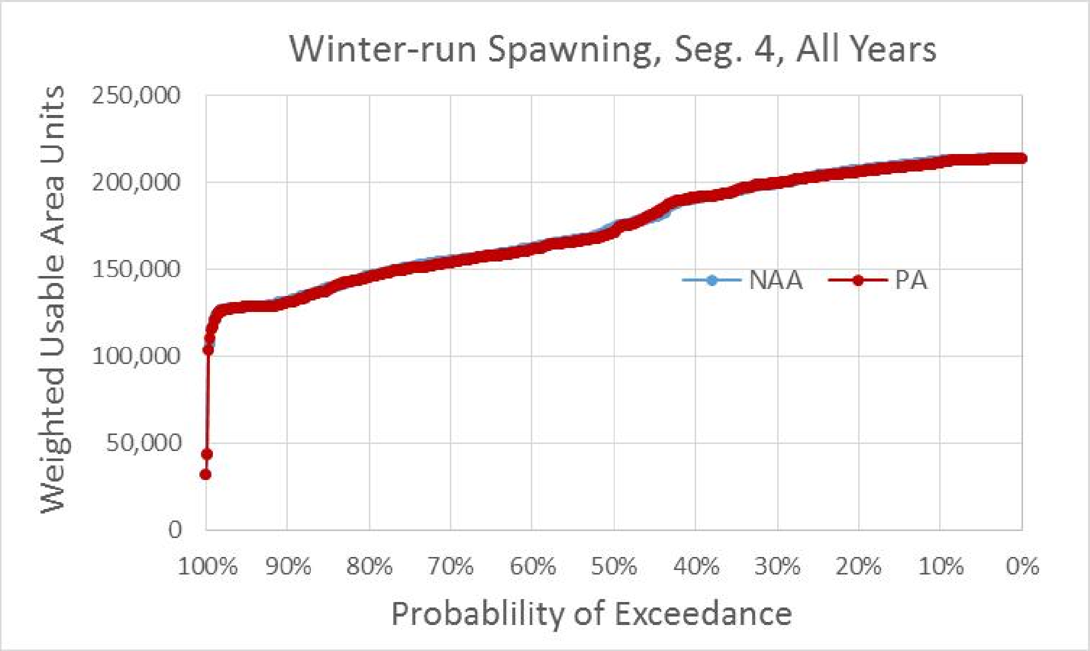

Figure 5.4-46. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

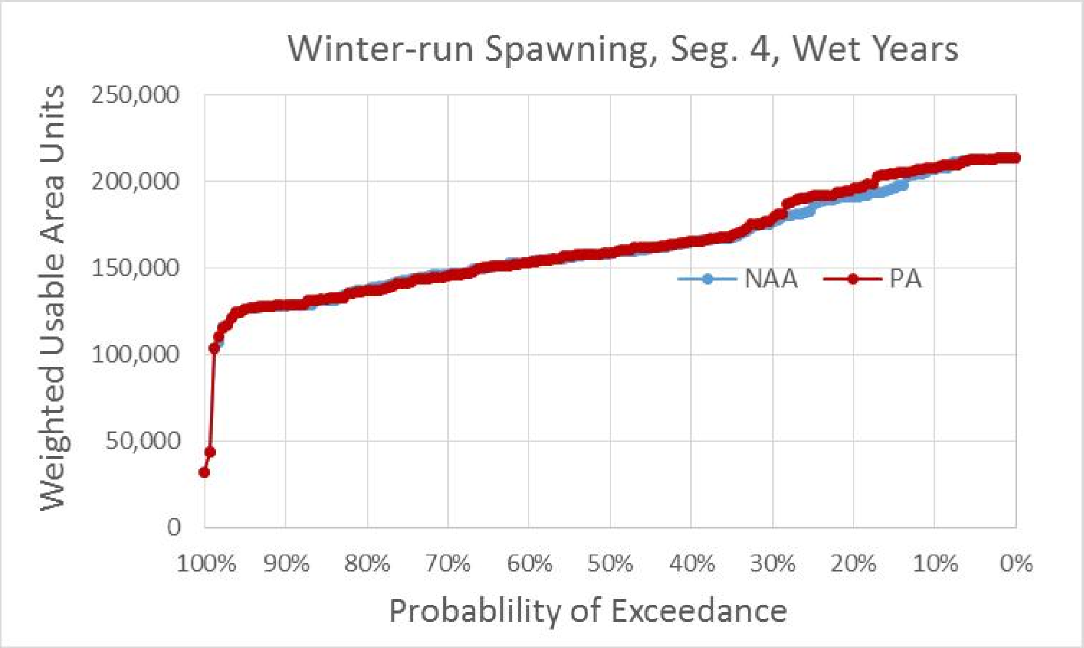

Figure 5.4-47. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

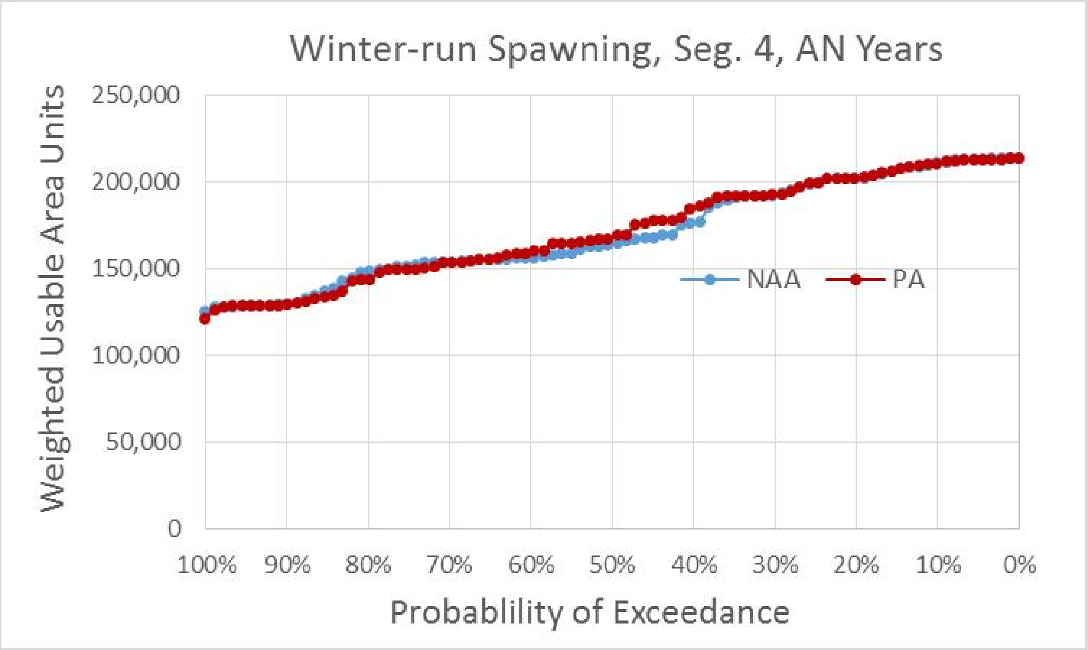

Figure 5.4-48. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

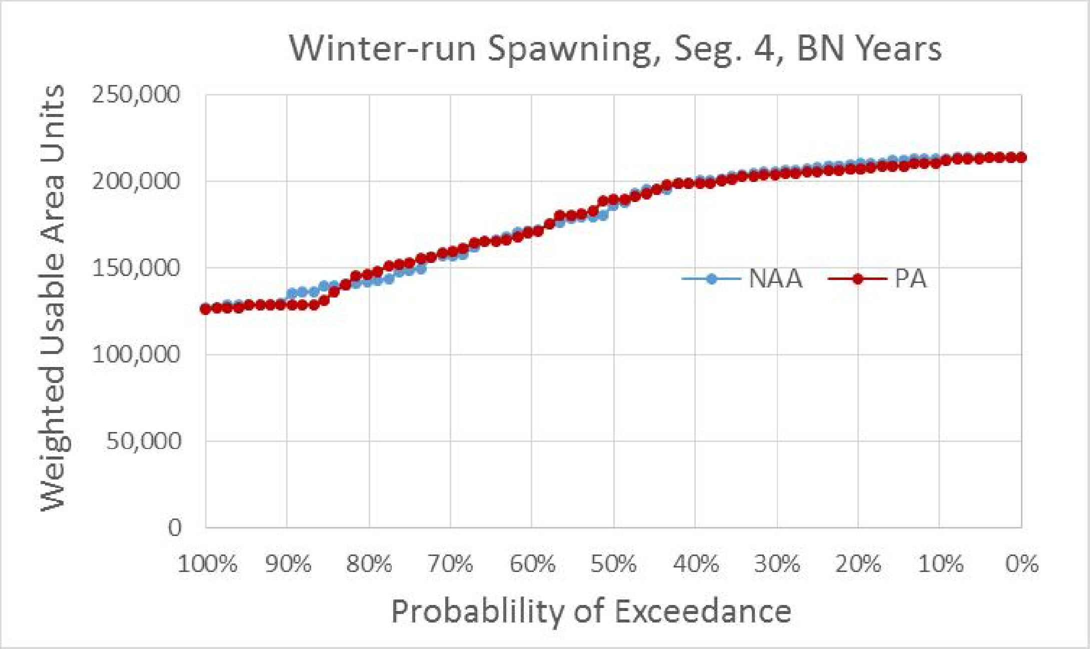

Figure 5.4-49. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

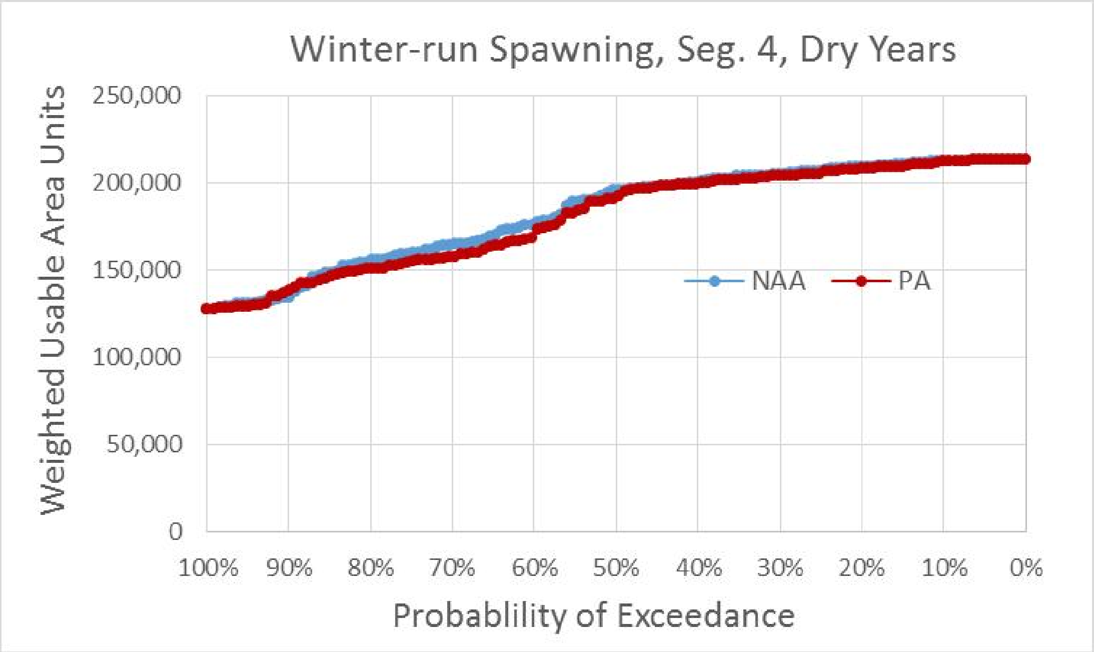

Figure 5.4-50. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

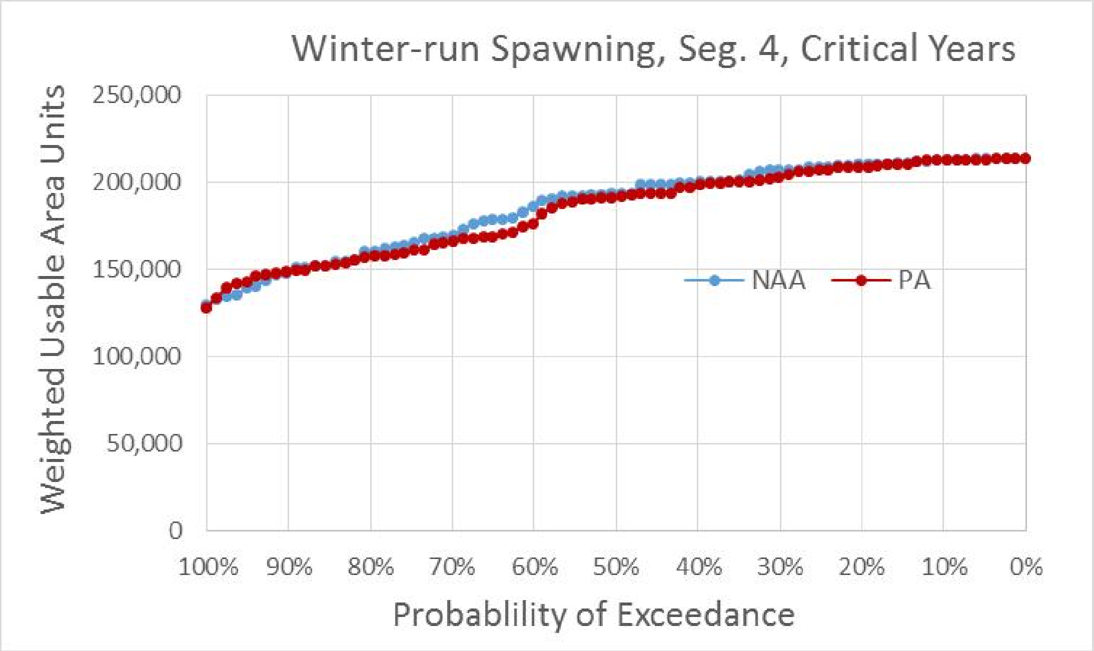

Figure 5.4-51. Exceedance Plot of Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in spawning WUA in each segment under the PAA and NAA were also examined using the grand mean spawning WUA for each month of the spawning period under each water year type and all water year types combined (Table 5.4-31 to Table 5.4-33). The means differed by less than 5% for most months and water year types, but mean WUA in Segment 6 under the

PA was up to 12% lower than that under the NAA in September (below normal years) and up to 15% higher in October (below normal years). In the other two segments, the largest differences in mean WUA between the PA and NAA were 6%, except for an 8% higher WUA for the PA in Segment 4 in September of above normal years. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

Table 5.4-31. Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) and Differences (Percent Differences) in River Segment 6 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
April	Wet	216,522	217,519	997 (0.5%)
	Above Normal	221,764	222,044	280 (0.1%)
	Below Normal	215,429	211,200	-4,229 (-2%)
	Dry	178,104	184,522	6,418 (4%)
	Critical	227,592	231,978	4,386 (2%)
	All	209,456	211,457	2,001 (1%)
May	Wet	276,320	275,628	-692 (-0.3%)
	Above Normal	262,042	263,867	1,825 (1%)
	Below Normal	265,550	264,156	-1,394 (-1%)
	Dry	245,321	253,132	7,812 (3%)
	Critical	244,786	248,484	3,699 (2%)
	All	260,436	262,766	2,330 (1%)
June	Wet	300,750	299,713	-1,037 (-0.3%)
	Above Normal	303,673	299,032	-4,641 (-1.5%)
	Below Normal	299,363	292,133	-7,230 (-2%)
	Dry	300,122	298,338	-1,785 (-1%)
	Critical	298,345	300,412	2,067 (1%)
	All	300,522	298,355	-2,167 (-1%)
July	Wet	288,622	287,598	-1,024 (-0.4%)
	Above Normal	275,604	276,013	408 (0.1%)
	Below Normal	281,204	278,891	-2,313 (-1%)
	Dry	289,472	291,323	1,851 (1%)
	Critical	295,595	299,558	3,964 (1%)
	All	286,791	287,252	461 (0.2%)
August	Wet	304,239	304,335	96 (0.03%)
	Above Normal	305,230	306,481	1,252 (0.4%)
	Below Normal	299,726	304,102	4,376 (1%)
	Dry	296,651	299,775	3,124 (1%)
	Critical	289,022	286,724	-2,298 (-1%)
	All	299,713	300,955	1,241 (0.4%)

Month	WYT	NAA	PA	PA vs. NAA
September	Wet	285,342	288,294	2,952 (1%)
	Above Normal	293,397	283,485	-9,912 (-3%)
	Below Normal	202,678	178,020	-24,658 (-12%)
	Dry	176,018	164,981	-11,038 (-6%)
	Critical	172,765	156,462	-16,303 (-9%)
	All	232,391	223,370	-9,021 (-4%)
October	Wet	272,932	253,563	-19,368 (-7%)
	Above Normal	249,434	248,612	-822 (-0.3%)
	Below Normal	215,956	248,266	32,310 (15%)
	Dry	205,448	223,098	17,650 (9%)
	Critical	166,658	160,394	-6,264 (-4%)
	All	229,306	230,785	1,479 (0.6%)

Table 5.4-32. Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) and Differences (Percent Differences) in River Segment 5 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
April	Wet	668,066	669,812	1,746 (0.3%)
	Above Normal	723,965	724,219	255 (0.04%)
	Below Normal	721,025	716,821	-4,204 (-1%)
	Dry	673,244	680,144	6,900 (1%)
	Critical	728,344	733,481	5,137 (1%)
	All	694,116	696,581	2,465 (0%)
May	Wet	764,672	764,118	-554 (-0.07%)
	Above Normal	760,631	762,898	2,266 (0.3%)
	Below Normal	772,514	771,235	-1,279 (-0.2%)
	Dry	746,462	754,220	7,758 (1%)
	Critical	758,547	760,080	1,533 (0.2%)
	All	759,746	761,874	2,128 (0.3%)
June	Wet	770,985	761,269	-9,715 (-1%)
	Above Normal	755,863	719,160	-36,703 (-5%)
	Below Normal	732,040	690,204	-41,836 (-6%)
	Dry	747,713	717,986	-29,728 (-4%)
	Critical	767,702	758,858	-8,844 (-1%)
	All	757,207	734,150	-23,056 (-3%)
July	Wet	641,046	634,097	-6,949 (-1%)
	Above Normal	565,302	568,741	3,440 (1%)
	Below Normal	591,210	582,317	-8,893 (-2%)
	Dry	651,436	662,086	10,650 (2%)
	Critical	700,751	729,890	29,139 (4%)

Month	WYT	NAA	PA	PA vs. NAA
	All	633,624	637,635	4,011 (1%)
August	Wet	777,517	775,814	-1,702 (-0.2%)
	Above Normal	782,416	788,046	5,630 (1%)
	Below Normal	739,346	785,280	45,935 (6%)
	Dry	784,795	785,457	662 (0.1%)
	Critical	781,243	776,562	-4,681 (-0.6%)
	All	775,493	781,485	5,991 (0.8%)
September	Wet	640,986	653,779	12,793 (2%)
	Above Normal	788,726	783,990	-4,736 (-1%)
	Below Normal	710,530	681,581	-28,949 (-4%)
	Dry	673,713	659,064	-14,649 (-2%)
	Critical	669,275	642,375	-26,900 (-4%)
	All	685,859	677,772	-8,088 (-1%)
October	Wet	776,954	764,281	-12,674 (-2%)
	Above Normal	762,221	759,184	-3,036 (-0.4%)
	Below Normal	734,311	764,065	29,754 (4%)
	Dry	716,970	739,011	22,041 (3%)
	Critical	662,073	642,143	-19,930 (-3%)
	All	737,150	739,163	2,012 (0.3%)

Table 5.4-33. Winter-Run Chinook Salmon Spawning Weighted Usable Area (WUA) and Differences (Percent Differences) in River Segment 4 between Model Scenarios (green indicates PA is at least 5% higher [raw difference value] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
April	Wet	173,839	173,836	-4 (0%)
	Above Normal	193,016	192,951	-65 (-0.03%)
	Below Normal	202,334	203,129	796 (0.4%)
	Dry	205,148	203,986	-1,162 (-0.6%)
	Critical	195,967	195,628	-339 (-0.2%)
	All	191,577	191,339	-238 (-0.1%)
May	Wet	174,435	174,717	281 (0.2%)
	Above Normal	191,050	190,875	-176 (-0.09%)
	Below Normal	191,405	192,361	956 (0.5%)
	Dry	194,209	189,802	-4,408 (-2%)
	Critical	201,976	200,657	-1,319 (-0.7%)
	All	188,199	187,121	-1,078 (-0.6%)
June	Wet	158,988	157,577	-1,411 (-0.9%)
	Above Normal	152,276	147,609	-4,667 (-3%)
	Below Normal	153,552	148,988	-4,564 (-3%)
	Dry	155,038	149,189	-5,849 (-4%)

Month	WYT	NAA	PA	PA vs. NAA
	Critical	168,125	161,557	-6,568 (-4%)
	All	157,569	153,381	-4,187 (-3%)
July	Wet	138,521	137,705	-816 (-0.6%)
	Above Normal	130,498	130,695	197 (0.2%)
	Below Normal	133,324	132,329	-995 (-0.7%)
	Dry	140,847	141,830	983 (0.7%)
	Critical	150,931	155,376	4,445 (3%)
	All	138,936	139,465	529 (0.4%)
August	Wet	161,112	160,047	-1,065 (-0.7%)
	Above Normal	159,962	159,092	-869 (-0.5%)
	Below Normal	156,705	165,699	8,994 (6%)
	Dry	176,037	171,523	-4,514 (-3%)
	Critical	177,817	174,836	-2,980 (-2%)
	All	166,423	165,617	-806 (-0.5%)
September	Wet	141,651	142,325	675 (0.5%)
	Above Normal	172,658	186,364	13,706 (7.9%)
	Below Normal	207,388	207,314	-74 (-0.04%)
	Dry	204,489	203,147	-1,343 (-0.7%)
	Critical	204,682	200,279	-4,404 (-2%)
	All	179,935	181,341	1,405 (0.8%)
October	Wet	185,912	195,946	10,034 (5.4%)
	Above Normal	199,651	197,487	-2,164 (-1.1%)
	Below Normal	207,180	199,433	-7,747 (-4%)
	Dry	205,507	206,168	661 (0.3%)
	Critical	202,654	198,392	-4,262 (-2%)
	All	198,154	199,534	1,380 (0.7%)

5.4.2.1.3.1.1.1.2 Redd scour

The probability of flows occurring under the PA and the NAA that would be high enough to mobilize sediments and scour winter-run Chinook salmon redds was estimated from CALSIM II estimates of mean monthly flows, using a relationship determined from the historical record between actual mean monthly flow and maximum daily flow (Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*). The actual monthly and daily flow data used in the analysis are from gage records just below Keswick Dam and at Bend Bridge, and the CALSIM II estimates used to compare probabilities of redd scour for the PA and the NAA are for the Keswick Dam and Red Bluff locations. As discussed in Appendix 5.D, Section 5.D.2.2, *Spawning Flow Methods*, 40,000 cfs is treated as the minimum daily flow at which redd scour occurs in the Sacramento River. The analysis of the Keswick Dam gage data shows that for months with a mean monthly flow of at least 27,300 cfs, the maximum daily flow in that month is always at least 40,000 cfs. The Bend Bridge gage data show that for months with a mean flow of at least 21,800 cfs, the maximum daily flow in that month is always 40,000 cfs. Therefore, redd scour probabilities for the PA and the NAA were evaluated by comparing frequencies of CALSIM II flows greater than 27,300 cfs at Keswick Dam or greater than 21,800 cfs at Red Bluff during the winter-run April through October spawning and incubation period. Further information on the redd scour analysis methods is provided in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*.

Table 5.4-34 shows that less than 1% of months in the CALSIM II record during the April through October spawning and incubation period of winter-run Chinook salmon would have flows of more than 27,300 cfs at Keswick Dam or more than 21,800 cfs at Red Bluff. This was expected, given that none of the months of the spawning and incubation period usually experiences such high flows. Only one water year and month with mean monthly flow greater than 27,300 cfs was predicted at Keswick Dam for the winter-run spawning and incubation period (Table 5.4-35), and several water years and months with mean monthly flow greater than 21,800 cfs were predicted at Red Bluff (Table 5.4-36) under both the NAA and PA. For winter-run Chinook salmon, there would be no differences between the PA and the NAA in the percentage of scouring flows at either location.

Table 5.4-34. Percent of Months during Spawning and Incubation Periods with CALSIM II Flow Greater than Redd Scouring Threshold Flow at Keswick Dam (27,300 cfs) and Red Bluff (21,800 cfs) between Model Scenarios

	Keswick Dam			Red Bluff		
Species/Race	**NAA**	**PA**	**PA vs. NAA**	**NAA**	**PA**	**PA vs. NAA**
Winter-run Chinook salmon	0.2	0.2	0 (0%)	0.7	0.7	0 (0%)
Spring-run Chinook salmon	0.7	0.5	-0.2 (-25%)	2.6	2.8	0.2 (7%)
CCV Steelhead	5.3	5.3	0 (0%)	14.6	15.7	1 (7%)

Table 5.4-35. Water Year and Month with Mean Flow > 27,300 cfs at Keswick Dam during the Winter-run Chinook Salmon Spawning and Incubation Period

			Flow (cfs)	
Water Year	**Month**	**WYT**	**NAA**	**PA**
1963	April	Wet	30,893	30,893

Table 5.4-36. Water Years and Months with Mean Flow > 21,800 cfs at Red Bluff during the Winter-run Chinook Salmon Spawning and Incubation Period

			Flow (cfs)	
Water Year	**Month**	**WYT**	**NAA**	**PA**
1941	April	Wet	24,464	24,464
1958	April	Wet	22,228	22,228
1963	April	Wet	42,184	42,182
1982	April	Wet	33,884	33,885

Note that SALMOD also predicts redd scour risk for winter-run Chinook salmon in the Sacramento River, although it is combined with redd dewatering and the combination is reported as “Incubation” mortality. Please see Table 5.4-38 below for these results.

5.4.2.1.3.1.1.1.3 Redd dewatering

The percentage of winter-run Chinook salmon redds dewatered by reductions in Sacramento River flow was estimated from CALSIM II estimates of mean monthly flows during the 3 months following each of the months that winter-run salmon spawn (Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*, Table 5.D-54). This analysis employed functional relationships developed in field studies by USFWS (2006) that predicted percentages of redds dewatered from an array of paired spawning and dewatering flows. The field studies were conducted in the Sacramento River between Keswick Dam and Battle Creek at the same locations as the spawning WUA studies, and one relationship was developed for the entire river reach (Segments 4 – 6). As noted in Section 5.4.2.1.3.1.1.1.1, *Spawning WUA*, winter-run spawning has peaked, on average, in river Segment 5 based on recent redd surveys, so the Segment 5 CALSIM II flows were used for the effects analysis to estimate redd dewatering under the PA and NAA, using the CALSIM II flow for each month of spawning together with the minimum flow during the 3 months following the spawning month. Because the CALSIM II flows for Segments 4 and 6 are similar to those for Segment 5, redd dewatering estimates using the Segment 4 and Segment 6 flows differ little from those for Segment 5 (Appendix 5.D, Section 5.D.2.6, *Redd Dewatering Results, Sacramento River Segments 4 and 6*). Further information on the redd dewatering analysis methods is provided in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*.

Differences in winter-run redd dewatering under the PA and NAA were examined using exceedance plots of mean monthly percent of redds dewatered for the April through August months during which winter-run spawn. The exceedance curves for the PA generally show higher redd dewatering percentages than those for the NAA for all water year types combined and for all individual water year types except critical years (Figure 5.4-52–Figure 5.4-57). The biggest differences in the dewatering curves are predicted for above normal water years, with about 25% of all months having greater than 10% of redds dewatered under the NAA, but about 38% of all months having greater than 10% of redds dewatered under the PA (a 13% increase). Other differences are smaller than this (up to 11% increase for below normal years at greater than 30% of redds dewatered) but, except for critical years, had consistently higher redd dewatering for the PA. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

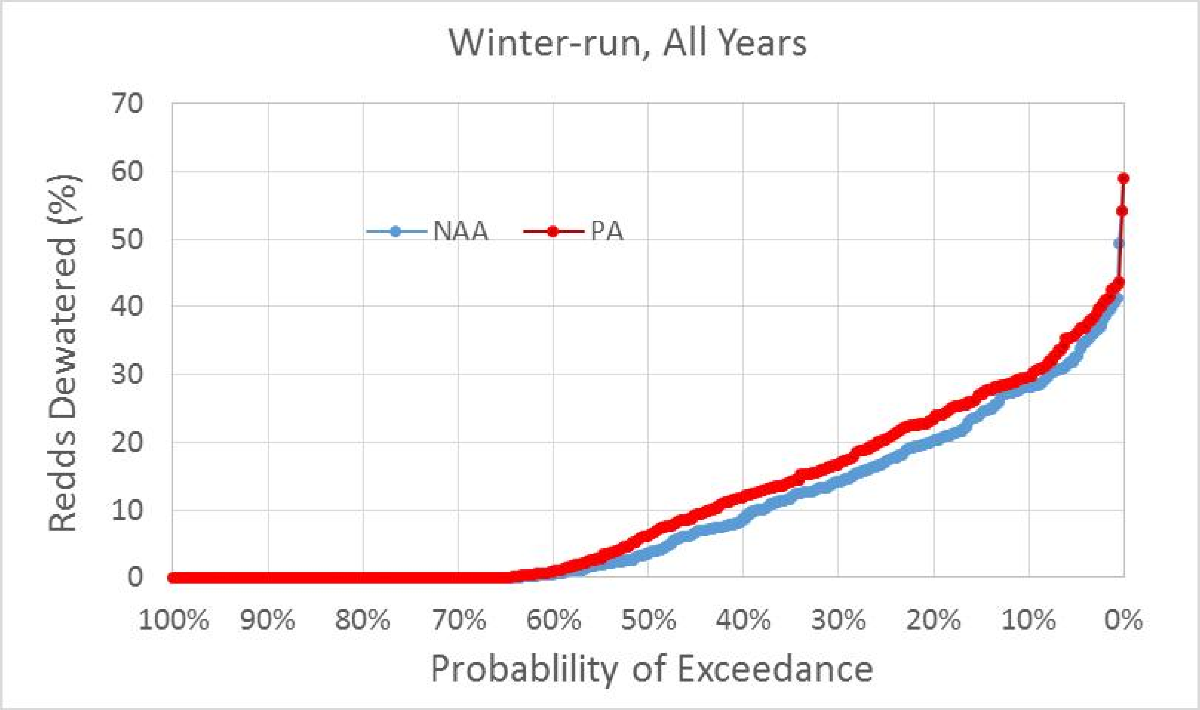

Figure 5.4-52. Exceedance Plot of Winter-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, All Water Years

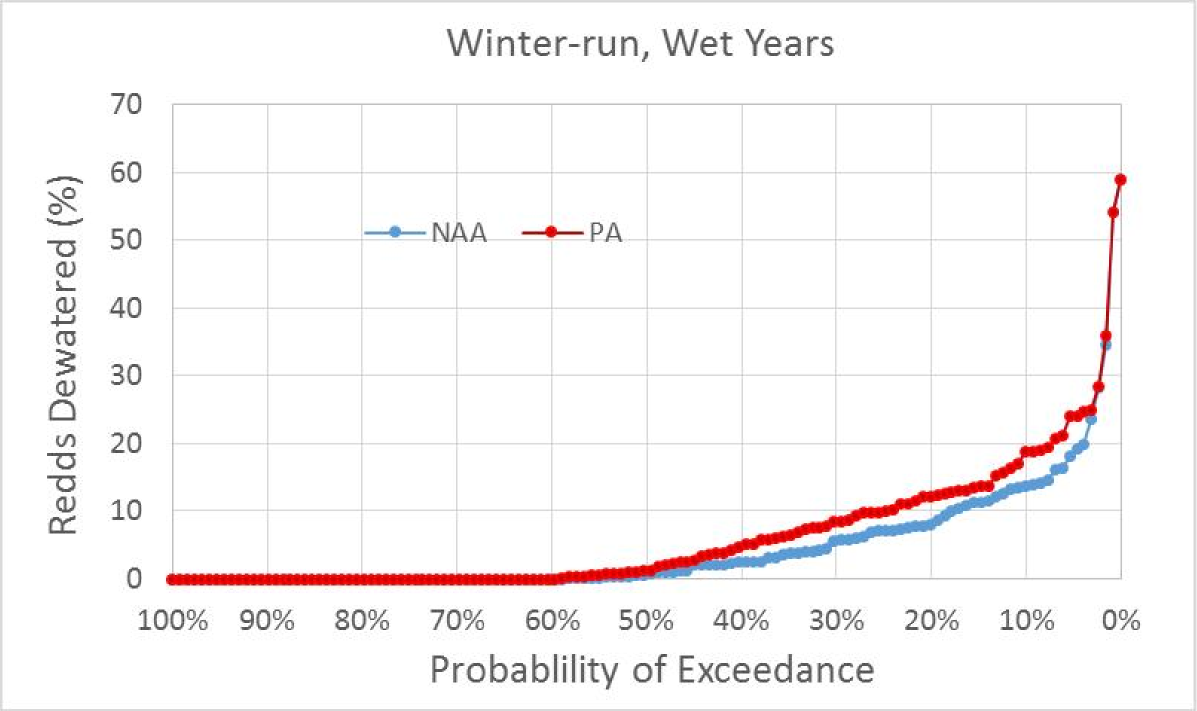

Figure 5.4-53. Exceedance Plot of Winter-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, Wet Water Years

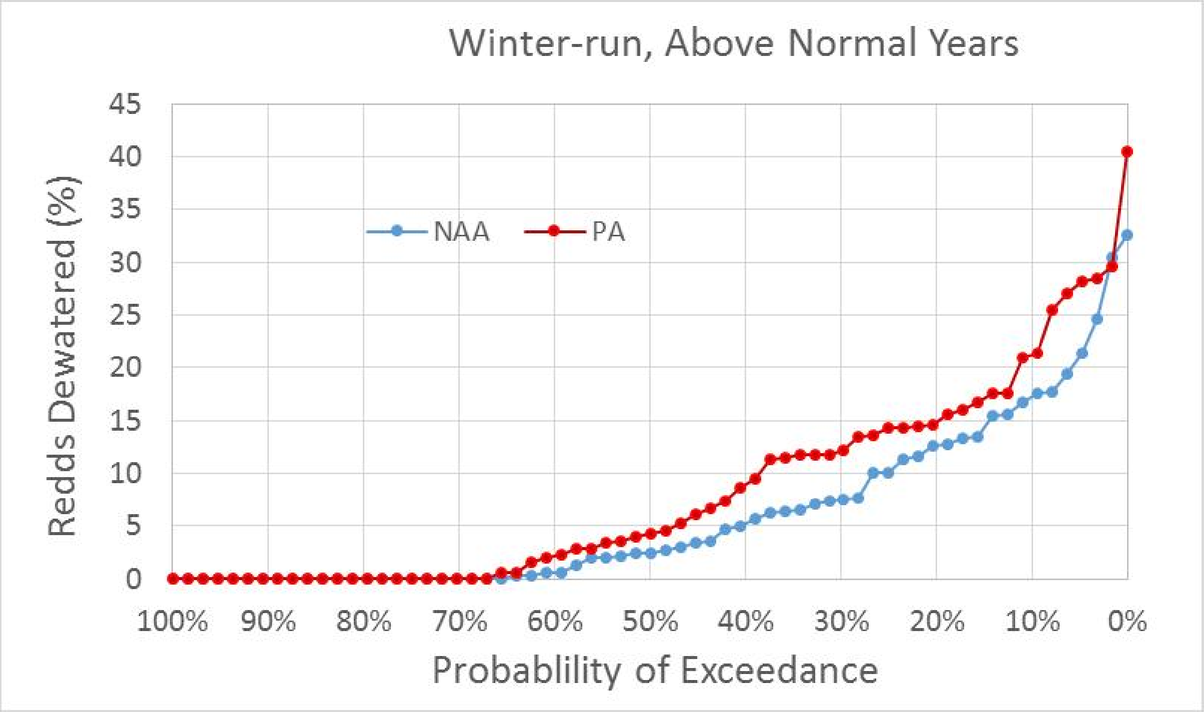

Figure 5.4-54. Exceedance Plot of Winter-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, Above Normal Water Years

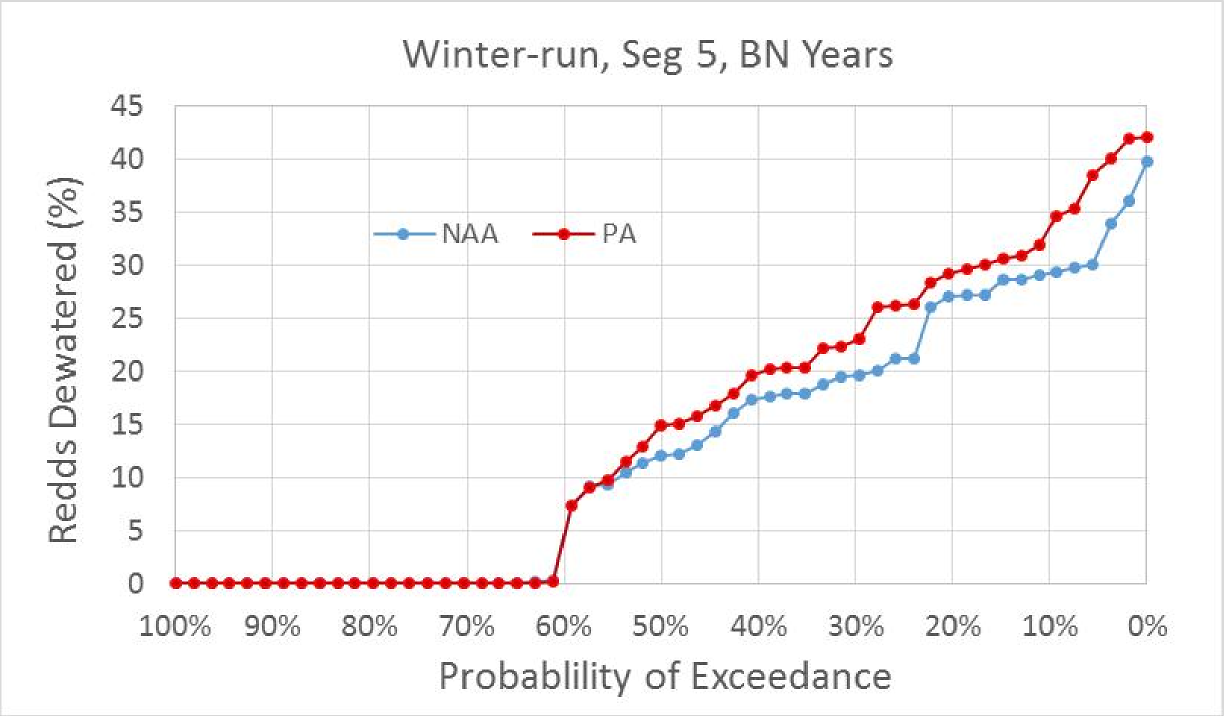

Figure 5.4-55. Exceedance Plot of Winter-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, Below Normal Water Years

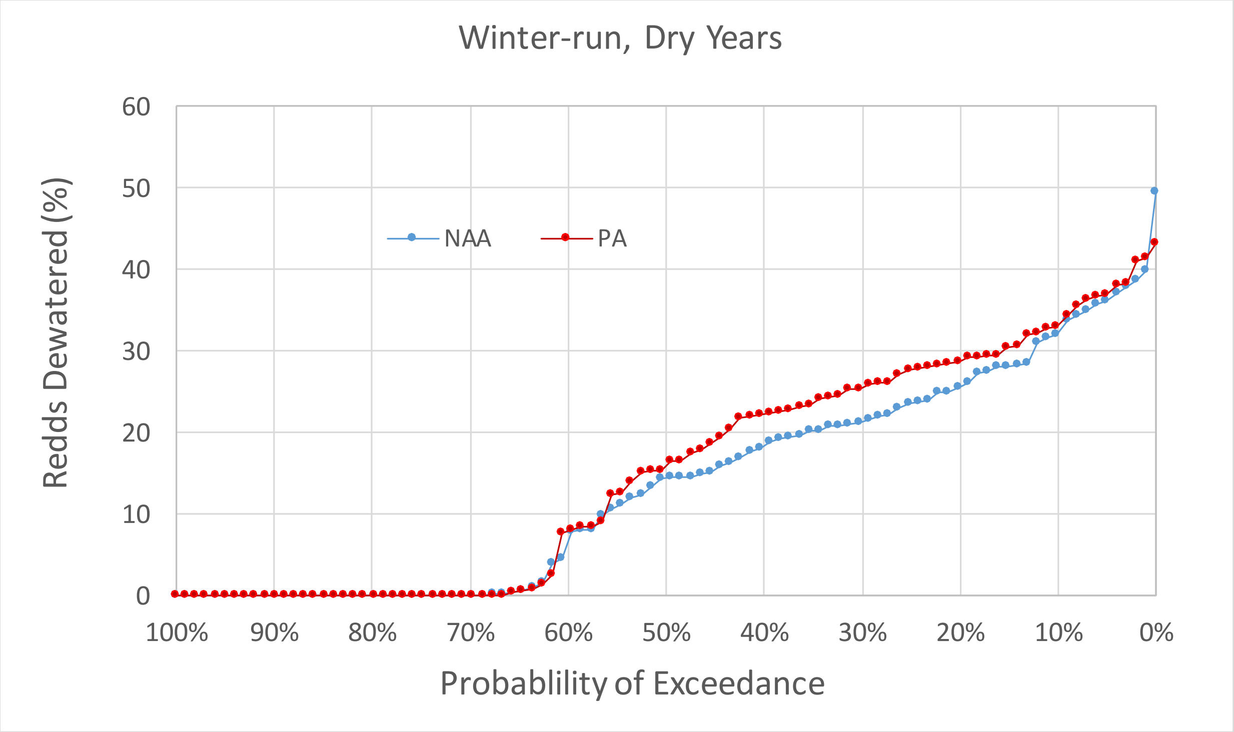

Figure 5.4-56. Exceedance Plot of Winter-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, Dry Water Years

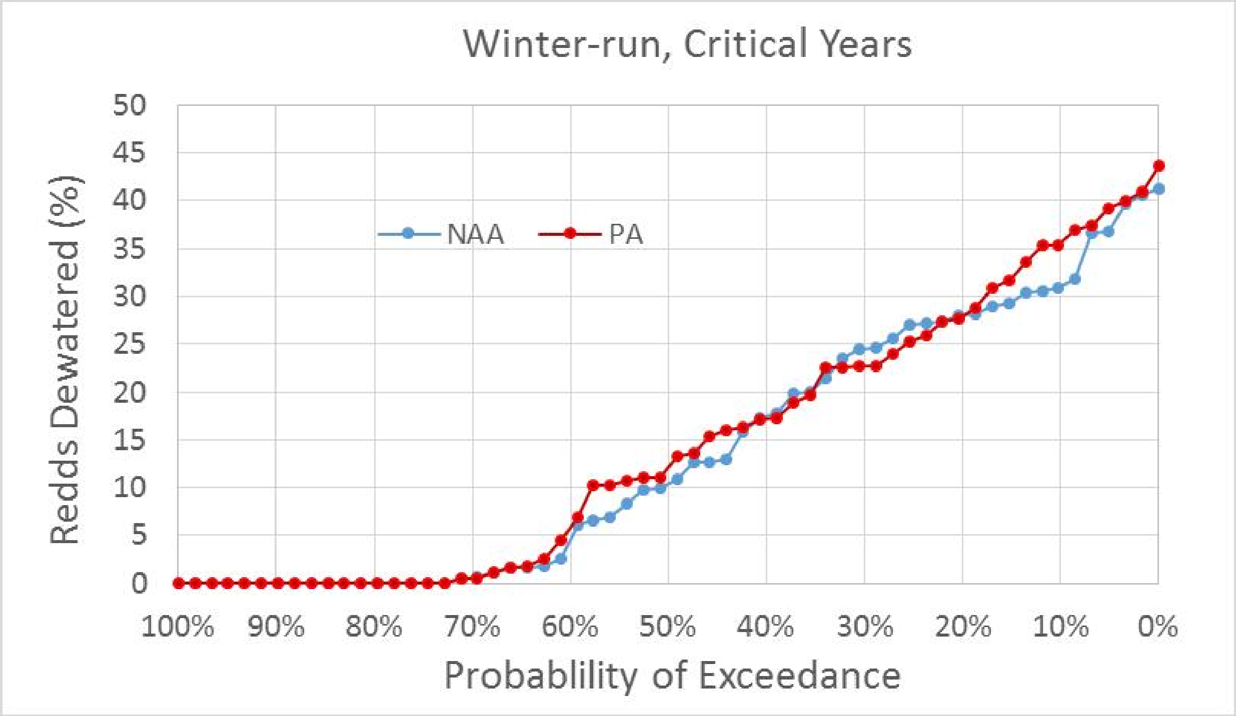

Figure 5.4-57. Exceedance Plot of Winter-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, Critical Water Years

Differences in redd dewatering between the PAA and NAA were also examined using the grand mean percentages of redds dewatered for each month of spawning under each water year type and all water year types combined (Table 5.4-37). The mean percent redds dewatered under the PA is predicted to range between 3 and 7% greater than the means under the NAA during June of all water year types except wet years, and to be 3 and 6% greater during August of wet and above normal years, respectively. The percent change (relative change rather than raw change) in the means for these months and water year types ranged from 26% to 89% greater under the PA than under the NAA. The large percentages for many of the months and water year types are artifacts of the low percentages of redds dewatered under both scenarios that were used in computing the percent changes. During April and May, redd dewatering would differ insignificantly between the PA and NAA. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

Table 5.4-37. Winter-Run Chinook Salmon Percent of Redds Dewatered (Percent of Total Redds) and Differences (Percent Differences) between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)

Month	WYT	NAA	PA	PA vs. NAA
April	Wet	6.1	6.0	0 (0%)
	Above Normal	0.8	0.9	0.14 (19%)
	Below Normal	0.0	0.0	0 (-61%)
	Dry	0.4	0.2	-0.2 (-53%)
	Critical	1.4	1.3	-0.1 (-9%)
	All	2.4	2.3	-0.1 (-2%)
May	Wet	0.4	0.4	0 (1%)
	Above Normal	0.3	0.4	0.1 (31%)
	Below Normal	0.0	0.0	0 (0%)
	Dry	0.7	0.6	-0.2 (-22%)
	Critical	0.2	0.2	0 (10%)
	All	0.4	0.4	0 (-6%)
June	Wet	1.1	1.2	0.1 (9%)
	Above Normal	3.5	6.3	2.8 (79%)
	Below Normal	16.1	22.9	6.8 (43%)
	Dry	20.5	25.8	5.3 (26%)
	Critical	16.5	21.8	5.3 (32%)
	All	10.5	13.9	3.5 (33%)
July	Wet	10.8	14.3	3.5 (32.4%)
	Above Normal	17.5	18.2	0.6 (4%)
	Below Normal	28.5	31.8	3.3 (12%)
	Dry	29.8	30.9	1.1 (4%)
	Critical	27.7	28.0	0.3 (0.9%)
	All	21.4	23.3	2 (9%)

August	Wet	5.5	8.5	3 (55%)
	Above Normal	7.1	13.4	6.3 (89%)
	Below Normal	18.9	17.9	-1 (-5%)
	Dry	16.5	18.5	2 (12%)
	Critical	21.7	20.6	-1.1 (-5%)
	All	12.6	14.8	2.2 (17%)

5.4.2.1.3.1.1.1.4 SALMOD Flow-related Outputs

The SALMOD model provides predicted flow-related mortality of winter-run Chinook salmon eggs and alevins in the Sacramento River (see Attachment 5.D.2, *SALMOD Model* for a full description). The SALMOD results for this type of mortality are presented in Table 5.4-38, together with results for the other sources of mortality of winter-run Chinook salmon predicted by SALMOD and discussed in other sections of this document. The flow-related mortality of winter-run Chinook salmon eggs and alevins is split up as “incubation” (which refers to redd dewatering and scour) and “superimposition” (of redds) mortality. The annual exceedance plot of flow-related mortality of winter-run Chinook salmon eggs and alevins is presented in Figure 5.4-58. These results indicate that there would be increases in flow-related mortality of winter-run Chinook salmon eggs and alevins from incubation-related factors under the PA relative to the NAA for all water year types (increase in average annual mortality of 61,712 eggs and alevins, or 17%, for all water year types combined). Note, however, that the increase for all years combined under the PA would be largely offset by a 7% reduction in temperature-related mortality of the life stage, yielding an increase in average annual total mortality for the life stage of 29,958 eggs and alevins, or 4% (Table 5.4-38). No mortality is predicted from redd superimposition for either scenario. It should be noted that SALMOD predicts redd superimposition for each race of salmon without consideration of redd densities of the other races. SALMOD predicts no superimposition mortality for winter-run because numbers of winter-run spawners are low. Fall-run and late fall–run Chinook salmon are currently the only races of salmon abundant enough in the upper Sacramento River for redd superimposition to be a mortality factor according to SALMOD. However, there is little temporal or spatial overlap of winter-run spawning with that of fall-run or late fall–run Chinook salmon, so the SALMOD prediction of low superimposition for winter-run can be considered reliable. The incubation-related mortality factors in Table 5.4-38 comprise redd dewatering and redd scour (Attachment 5.D.2, *SALMOD Model*). Redd scour, as described in Section 5.4.2.1.3.1.1.1.2, *Redd Scour*, is expected to have little effect on winter-run Chinook salmon under either project scenario, but redd dewatering (Section 5.4.2.1.3.1.1.1.3, *Redd Dewatering*) is predicted to increase under the PA for June and August egg cohorts of some water year types (Table 5.4-37). Therefore, the increase in incubation-related mortality is attributable primarily to the predicted increase in redd dewatering. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

Table 5.4-38. Mean Annual Winter-Run Chinook Salmon Mortality[1] (# of Fish/Year) Predicted by SALMOD

Analysis Period	Spawning, Egg Incubation, and Alevins							Fry and Juvenile Rearing									Grand Total
	Temperature-Related Mortality			Flow-Related Mortality			Life Stage Total	Temperature-Related Mortality				Flow-Related Mortality				Life Stage Total	
	Pre-Spawn	Eggs	Subtotal	Incubation	Super-imposition	Subtotal		Fry	Pre-smolt	Immature Smolt	Subtotal	Fry	Pre-smolt	Immature Smolt	Subtotal		
All Water Year Types[2]																	
NAA	9,092	423,231	432,323	368,939	0	368,939	801,262	5,343	2,391	0	7,734	123,789	115	0	123,904	131,638	932,900
PA	9,119	391,450	400,568	430,651	0	430,651	831,220	5,495	2,125	0	7,620	120,680	104	0	120,784	128,404	959,624
Difference	27	-31,781	-31,755	61,712	0	61,712	29,958	152	-266	0	-114	-3,109	-11	0	-3,120	-3,234	26,723
Percent Difference[3]	0	-8	-7	17	0	17	4	3	-11	0	-1	-3	-10	0	-3	-2	3
Water Year Types[4]																	
Wet (32.5%)																	
NAA	8,774	806	9,580	167,602	0	167,602	177,182	0	0	0	0	173,745	36	0	173,781	173,781	350,962
PA	8,890	670	9,560	244,211	0	244,211	253,771	0	0	0	0	154,086	27	0	154,113	154,113	407,884
Difference	116	-136	-19	76,609	0	76,609	76,589	0	0	0	0	-19,659	-9	0	-19,667	-19,667	56,922
Percent Difference	1	-17	0	46	0	46	43	0	0	0	NA	-11	-25	0	-11	-11	16
Above Normal (12.5%)																	
NAA	9,001	457	9,459	316,112	0	316,112	325,570	0	0	0	0	159,631	24	0	159,655	159,655	485,225
PA	9,001	376	9,378	369,936	0	369,936	379,313	0	0	0	0	139,838	16	0	139,854	139,854	519,167
Difference	0	-81	-81	53,824	0	53,824	53,743	0	0	0	0	-19,793	-8	0	-19,801	-19,801	33,942
Percent Difference	0	-18	-1	17	0	17	17	0	0	0	NA	-12	-32	0	-12	-12	7
Below Normal (17.5%)																	
NAA	7,909	8,021	15,930	587,438	0	587,438	603,368	10	1	0	11	95,189	127	0	95,316	95,327	698,696
PA	8,455	12,730	21,184	714,331	0	714,331	735,515	11	1	0	12	105,939	117	0	106,056	106,068	841,584
Difference	545	4,709	5,254	126,893	0	126,893	132,147	1	0	0	1	10,749	-10	0	10,740	10,741	142,888
Percent Difference	7	59	33	22	0	22	22	15	-8	0	12	11	-8	0	11	11	20
Dry (22.5%)																	
NAA	9,789	29,678	39,467	610,519	0	610,519	649,986	24	6	0	30	106,542	246	0	106,788	106,818	756,803
PA	9,474	21,650	31,123	648,552	0	648,552	679,676	25	4	0	29	122,973	182	0	123,155	123,184	802,859
Difference	-316	-8,028	-8,344	38,034	0	38,034	29,690	1	-2	0	-1	16,431	-64	0	16,367	16,366	46,056
Percent Difference	-3	-27	-21	6	0	6	5	5	-33	0	-3	15	-26	0	15	15	6
Critical (15%)																	
NAA	9,853	2,764,994	2,774,847	275,207	0	275,207	3,050,054	35,573	15,929	0	51,502	33,235	160	0	33,395	84,897	3,134,950
PA	9,779	2,561,888	2,571,667	290,273	0	290,273	2,861,940	36,581	14,162	0	50,743	39,024	223	0	39,247	89,990	2,951,930
Difference	-74	-203,106	-203,180	15,066	0	15,066	-188,113	1,008	-1,767	0	-759	5,789	63	0	5,852	5,093	-183,021
Percent Difference	-1	-7	-7	5	0	5	-6	3	-11	0	-1	17	40	0	18	6	-6

[1] Mortality values do not include base mortality

[2] Based on the 80-year simulation period

[3] Relative difference of the Annual average

[4] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1995). Water years may not correspond to the biological years in SALMOD.

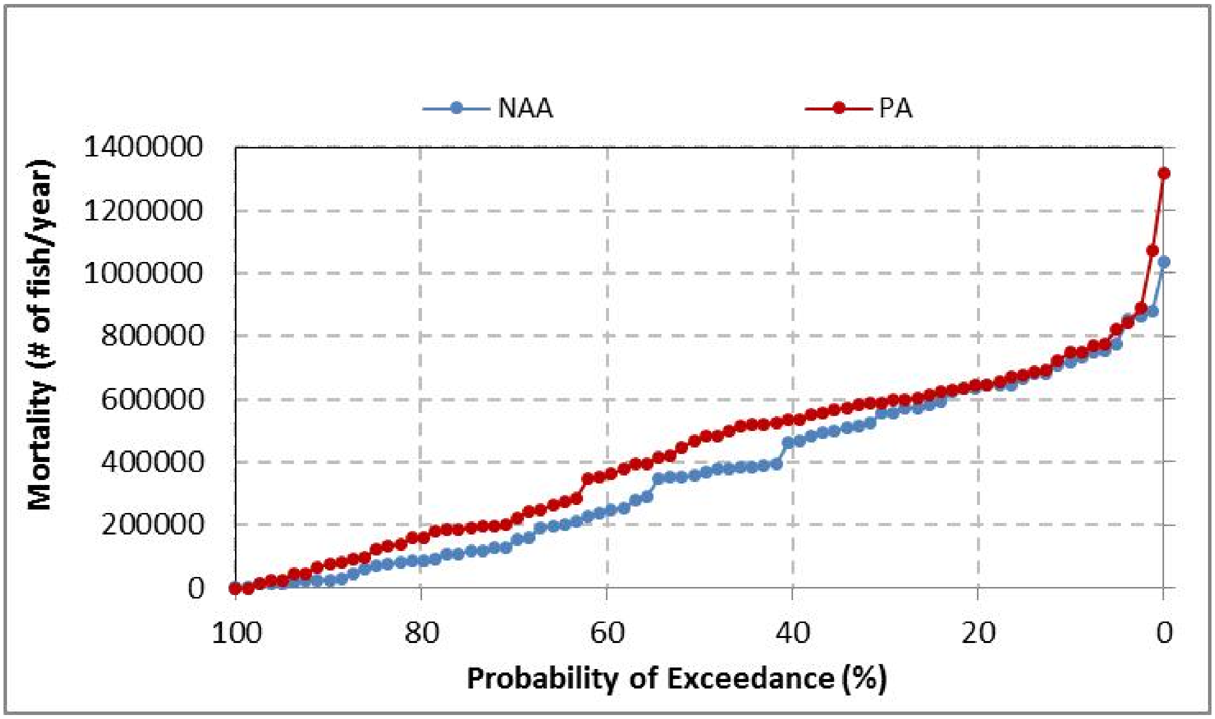

Figure 5.4-58. Exceedance Plot of Annual Flow-Based Mortality (#of Fish/Year) of Winter-Run Chinook Salmon Spawning, Egg Incubation, and Alevins

5.4.2.1.3.1.1.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the April through October spawning and incubation period for winter-run Chinook salmon, with peak presence of July through September (Table 5.4-25) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately a 1% change) throughout the spawning reach of Keswick Dam to Red Bluff in all months of the period and water year types. The largest increase in mean monthly water temperatures under the PA relative to the NAA would be 0.6°F, or up to 1.1%, and would occur at Red Bluff in above normal water years during August and in above- and below normal years during September; and at Bend Bridge in below normal years during September. These largest increases would occur during the period of peak presence of spawners, eggs, and alevins.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results*, Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The values for the PA in these exceedance plots generally overlap those of the NAA. Further examination of above normal water years during August (Figure 5.4-59) and September (
Figure 5.4-60) at Red Bluff, below normal years during September at Red Bluff (Figure 5.4-61), and in below normal years during September at Bend Bridge (Figure 5.4-62), where the largest increases in mean monthly water temperatures were modeled, reveals that there is a general trend towards marginally higher temperatures under the PA.

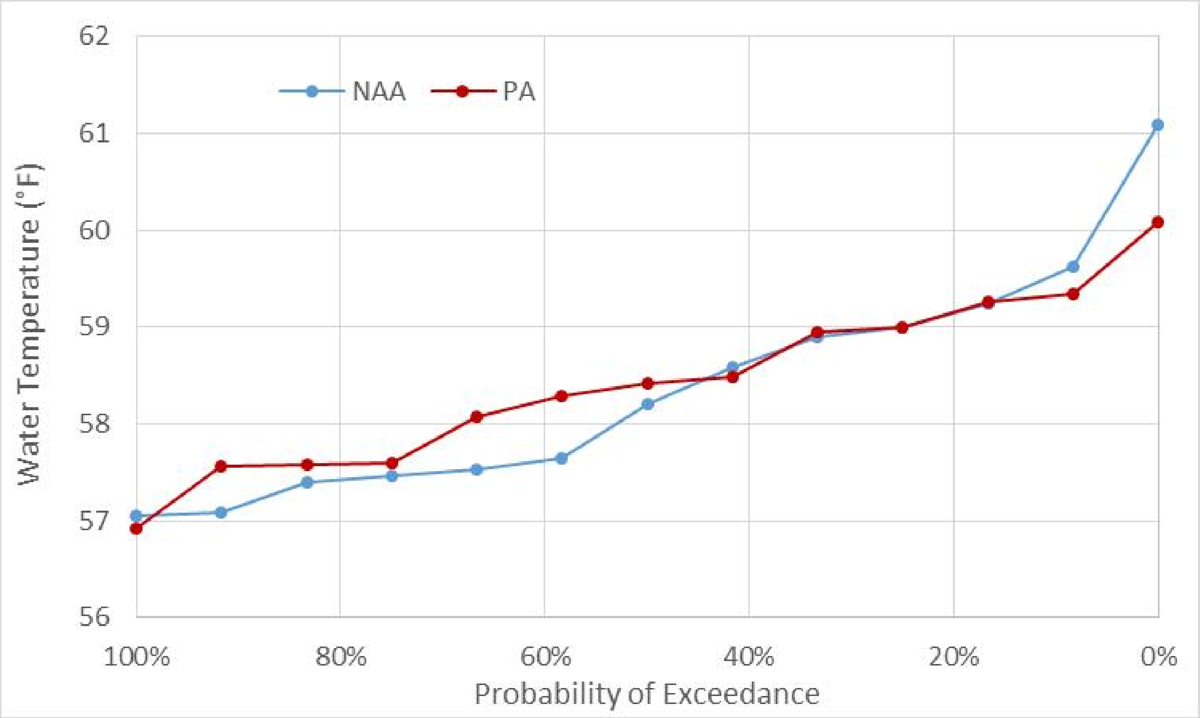

Figure 5.4-59. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in August of Above Normal Water Years

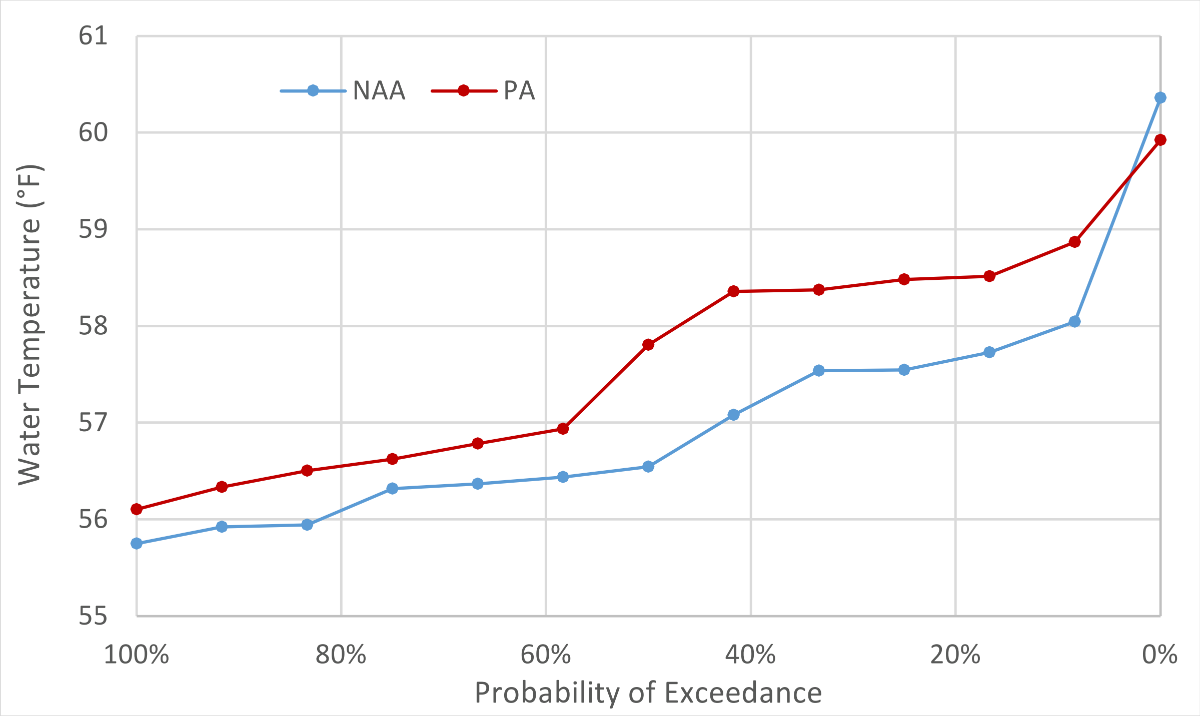

Figure 5.4-60. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in September of Above Normal Water Years

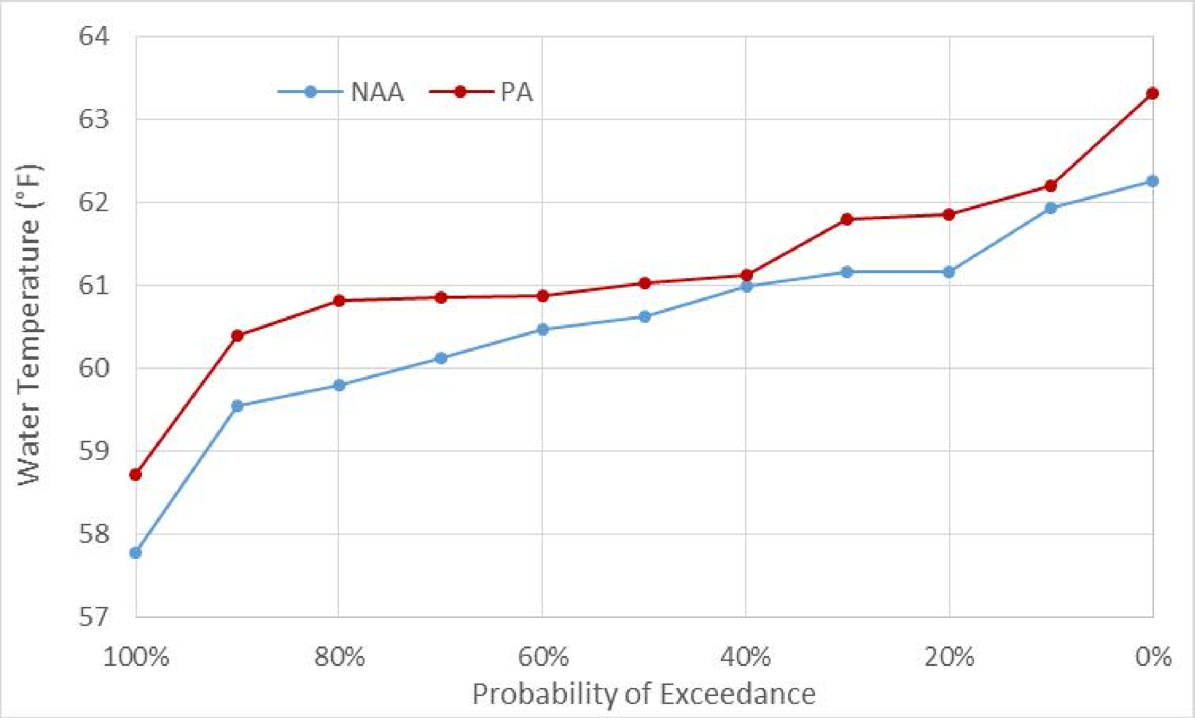

Figure 5.4-61. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in September of Below Normal Water Years

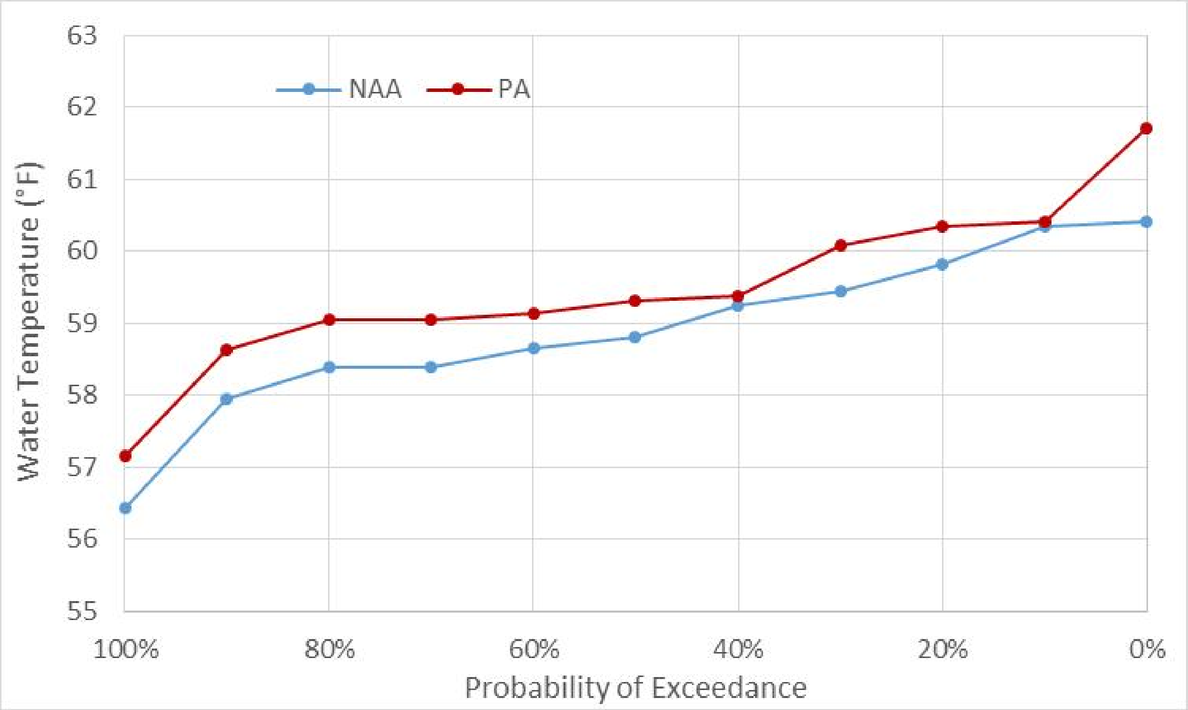

Figure 5.4-62. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Bend Bridge in September of Below Normal Water Years

The exceedance of temperature thresholds in the Sacramento River presented in Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49 by modeled daily water temperatures were evaluated according to temperature thresholds identified from the literature including the USEPA's temperature water quality guidance (U.S. Environmental Protection Agency 2003). As described in Section 5.D.2.1.2.2, *Water Temperature Threshold Analysis*, the analysis evaluates both the frequency and magnitude of exceedance above a threshold. A *biologically meaningful* effect for the water temperature threshold analysis was defined as the months and water year types in which water temperature results met two criteria: (1) the difference between NAA and PA in frequency of exceedance of the threshold was greater than 5%, and (2) the difference between NAA and PA in average daily exceedance was greater than 0.5°F. The 5% criterion was based on best professional judgment of fisheries biologists from NMFS, CDFW, DWR, and Reclamation. The 0.5°F criterion was based on: (1) a review of the water temperature-related mortality rates for steelhead eggs and juveniles (D. Swank, pers. comm.), and (2) a reasonable water temperature differential that could be resolved through real-time reservoir operations.

For spawning and egg/alevin incubation, the threshold used was from the USEPA's 7-day average daily maximum (7DADM) value of 55.4°F, converted by month to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-63 through Table 5.D-67. At Keswick Dam, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and no more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-63).

In the Sacramento River at Clear Creek, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during May (6.2%), August (7.6%), and September (6.4%) of below normal years, and October of dry years (7.3%) (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-64). There would be a concurrent difference between the NAA and PA in average daily exceedance of more than 0.5°F during May of below normal years only (1.3°F). It was concluded that there would be no biologically meaningful effect in these other months based on the criteria described in Appendix 5.D, Section 5.D.2.1.2.2, *Water Temperature Threshold Analysis*. For May of below normal years, a closer examination of the exceedance plot (Figure 5.4-63) reveals that this appears to be due to CALSIM II attempting to balance storage levels among the CVP reservoirs. This effect is due entirely to 1 year (1923) during which temperatures would be much higher, and there is no practical reason why actual operations under the PA would be different from those under the NAA in this 1 year. Therefore, it was concluded that this result is due to modeling limitations.

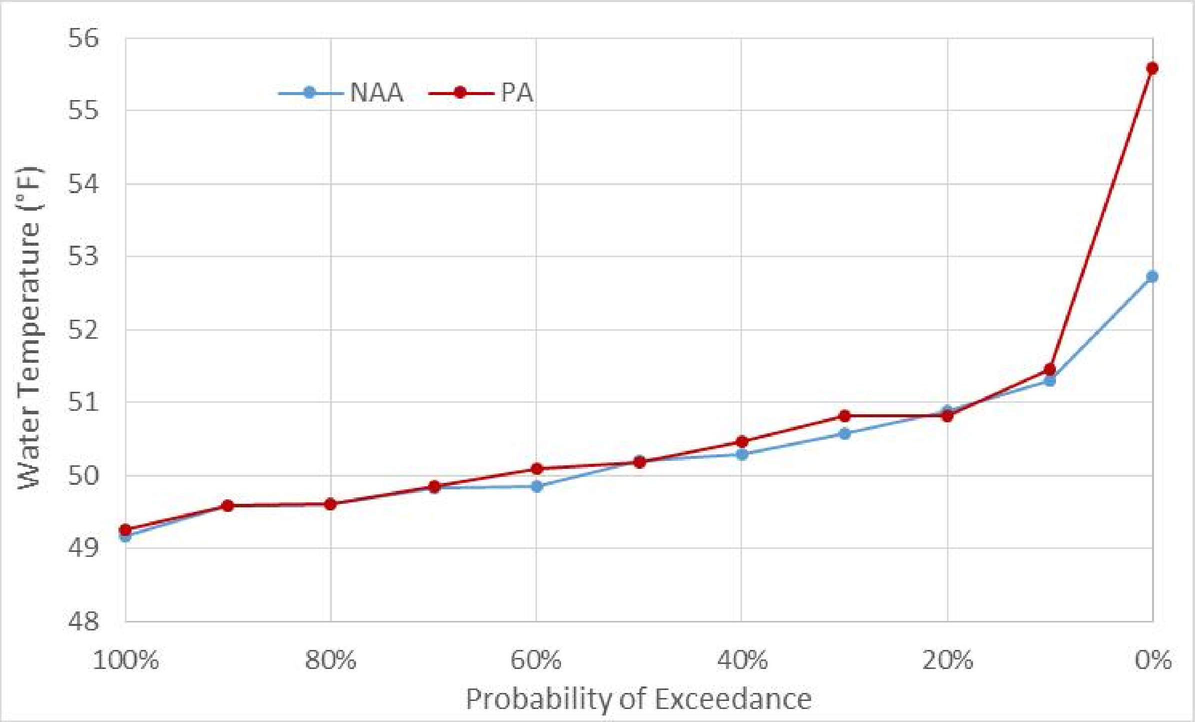

Figure 5.4-63. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River above Clear Creek in May of Below Normal Water Years

At Balls Ferry, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during May of below normal years (6.2%), and July (5.5%), August (7.4%) and September (16.7%) of above normal years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-65). There would also be a reduction in exceedance of 9.2% in June of dry years. Among these months and water year types, only May of below normal water years would also have a more-than-0.5°F increase in the magnitude of average daily exceedance (0.55°F). Similar to the Sacrament River at Clear Creek, a closer examination of the exceedance plot (Figure 5.4-64) reveals that this effect is due entirely to 1 year (1923) during which temperatures would be much higher.

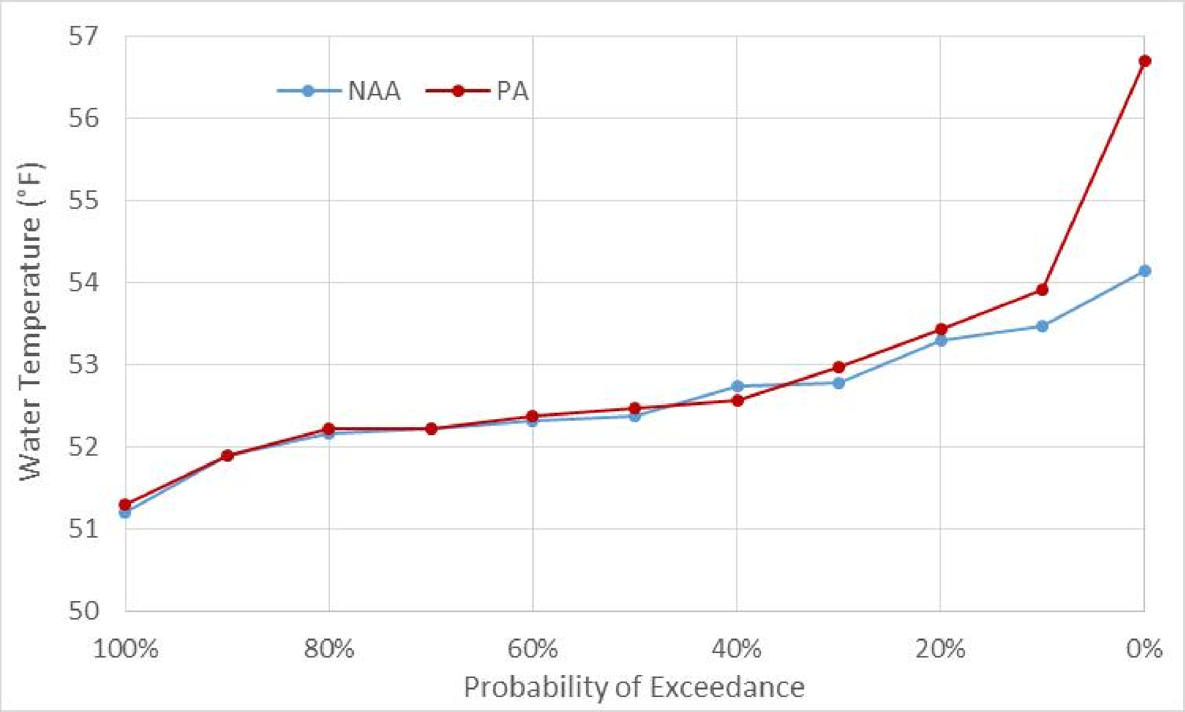

Figure 5.4-64. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Balls Ferry in May of Below Normal Water Years

At Bend Bridge, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during September of above normal years and the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% lower than under the NAA during June of above normal years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results,* Table 5.D-66). However, in neither of these situations would there also be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect at Bend Bridge.

At Red Bluff, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and no more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-67).

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) under the PA in certain months and water year types compared to the NAA. In all but two cases, these exceedances would not result in biologically meaningful water temperature-related effects on winter-run spawning, egg incubation, and alevins, as defined in Appendix 5.D, Section 5.D.2.1.2.2, *Water Temperature Threshold Analysis.* The two cases where modeled water temperatures under the PA exceed the threshold greater than 5% more often than the NAA and by greater than 0.5°F more than under the NAA (May of below normal water years at Clear Creek and Balls Ferry) appear to be the result of a single year (1923) in which water temperature would be substantially higher (approximately 2°F to 3°F). This appear to be due to CALSIM II attempting to balance storage levels among the CVP reservoirs and there is no practical reason why actual operations under the PA would be different from those under the NAA in this one year. Further, CALSIM modeling results given here do not consider revisions to the OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve egg-to-fry survival. CALSIM modeling also does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects.

The Reclamation Egg Mortality Model provides temperature-related estimates of winter-run egg mortality in the Sacramento River (see Appendix 5.D, Attachment 1, *Reclamation Egg Mortality Model*, for full model description). As noted in Appendix 5.D, Section 5.D.2.1. *Water Temperature Analysis Methods*, NMFS believes this model underestimates temperature related mortality and is likely not sensitive enough to capture small differences in scenarios or temperature related mortality experienced by recent winter-run brood years and, as a result, results should be viewed with caution until a more accurate model is developed or there is better understanding of temperature effects on juvenile production. Because of this, and the fact that the egg life stage has the highest potential effect on the propagation of population size given the constraint of temperature management, a more conservative value of a more-than-2% difference in percent of total individuals (on a raw scale) between the PA and NAA was considered a biologically meaningful effect (see Appendix 5.D, Section 5.D.2.1.2.3, *Reclamation Egg Mortality Model*, for details). Results of the model are presented in Table 5.4-39 and Figure 5.4-65 through Figure 5.4-70.

These results indicate that there would be no biologically meaningful increases in egg mortality under the PA relative to the NAA. Although large on a relative scale due to low mortality values under the NAA, raw differences in below normal and dry water years are insignificant (less than 1% difference) (Table 5.4-39). Also, the difference between means in below normal water years is driven by a single year (1923), as indicated in Figure 5.4-68, and medians and all other metrics are nearly identical. As discussed above, this appears to be due to CALSIM II attempting to balance storage levels among the CVP reservoirs and there is no practical reason why actual operations under the PA would be different from those under the NAA in this 1 year. Further, CALSIM modeling results given here do not consider revisions to the OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve egg-to-fry survival. CALSIM modeling also does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects.

Table 5.4-39. Winter-Run Chinook Salmon Egg Mortality (Percent of Total Individuals) and Differences (Percent Differences) between Model Scenarios, Reclamation Egg Mortality Model

WYT	NAA	PA	PA vs. NAA
Wet	0.6	0.6	0 (0%)
Above Normal	0.1	0.1	0.002 (2%)
Below Normal	0.3	1.1	0.7 (220%)
Dry	0.3	0.3	-0.03 (-9%)
Critical	31.8	31.3	-0.5 (-2%)
All	5.0	5.0	0 (0%)

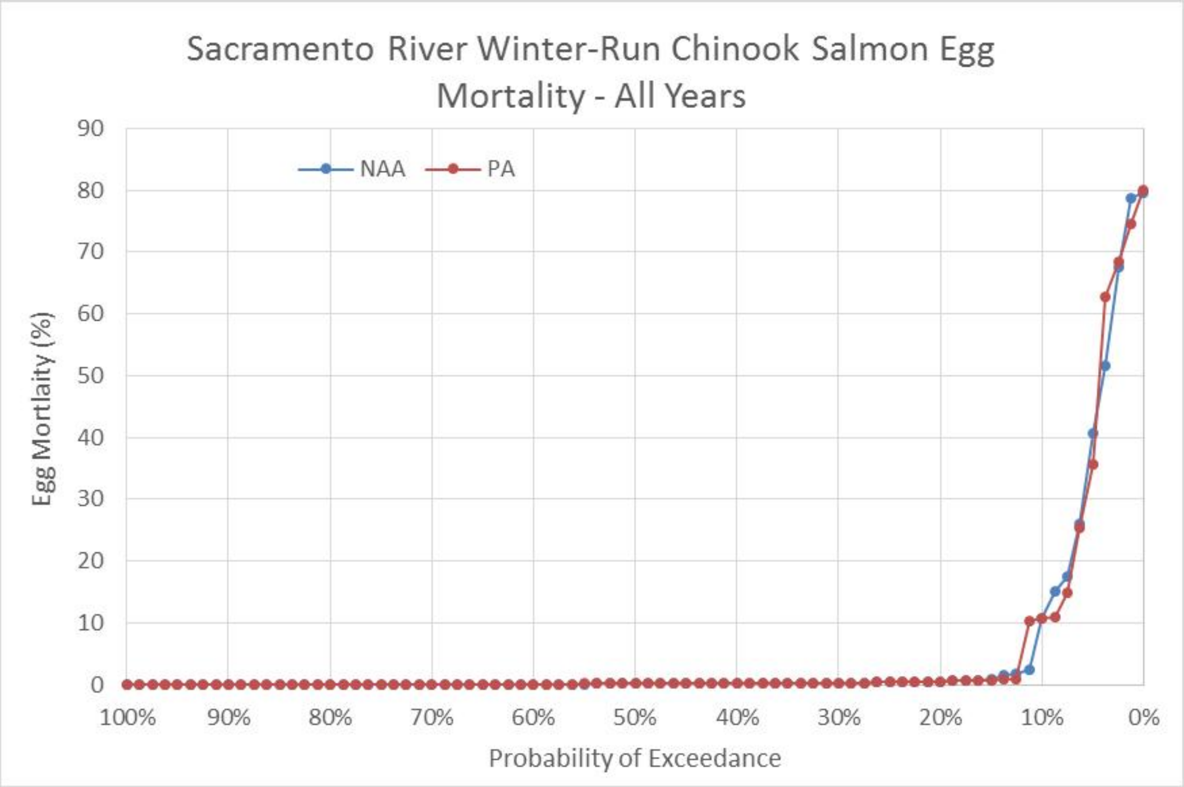

Figure 5.4-65. Exceedance Plot of Winter-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, All Water Years

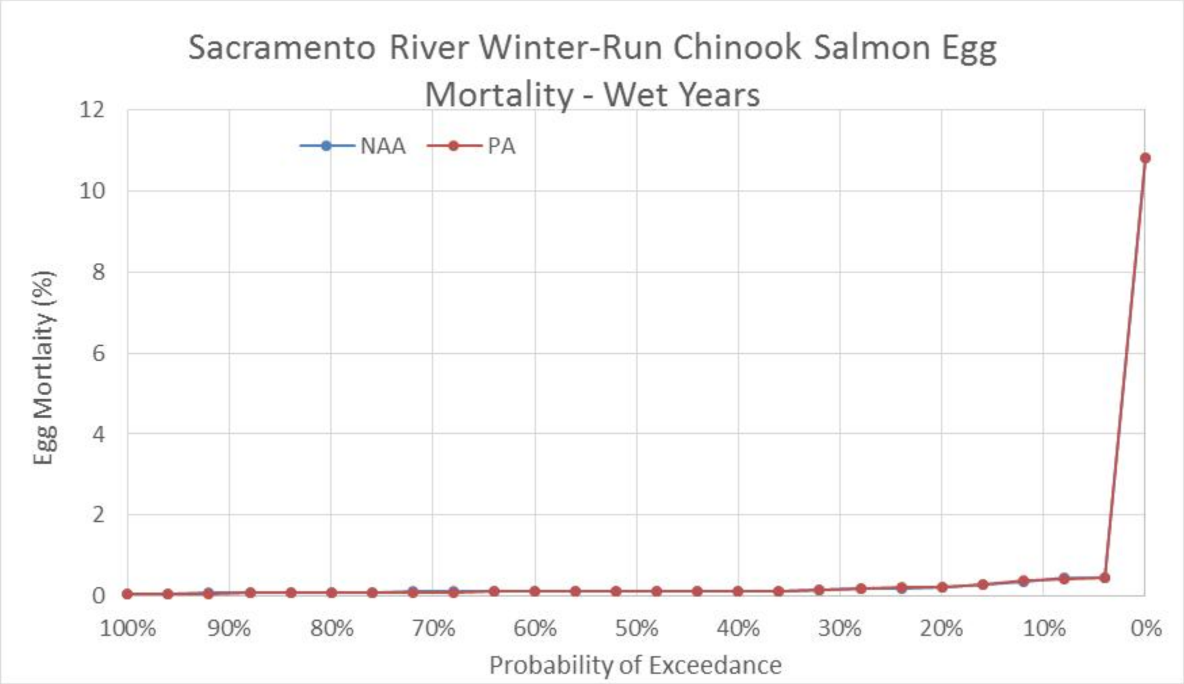

Figure 5.4-66. Exceedance Plot of Winter-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Wet Water Years

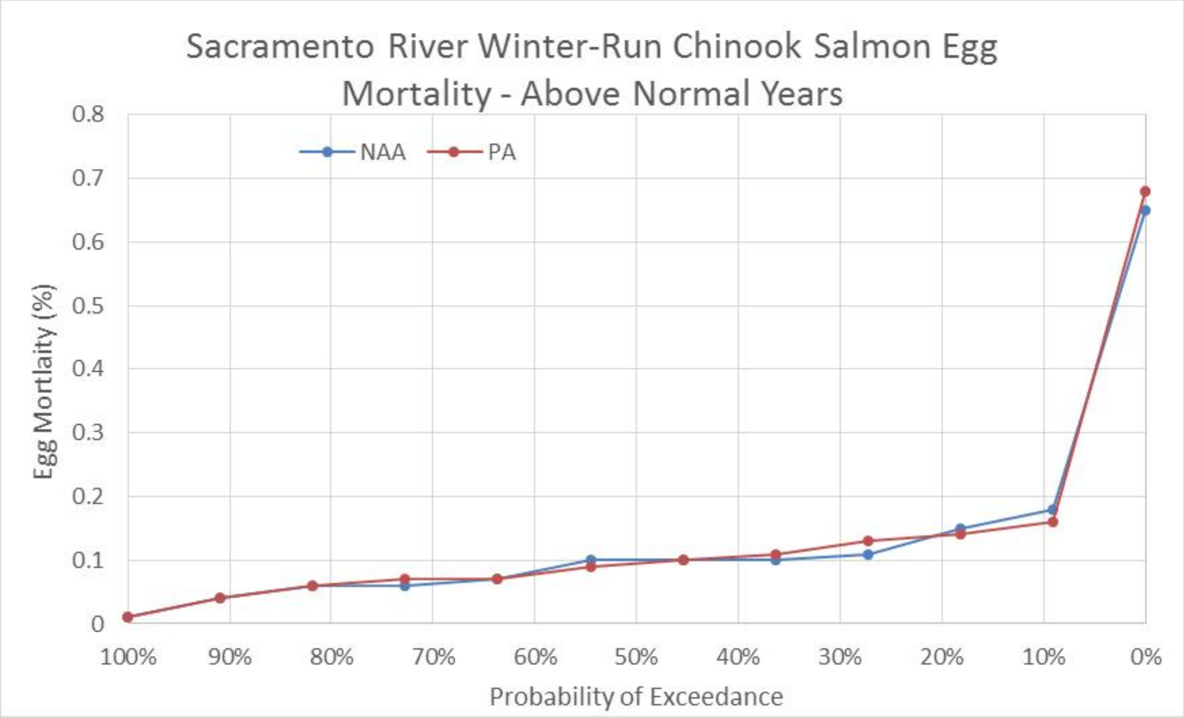

Figure 5.4-67. Exceedance Plot of Winter-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Above Normal Water Years

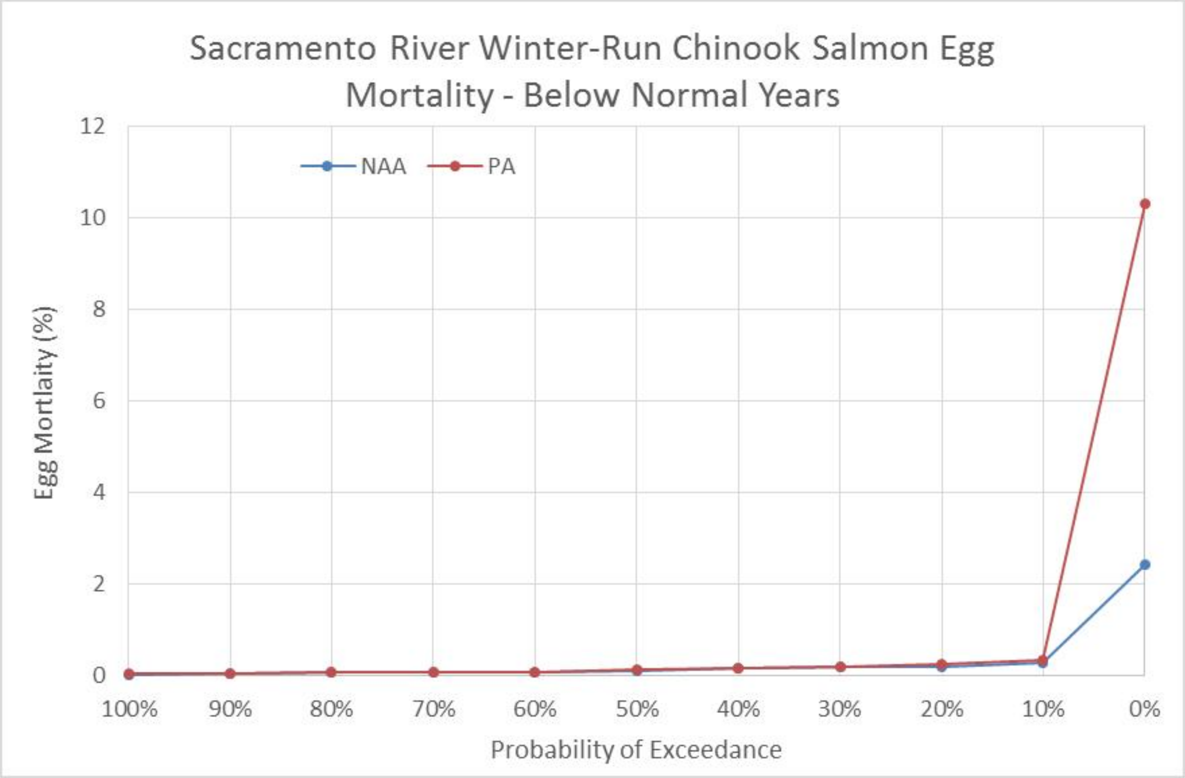

Figure 5.4-68. Exceedance Plot of Winter-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Below Normal Water Years

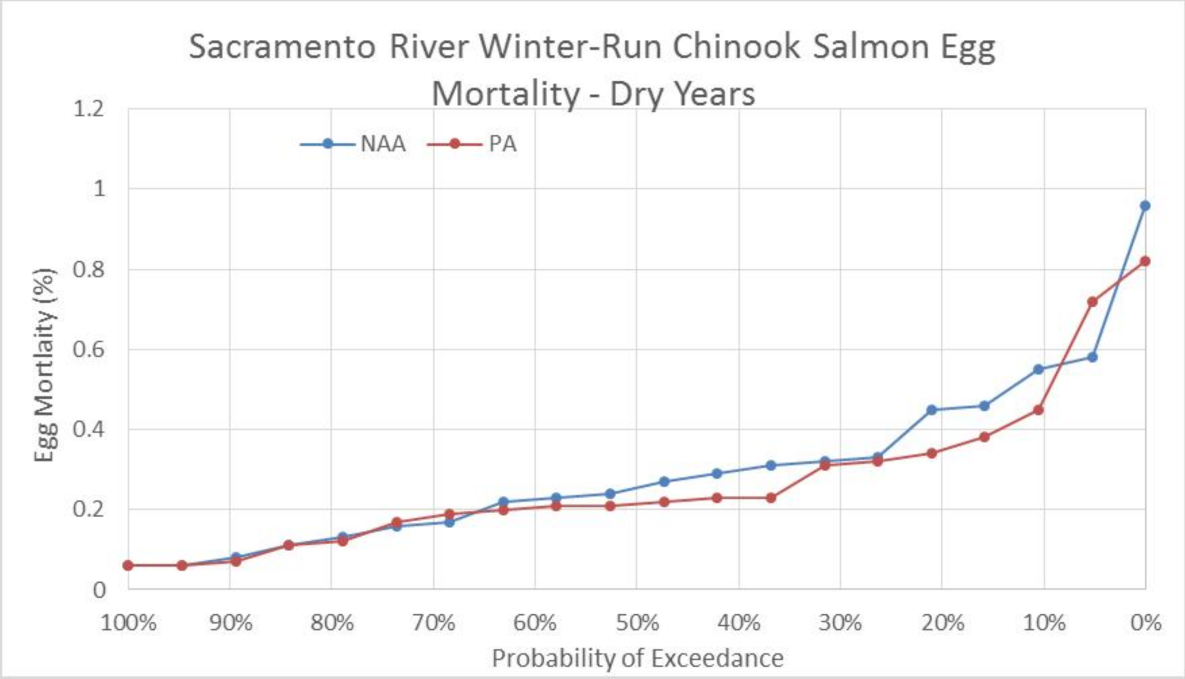

Figure 5.4-69. Exceedance Plot of Winter-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Dry Water Years

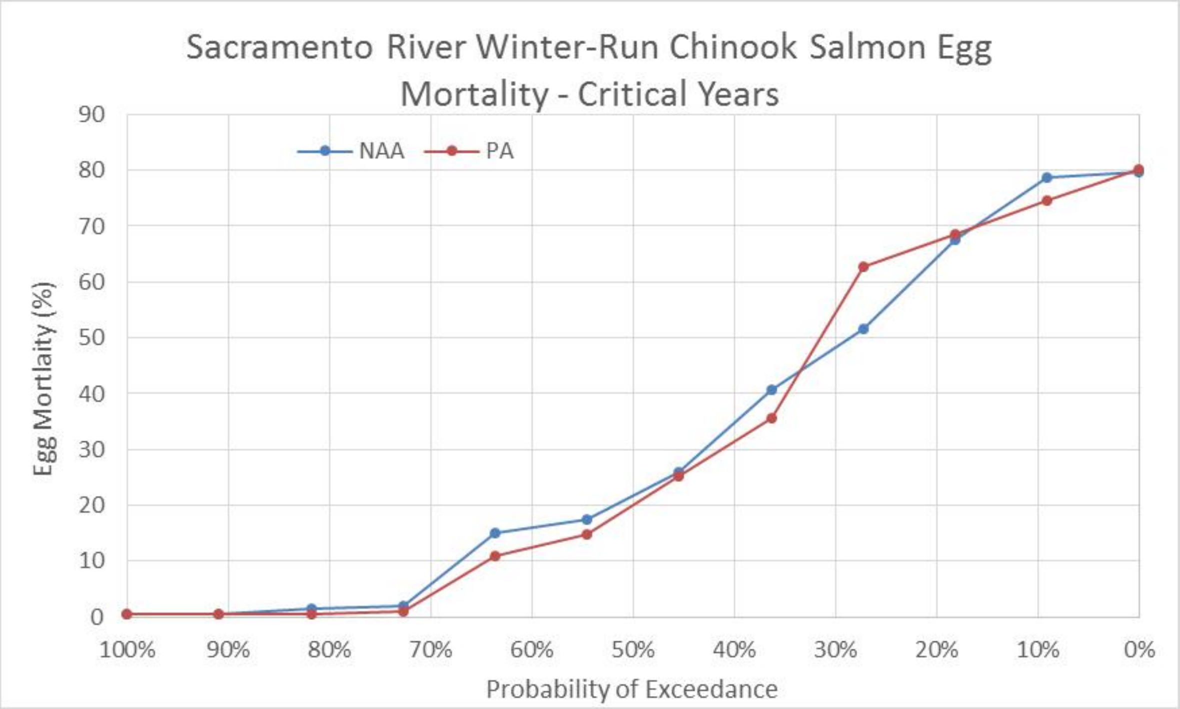

Figure 5.4-70. Exceedance Plot of Winter-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Critical Water Years

The SALMOD model provides predicted water temperature-related mortality of winter-run Chinook salmon spawning, eggs, and alevins the Sacramento River. This water temperature-related mortality of winter-run Chinook salmon spawning, eggs, and alevins is split up as pre-spawn (in vivo, or in the mother before spawning) and egg (in the gravel) mortality (see Attachment 5.D.2, SALMOD Model, for a full description). Table 5.4-38 presents results for water temperature-related mortality of spawning, eggs, and alevins, in addition to all sources of mortality for winter-run Chinook salmon predicted by SALMOD discussed in other sections of this document. The annual exceedance plot of temperature-related mortality of winter-run Chinook salmon spawning, eggs, and alevins for all water years combined is presented in Figure 5.4-71. These results indicate that, combining all water year types, there would be no increase in temperature-related mortality of winter-run Chinook salmon spawning, eggs, and alevins under the PA relative to the NAA and, in fact, average annual mortality would decrease by 31,755 fish, or 7%, under the PA. For individual water year types, most of the temperature-related mortality (>95%) is predicted to occur in critical years. In this water year type, mortality would average 203,180 fish (7%) lower under the PA relative to the NAA. Almost all of the mortality (>99%) in both the NAA and PA would occur while the eggs are in the gravel and not *in vivo* (pre-spawn).

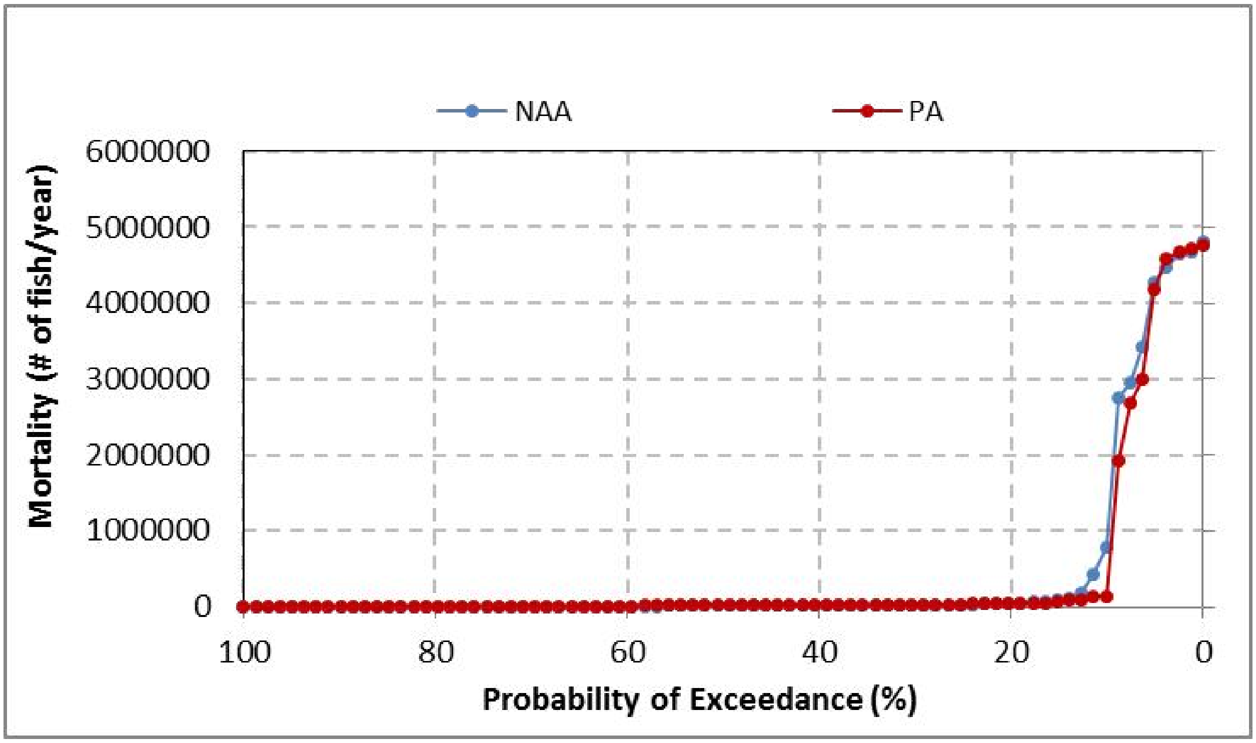

Figure 5.4-71. Exceedance Plot of Annual Water Temperature-Based Mortality (#of Fish/Year) of Winter-Run Chinook Salmon Spawning, Egg Incubation, and Alevins.

5.4.2.1.3.1.2 Fry and Juvenile Rearing

5.4.2.1.3.1.2.1 Flow-Related Effects

As discussed in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* the stranding of juvenile salmonids is not evaluated in the effects analysis due to limitations of CALSIM modeling. The effect of juvenile stranding on production of Chinook salmon and steelhead populations is not well understood, but stranding is frequently identified as a potentially important mortality factor for the populations in the Sacramento River and its tributaries (Jarret and Killam 2014, 2105, Cramer Fish Sciences 2014, National Marine Fisheries Service 2009, Bureau of Reclamation 2008, Water Forum 2005, California Department of Fish and Game 2001, U.S. Fish and Wildlife Service 2001). Juvenile stranding generally results from reductions in flow that occur over short periods of time, and the CALSIM modeling used to evaluate flow in this effects analysis has a monthly time step, which is too long for any meaningful analysis of juvenile stranding.

Juvenile salmon typically rest in shallow slow-moving water between feeding forays into swifter water. This tendency makes them particularly susceptible to stranding during rapid reductions in flow that dewater and isolate the shallow river margin areas (Jarrett and Killam 2015). Juveniles are most vulnerable to stranding during periods of high and fluctuating flow, when they typically move into side channel habitats that may be extensively inundated. Stranding can lead to direct mortality when these areas drain or dry up, or to indirect mortality from predators or rising water temperatures and deteriorating water quality. High, rapidly changing flows may result from flow release pulses to meet Delta water quality standards and from flood control releases, as well as from tributary freshets following rain events (Jarrett and Killam 2015, Bureau of Reclamation 2008). Stranding may also occur during periods of controlled flow reductions, such as when irrigation demand declines in the fall (National Marine Fisheries Service 2009) or following gate removal at the ACID dam in November and the RBDD dam in September (National Marine Fisheries Service 2009).

As described in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* the NMFS 2009 BO includes ramping rate restrictions on flow releases from both Keswick Dam and Nimbus Dam to reduce the risk of juvenile stranding and redd dewatering. All ramping restrictions for dams on the Sacramento River and its tributaries would be kept in place for the PA, and, therefore, it is expected that the juvenile stranding risk would be similar for the PA and the NAA.

Estimated mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at the Keswick to Red Bluff locations during the July through November fry and juvenile rearing period for winter-run Chinook salmon (Table 5.4-25, Tables 5.A.6-10, 5.A.6-35). Changes in flow can affect the instream area available for rearing, along with the quality of the habitat for feeding, protective cover, resting, temperature, and other requirements, and can affect stranding of fry and juveniles, especially in side-channel habitats.

Shasta Reservoir storage volume at the end of May can influence flow rates in the Sacramento River below the dam during the first three months of the winter-run salmon rearing period (July – September) and Shasta storage volume at the end of September may influence flow rates during the last two months (October and November). Mean Shasta May storage volume under the PA would be similar (less than 5% difference) to storage under the NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-3). Mean Shasta September storage under the PA would also be similar (less than 5% difference) to storage under the NAA for all water year types, except for a 7% higher mean storage volume during critical water years under the PA.

During most months and water year types of the rearing period, mean flow under the PA would be similar (less than 5% difference) or lower than flow under the NAA. Flows at Keswick Dam and Red Bluff in the Sacramento River would be lower under the PA than under the NAA during November of all water year types except critical water years, with 26% lower flows under the PA than under the NAA for wet and above normal water year types at Keswick Dam and 21% lower flows at Red Bluff (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-10, Table 5.A.6-35). Flows under the PA would be 10% lower in August of below normal water years, up to 11% lower in September of above normal and below normal water year types, and up to 11% lower in October of wet years. Mean flows under the PA in October of below normal year types and November of critical years would be up to 17% greater than flows under the NAA. The results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

Rearing weighted usable area (WUA) provides an index of rearing habitat availability that takes into considerations the rearing requirements of the fish with respect to water depth, flow velocity, and cover. Rearing WUA for winter-run Chinook salmon fry and juveniles was determined by USFWS (2005b) for a range of flows in three segments of the Sacramento River between Keswick Dam and the Battle Creek confluence (Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods*). The three river segments are the same as those used for the spawning habitat WUA studies (U.S. Fish and Wildlife Service 2003a, 2006). Segment 4 stretches 8 miles, from Battle Creek to the confluence with Cow Creek; Segment 5 reaches 16 miles, from Cow Creek to ACID Dam; and Segment 6 covers 2 miles, from ACID Dam to Keswick Dam. To estimate changes in rearing WUA that would result from the PA relative to the NAA, the rearing habitat WUA curve developed for each of these segments was used with mean monthly CALSIM II flow estimates under the PA and the NAA for the midpoint of each segment during each month of the winter-run fry and juvenile rearing periods (Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* Table 5.D-62). For this analysis, fry were defined as fish less than 60 mm, and juveniles were those greater than 60 mm. Further information on the rearing WUA analysis methods is provided in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods*.

Differences between the PA and NAA in rearing WUA for winter-run fry and juveniles were examined using exceedance plots of mean monthly WUA for the winter-run fry (Figure 5.4-72–Figure 5.4-89) and juvenile (Figure 5.4-90–Figure 5.4-107) rearing periods in each of the river segments for each water year type and all water year types combined. The PA exceedance curves for fry and juvenile rearing WUA for all water years combined are similar to the NAA exceedance curves for Segments 6 and 5 (Figure 5.4-72, Figure 5.4-78, Figure 5.4-84, Figure 5.4-90, and Figure 5.4-96), but for Segment 4, part of the juvenile exceedance curve for the PA is higher than the NAA curve (Figure 5.4-102). With the curves broken out by water year type, reductions in fry rearing WUA under the PA are evident in Segment 6 during critical water years (Figure 5.4-77) and Segment 5 during below normal years (Figure 5.4-81), while reductions in juvenile rearing WUA under the PA are seen in Segment 6 in above normal years (Figure 5.4-92). Increases in juvenile rearing WUA under the PA are evident in Segment 4 during wet and above normal years (Figure 5.4-103 and Figure 5.4-104) and both increases and reductions in juvenile rearing WUA can be seen in Segment 5 during below normal years (Figure 5.4-99). The WUA modeling indicates that the PA would reduce winter-run Chinook salmon rearing habitat during some months and water year types, especially in Segments 6 and 5, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

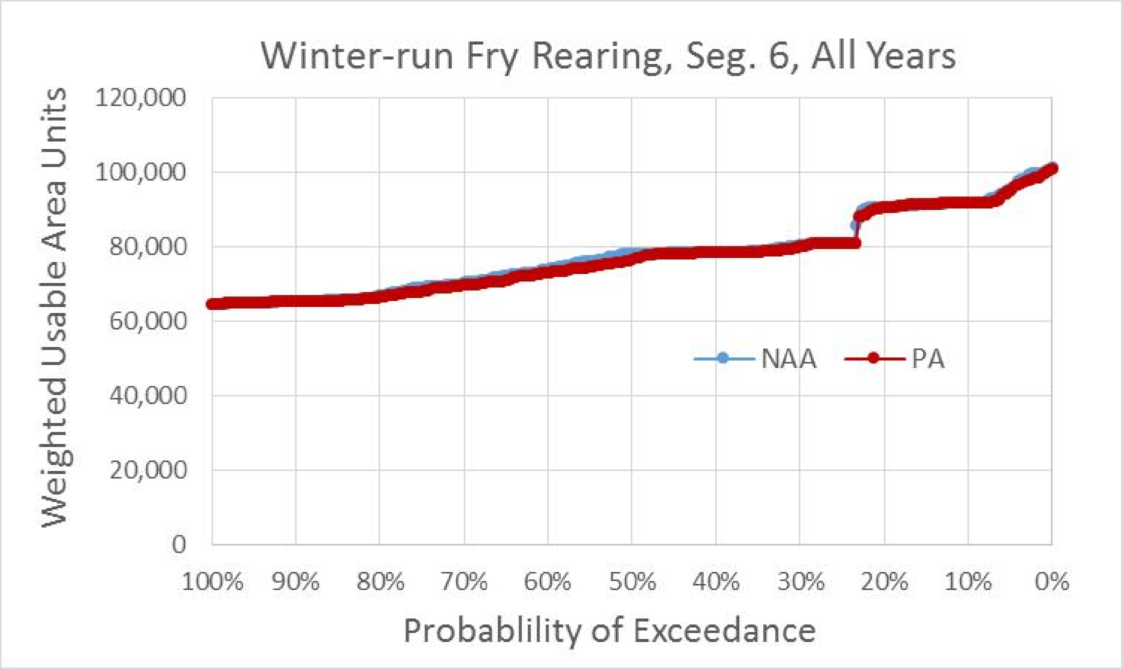

Figure 5.4-72. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

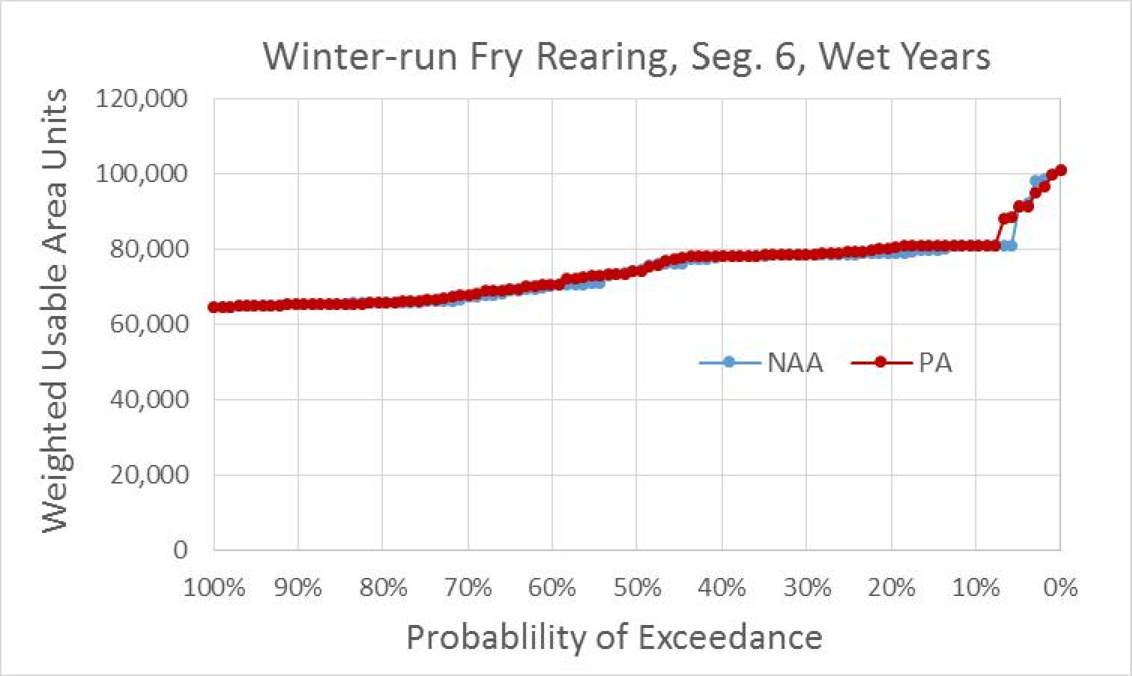

Figure 5.4-73. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

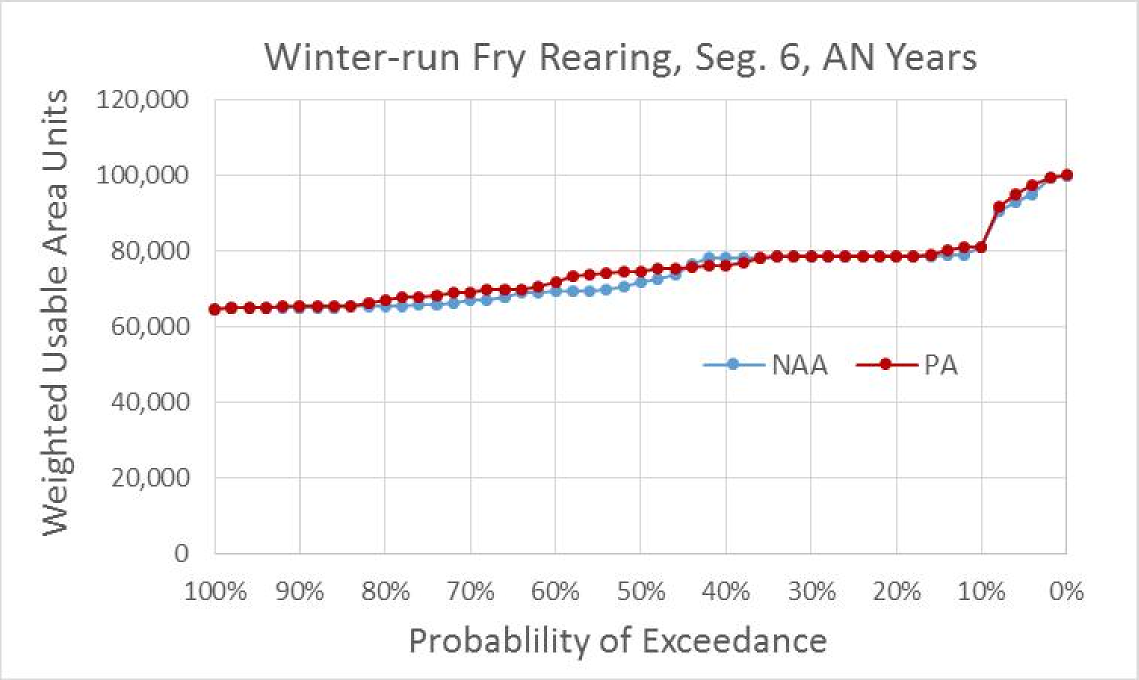

Figure 5.4-74. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

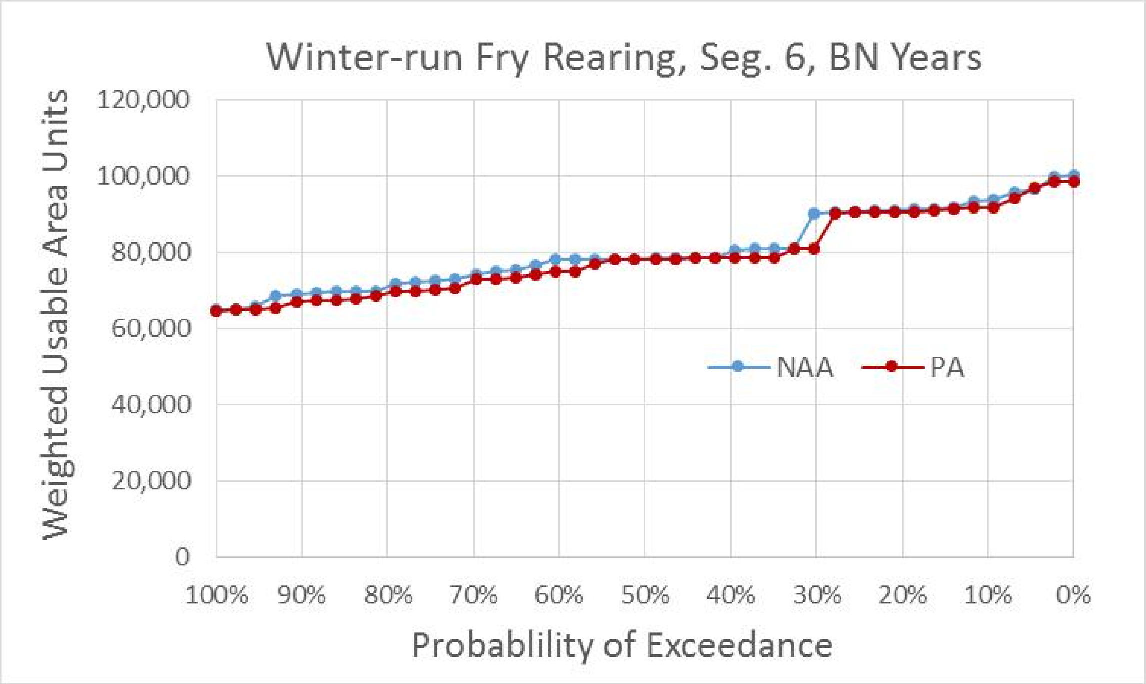

Figure 5.4-75. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

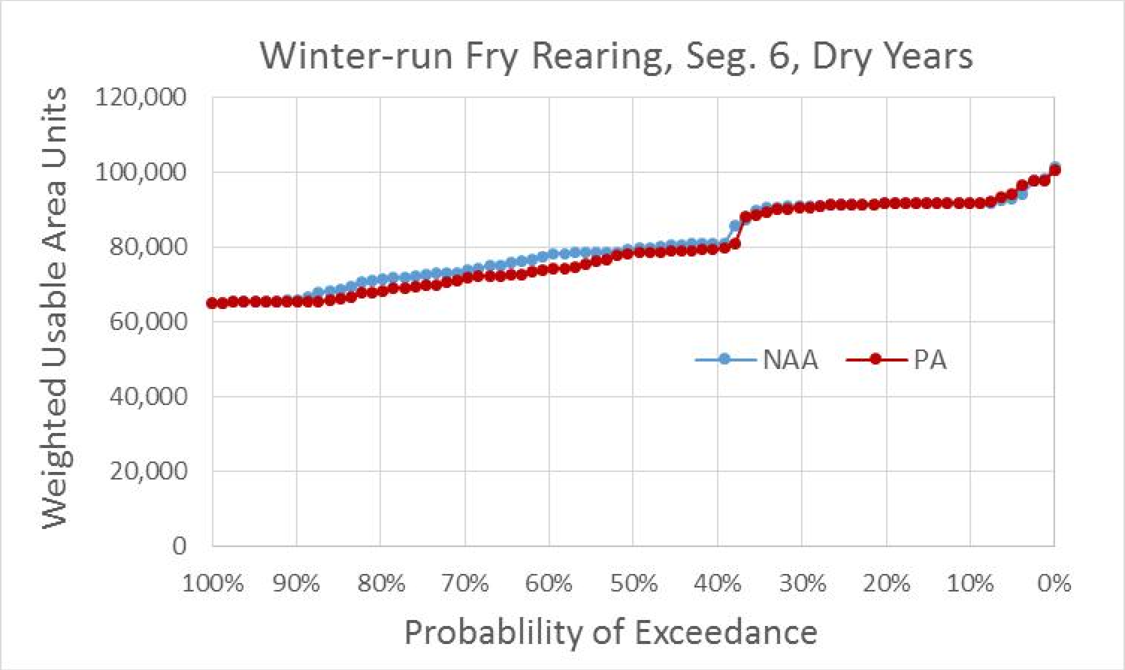

Figure 5.4-76. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

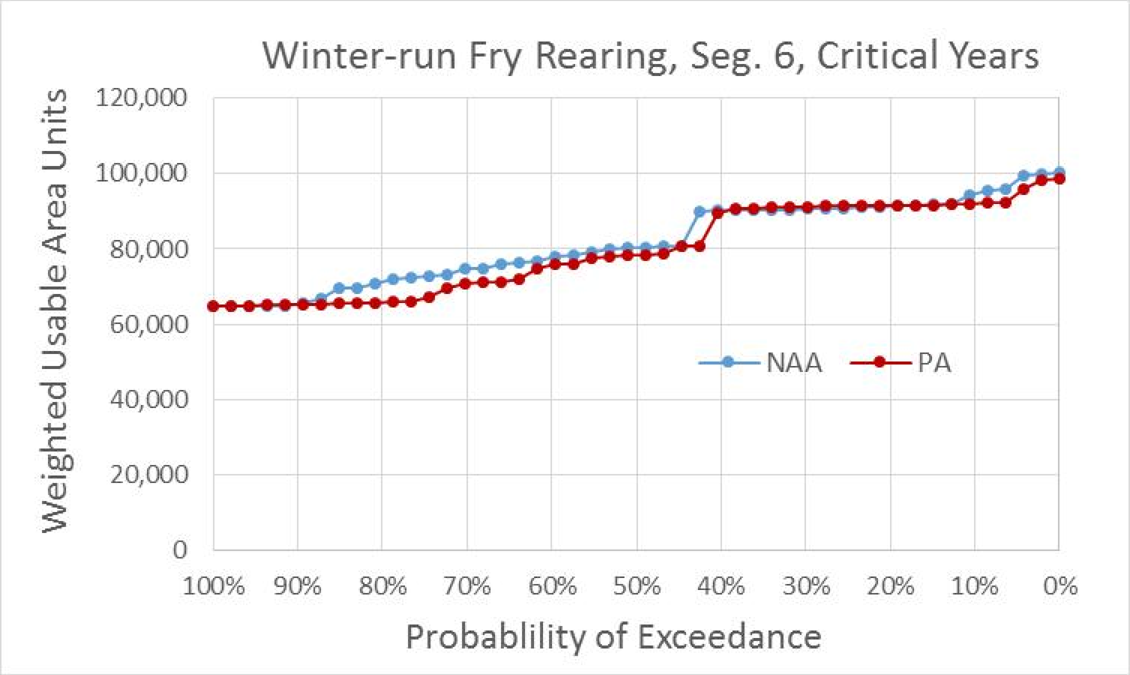

Figure 5.4-77. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

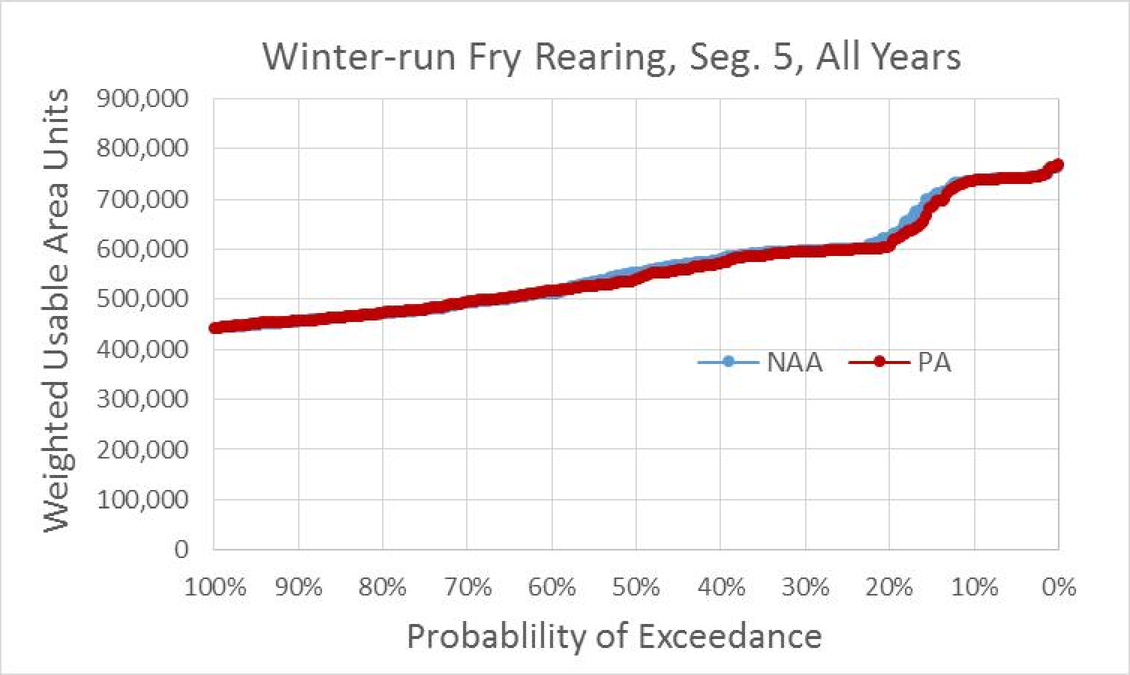

Figure 5.4-78. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

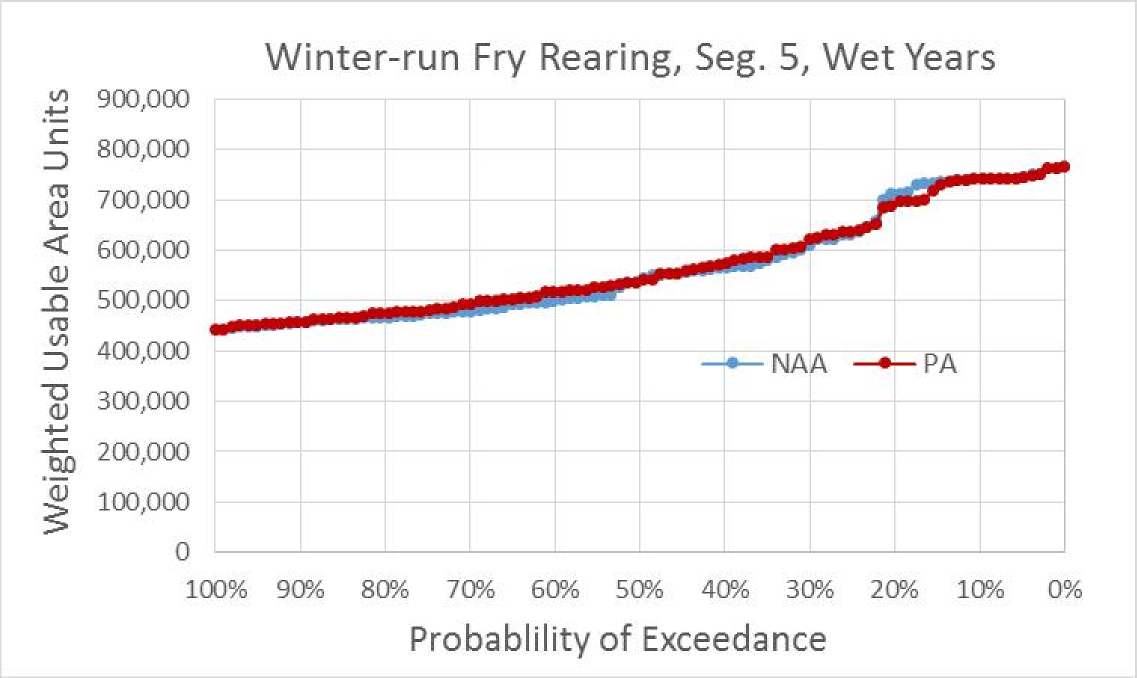

Figure 5.4-79. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years.

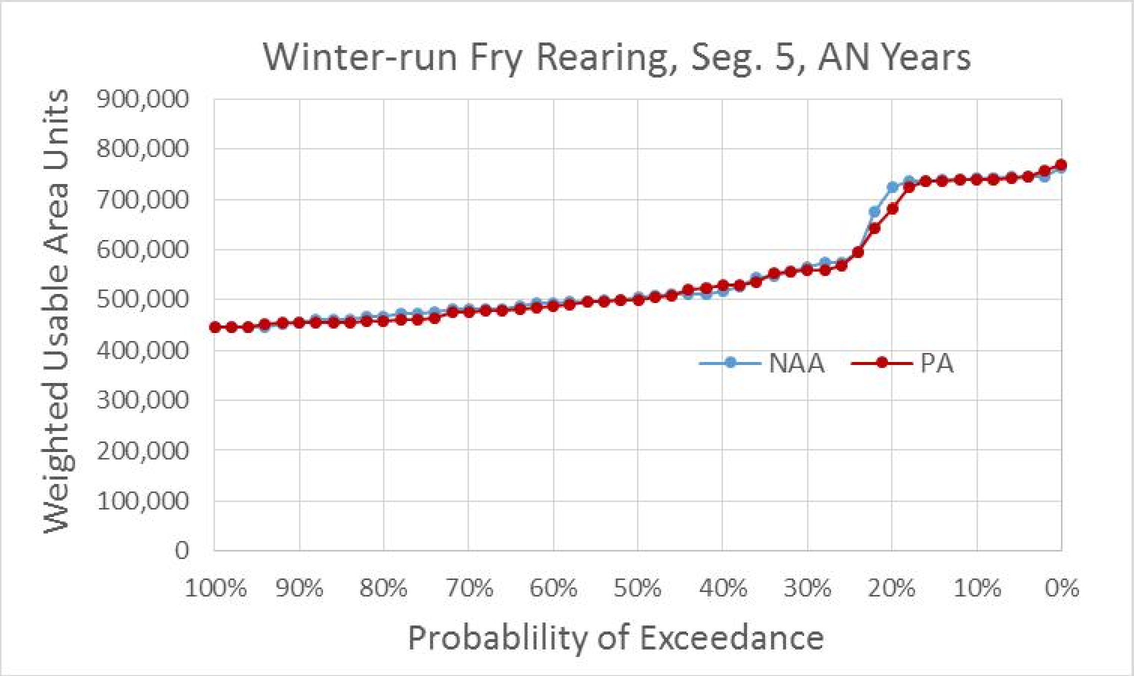

Figure 5.4-80. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

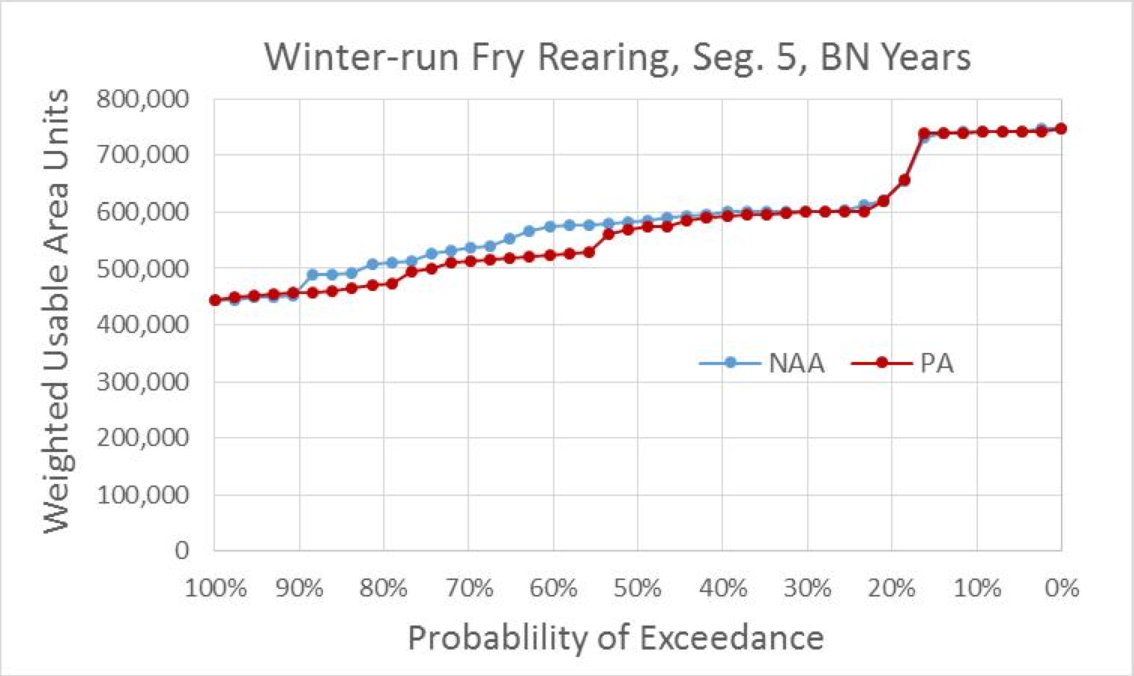

Figure 5.4-81. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

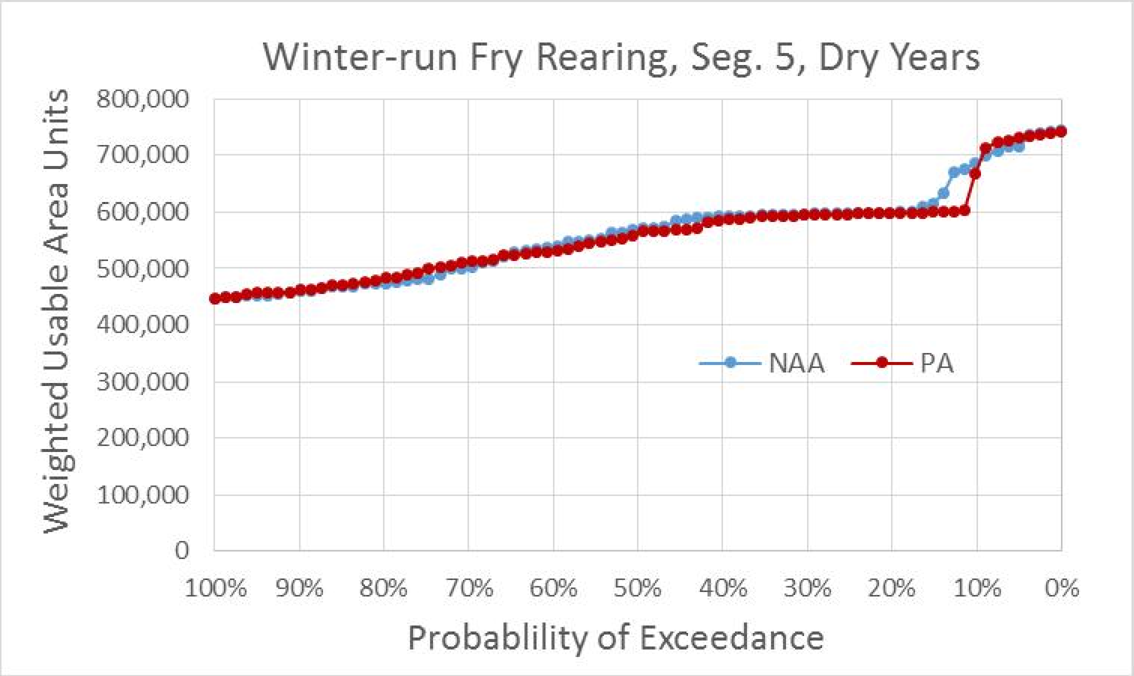

Figure 5.4-82. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

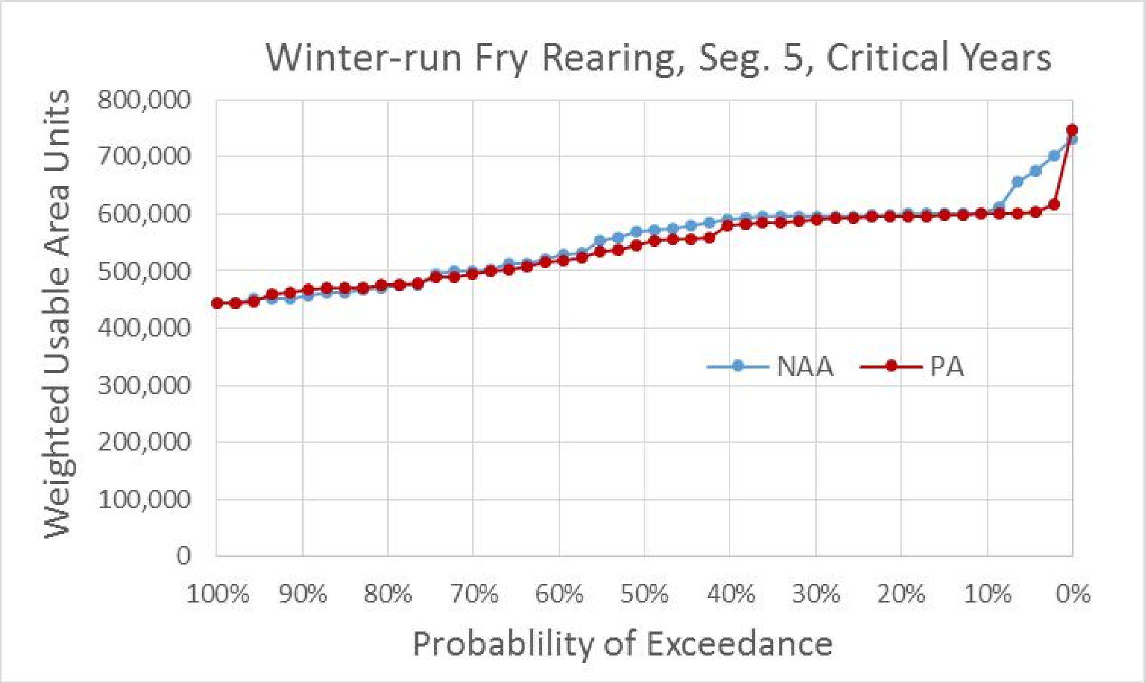

Figure 5.4-83. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

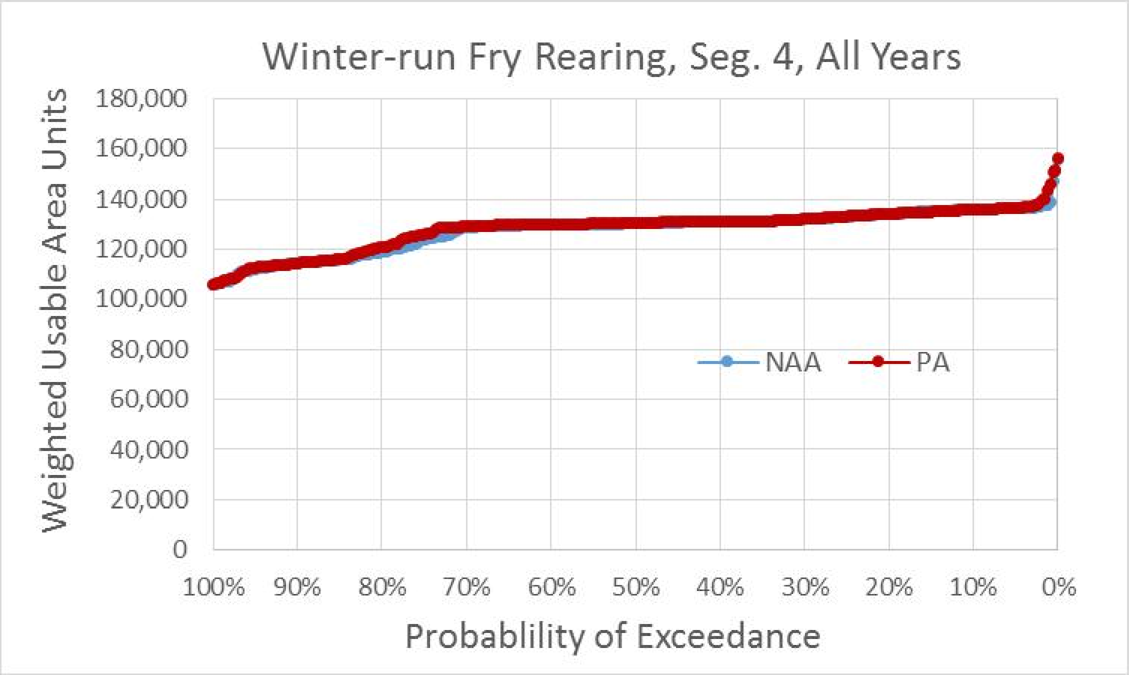

Figure 5.4-84. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

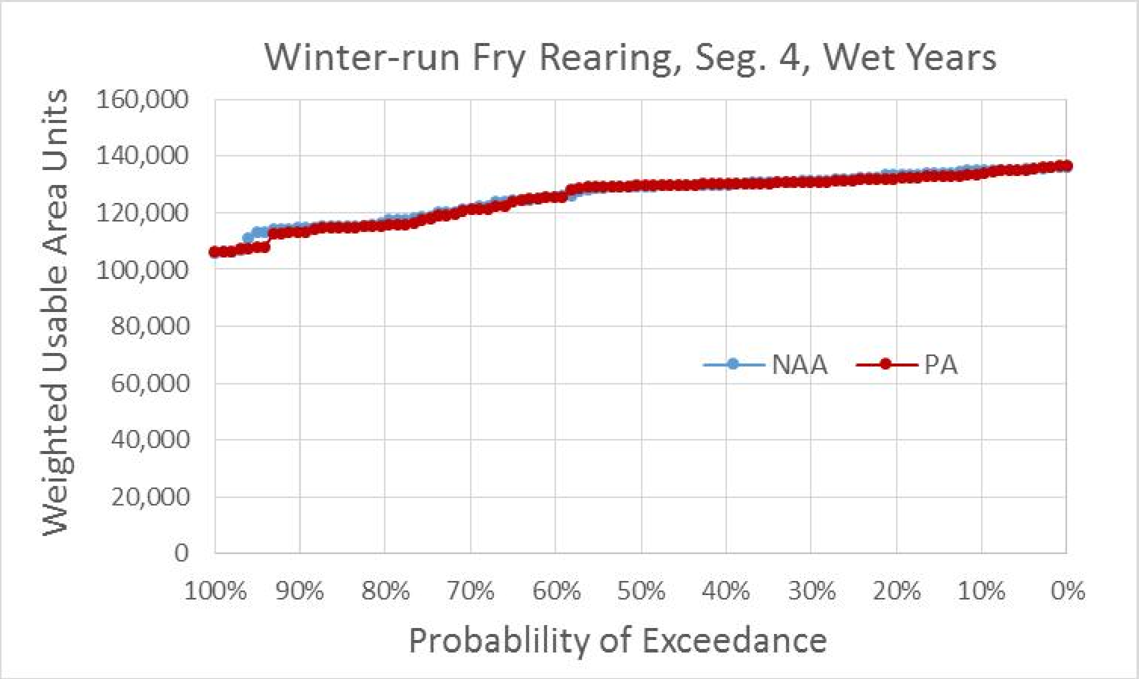

Figure 5.4-85. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

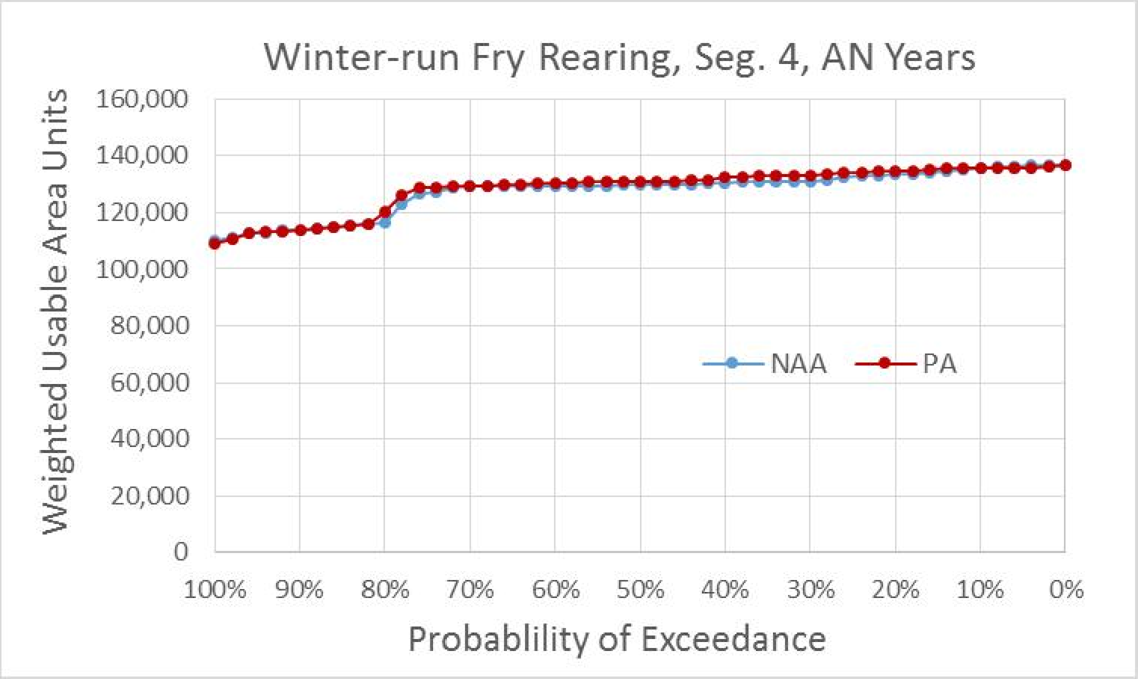

Figure 5.4-86. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

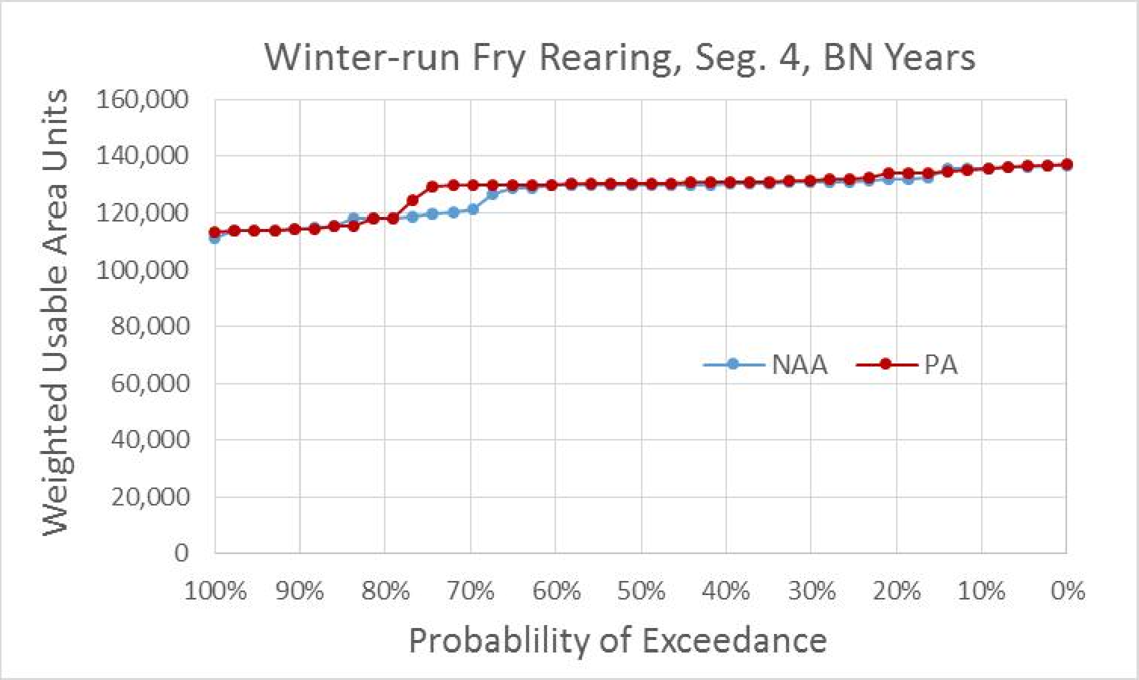

Figure 5.4-87. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

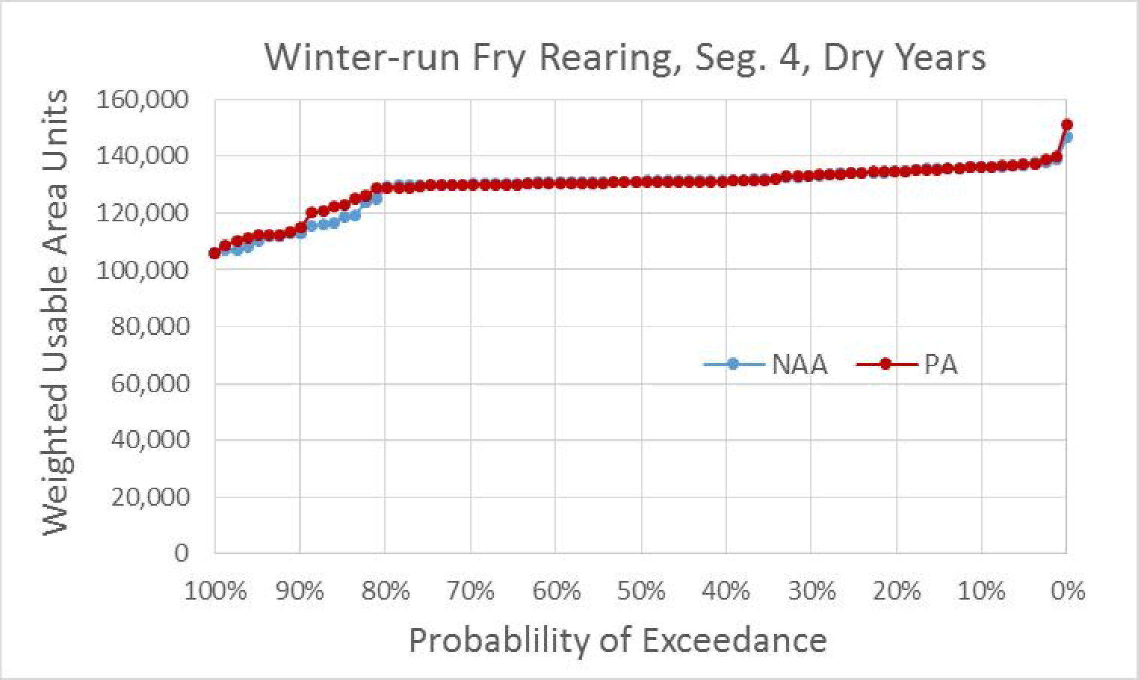

Figure 5.4-88. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

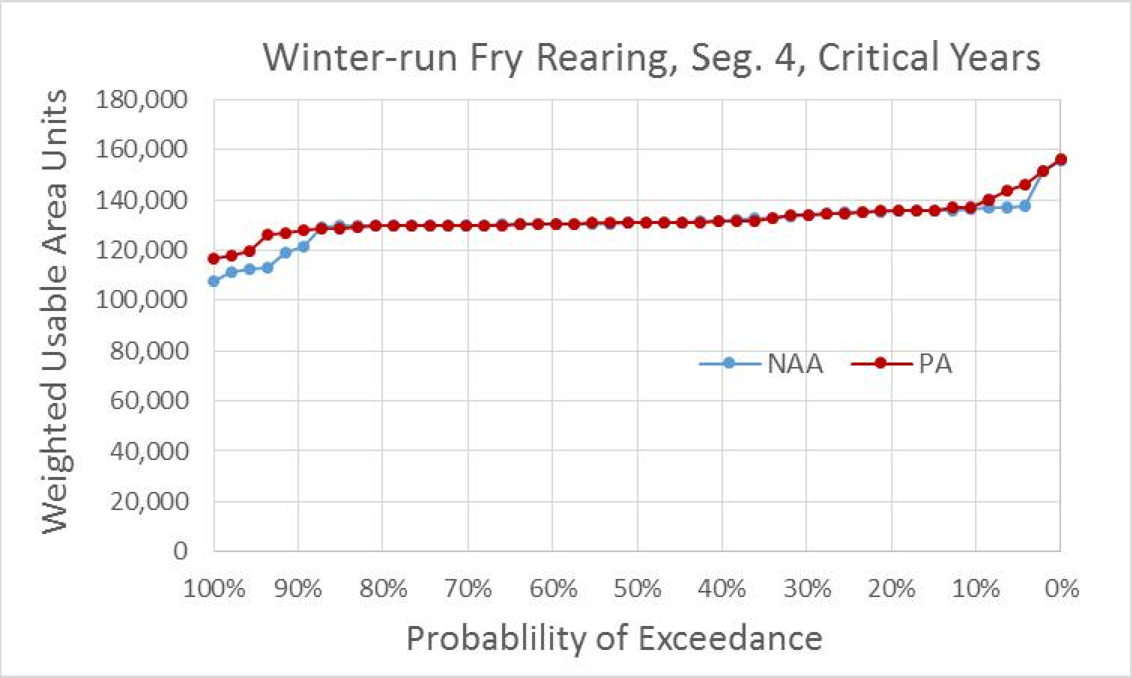

Figure 5.4-89. Exceedance Plot of Winter-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

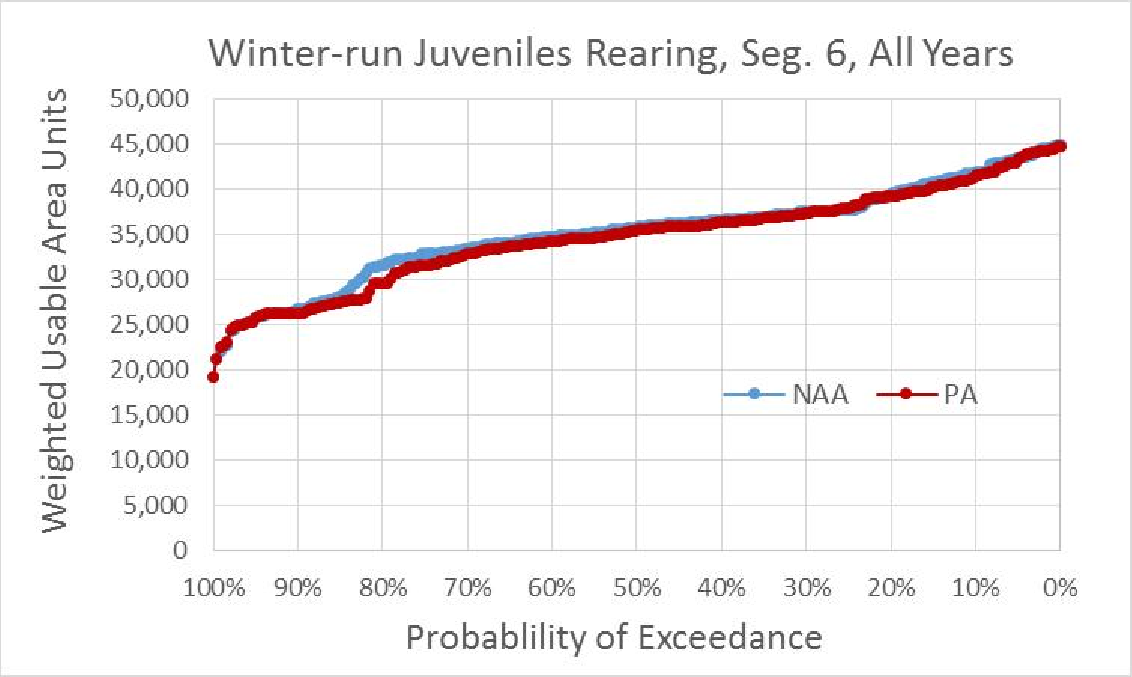

Figure 5.4-90. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

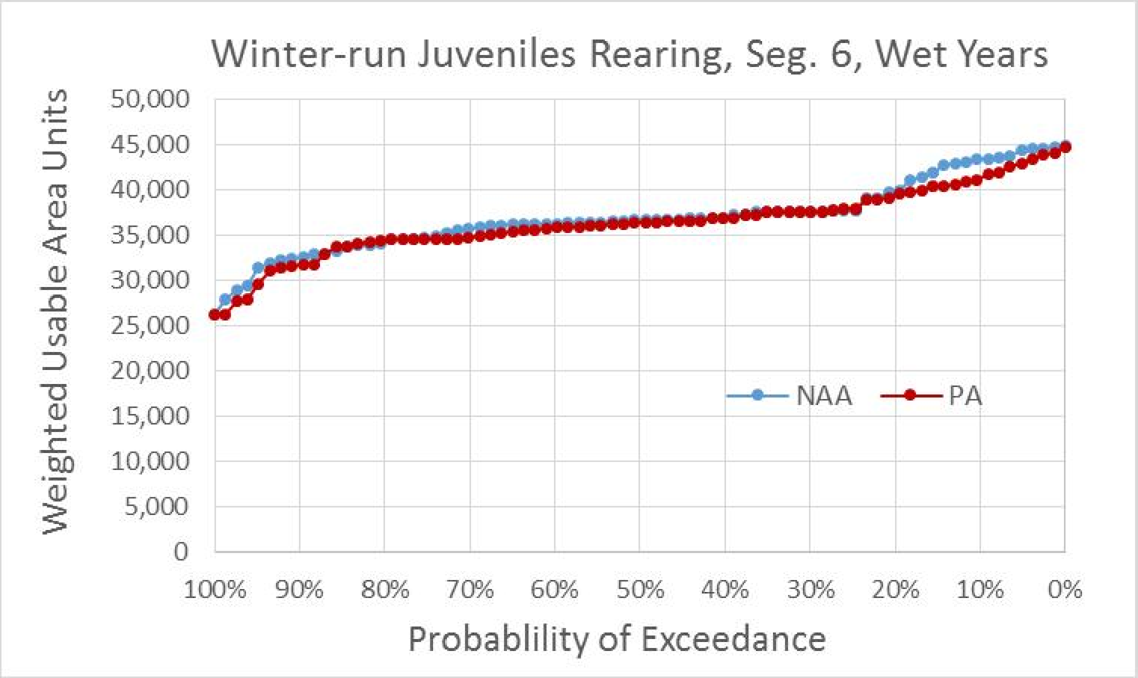

Figure 5.4-91. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

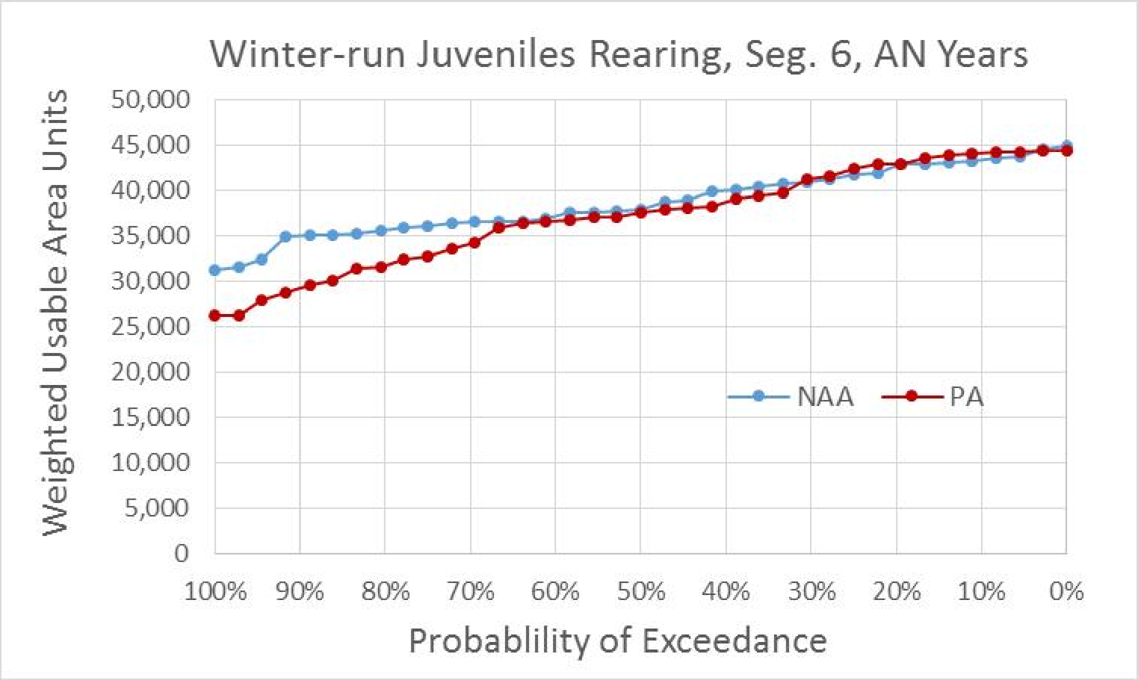

Figure 5.4-92. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

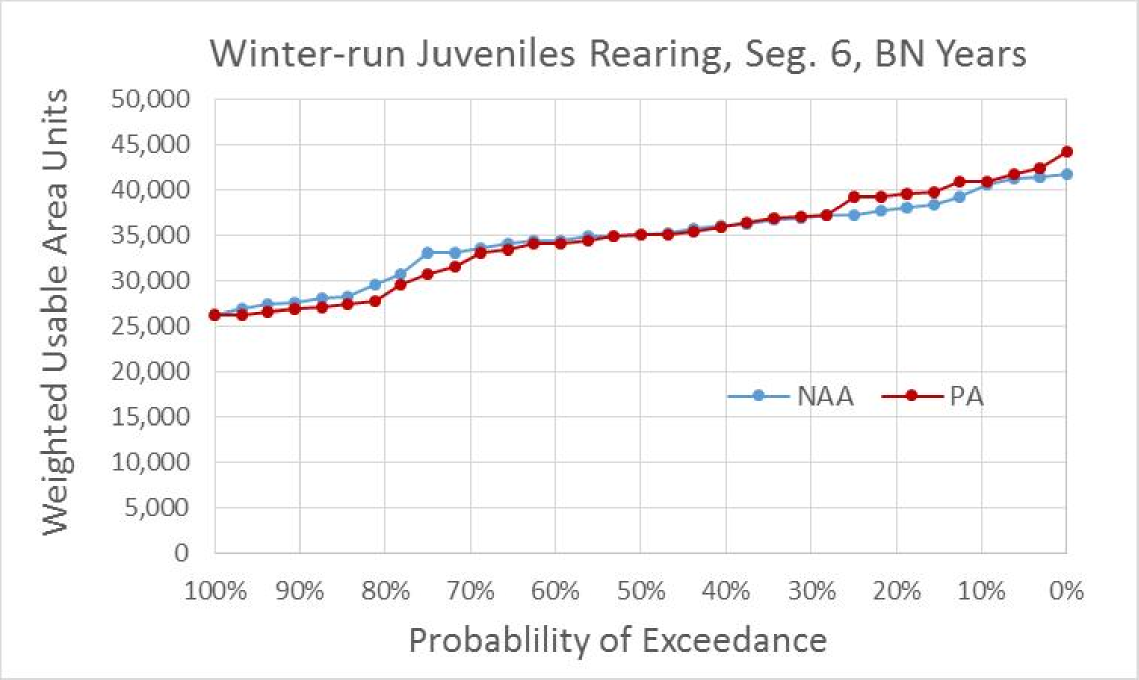

Figure 5.4-93. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

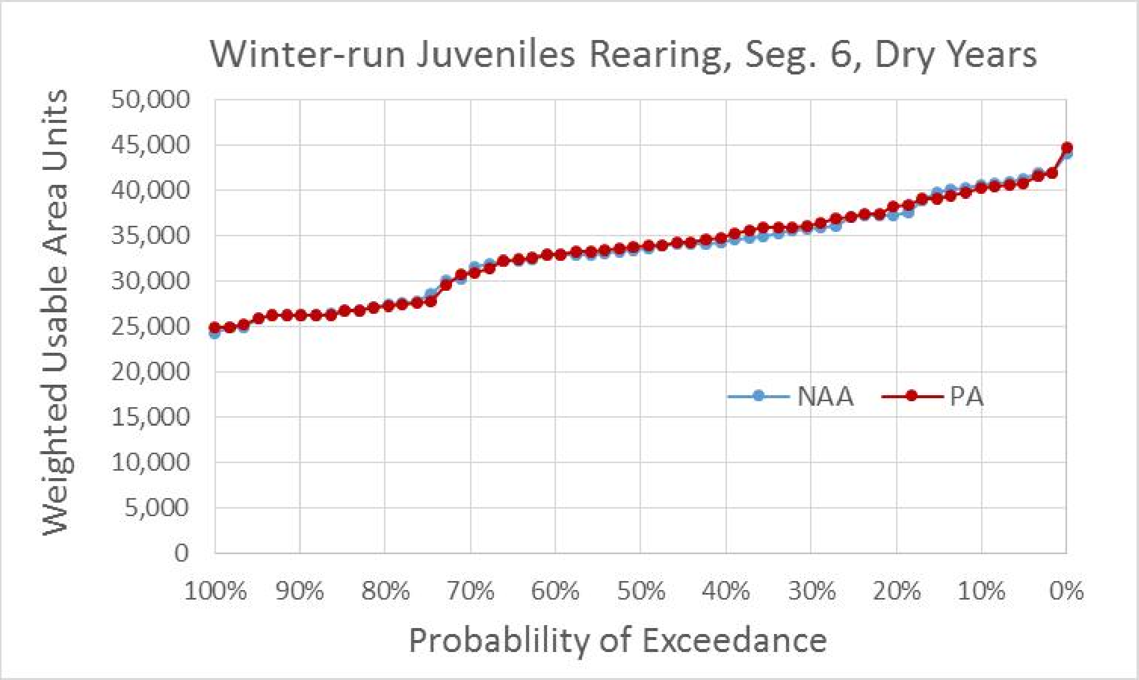

Figure 5.4-94. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

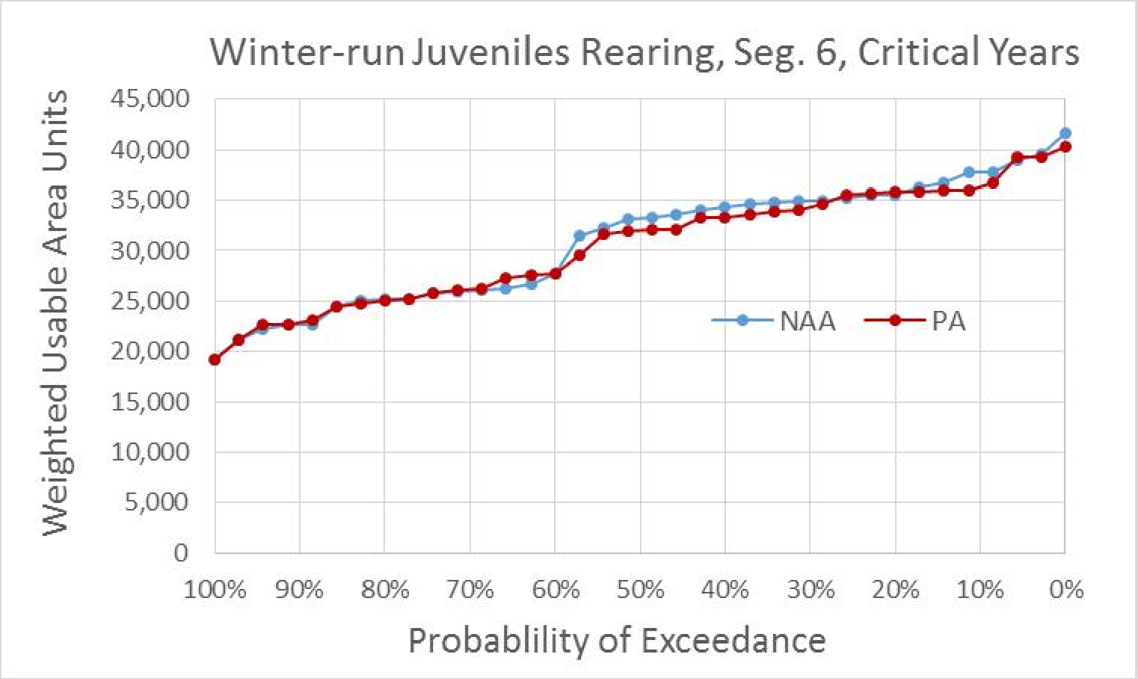

Figure 5.4-95. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

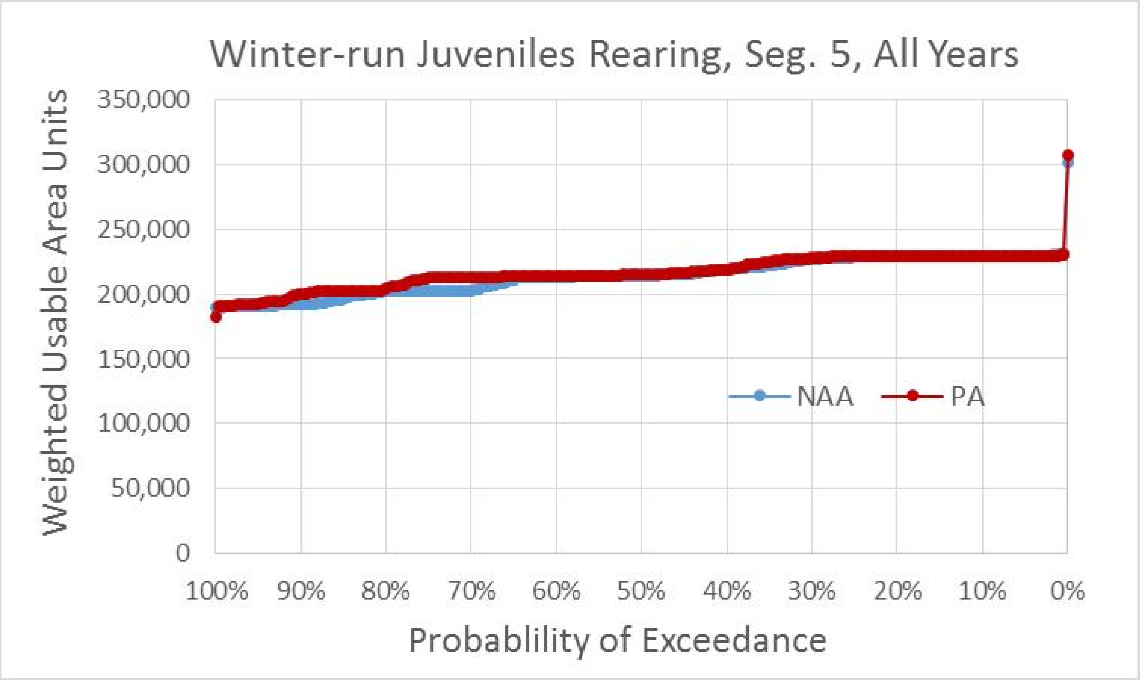

Figure 5.4-96. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

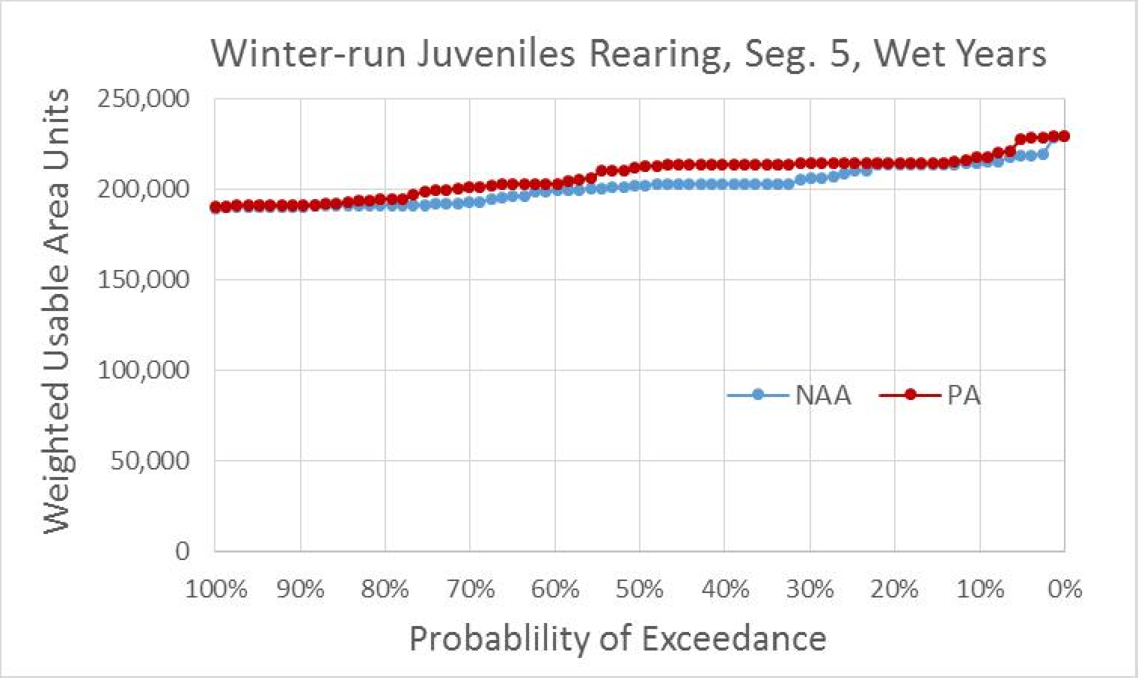

Figure 5.4-97. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

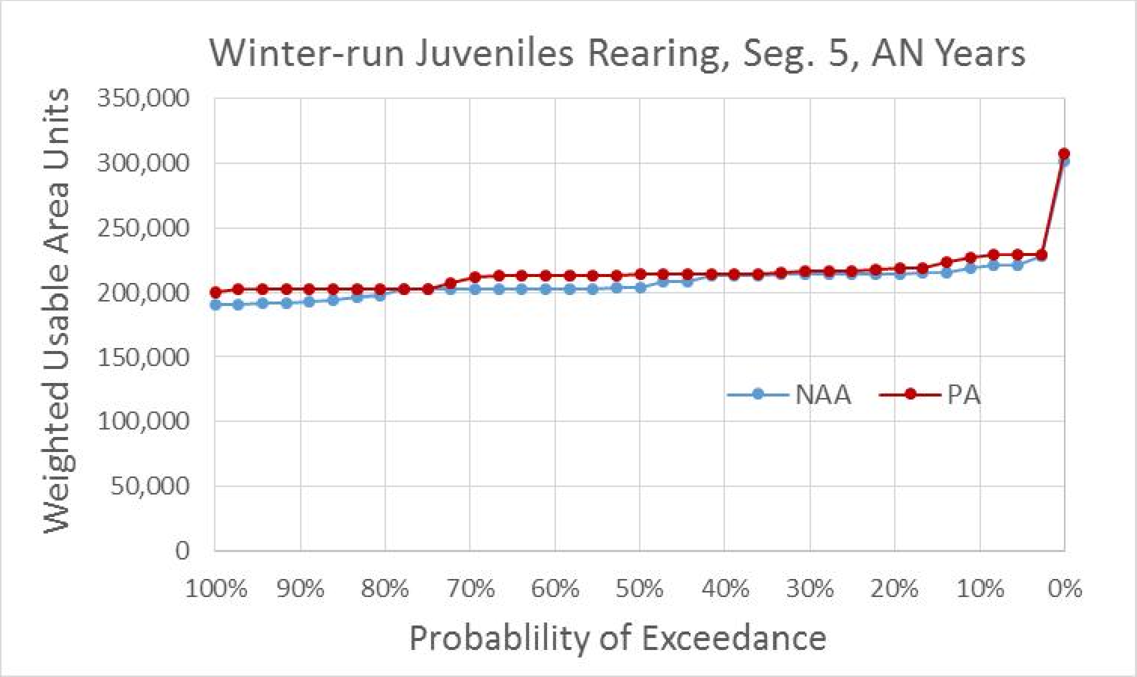

Figure 5.4-98. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

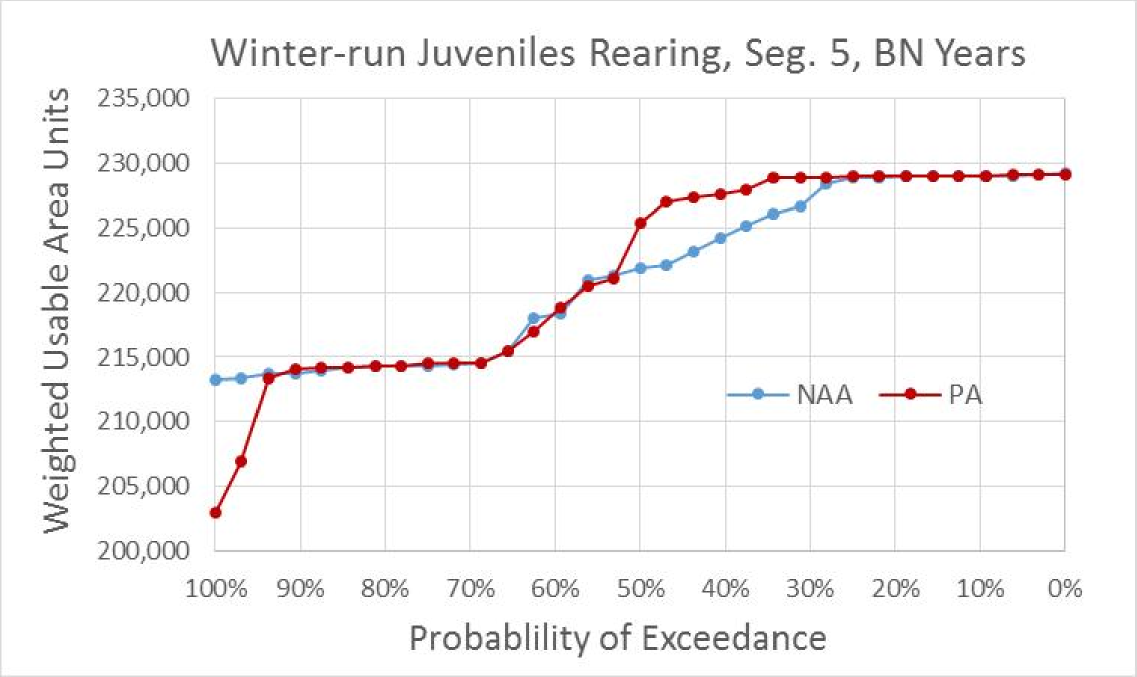

Figure 5.4-99. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

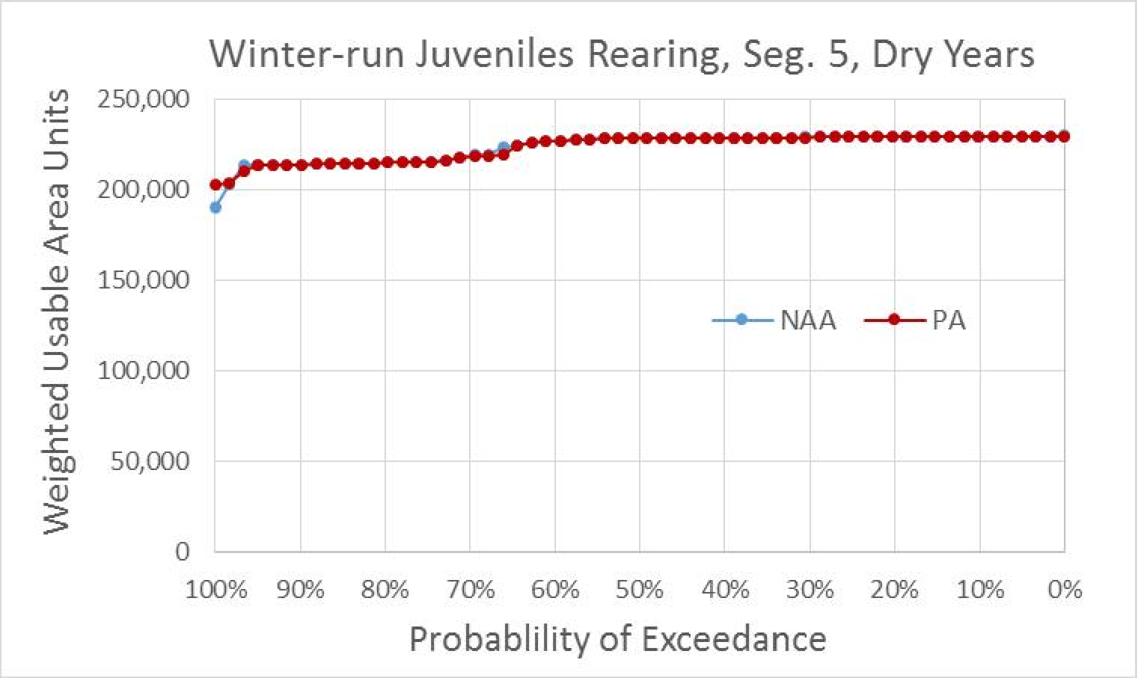

Figure 5.4-100. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

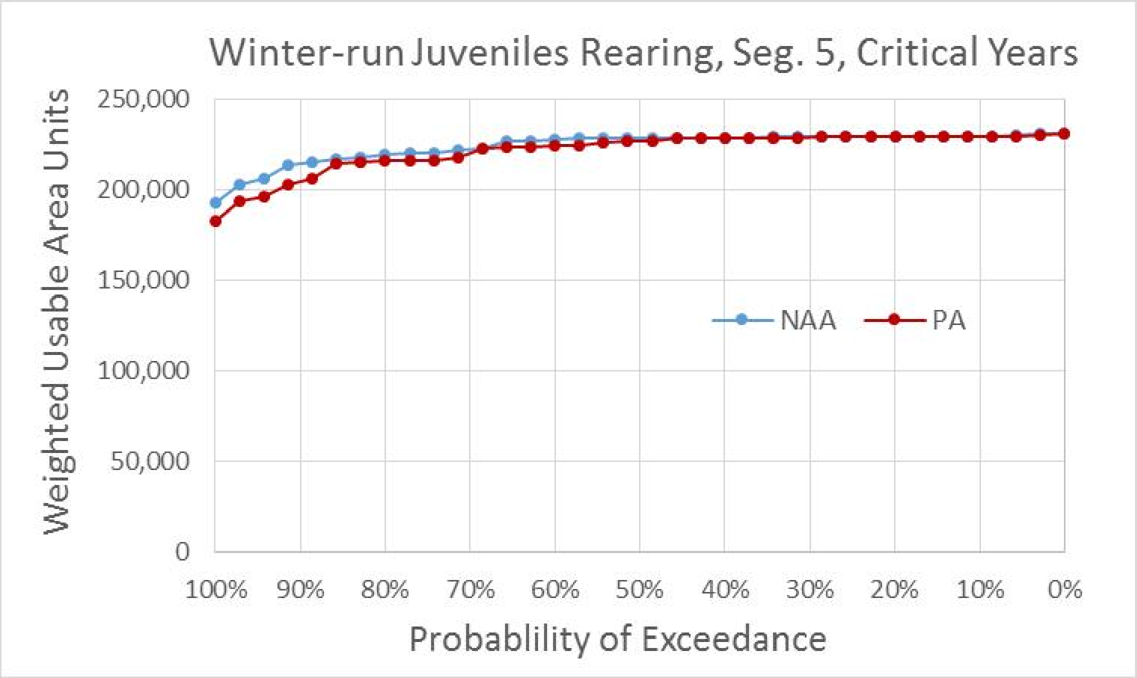

Figure 5.4-101. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

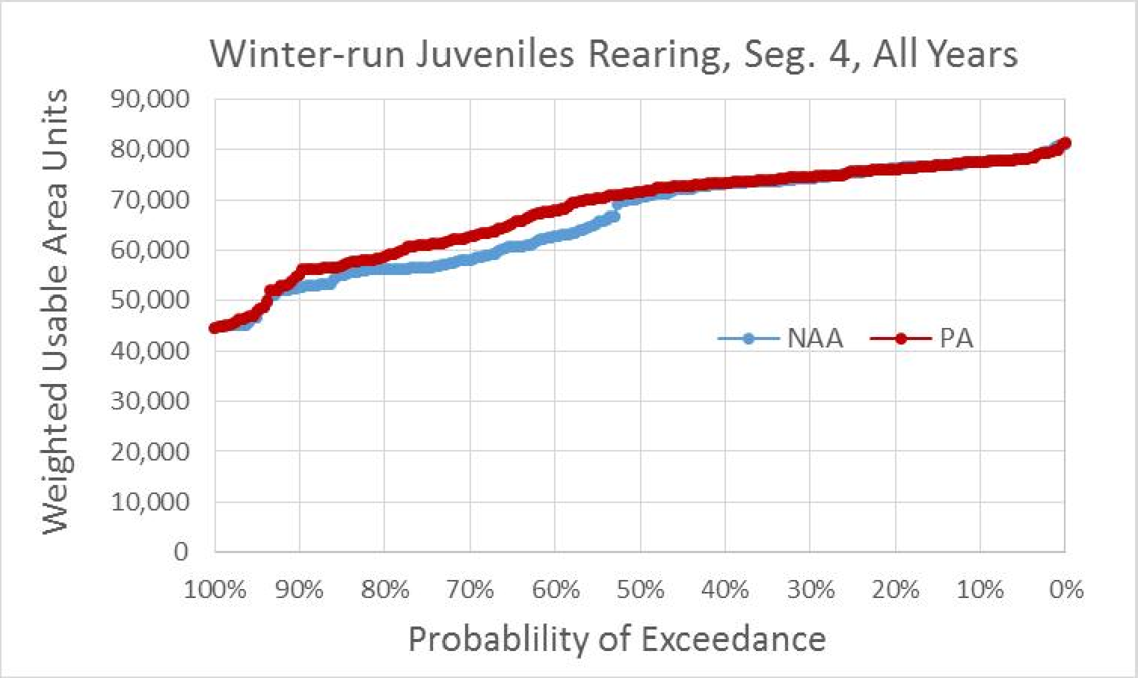

Figure 5.4-102. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

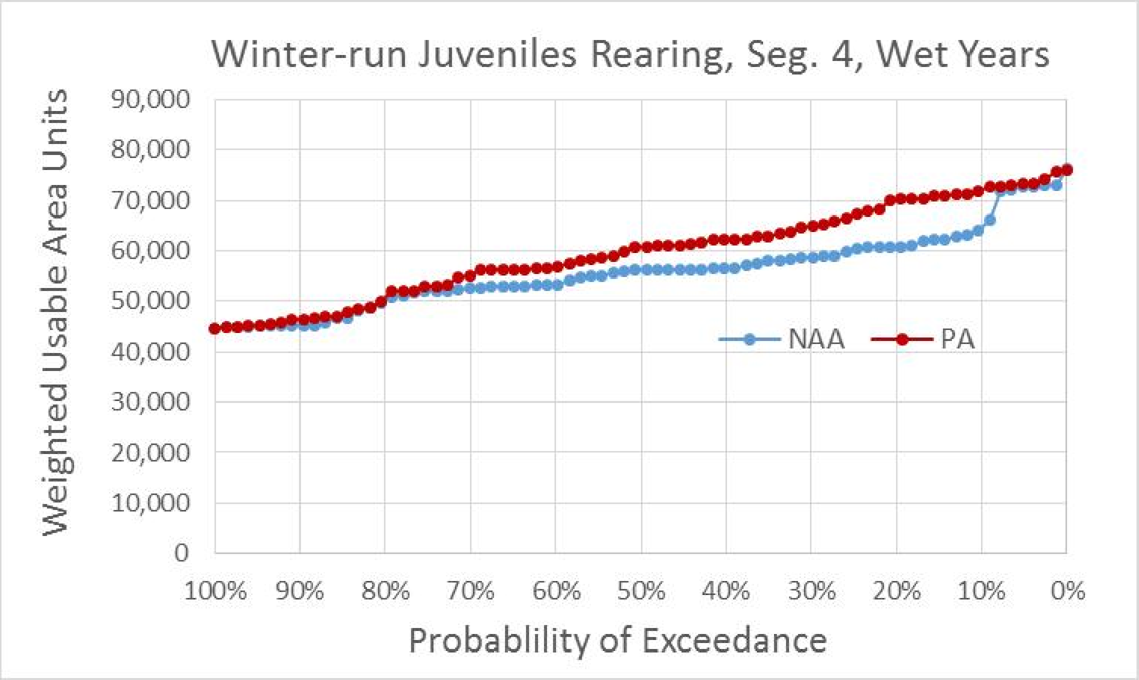

Figure 5.4-103. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

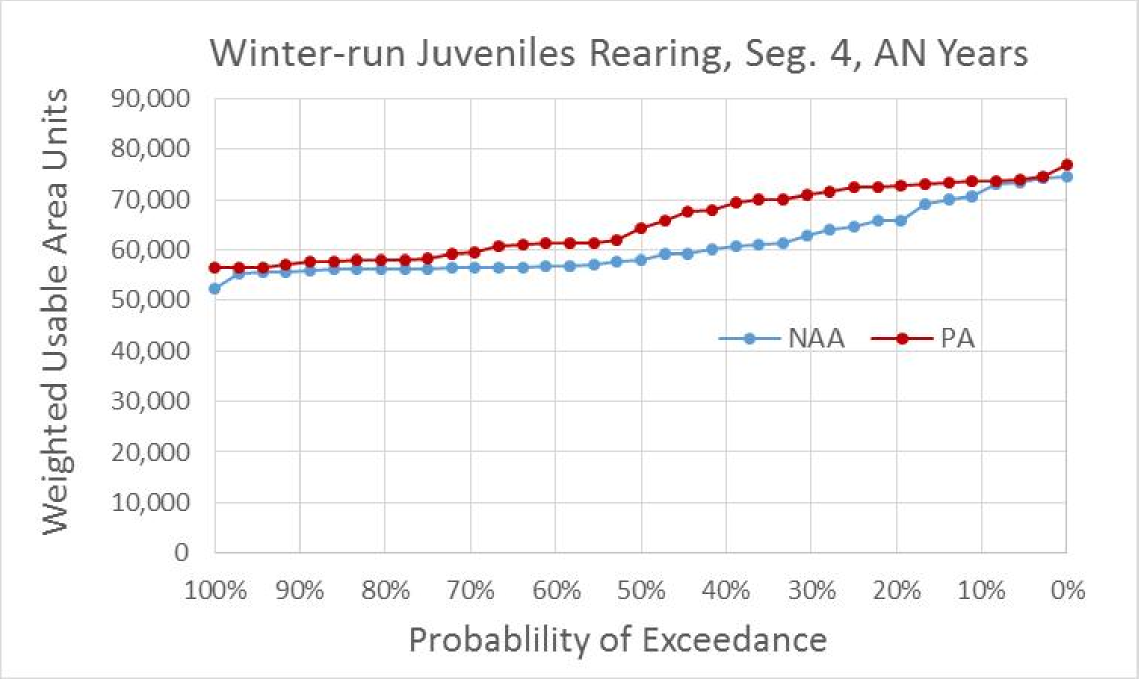

Figure 5.4-104. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

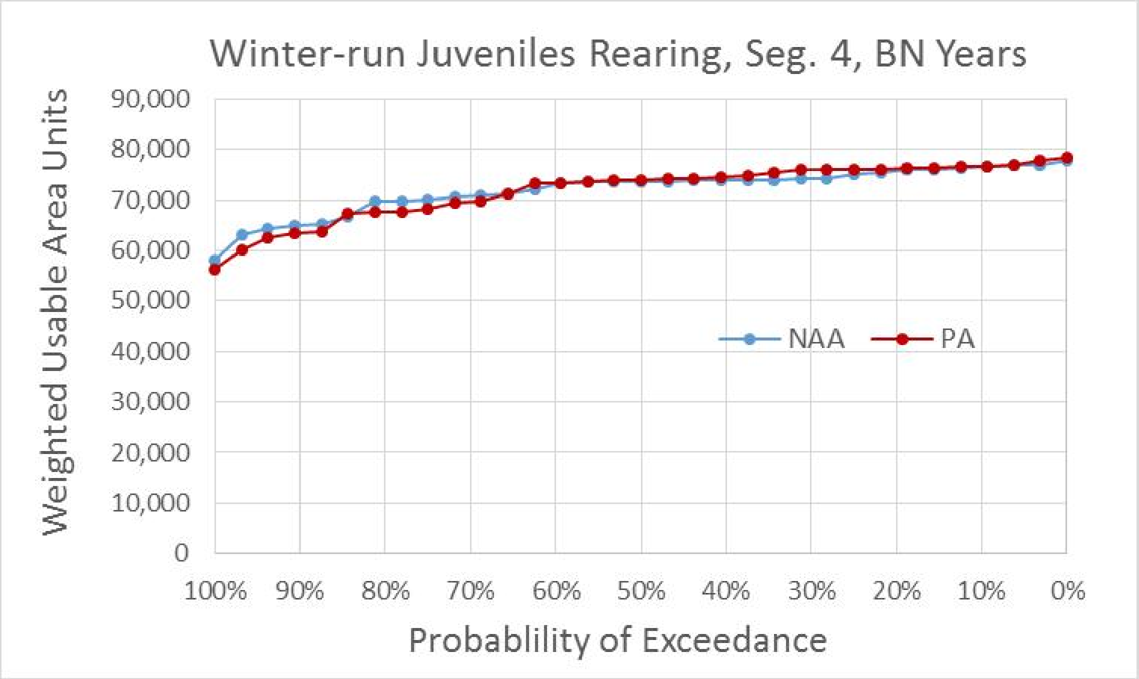

Figure 5.4-105. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

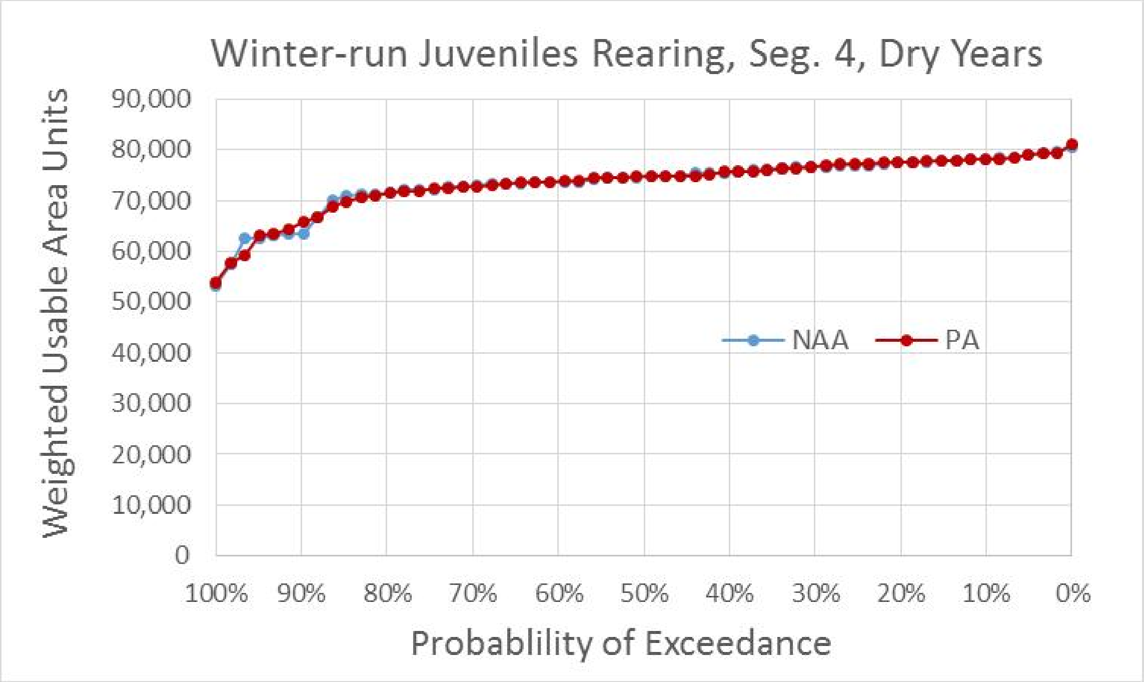

Figure 5.4-106. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

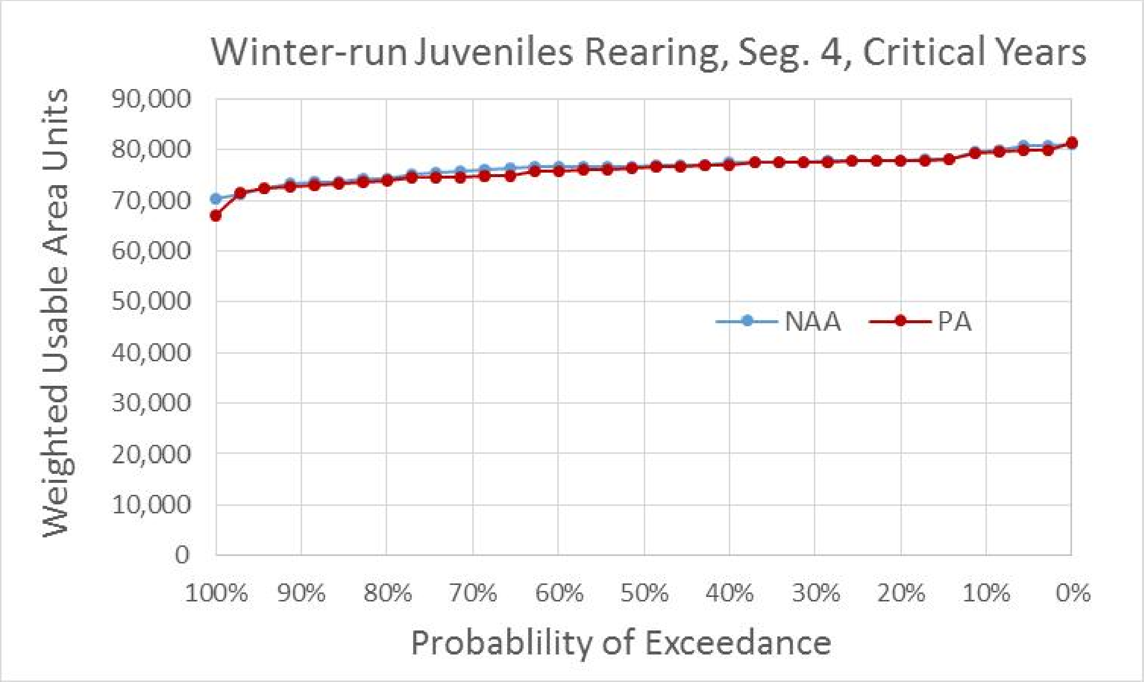

Figure 5.4-107. Exceedance Plot of Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in winter-run Chinook salmon fry and juvenile rearing WUA in each segment under the PA compared to the NAA were also examined using the grand mean rearing WUA for each month of the fry and juvenile rearing periods under each water year type and all water year types combined (Table 5.4-40 to Table 5.4-45). The means for fry rearing WUA differed by less than 5% for most months and water year types, but mean WUA in Segments 6 and 5 under the PA was up to 9% lower than that under the NAA (August and October of below normal years) (Table 5.4-40 and Table 5.4-41). The means for juvenile rearing WUA also differed by less than 5% for most months and water year types, but mean WUA in all three segments differed during November, including a 12% reduction under the PA during above normal years in Segment 6 (Table 5.4-43) and 13% and 18% increases under the PA during wet and above normal years, respectively, in Segment 4 (Table 5.4-45). Mean WUA for juvenile rearing under the PA was 6% lower during October of below normal years and 6% higher during October and/or November in all three segments, depending on the water year type. As indicated above for the WUA exceedance plot results, the grand mean rearing WUA results indicate that the PA would reduce winter-run Chinook salmon rearing habitat in a few months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects.

Table 5.4-40. Winter-Run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 6 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
July	Wet	74,888	75,684	797 (1%)
	Above Normal	77,711	78,038	327 (0.4%)
	Below Normal	78,567	77,632	-934 (-1%)
	Dry	75,180	73,369	-1,811 (-2%)
	Critical	73,844	70,907	-2,937 (-4%)
	All	75,747	75,055	-692 (-0.9%)
August	Wet	68,251	68,063	-188 (-0.3%)
	Above Normal	66,454	65,992	-462 (-0.7%)
	Below Normal	70,946	68,496	-2,450 (-3%)
	Dry	72,100	69,719	-2,381 (-3%)
	Critical	72,995	71,619	-1,376 (-2%)
	All	69,961	68,717	-1,243 (-2%)
September	Wet	74,979	74,387	-592 (-0.8%)
	Above Normal	71,479	74,871	3,392 (5%)
	Below Normal	87,992	92,677	4,685 (5%)
	Dry	89,839	91,748	1,910 (2%)
	Critical	92,093	90,267	-1,825 (-2%)
	All	82,298	83,476	1,177 (1%)

Month	Water Year Type	NAA	PA	PA vs. NAA
October	Wet	78,151	80,199	2,048 (3%)
	Above Normal	81,033	81,921	888 (1%)
	Below Normal	84,215	76,898	-7,317 (-9%)
	Dry	85,753	82,882	-2,871 (-3%)
	Critical	88,010	86,593	-1,417 (-2%)
	All	82,739	81,615	-1,124 (-1%)

Table 5.4-41. Winter-Run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 5 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
July	Wet	641,799	648,643	6,844 (1%)
	Above Normal	722,286	716,128	-6,159 (-0.9%)
	Below Normal	692,543	703,019	10,476 (2%)
	Dry	630,808	620,367	-10,441 (-2%)
	Critical	571,751	541,702	-30,049 (-5%)
	All	648,435	644,090	-4,345 (-0.7%)
August	Wet	490,701	492,357	1,656 (0.3%)
	Above Normal	492,465	483,771	-8,694 (-2%)
	Below Normal	524,955	476,186	-48,770 (-9%)
	Dry	477,850	480,511	2,661 (0.6%)
	Critical	483,342	495,327	11,985 (2%)
	All	491,365	486,372	-4,992 (-1%)
September	Wet	640,883	626,609	-14,274 (-2%)
	Above Normal	476,374	478,456	2,082 (0.4%)
	Below Normal	570,367	590,554	20,186 (4%)
	Dry	581,481	589,147	7,666 (1%)
	Critical	582,039	576,547	-5,491 (-0.9%)
	All	582,243	581,821	-422 (-0.1%)
October	Wet	490,575	512,763	22,188 (5%)
	Above Normal	518,601	515,736	-2,864 (-0.6%)
	Below Normal	555,774	519,724	-36,051 (-6%)
	Dry	556,999	544,318	-12,681 (-2%)
	Critical	567,207	552,775	-14,432 (-3%)
	All	531,335	527,868	-3,467 (-0.7%)

Table 5.4-42. Winter-Run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 4 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
July	Wet	118,256	117,959	-296 (-0.3%)
	Above Normal	115,451	116,105	654 (0.6%)
	Below Normal	116,318	116,358	40 (0.03%)
	Dry	117,865	120,117	2,252 (2%)
	Critical	123,423	127,532	4,109 (3%)
	All	118,212	119,378	1,166 (1%)
August	Wet	130,664	130,806	143 (0.1%)
	Above Normal	130,491	131,348	857 (0.7%)
	Below Normal	128,833	132,838	4,005 (3%)
	Dry	132,484	131,855	-629 (-0.5%)
	Critical	132,698	131,293	-1,404 (-1%)
	All	131,132	131,492	359 (0.3%)
September	Wet	122,118	121,105	-1,013 (-0.8%)
	Above Normal	132,593	133,766	1,173 (0.9%)
	Below Normal	131,285	131,954	669 (0.5%)
	Dry	134,369	135,027	658 (0.5%)
	Critical	133,689	137,226	3,537 (3%)
	All	129,690	130,322	632 (0.5%)
October	Wet	132,910	132,044	-866 (-0.7%)
	Above Normal	131,812	132,659	847 (0.6%)
	Below Normal	130,852	130,849	-3 (-0.002%)
	Dry	131,282	130,998	-284 (-0.2%)
	Critical	134,211	133,427	-784 (-0.6%)
	All	132,259	131,919	-339 (-0.3%)

Table 5.4-43. Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 6 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
September	Wet	37,175	37,171	-4 (-0.01%)
	Above Normal	41,433	41,844	411 (1%)
	Below Normal	36,591	35,194	-1,398 (-4%)
	Dry	35,386	34,295	-1,091 (-3%)
	Critical	34,640	33,310	-1,330 (-4%)
	All	36,964	36,380	-584 (-2%)
October	Wet	40,426	39,061	-1,365 (-3%)
	Above Normal	39,473	38,542	-931 (-2%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	Below Normal	37,544	39,778	2,235 (6%)
	Dry	36,820	38,173	1,354 (4%)
	Critical	34,103	32,991	-1,112 (-3%)
	All	38,066	37,963	-103 (-0.3%)
November	Wet	33,382	32,986	-396 (-1%)
	Above Normal	34,792	30,646	-4,145 (-12%)
	Below Normal	29,663	28,719	-944 (-3%)
	Dry	27,742	27,794	52 (0.2%)
	Critical	24,017	25,355	1,339 (6%)
	All	30,306	29,648	-658 (-2%)

Table 5.4-44. Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 5 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
September	Wet	197,659	196,662	-997 (-0.5%)
	Above Normal	201,793	206,800	5,008 (2%)
	Below Normal	222,576	226,548	3,972 (2%)
	Dry	225,400	227,524	2,124 (0.9%)
	Critical	224,334	224,155	-179 (-0.1%)
	All	212,326	213,829	1,503 (0.7%)
October	Wet	208,589	213,299	4,710 (2%)
	Above Normal	213,823	213,959	137 (0.1%)
	Below Normal	219,626	214,288	-5,337 (-2%)
	Dry	220,551	217,706	-2,845 (-1%)
	Critical	221,158	215,703	-5,455 (-2%)
	All	215,679	214,976	-703 (-0.3%)
November	Wet	199,672	212,182	12,510 (6%)
	Above Normal	212,519	226,165	13,647 (6%)
	Below Normal	222,023	224,073	2,050 (0.9%)
	Dry	224,569	225,399	830 (0.4%)
	Critical	226,766	224,475	-2,291 (-1%)
	All	214,772	220,953	6,181 (3%)

Table 5.4-45. Winter-Run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 4 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
September	Wet	50,385	50,553	168 (0.3%)
	Above Normal	58,820	61,680	2,860 (5%)
	Below Normal	73,700	76,110	2,410 (3%)
	Dry	76,392	77,247	855 (1%)
	Critical	76,162	77,129	968 (1%)
	All	64,965	66,146	1,180 (2%)
October	Wet	61,807	65,434	3,628 (6%)
	Above Normal	66,065	65,675	-390 (-0.6%)
	Below Normal	70,765	66,612	-4,152 (-6%)
	Dry	71,531	70,120	-1,411 (-2%)
	Critical	75,147	74,092	-1,055 (-1%)
	All	68,032	68,070	38 (0.1%)
November	Wet	55,868	63,204	7,336 (13%)
	Above Normal	58,426	68,808	10,382 (18%)
	Below Normal	71,476	72,794	1,317 (2%)
	Dry	72,396	72,890	495 (0.7%)
	Critical	78,216	76,756	-1,460 (-2%)
	All	65,758	69,736	3,978 (6%)

5.4.2.1.3.1.2.1.1 SALMOD flow-related outputs

The SALMOD model provides predicted flow-related fry and juvenile winter-run Chinook salmon mortality, which is presented as mortality of the fry, pre-smolt, and immature smolt life stages (see Attachment 5.D.2, *SALMOD Model*, for a full description). Results for flow-related mortality of these life stages are presented in Table 5.4-38 and the annual exceedance plot for all water year types combined is presented in Figure 5.4-108. These results indicate that flow-related mortality of winter-run Chinook salmon fry would increase moderately under the PA relative to the NAA for drier water year types (ranging from 11% higher for below normal years to 17% higher for critical years), and would decrease moderately in wet and above normal years (11% and 12% lower, respectively). The flow-related mortality of fry for all water year types combined would be similar between the NAA and PA. The flow-related mortality of winter-run Chinook salmon pre-smolts would be moderately lower under the PA relative to the NAA for all water year types combined and for all water year types separately except critical water years, which would have 40% higher mortality under the PA. SALMOD predicted no mortality for the immature smolt life stage. Almost all of the flow-related mortality predicted for winter-run Chinook salmon fry, pre-smolts and immature smolts consists of fry mortality and, therefore, flow-related mortality for the three life stages combined would be similar to that for fry alone (Table 5.4-38). Accordingly, these results indicate that the PA would increase flow-related mortality of fry and juvenile winter-run Chinook salmon relative to the NAA in drier water years and reduce flow-related mortality in wetter years, but would result in negligible[46] change for all water year types combined. These results are based on CALSIM outputs, which does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects.

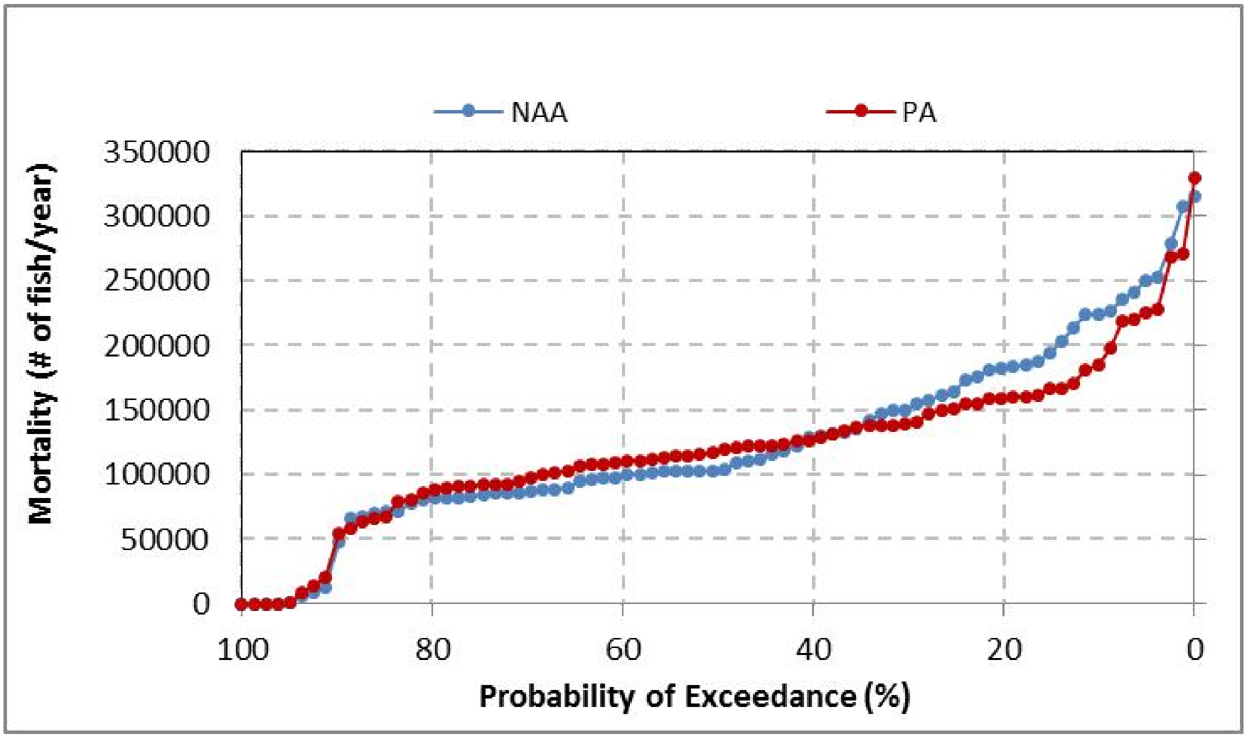

Figure 5.4-108. Exceedance Plot of Annual Flow-Based Mortality (# of Fish/Year) of Winter-Run Chinook Salmon Fry and Juveniles

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[46] "Negligible" is defined as a difference between the NAA and PA of <5%. It can differ from the term "biologically meaningful".

5.4.2.1.3.1.2.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the July through November juvenile rearing period for winter-run Chinook salmon in the Sacramento River upstream of the Delta (Table 5.4-25) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-10[47]. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the juvenile rearing reach of Keswick Dam to Knights Landing in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 1.0°F (1.4%), and would occur at Knights Landing in below normal years during August.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the juvenile rearing period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.10-7[48]). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of below normal water years in August at Knights Landing, where the largest increase in mean monthly water temperature was seen, indicates that water temperatures under the PA would be higher than those under NAA for most of the exceedance range by up to approximately 2.2°F, particularly in the colder end of the range (Figure 5.4-109). As indicated below in the temperature threshold analysis results description, temperatures predicted for Knights Landing during August of below normal water years would be greater than the 64°F 7DADM threshold on 100% of days under both the NAA and PA, although there is low certainty that modeled values are comparable to actual values. Therefore, this suggests that, with low certainty, conditions would already be unsuitable for winter-run Chinook salmon fry and juvenile rearing for reasons that are independent of the PA.

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[47] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

[48] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

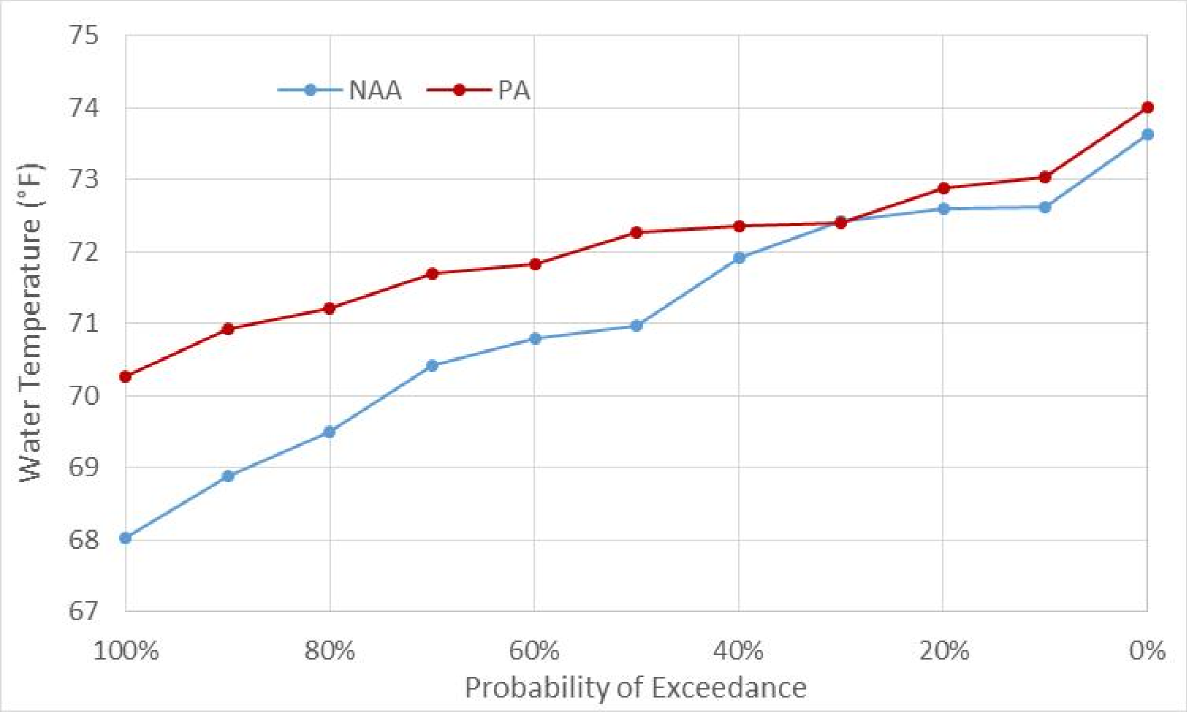

Figure 5.4-109. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Wilkins Slough/Knights Landing in August of Below Normal Water Years[49]

For purposes of this analysis, the water temperature thresholds analysis for juvenile rearing and emigration have been combined and the period of July through March was evaluated. The threshold used was from the USEPA's 7DADM value of 61°F for the core juvenile rearing reach from Keswick Dam to Red Bluff and 64°F for the non-core juvenile rearing reach at Knights Landing (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49). The 7DADM values were converted by month to function with daily model outputs (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-68 through 5.D-73. At Keswick Dam, there would be no months or water year types in which there would be both more than 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5 *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-68).

At Clear Creek, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the 61°F 7DADM threshold and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-69). However, the percent of days exceeding the threshold under the PA

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[49] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

would be more than 5% lower than under the NAA during September and October of critical water years (6.7% and 11.8%, respectively). Despite this reduction during September of critical water years, the difference in mean daily exceedance would increase by 0.7°F. This indicates that the frequency of days above the threshold would decrease under the PA, but exceedances would be higher on average.

At Balls Ferry, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the 61°F 7DADM threshold and no more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-70). Therefore, it was concluded that there would be no biologically meaningful effect. There are also two situations at Balls Ferry during which the percent of days exceeding the threshold under the PA would be more than 5% lower than under the NAA during September and October of critical water years (10% and 14%, respectively). Despite this reduction during September of critical water years, the difference in mean daily exceedance would increase by 0.7°F. This indicates that the frequency of days above the threshold would decrease under the PA, but exceedances would be higher on average.

At Bend Bridge, the percent of days exceeding the 61°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during July (7.8%) of critical years, August (5.9%) and September (15.8%) of below normal years, and September of dry years (8.0%) (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-71). However, in none of these situations would there concurrently be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect at Bend Bridge. There are also three situations at Bend Bridge during which the percent of days exceeding the threshold under the PA would be more than 5% lower than under the NAA: August of dry years (8.4%), August of critical years (11.6%), and October of critical years (11%). In August of critical years, despite the reduction in threshold exceedance frequency, there would be a 0.6°F increase in average daily exceedance under the PA relative to the NAA.

At Red Bluff, the percent of days exceeding the 64°F 7DADM threshold for non-core rearing and emigration habitat under the PA would be more than 5% higher than under the NAA during July (5.1%) of critical water years, and during September of below normal (11.5%) and dry (5.8%) water years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-72). However, in none of these situations would there also be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect.

At Knights Landing, the percent of days exceeding the 64°F 7DADM threshold for non-core rearing and emigration habitat under the PA would be more than 5% higher than under the NAA during October of wet water years (6.9%) (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-73). There would also be a 7.9% reduction in the percent of days exceeding the threshold during October of below normal water years. However, in neither of these situations would there also be a more than 0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA

The SALMOD model provides predicted water temperature-related fry and juvenile winter-run Chinook salmon mortality, which is a combination of mortality of the fry, pre-smolt, and immature smolt life stages (see Attachment 5.D.2, *SALMOD Model*, for a full description). Results for water temperature-related mortality of these life stages are presented in Table 5.4-38 and the annual exceedance plot for all water year types combined is presented in Figure 5.4-110. These results indicate that differences under the PA in temperature-related mortality relative to the NAA would generally be insignificant. The highest mean annual mortality would occur in critical water years in both the NAA and PA and there would be insignificant differences between scenarios in mortality (759 fish, or 1% lower under the PA). Accordingly, these results indicate that the PA would not increase water temperature-related mortality of fry and juvenile winter-run Chinook salmon relative to the NAA.

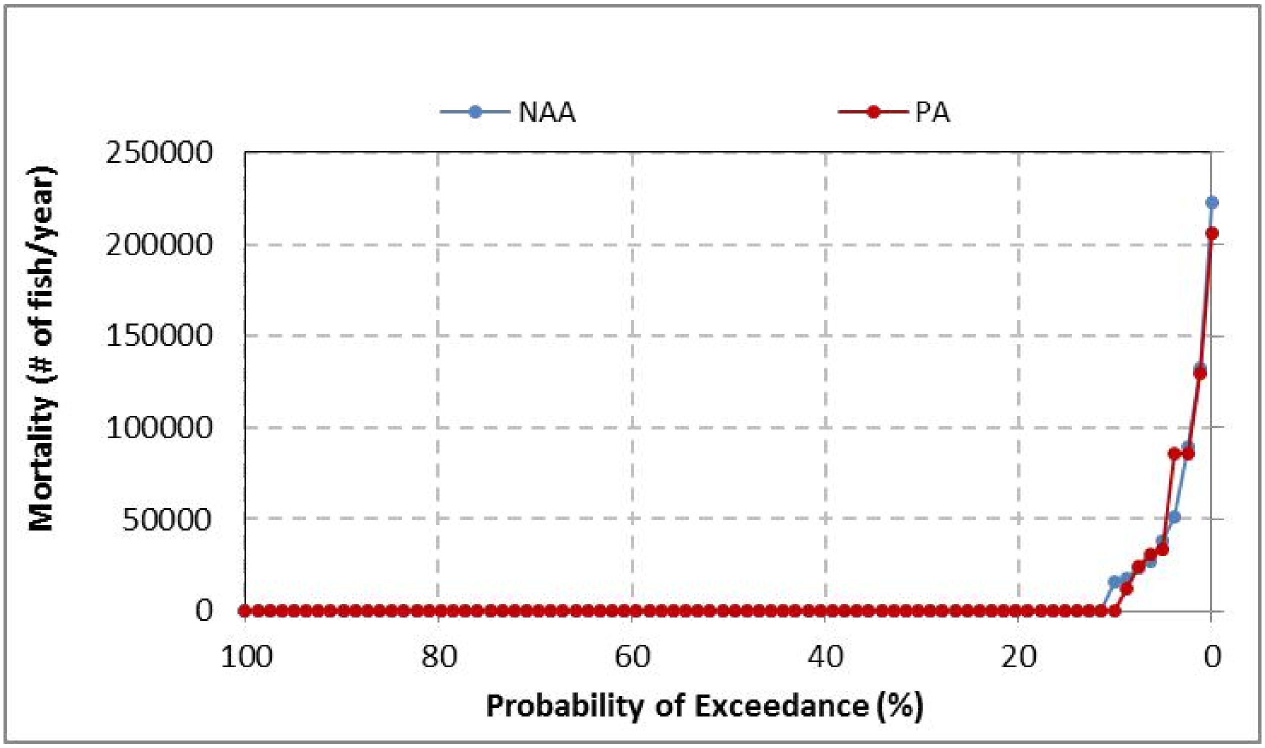

Figure 5.4-110. Exceedance Plot of Annual Water Temperature-Based Mortality (# of Fish/Year) of Winter-Run Chinook Salmon Fry and Juveniles

5.4.2.1.3.1.3 Juvenile Emigration

5.4.2.1.3.1.3.1 Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at four locations along the downstream migration corridor of juvenile winter-run Chinook salmon (i.e., Keswick, Red Bluff, Wilkins Slough, and Verona) during the July through March emigration period, with peak emigration at Keswick Dam and Red Bluff during September and October (Table 5.4-25). Changes in flow potentially affect the emigration of juveniles, including the timing and rate of emigration, as well as conditions for feeding, protective cover, resting, temperature, turbidity, and other habitat factors. Crowding and stranding, especially in side-channel habitats, can also be affected (Quinn 2005; Williams 2006; del Rosario et al. 2013). As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* quantitative relationships between flow and downstream migration generally are highly variable and poorly understood, but on balance, except under very high flows, benefits of increased flow generally outweigh the costs. Therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for the emigration of juvenile winter-run Chinook salmon. Milner et al. 2012 and del Rosario et al. 2013 found that migration cues for anadromous fish species are often the result of natural pulse flows, or pulse flows caused by natural events, such as an extensive rainfall event, which will not be affected by the PA.

Shasta Reservoir storage volume at the end of May influences flow rates in the Sacramento River during the first three months of the juvenile emigration period; Shasta storage volume at the end of September may influence flow during the rest of the period. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3).

In general, mean flow under the PA at the Keswick, Red Bluff, Wilkins Slough, and Verona locations in the Sacramento River would be similar to (less than 5% difference) or lower than the flow under the NAA during the first five months of the winter-run Chinook salmon juvenile migration period and similar to (less than 5% difference) or higher than under the NAA during the last four months, with some exceptions (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During July, mean flow in critical water years under the PA would be 10% and 13% lower than it would be under the NAA at Wilkins Slough and Verona, but the flows would be similar (less than 5% difference) at Keswick and Red Bluff. During August, mean flow in below normal years would be lower at all four locations (up to 18% lower flow at Wilkins Slough). During August of dry and critical years, at Wilkins Slough and Verona only, flow under the PA would be greater (up to 10% greater). Mean flow during September would be lower for most water year types at all the locations (up to 24% lower in below normal years at Verona). During October, flow under the PA would be 7% to 11% lower in wet years at all the locations but would be up to 17% higher in below normal and dry years. The changes in flow during September and October coincide with the peak of the juvenile emigration period at Keswick and Red Bluff. During November of wet and above normal water years, flow would be 26% lower under the PA than it would be under the NAA at Keswick Dam, 21% lower at Red Bluff, up to 24% lower at Wilkins Slough, and up to 17% lower at Verona, but in critical water years, flow would be greater at all the locations (up to 13% greater at Keswick). During January, mean flow under the PA at Keswick would be 18% greater than it would be under the NAA in critical water year types and 8% greater in wet years. At Red Bluff, the mean January flow in critical years would be 7% greater under the PA; at the other two locations, all differences in January flow would be less than 5%. During February, mean flow would be lower (up to 13% lower at Keswick) under the PA compared with the NAA at all the locations, except Verona. During March, flow under the PA at Keswick would be 9% greater in above normal and below normal years and 8% greater in critical years; there would be no differences greater than 5% at the other locations.

The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.1.3.1.3.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the Sacramento River in the reach from Keswick Dam to Knights Landing during the July through March juvenile emigration period for winter-run Chinook salmon, with a peak during September and October (Table 5.4-25) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-10[50]. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) throughout the Sacramento River upstream of the Delta in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 1.0°F (1.4%), and would occur at Knights Landing in below normal years during August.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the winter-run Chinook salmon juvenile emigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.10-7[51]). The curves for PA generally match those of the NAA, except in below normal water years in August at Knights Landing, during which water temperatures under the PA would be higher than those under NAA for most of the exceedance range by up to approximately 2.2°F, particularly in the colder end of the range (Figure 5.4-108). As indicated above, temperatures predicted for Knights Landing during August of below normal water years would be greater than the 64°F 7DADM threshold on 100% of days under both the NAA and PA, although there is low certainty that modeled values are comparable to actual values. Therefore, this suggests that, with low certainty, conditions would already be unsuitable for winter-run Chinook salmon fry and juvenile rearing for reasons that are independent of the PA.

Please see the discussion of water temperature thresholds for juvenile winter-run Chinook salmon emigration in Section 5.4.2.1.3.1.2, *Fry and Juvenile Rearing*, which concludes that there would be more exceedances (5% or greater) in certain months and water year types under the PA. These exceedances could have lethal or sublethal effects on juvenile emigrants, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

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[50] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

[51] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

5.4.2.1.3.1.4 Adult Immigration

5.4.2.1.3.1.4.1 Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at four locations along the upstream migration corridor of adult winter-run Chinook salmon (i.e., Keswick, Red Bluff, Wilkins Slough and Verona) during the December through August immigration period, with peak migration from February through April (Table 5.4-25). Changes in flow potentially affect conditions for upstream migration of adults, including bioenergetic cost, water quality, crowding, cues for locating natal streams, and passage conditions, but quantitative relationships between flow and such conditions are generally poorly understood (Quinn 2005; Milner et al. 2012). As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* on balance, except under very high flows, the benefits of increased flow generally outweigh the costs and, therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for upstream migration of adult winter-run Chinook salmon. It is known that migration cues for anadromous fish species are often the result of natural pulse flows, which will not be affected by the PA (Milner et al. 2012; del Rosario et al. 2013).

Shasta Reservoir storage volume at the end of September may influence flow rates in the Sacramento River during the first part of the winter-run Chinook salmon immigration period; Shasta storage volume at the end of May would influence flows during the last part of the immigration period. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA. Mean Shasta May storage under the PA would also be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-3).

For most months and water year types of the adult immigration period, mean flow at Keswick, Red Bluff, Wilkins Slough and Verona would be similar (less than 5% difference) between the PA and the NAA or would be greater under the PA. During January, mean flow under the PA at Keswick would be 18% greater than it would be under the NAA in critical water years and 8% greater in wet years. At Red Bluff, the mean January flow in critical years would be 7% greater under the PA; at the other two locations, all differences in January flow would be less than 5% (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-10, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During February, mean flow would be lower (up to 13% lower at Keswick) under the PA compared with the NAA at all the locations, except Verona. During March, flow under the PA at Keswick would be 9% greater in above normal and below normal years and 8% greater in critical years; there would be no differences greater than 5% at the other locations. The flow differences during February and March coincide with the peak immigration period. During May, flow under the PA would be greater (up to 8% greater at Wilkins Slough) at all the locations, except Verona. During June, flow under the PA would be greater at all the locations, including all water year types at Verona and all water year types, except wet years at the other locations. The increases for all water year types would be greater at Wilkins Sough and Verona (up to 25% greater in above normal years) than those at Keswick and Red Bluff. During July, mean flow in critical years under the PA would be up to 13% lower at Wilkins Slough and Verona; during August, mean flow in below normal years would be lower at all four locations, including up to 18% lower flow at Wilkins Slough. During August of dry and critical years, flow under the PA would be greater (up to 10% greater) at Wilkins Slough and Verona.

The CALSIM modeling results given here indicate that the PA would reduce flow in only three months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* mean monthly flow below about 3,250 cfs is considered to have potentially adverse effects on Chinook salmon, CCV steelhead, and green sturgeon adult immigration conditions in the Sacramento River. The effect of the PA on the frequency of flows below this threshold was evaluated by comparing CALSIM flows between the PA and the NAA at three of the migration corridor locations in the river: Keswick, Red Bluff, and Wilkins Slough. The CALSIM results include no flows below 3,250 cfs for the Sacramento River at any of these locations for any month of the winter-run Chinook salmon adult immigration period.

5.4.2.1.3.1.4.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the Sacramento River at Keswick Dam, Bend Bridge, and Red Bluff during the December through August adult immigration period for winter-run Chinook salmon (Table 5.4-25) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-7, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.6°F (0.9%), and would occur at Red Bluff in below normal years during August.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the juvenile emigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The values for the PA in these exceedance plots generally match those of the NAA. For below normal water years in August at Red Bluff, where the largest increases in mean monthly water temperatures were seen, the PA curve is consistently higher than the NAA curve by approximately 0.5°F (Figure 5.4-111). As indicated below in the threshold analysis, temperatures predicted at Red Bluff during August of below normal water years would be lower than the 68°F 7DADM for all days in both the NAA and PA and, therefore, there would be no biologically meaningful effect on winter-run Chinook salmon adult immigrants moving through the Red Bluff area.

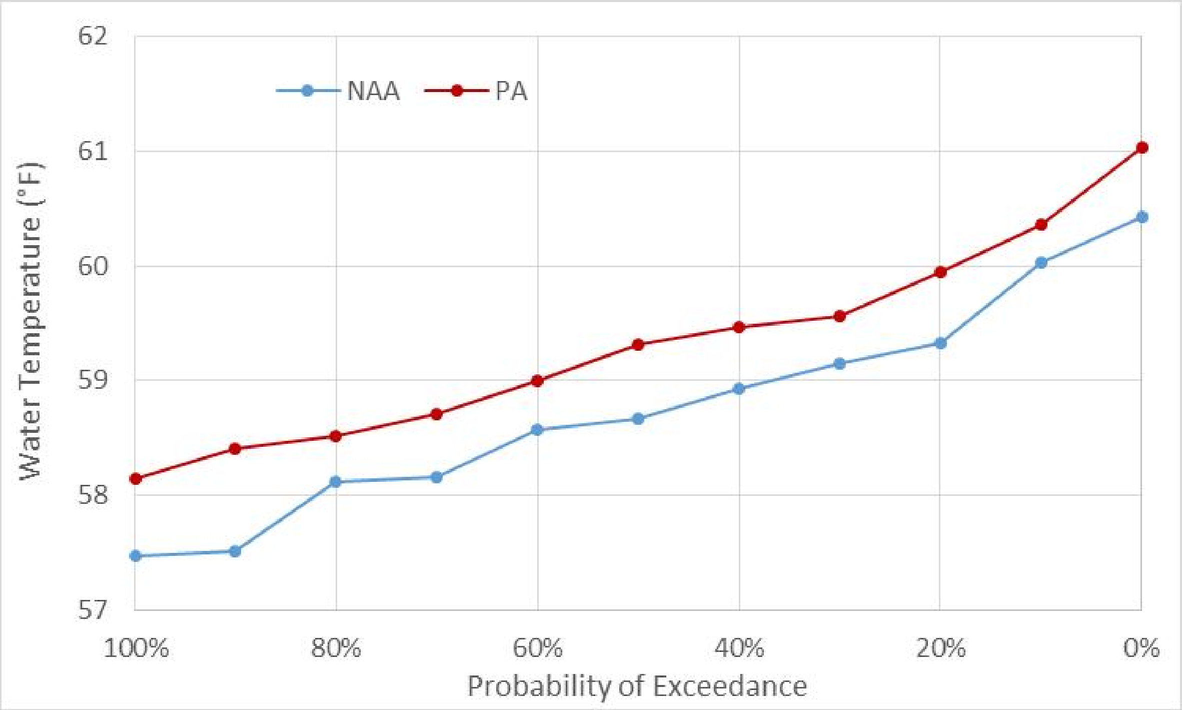

Figure 5.4-111. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in August of Below Normal Water Years

The USEPA's 7DADM threshold value of 68°F was used to evaluate water temperature threshold exceedance during the winter-run Chinook salmon adult immigration life stage at Keswick Dam, Bend Bridge, and Red Bluff (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-74 through Table 5.D-76. At Keswick Dam and Red Bluff, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold, and no more-than-0.5°F difference in the magnitude of average daily exceedance.

At Bend Bridge, there is one instance during which the percent of days exceeding the 68°F DADM under the PA would be more than 5% higher than under the NAA: August in critical years (5.1% higher under the PA) (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-75). However, there would be an insignificant (less than 0.1°F) difference in average daily exceedance in this instance. Therefore, it was concluded that there would be no biologically meaningful effect on winter-run adult immigration.

Overall, there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could have lethal or sublethal effects on adult immigrants, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time*

Operations Upstream of the Delta, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

5.4.2.1.3.1.5 Adult Holding

5.4.2.1.3.1.5.1 Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at the Keswick Dam and Red Bluff locations during the January through August holding period, with peak occurrence during April through June, for winter-run Chinook salmon (Table 5.4-25). Changes in flow likely affect holding habitat for winter-run, with higher flows potentially providing greater depths and improved water quality in pools. Shasta Reservoir storage volume at the end of May influences flow rates below the dam during much of the winter-run holding period. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-3). During the majority of months and water year types of the winter-run holding period, the PA would result in minor changes (less than 5% difference) in mean flow in the Sacramento River at the Keswick Dam and Red Bluff locations (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-10, Table 5.A.6-35). However, at both locations flows under the PA would be 5% to 7% higher during May of dry years and June of all water year types except wet years. During January of critical years, mean flow under the PA would be up to 18% higher than flow under the NAA; during February of critical years flow under the PA would be up to 13% lower; and during August of below normal years flow would be 10% lower under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35). The flow increases during May and June occur within the peak winter-run adult holding period (April through June). Because flow would generally be higher (greater than 5% difference) under the PA during the peak holding period, and increases and decreases in flow would, on balance, be similar during the rest of the holding period, the PA is predicted to have a small positive effect on flow conditions for winter-run holding habitat.

5.4.2.1.3.1.5.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the Sacramento River at Keswick Dam, Balls Ferry, and Red Bluff during the January through August adult holding period for winter-run Chinook salmon (Table 5.4-25) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-5, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.6°F (0.9%), and would occur at Red Bluff in below normal years during August.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the adult holding period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.5-7, Figure 5.C.7.8-7). The curves for PA generally match those of the NAA. For below normal water years in August at Red Bluff, where the largest increase in mean monthly water temperature was seen, the PA curve is consistently higher than the NAA curve by approximately 0.5°F (Figure 5.4-111).

To evaluate water temperature threshold exceedance during the adult holding life stage at Keswick Dam, Balls Ferry, and Red Bluff, the USEPA's 7DADM threshold value of 61°F was used Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49) (U.S. Environmental Protection Agency 2003). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-77 through 5.D-79. At Keswick Dam, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and no more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-77).

At Balls Ferry, the percent of days exceeding the 61°F 7DADM threshold for adult holding habitat under the PA would not differ by more than 5% in any month or water year type (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-78). The average daily exceedance under the PA would increase by 0.7°F in August of all water year types combined. However, combined, these results indicate that there would be no biologically meaningful effect at Balls Ferry.

At Red Bluff, the percent of days exceeding the 61°F 7DADM threshold for adult holding habitat under the PA would be more than 5% higher than under the NAA during July (6.5%) of critical water years and during August of below normal water years (9.4%) (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-79). There would also be reductions in the percent of days exceeding the threshold in June of critical years (5.8%) and August of dry (6.1%) and critical (6.5%) water years. However, in none of these situations would there also be a more than 0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could have lethal or sublethal effects on holding adults, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. CALSIM modeling also does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival. This process may result in refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management and RPA revisions is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

5.4.2.1.3.1.6 Life Cycle Models

Two winter-run Chinook salmon life cycle models, Interactive Object-Oriented Salmon Simulation (IOS) and Oncorhynchus Bayesian Analysis (OBAN), and SALMOD, a model that behaves like a life cycle model in some ways, are described in this section. Because these models integrate multiple life stages, they are described separately from the life stage-specific results for the winter-run Chinook salmon analysis in the Sacramento River. A full description of each model can be found as follows:

- IOS: Appendix 5.D, Section 5.D.3.1, *IOS*
- OBAN: Appendix 5.D, Section 5.D.3.2, *OBAN*
- SALMOD: Appendix 5.D, Attachment 5.D.2, *SALMOD Model*,

5.4.2.1.3.1.6.1 IOS

Results of the IOS model are presented in Appendix 5.D Section 5.D.3.1, *IOS*. The model predicts that upstream effects of the PA would be insignificant. Median egg survival under the PA (0.991) would be nearly identical to that under the NAA (0.990) with overlapping 95% confidence intervals in all but 12 of the 81 simulated years. In addition, median fry survival under the PA (0.991) would be nearly identical to that under the NAA (0.990), with overlapping 95% confidence intervals in all but 15 of the 81 simulated years. Such small differences in upstream survival would be unlikely to measurably affect escapement. Median escapement is predicted to be lower under the PA relative to the NAA, but this is largely an effect of in-Delta survival resulting from lower flows downstream of the North Delta intake facilities. Median through-Delta survival under the PA was predicted to be 0.354, compared to 0.380 under the NAA, with overlapping confidence intervals in all but one out of 81 simulated years.

It is worth noting that the difference in egg survival and fry survival between the NAA and PA shifts temporally during the 80-year time series (Appendix 5.D, Section 5.D.3.1, *IOS*). In the late 1920s to early 1930s, egg and fry survival under the PA was lower than survival under the NAA. In the late 1980s and early 1990s, egg and fry survival under the PA was higher than survival under the NAA. Despite this pattern, the escapement results primarily result from reduced in-Delta survival under the PA.

5.4.2.1.3.1.6.2 OBAN

Results of the OBAN model are presented in Appendix 5.D, Section 5.D.3.2, *OBAN*. The model predicts temporal variability in escapement, with insignificant differences between the NAA and PA. These patterns were driven predominantly by fluctuations in water temperatures and flows in the spawning reach of the Sacramento River. Therefore, upstream conditions affect escapement, but these upstream conditions are generally similar between NAA and PA such that there is no overall difference in median escapement.

5.4.2.1.3.1.6.3 SALMOD

The SALMOD model is not a full life cycle model, but it does integrate all early life stages of a Chinook salmon race together on an annual basis to provide an *Annual Potential Production* value (Attachment 5.D.2, *SALMOD Model*). This value represents all individuals that survive from the *pre-spawn egg* stage to the end of the year in each year of the 80-year simulation period. Individual years are independent of one another and, therefore, effects through time cannot be evaluated as a time series.

Mean winter-run Chinook salmon annual potential production values from SALMOD and differences between scenarios are presented in Table 5.4-46 and an exceedance plot is provided in Figure 5.4-112. Overall, these results indicate that changes in winter-run Chinook salmon annual potential production under the PA relative to the NAA would be insignificant. This result is consistent among water year types and when all water year types are combined. Despite the small magnitude of the effect of the PA on mean winter-run Chinook salmon annual potential production, it could compound with in-Delta effects to negatively affect the species if there were no benefits implemented to offset them. As a model that integrates early life stages, but not all life stages, SALMOD does not provide a basis to evaluate the subsequent impacts of in-Delta effects on the predicted total annual potential production. However, this modeling does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further, this modeling also does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival. This process may result in refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates.

Table 5.4-46. Mean Annual Potential Production of Winter-Run Chinook Salmon and Differences between Model Scenarios, SALMOD

Analysis Period	Annual Potential Production (# of Fish/year)
All Water Year Types Combined	
Full Simulation Period[1]	
NAA	1,810,410
PA	1,797,449
Difference	-12,961
Percent Difference[2]	-1
Water Year Types[3]	
Wet (32.5%)	
NAA	1,983,169
PA	1,963,584
Difference	-19,584
Percent Difference	-1
Above Normal (12.5%)	

Analysis Period	Annual Potential Production (# of Fish/year)
NAA	1,639,594
PA	1,633,821
Difference	-5,773
Percent Difference	0
Below Normal (17.5%)	
NAA	2,069,244
PA	2,019,856
Difference	-49,389
Percent Difference	-2
Dry (22.5%)	
NAA	1,801,338
PA	1,775,288
Difference	-26,050
Percent Difference	-1
Critical (15%)	
NAA	1,399,166
PA	1,448,020
Difference	48,854
Percent Difference	3

[1] Based on the 80-year simulation period

[2] Relative difference of the annual average

[3] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1995). Water years may not correspond to the biological years in SALMOD.

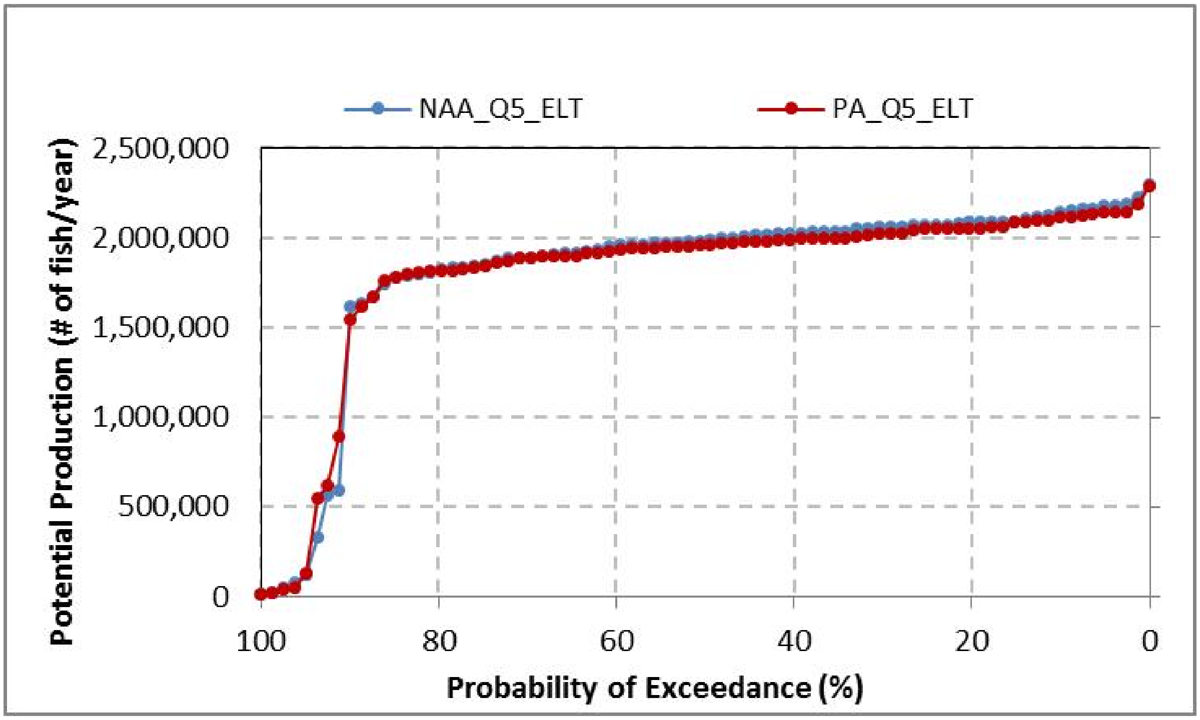

Figure 5.4-112. Exceedance Plot for Annual Potential Production (# of Fish/Year) of Winter-Run Chinook Salmon, SALMOD

The frequency at which annual production was below minimum production thresholds was evaluated as a measure of a worst-case scenario for winter-run Chinook salmon. Thresholds were determined as 5% and 10% of the number of eggs used as inputs into the model (see Attachment 5.D.2, *SALMOD Model*, for details). The initial egg value was 5,913,000 for both NAA and PA and, therefore, the 5% and 10% values were 295,650 fish per year and 591,300 fish per year, respectively. Results are presented in Table 5.4-47. There would be 5 years during which production would be below the 5% (295,650 fish) threshold under both the NAA and PA. There would be 1 year fewer (14% lower) under the PA compared to the NAA during which production would be below the 10% (591,300 fish) threshold. Therefore, the PA would have insignificant effects on the frequency of worst-case scenario years for winter-run Chinook salmon.

Table 5.4-47. Number of Years during which Winter-Run Chinook Salmon Production Would be Lower than Production Thresholds and Differences (Percent Differences) between Model Scenarios, SALMOD

Production Threshold (# of Fish)	NAA (# of Years)	PA (# of Years)	PA vs. NAA (# of Years [%])
295,650 (based on 5% of eggs)	5	5	0 (0%)
591,300 (based on 10% of eggs)	7	6	-1 (-14%)

5.4.2.1.3.2 Spring-run Chinook salmon

5.4.2.1.3.2.1 Spawning, Egg Incubation, and Alevins

5.4.2.1.3.2.1.1 Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA during the August through December spawning and incubation period, with peak occurrence during September and October, for spring-run Chinook salmon (Table 5.4-27). Changes in flow can affect the instream area available for spawning and egg incubation, along with the quality of the habitat, and can result in dewatering or scour of the redds. Shasta Reservoir storage volume at the end of September influences flow rates below the dam during much of the spring-run spawning and egg incubation period. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A*, CALSIM Methods and Results,* Table 5.A.6-3). Mean flow due to the PA at the Keswick Dam and Red Bluff locations in the Sacramento River would be lower than flow under the NAA during November of all except critical water year types, with 26% lower flows under the PA than under the NAA for wet and above normal water year types at Keswick Dam and 21% lower flows at Red Bluff (Appendix 5.A*, CALSIM Methods and Results,* Table 5.A.6-10, Table 5.A.635). During the majority of the remaining months and water year types of the spawning period, changes in mean flow would be minor (less than 5% difference). However, flows under the PA would be 10% lower in August of below normal water years, up to 11% lower in September of above normal and below normal water year types, and up to 11% lower in October of wet years. Flows under the PA in October of below normal year types and November of critical years would be up to 17% greater than flows under the NAA (Appendix 5.A*, CALSIM Methods and Results,* Table 5.A.6-10, Table 5.A.6-35). During the September and October peak spring-run spawning period, flow reductions would be greater than 5% for several water year types. The results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.1.3.2.1.1.1 Spawning WUA

Because, as described in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*, spawning habitat for spring-run Chinook salmon was not estimated directly by USFWS (2003b, 2006) and no spring-run Chinook salmon WUA curves are provided, spring-run Chinook salmon spawning habitat was modeled using the WUA curves provided for fall-run Chinook salmon. The spawning WUA curves for fall-run Chinook salmon were used because the spawning and incubation period of fall-run is similar to that of spring-run, and because this substitution follows previous practice (Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods).* However, as noted by USFWS (2003a), the validity of using the fall-run WUA curves to characterize spring-run spawning habitat is uncertain. To evaluate the effects of the PA on spring-run spawning habitat, spring-run spawning WUA was estimated for flows during the August through December spawning period under the NAA and the PA in the same three segments of the Sacramento River that were used for winter-run: Segment 4 (Battle Creek to the confluence with Cow Creek), Segment 5 (Cow Creek to the A.C.I.D. Dam), and Segment 6 (A.C.I.D. Dam to Keswick Dam). According to the CDFW aerial surveys (Table 5.4-28), about 12% of spring-run redds occur within Segment 6, over 60% are found within Segment 5, and over 7% are in Segment 4.

Differences in spring-run spawning WUA under the PA and NAA were examined using exceedance plots of monthly mean WUA for the spring-run spawning period in each of the river segments for each water year type and all water year types combined Figure 5.4-109 through Figures 5.4-126). The exceedance curves for the PA for all water years combined are similar to or slightly higher than those for the NAA for all three river segments (Figure 5.4-113, Figure 5.4-119, and Figure 5.4-125). With the curves broken out by water year type, increases in WUA under the PA are evident for wet and above normal water year types in all three river segments and for below normal years in Segments 6 and 5 (Figure 5.4-114 through Figure 5.4-116, Figure 5.4-120 through Figure 5.4-122, and Figure 5.4-126 through Figure 5.4-127). Reductions in WUA are evident for critical water years in Segments 6 and 5 (Figure 5.4-118 and Figure 5.4-124).

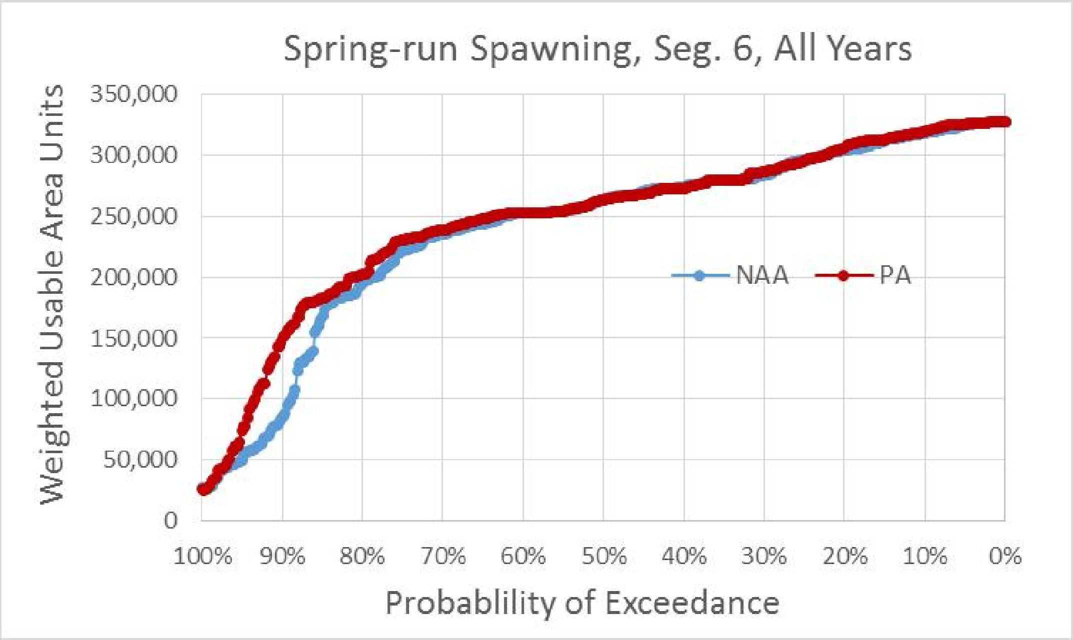

Figure 5.4-113. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

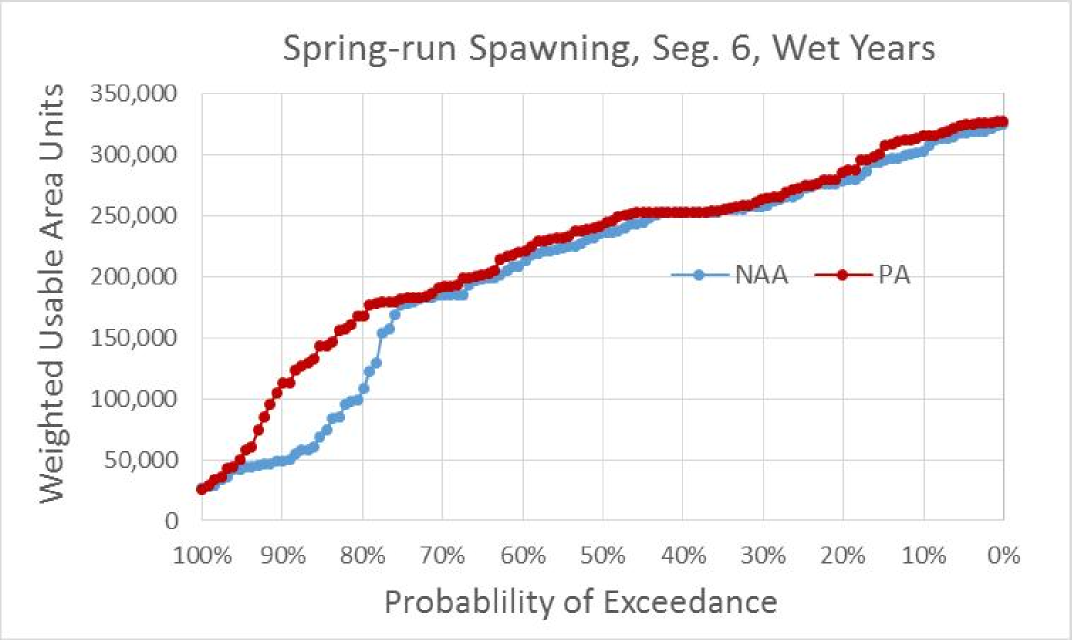

Figure 5.4-114. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

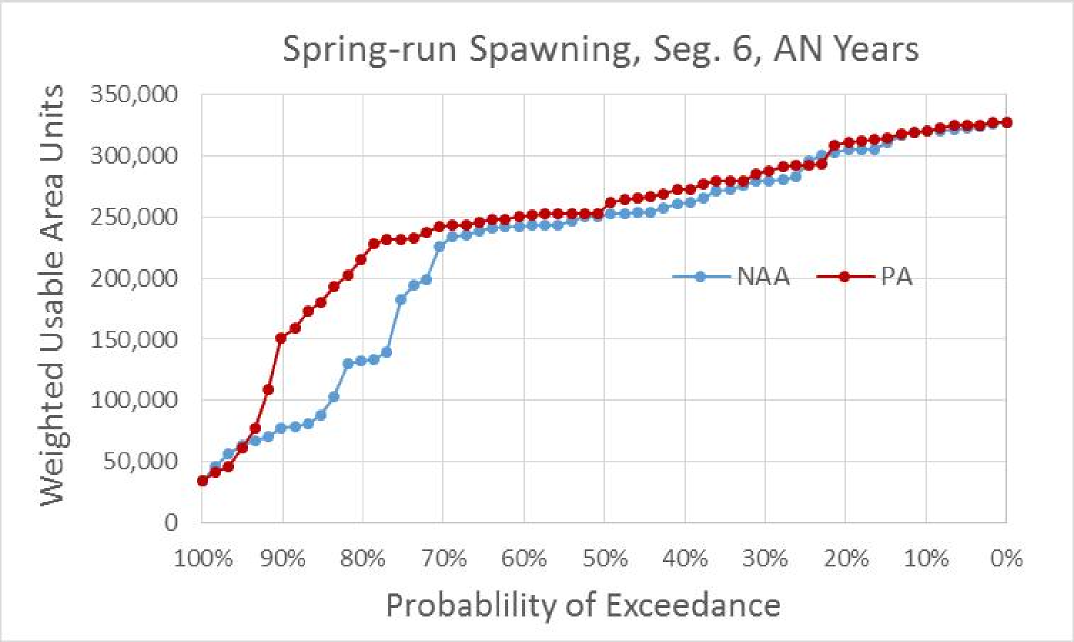

Figure 5.4-115. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

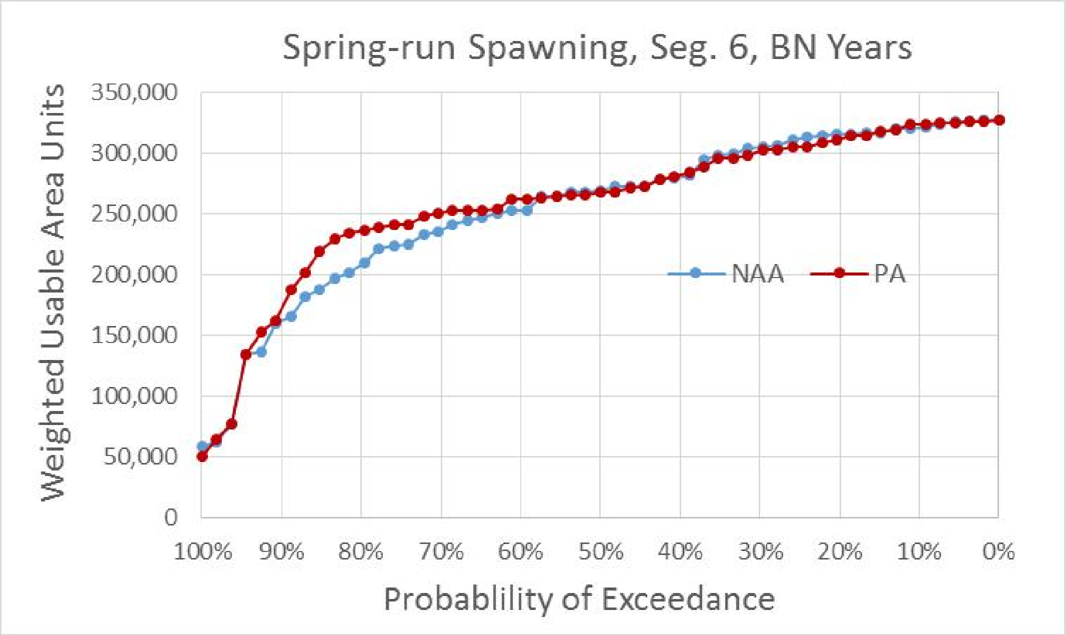

Figure 5.4-116. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

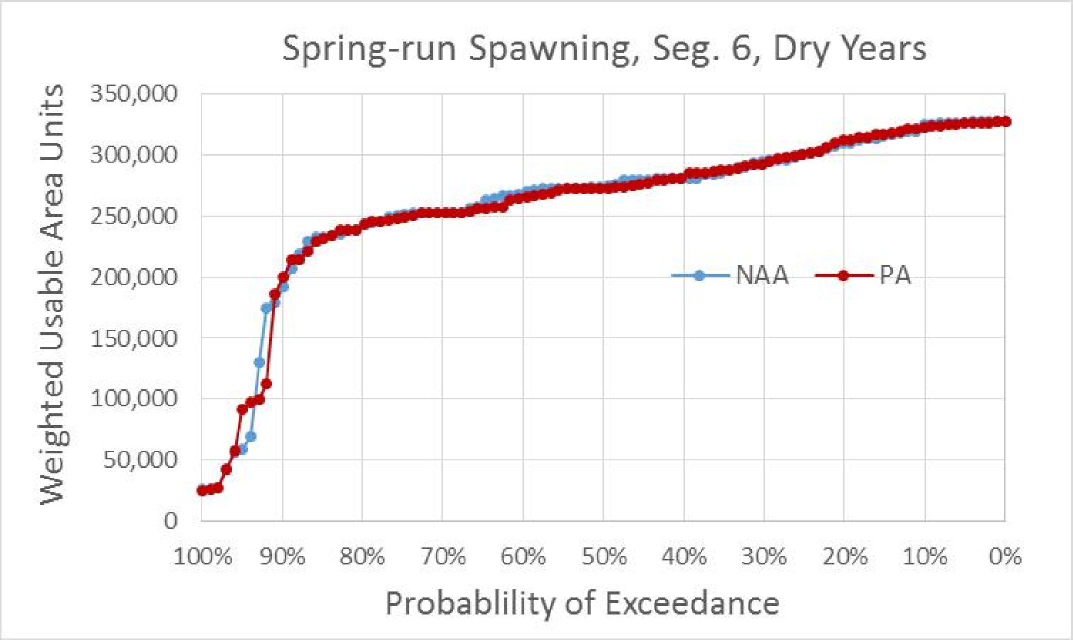

Figure 5.4-117. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

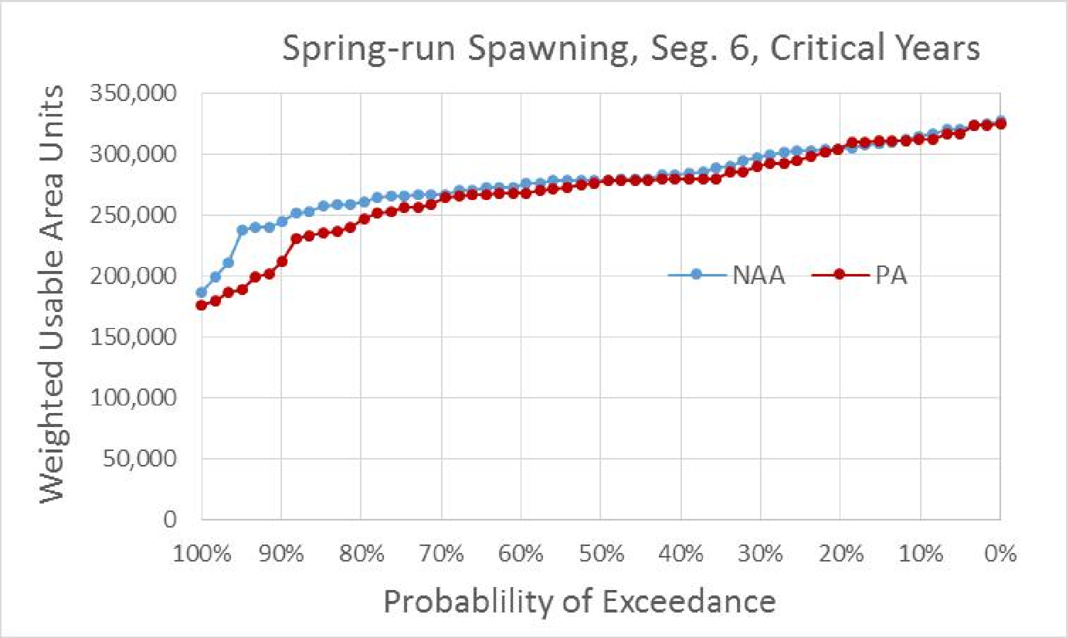

Figure 5.4-118. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

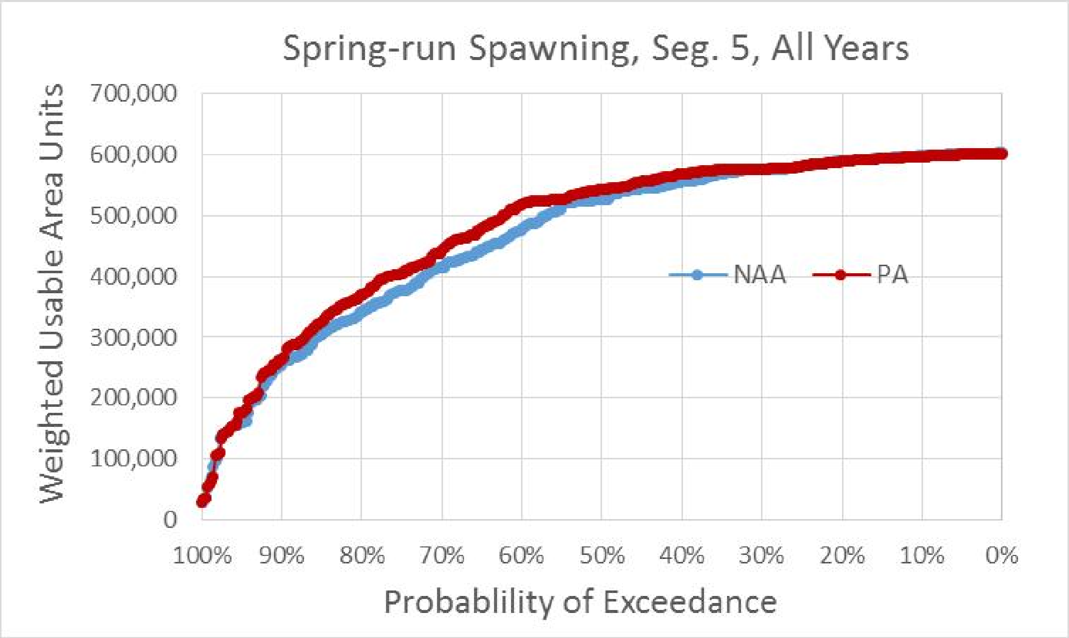

Figure 5.4-119. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

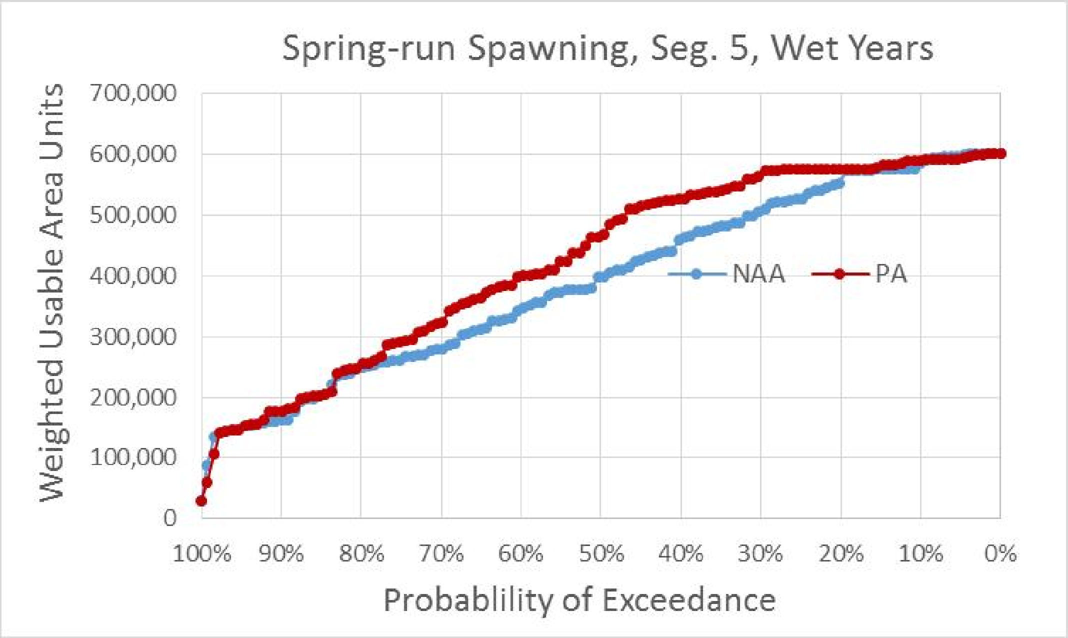

Figure 5.4-120. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

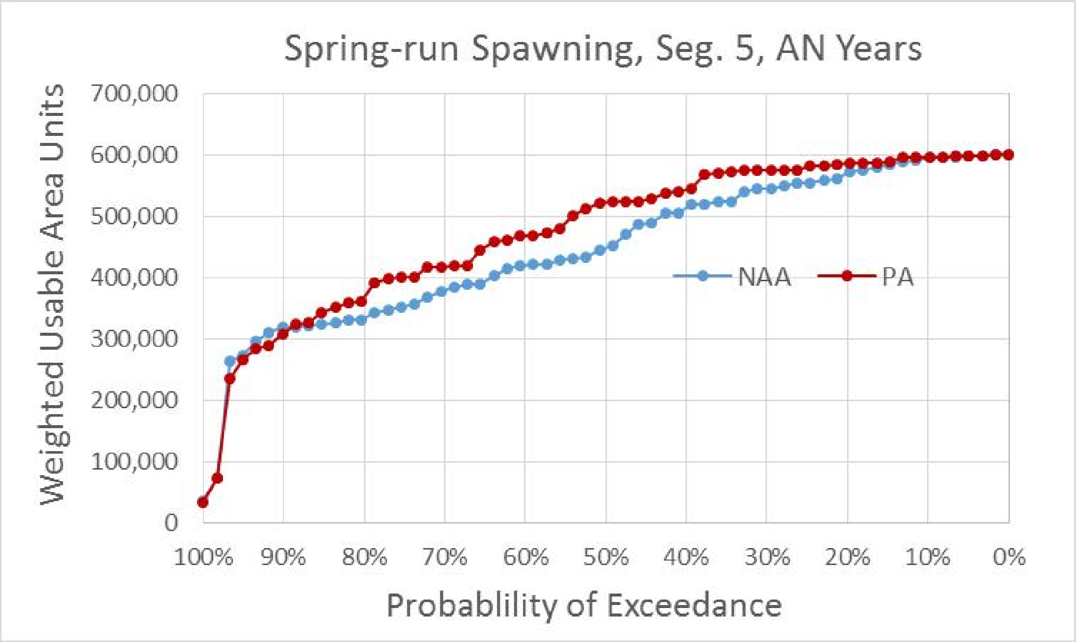

Figure 5.4-121. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

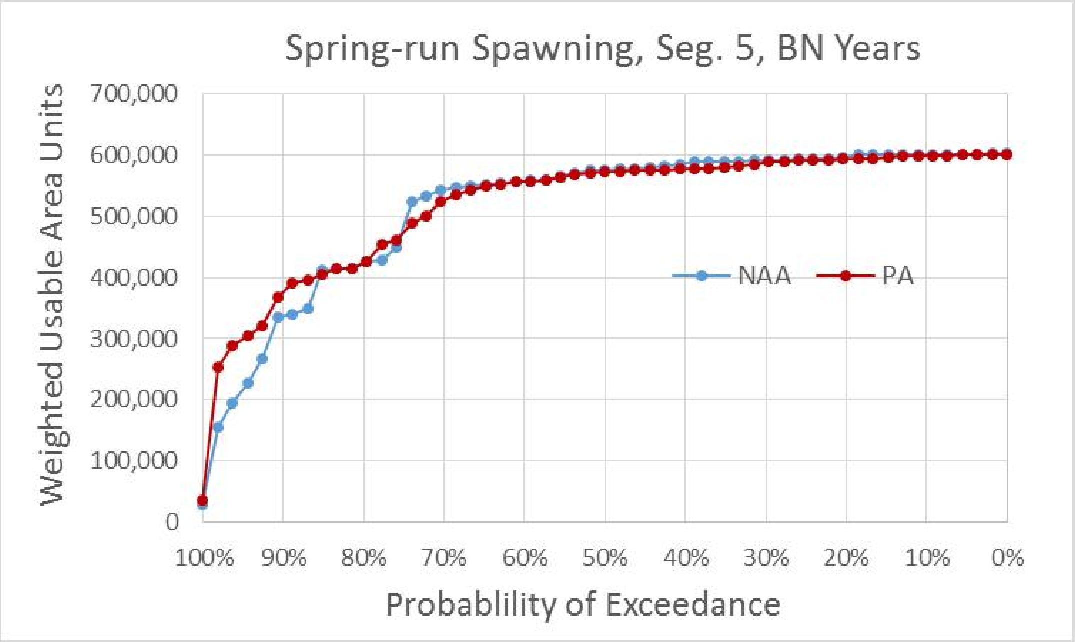

Figure 5.4-122. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

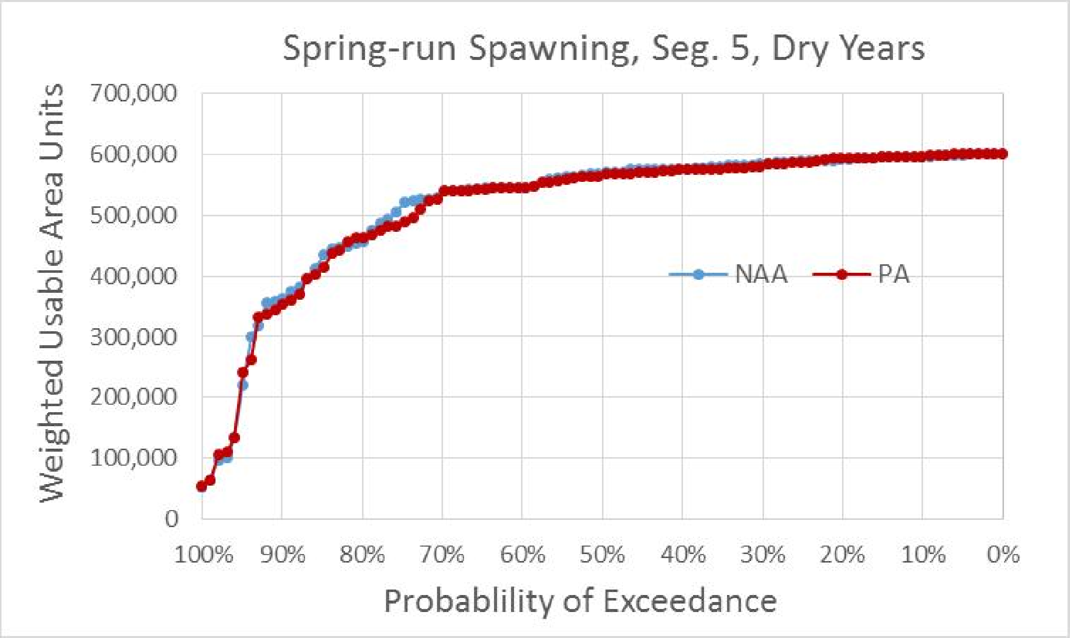

Figure 5.4-123. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

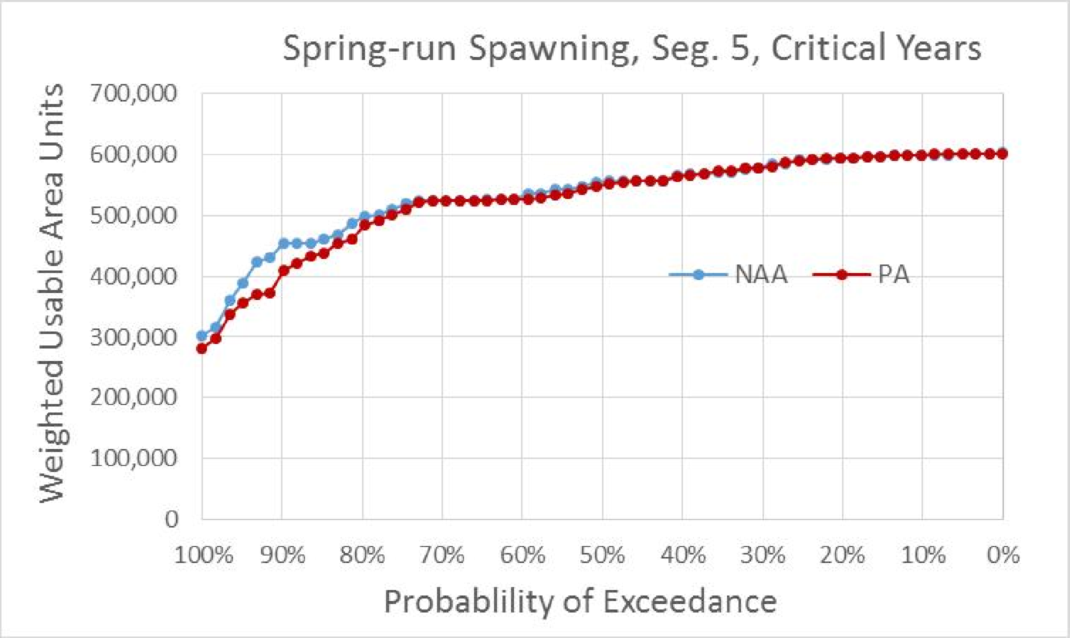

Figure 5.4-124. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

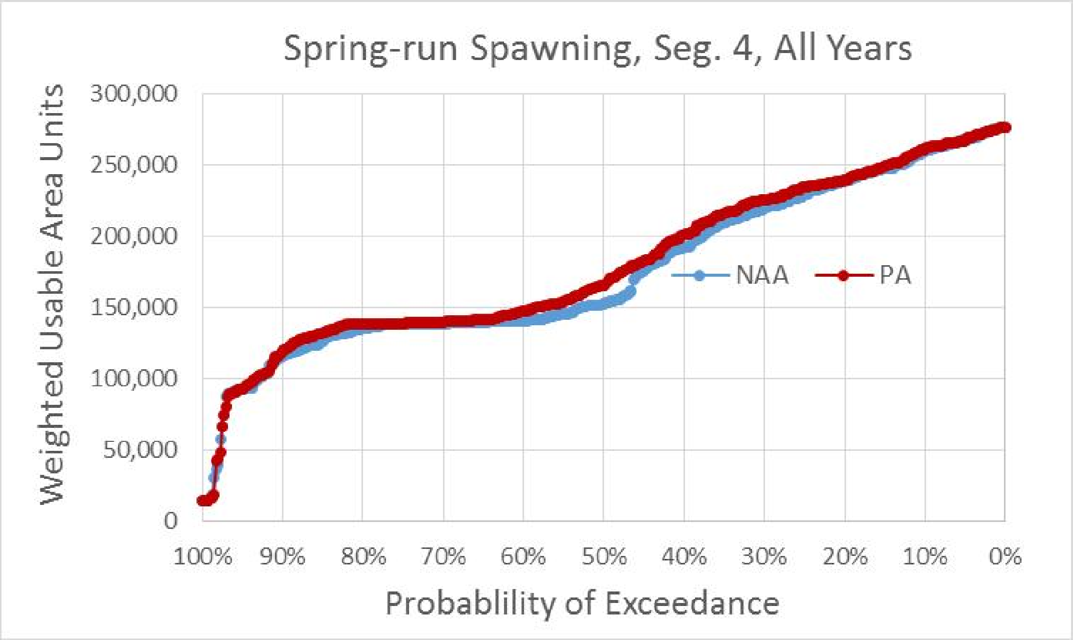

Figure 5.4-125. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

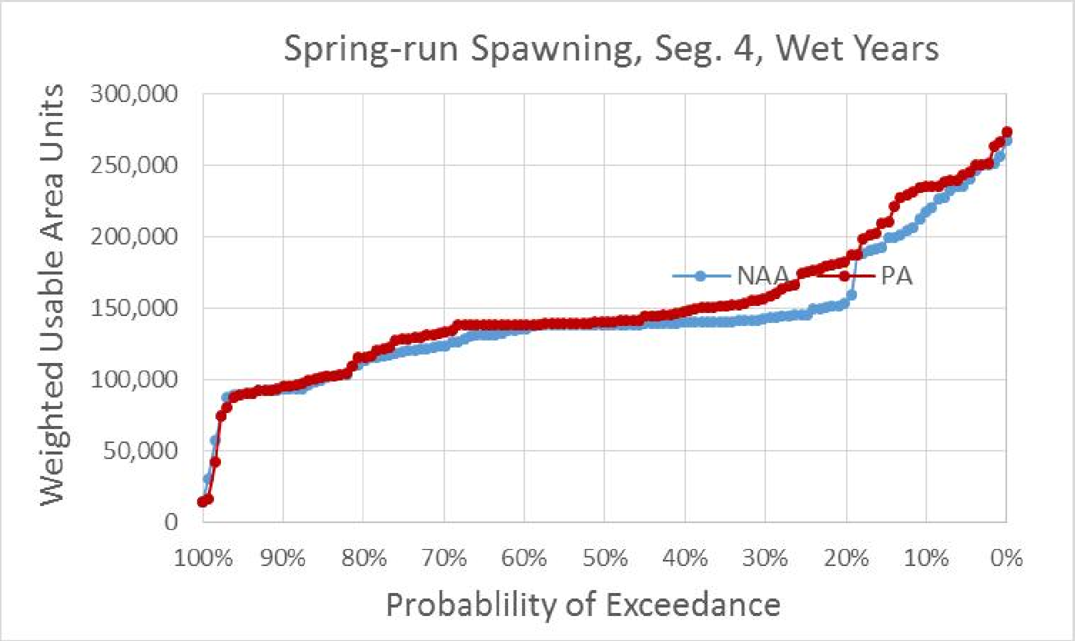

Figure 5.4-126. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

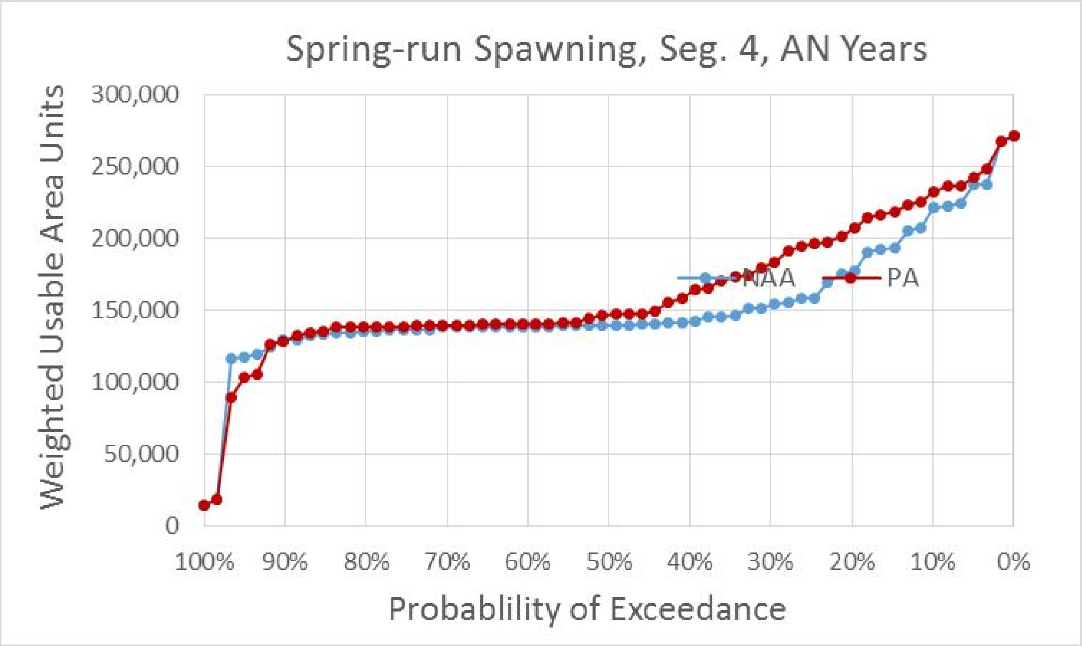

Figure 5.4-127. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

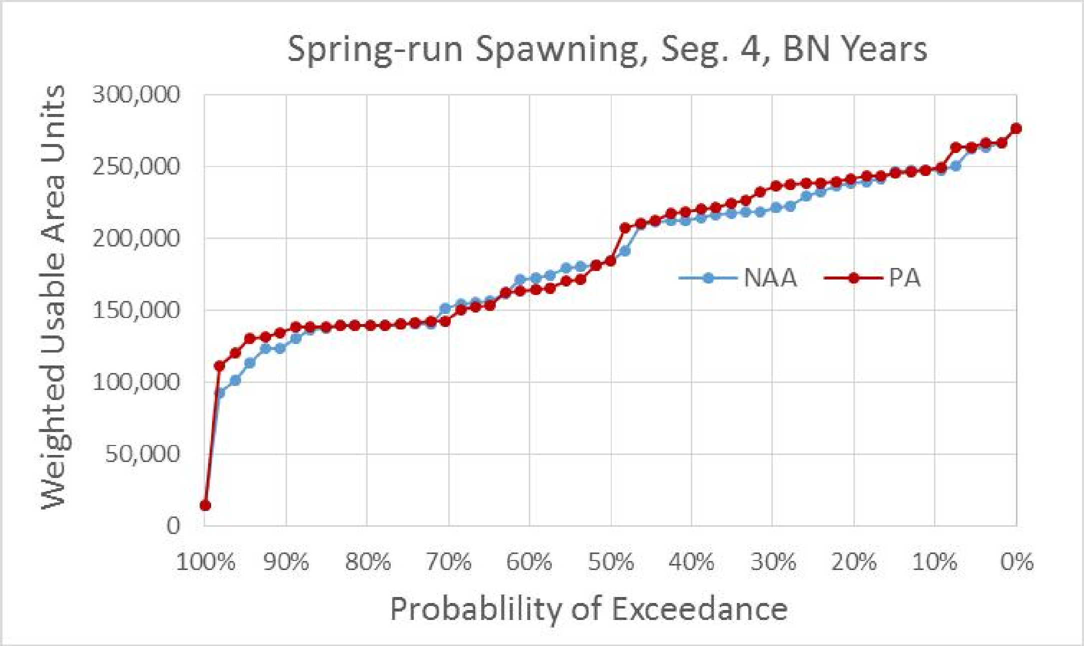

Figure 5.4-128. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

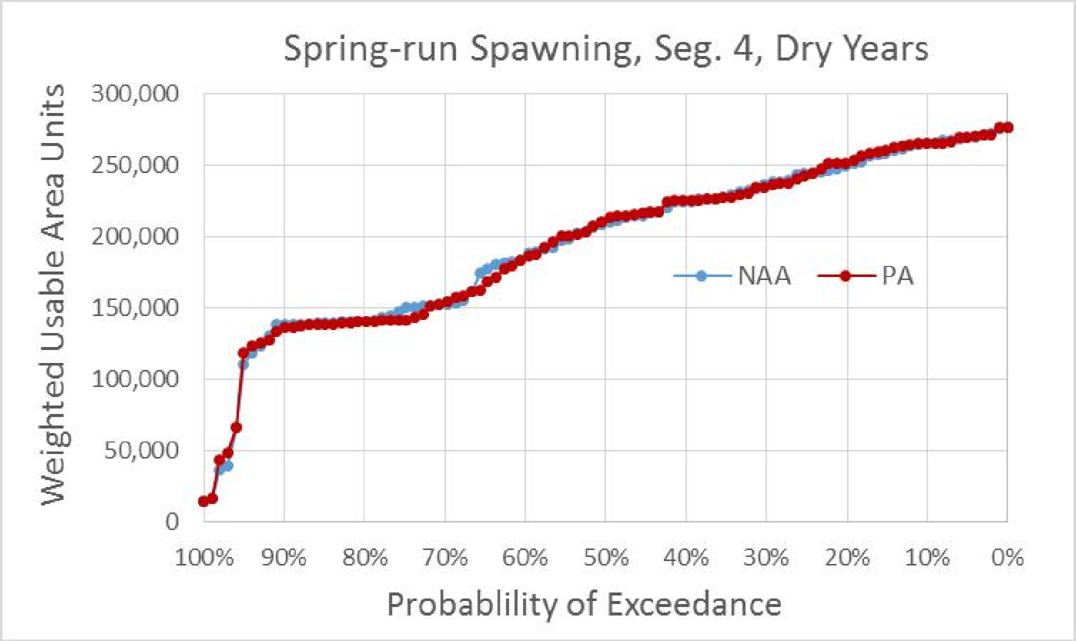

Figure 5.4-129. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

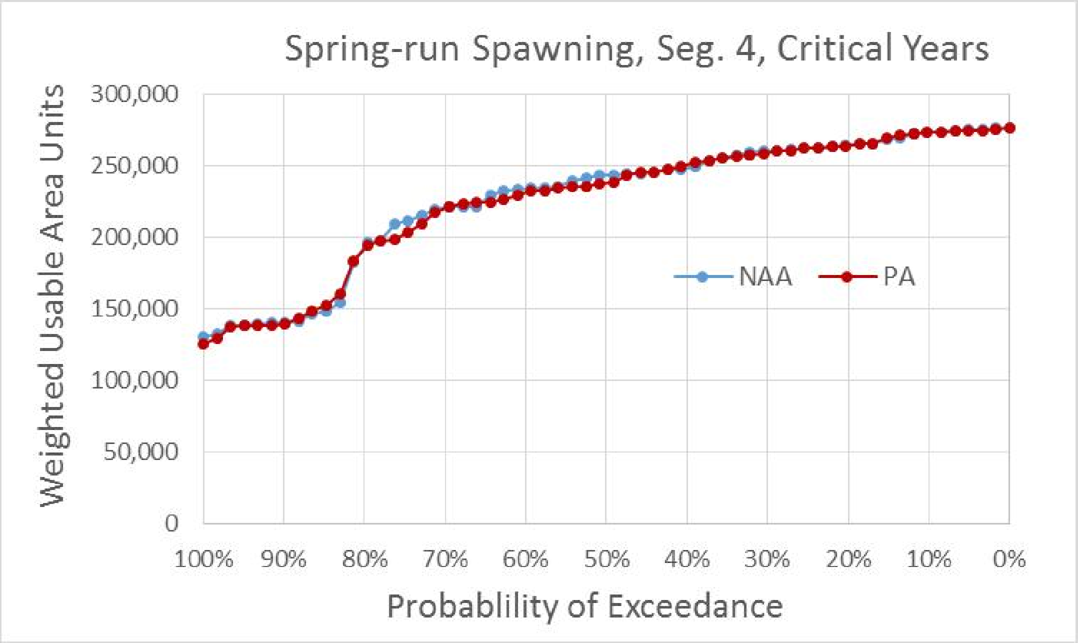

Figure 5.4-130. Exceedance Plot of Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in spawning WUA in each river segment under the PAA and NAA were also examined using the grand mean spawning WUA for each month of the spawning period under each water year type and all water year types combined (Table 5.4-48 to Table 5.4-50). Mean WUA would increase under the PA during November of wet and above normal years in all three segments by 18% to 84%. As noted above, mean flows in the Sacramento River are expected to be 21% to 26% lower under the PA during November of wet and above normal years, showing that reduced flow may enhance spawning WUA under some conditions. Mean WUA would be 5% lower under the PA than under the NAA during September of critical year types in Segment 6, and up to 13% lower during October of below normal and dry water year types in Segment 4. September and October are the peak spawning months for spring-run Chinook salmon.

Table 5.4-48. Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) and Differences (Percent Differences) in River Segment 6 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
August	Wet	251,743	250,121	-1,622 (-0.6%)
	Above Normal	249,843	249,892	50 (0.02%)
	Below Normal	242,565	260,419	17,854 (7%)
	Dry	275,674	268,798	-6,876 (-2%)
	Critical	278,675	272,849	-5,826 (-2%)
	All	259,988	259,347	-641 (-0.2%)
September	Wet	211,699	214,296	2,598 (1%)
	Above Normal	276,118	295,892	19,774 (7%)
	Below Normal	310,740	302,440	-8,300 (-3%)
	Dry	297,451	292,461	-4,990 (-2%)
	Critical	295,609	280,631	-14,979 (-5%)
	All	268,392	267,828	-564 (0%)
October	Wet	299,153	309,714	10,561 (4%)
	Above Normal	314,152	310,779	-3,373 (-1%)
	Below Normal	315,959	316,970	1,010 (0.3%)
	Dry	304,903	313,978	9,075 (3%)
	Critical	285,343	276,228	-9,115 (-3%)
	All	303,031	306,949	3,918 (1.3%)
November	Wet	85,349	144,206	58,856 (69%)
	Above Normal	98,745	181,551	82,805 (84%)
	Below Normal	205,611	218,534	12,923 (6%)
	Dry	226,866	229,131	2,266 (1%)
	Critical	263,119	246,772	-16,348 (-6%)
	All	164,944	195,997	31,052 (19%)

Month	WYT	NAA	PA	PA vs. NAA
December	Wet	189,341	192,905	3,565 (2%)
	Above Normal	186,103	186,289	186 (0.1%)
	Below Normal	198,802	198,407	-395 (-0.2%)
	Dry	192,969	189,522	-3,447 (-2%)
	Critical	274,875	276,177	1,303 (0.5%)
	All	203,713	204,173	460 (0.2%)

Table 5.4-49. Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) and Differences (Percent Differences) in River Segment 5 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
August	Wet	357,991	352,739	-5,253 (-1%)
	Above Normal	349,522	350,996	1,474 (0.4%)
	Below Normal	331,458	384,187	52,730 (16%)
	Dry	430,234	408,673	-21,561 (-5%)
	Critical	441,885	425,204	-16,681 (-4%)
	All	382,986	380,928	-2,058 (-0.5%)
September	Wet	236,285	242,981	6,696 (3%)
	Above Normal	430,088	490,178	60,089 (14%)
	Below Normal	585,549	589,389	3,840 (0.7%)
	Dry	579,037	577,758	-1,280 (-0.2%)
	Critical	579,158	563,100	-16,058 (-3%)
	All	447,637	457,140	9,502 (2.1%)
October	Wet	498,680	538,887	40,207 (8%)
	Above Normal	552,311	545,589	-6,721 (-1%)
	Below Normal	585,179	557,994	-27,185 (-5%)
	Dry	572,802	575,143	2,341 (0.4%)
	Critical	567,178	551,594	-15,584 (-3%)
	All	546,822	553,309	6,488 (1.2%)
November	Wet	380,656	520,050	139,394 (37%)
	Above Normal	422,460	533,933	111,473 (26%)
	Below Normal	587,346	586,203	-1,143 (-0.2%)
	Dry	564,042	569,862	5,820 (1%)
	Critical	539,474	552,498	13,024 (2%)
	All	483,727	548,197	64,470 (13%)

Month	WYT	NAA	PA	PA vs. NAA
December	Wet	475,398	457,821	-17,577 (-4%)
	Above Normal	493,732	461,657	-32,075 (-6%)
	Below Normal	475,415	470,507	-4,908 (-1%)
	Dry	432,047	432,627	580 (0.1%)
	Critical	535,780	532,304	-3,475 (-0.6%)
	All	476,358	464,926	-11,432 (-2%)

Table 5.4-50. Spring-Run Chinook Salmon Spawning Weighted Usable Area (WUA) and Differences (Percent Differences) in River Segment 4 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
August	Wet	134,404	133,896	-508 (-0.4%)
	Above Normal	136,051	136,053	2 (0%)
	Below Normal	127,707	136,842	9,135 (7%)
	Dry	142,402	140,006	-2,396 (-2%)
	Critical	148,854	149,882	1,029 (0.7%)
	All	137,832	138,463	631 (0%)
September	Wet	110,983	111,256	272 (0.2%)
	Above Normal	146,690	152,626	5,936 (4%)
	Below Normal	219,170	240,628	21,457 (10%)
	Dry	242,792	252,590	9,798 (4%)
	Critical	242,618	252,566	9,948 (4%)
	All	182,569	190,321	7,751 (4%)
October	Wet	155,097	167,335	12,237 (8%)
	Above Normal	168,198	169,618	1,420 (0.8%)
	Below Normal	194,636	169,106	-25,530 (-13%)
	Dry	203,681	188,415	-15,266 (-7%)
	Critical	233,616	231,468	-2,148 (-1%)
	All	186,036	182,620	-3,416 (-2%)
November	Wet	131,699	156,053	24,354 (18%)
	Above Normal	131,743	172,295	40,553 (31%)
	Below Normal	198,448	210,003	11,555 (6%)
	Dry	211,308	216,165	4,858 (2%)
	Critical	261,540	245,589	-15,950 (-6%)
	All	179,662	193,893	14,231 (8%)

Month	WYT	NAA	PA	PA vs. NAA
December	Wet	182,846	186,060	3,215 (2%)
	Above Normal	183,340	184,920	1,579 (0.9%)
	Below Normal	193,754	192,608	-1,146 (-0.6%)
	Dry	176,833	179,354	2,521 (1%)
	Critical	248,662	250,069	1,407 (0.6%)
	All	192,666	194,607	1,941 (1%)

5.4.2.1.3.2.1.1.2 Redd scour

The probability of flows occurring under the PA and the NAA that would be high enough to mobilize sediments and scour spring-run Chinook salmon redds was estimated from CALSIM II estimates of mean monthly flows, using a relationship determined from the historical record between actual mean monthly flow and maximum daily flow (Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*). The actual monthly and daily flow data used in the analysis are from gage records just below Keswick Dam and at Bend Bridge, and the CALSIM II estimates used to compare probabilities of redd scour for the PA and the NAA are for the Keswick Dam and Red Bluff locations. As discussed in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*, 40,000 cfs is treated as the minimum daily flow at which redd scour occurs in the Sacramento River. The analysis of the Keswick Dam gage data shows that for months with a mean monthly flow of at least 27,300 cfs, the maximum daily flow in that month is always at least 40,000 cfs. The Bend Bridge gage data show that for months with a mean flow of at least 21,800 cfs, the maximum daily flow in that month is always 40,000 cfs. Therefore, redd scour probabilities for the PA and the NAA were evaluated by comparing frequencies of CALSIM II flows greater than 27,300 cfs at Keswick Dam or greater than 21,800 cfs at Red Bluff during the spring-run August through December spawning and incubation period. Further information on the redd scour analysis methods is provided in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*.

Table 5.4-53 shows that fewer than 5% of months in the CALSIM II record during the spawning and incubation period of spring-run Chinook salmon (August through December) would have flows of more than 27,300 cfs at Keswick Dam or more than 21,800 cfs at Red Bluff. This was expected, given that all of the months of the spring-run spawning and incubation period except December rarely experience such high flows. Water years and months with mean monthly flow greater than 27,300 cfs predicted at Keswick Dam for the spring-run spawning and incubation period (under either the PA or the NAA or both) are listed in Table 5.4-46a, and those with mean monthly flow greater than 21,800 cfs predicted at Red Bluff are listed in Table 5.4.46b. Differences between the PA and the NAA in the percentage of scouring flows at either location are insignificant.

Table 5.4-51. Water Years and Months with Mean Flow > 27,300 cfs at Keswick Dam for the PA and/or the NAA during the Spring-run Chinook Salmon Spawning and Incubation Period

Water Year	Month	WYT	Flow (cfs)	
			NAA	PA
1945	December	Below Normal	31,540	29,102
1955	December	Dry	27,318	26,935
1973	November	Above Normal	29,514	29,913
1983	December	Wet	33,201	33,201

Table 5.4-52. Water Years and Months with Mean Flow > 21,800 cfs at Red Bluff for the NAA and/or the NAA during the Spring-run Chinook Salmon Spawning and Incubation Period

Water Year	Month	WYT	Flow (cfs)	
			NAA	PA
1937	December	Dry	30,649	30,029
1940	December	Above Normal	20,610	22,620
1941	December	Wet	21,964	23,292
1945	December	Below Normal	44,541	42,119
1950	December	Dry	24,773	24,789
1951	December	Above Normal	20,624	23,775
1955	December	Dry	43,925	43,545
1958	December	Wet	22,228	22,228
1964	December	Dry	34,329	32,345
1969	December	Wet	26,013	28,454
1973	November	Above Normal	38,394	38,789
1973	December	Above Normal	33,753	33,749
1981	December	Dry	38,173	38,204
1982	December	Wet	23,928	23,927
1983	December	Wet	53,169	53,169
1996	December	Wet	30,177	34,956
2002	December	Dry	22,758	21,248

Note that SALMOD also predicts redd scour risk for spring-run Chinook salmon in the Sacramento River, although it is combined with redd dewatering and the combination is reported as "Incubation" mortality. Please see Table 5.4-50 below for these results.

5.4.2.1.3.2.1.1.3 Redd dewatering

The percentage of spring-run Chinook salmon redds dewatered by reductions in Sacramento River flow was estimated from CALSIM II estimates of monthly mean flows during the 3 months following each of the months that spring-run spawn (Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods,* Table 5.D-54). This analysis employed functional relationships developed in field studies by USFWS (2006) that predicted percentages of redds dewatered from an array of paired spawning and dewatering flows. As described above for the spawning WUA analyses, redd dewatering for spring-run was modeled using the relationship developed for fall-run Chinook salmon. Because, as noted in Section 5.4.2.1.3.1.1.1.1, *Spawning WUA*, spring-run spawning has peaked, on average, in river Segment 5 based on recent redd surveys, the Segment 5 CALSIM II flows were used to estimate redd dewatering under the PA and NAA. The CALSIM II flows for Segments 4 and 6 are similar to those for Segment 5, so redd dewatering estimates using the Segment 4 and Segment 6 flows differ little from those for Segment 5 (Appendix 5.D, Section 2.6, *Redd Dewatering Results, Sacramento River Segments 4 and 6*). Further information on the redd dewatering analysis methods is provided in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*.

Differences in spring-run redd dewatering under the PA and NAA were examined using exceedance plots of mean monthly percent dewatered for the August through October months that spring-run spawn. The exceedance curves for the PA generally show slightly higher redd dewatering percentages than those for the NAA for all water year types combined, and substantially higher dewatering percentages for above normal and below normal water year types in particular (Figure 5.4-131 through Figure 5.4-136). The biggest differences in the dewatering curves are predicted for above normal water years, with about 24% of all months having greater than 20% of redds dewatered under the NAA, but about 43% of all months having greater than 20% of redds dewatered under the PA.

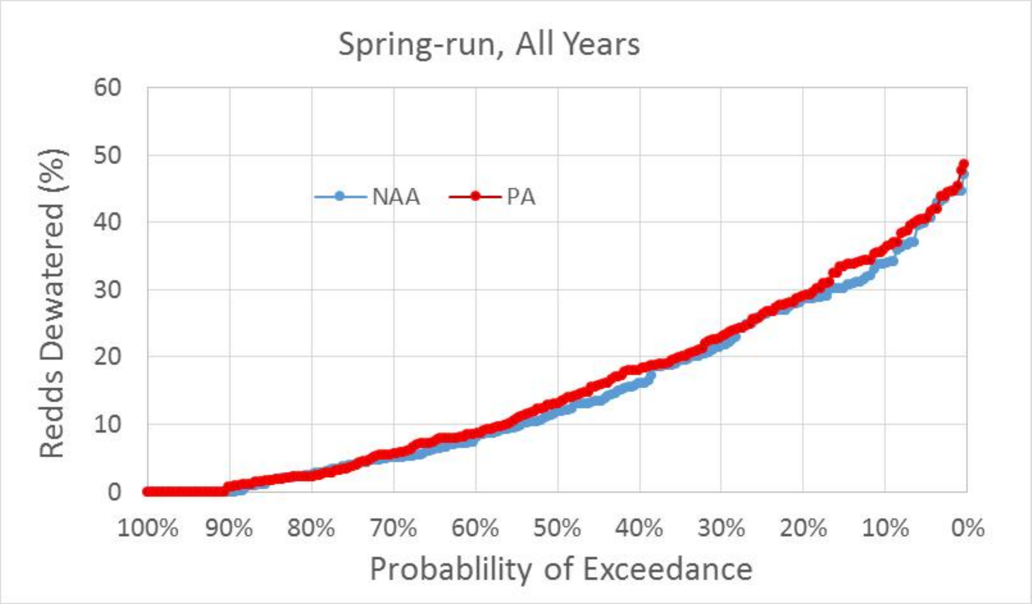

Figure 5.4-131. Exceedance Plot of Spring-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, All Water Years

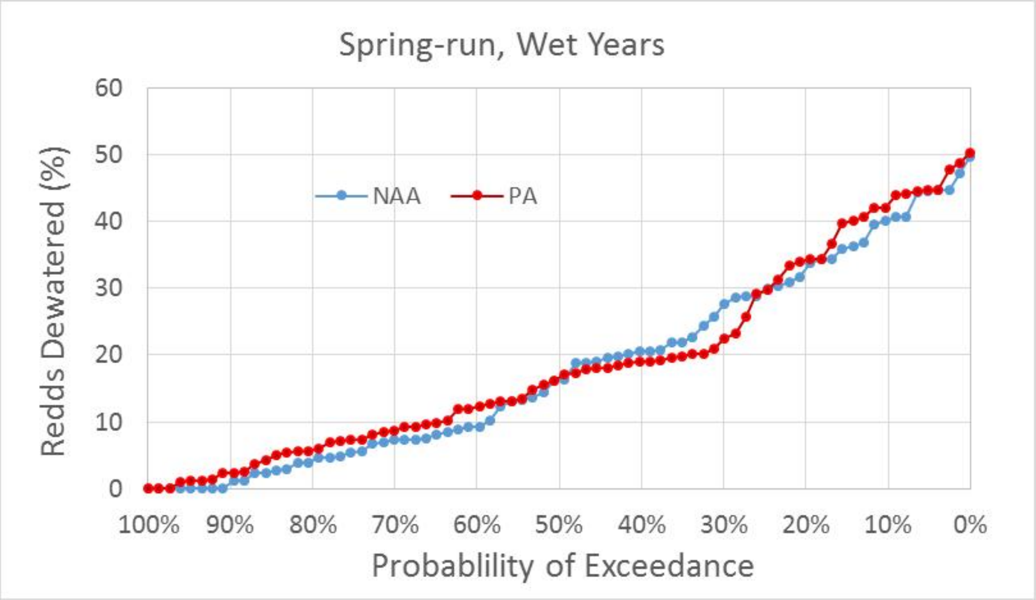

Figure 5.4-132. Exceedance Plot of Spring-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, Wet Water Years

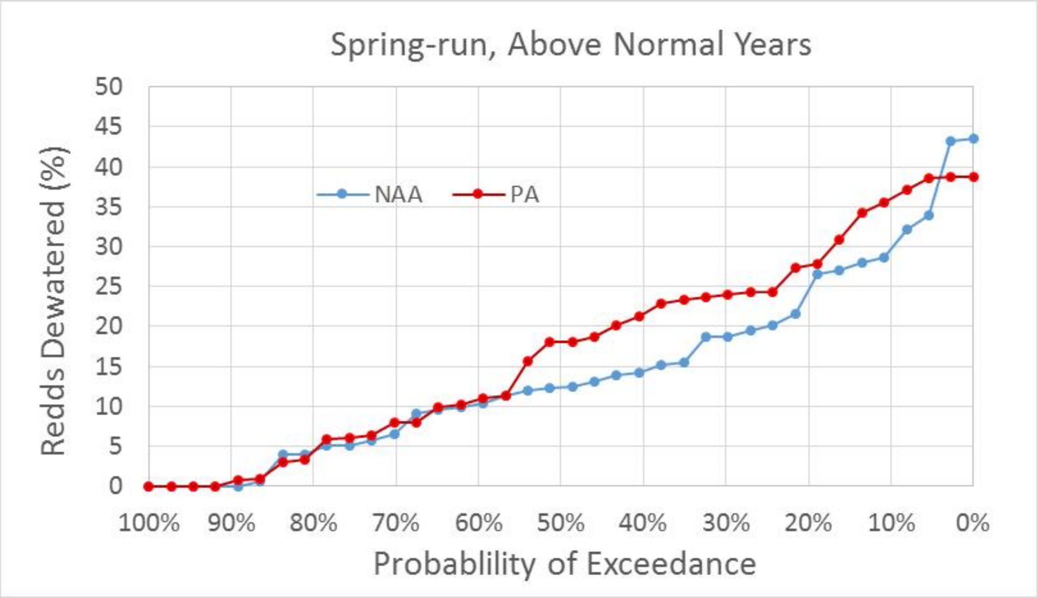

Figure 5.4-133. Exceedance Plot of Spring-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, Above Normal Water Years

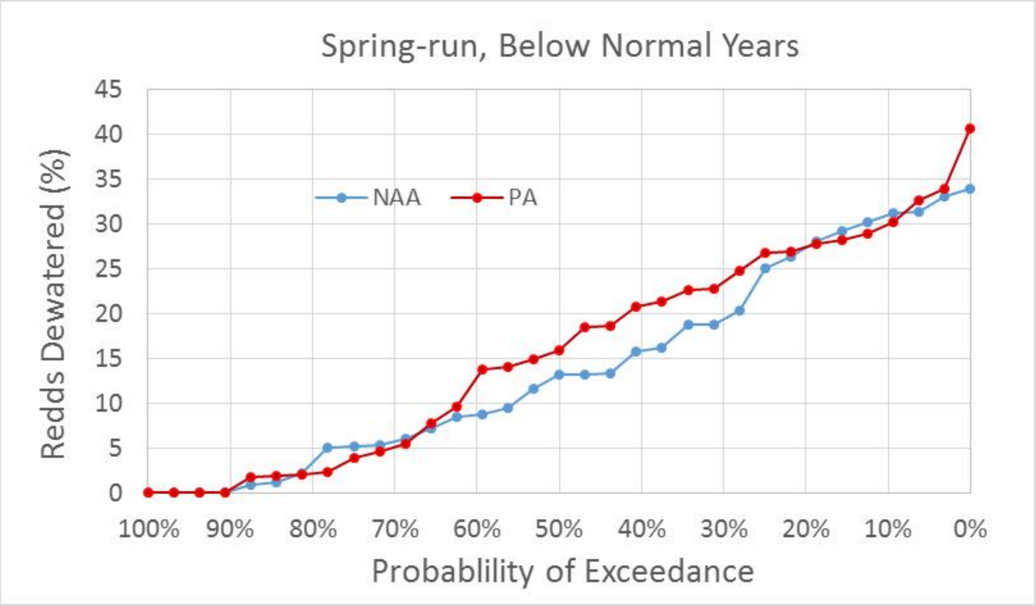

Figure 5.4-134. Exceedance Plot of Spring-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, Below Normal Water Years

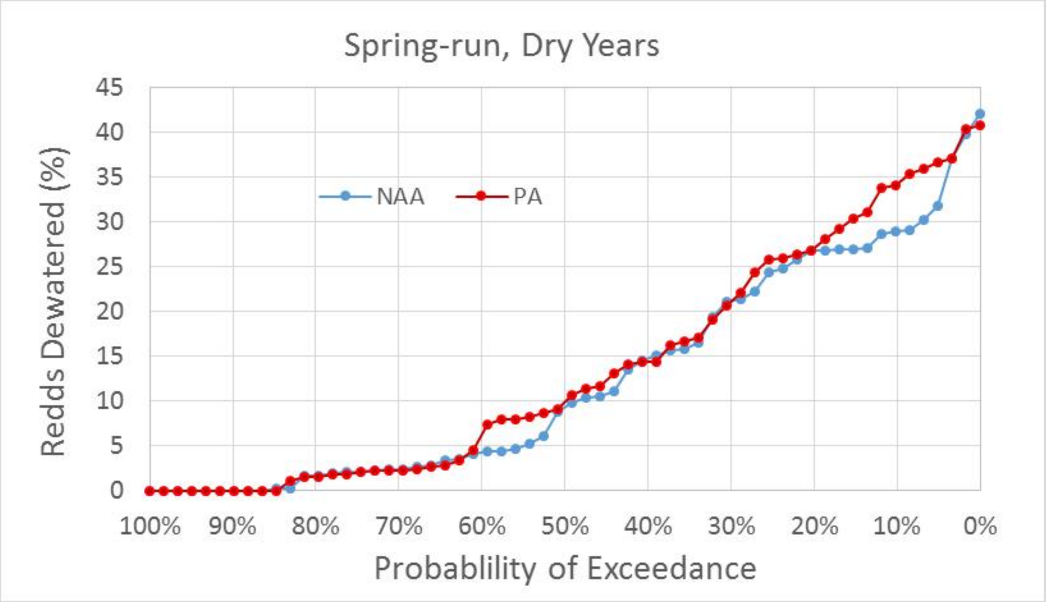

Figure 5.4-135. Exceedance Plot of Spring-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, Dry Water Years

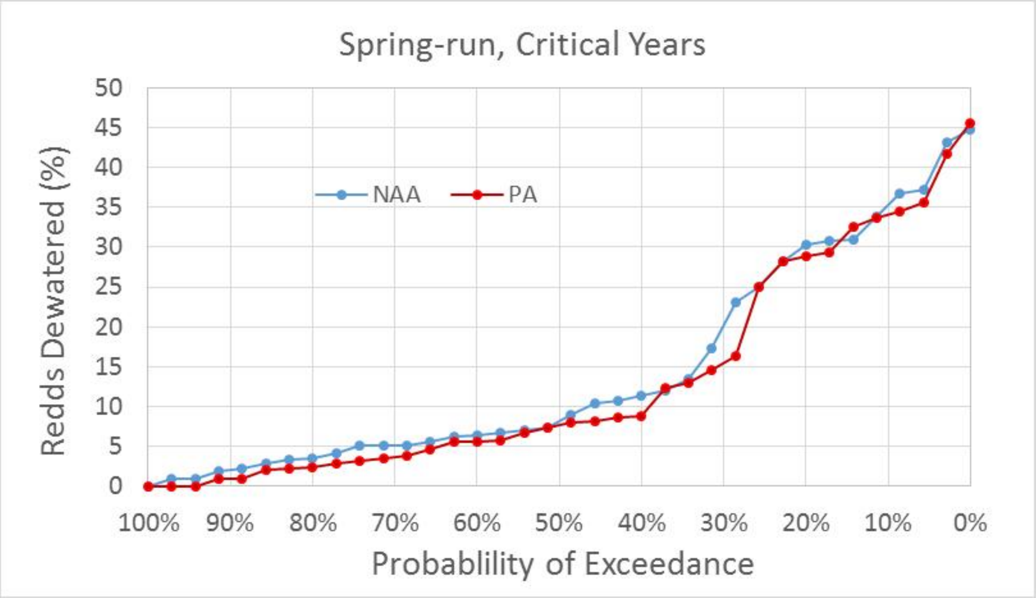

Figure 5.4-136. Exceedance Plot of Spring-Run Chinook Salmon Percent of Redds Dewatered for NAA and PA Model Scenarios, Critical Water Years

Differences in redd dewatering between the PA and NAA were also examined using the grand mean percentages of redds dewatered for each month of spawning under each water type and all water year types combined (Table 5.4-53). During August, the mean percent of redds dewatered would be 5% and 8% greater under the PA than under the NAA in wet and above normal water years, respectively. During October, the mean under the PA would be 5% lower in wet years and 6% higher in below normal years. During September of below normal water years, the mean percent of redds dewatered would be up to 3% lower under the PA than under the NAA. The percent differences between the PA and the NAA in the percent of redds dewatered are generally large, but for many months and water year types this is an artifact of the low percentages of redds dewatered under both scenarios. These results indicate that, in general, a greater percentage of spring-run Chinook salmon redds would be dewatered in August under the PA, but the differences, on balance, would be insignificant between the PA and the NAA during September and October. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

Table 5.4-53. Spring-Run Chinook Salmon Percent of Redds Dewatered (Percent of Total Redds) and Differences (Percent Differences) between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)

Month	WYT	NAA	PA	PA vs. NAA
August	Wet	10.0	15.0	5 (50%)
	Above Normal	13.0	21.4	8 (64%)
	Below Normal	27.9	29.4	1 (5%)
	Dry	27.1	29.4	2 (9%)
	Critical	30.9	29.7	-1 (-4%)
	All	20.1	23.6	3 (17%)
September	Wet	30.2	31.9	2 (6%)
	Above Normal	17.9	16.5	-1 (-8%)
	Below Normal	5.6	2.7	-3 (-52%)
	Dry	3.1	1.9	-1 (-38%)
	Critical	6.0	4.4	-2 (-26%)
	All	14.8	14.2	-0.6 (-4%)
October	Wet	14.5	9.9	-5 (-32%)
	Above Normal	12.4	13.1	1 (5%)
	Below Normal	9.1	15.4	6 (70%)
	Dry	7.9	9.9	2 (26%)
	Critical	6.7	6.1	-1 (-9%)
	All	10.7	10.6	-0.1 (-1%)

5.4.2.1.3.2.1.1.4 SALMOD flow-related outputs

The SALMOD model provides predicted flow-related mortality of spring-run Chinook salmon spawning, eggs, and alevins in the Sacramento River. The SALMOD results for flow-related mortality are presented in Table 5.4-54, together with results for the other sources of mortality of spring-run Chinook salmon predicted by SALMOD and discussed in other sections of this document. The flow-related mortality of spring-run Chinook salmon spawning, eggs, and alevins is split up as “incubation” (which refers to redd dewatering and scour) and “superimposition” (of redds) mortality (see Attachment 5.D.2, *SALMOD Model*, for full model description). The annual exceedance plot of flow-related mortality of spring-run Chinook salmon spawning, eggs, and alevins is presented in Figure 5.4-137. These results indicate that there would be increases in flow-related mortality of spring-run Chinook salmon spawning, eggs, and alevins from incubation-related factors under the PA relative to the NAA for all water year types except dry years. The largest increases, about 30%, would be for wet, above normal and below normal water year types. No mortality is predicted from redd superimposition for either scenario. It should be noted, however, that SALMOD predicts redd superimposition for each race of salmon without consideration of redd densities of the other races. SALMOD predicts no superimposition for spring-run because numbers of spring-run spawners are low. However, the spring-run spawning period (August to December) considerably overlaps that of fall-run Chinook salmon (September through January) and the spawning reaches also overlap, so the SALMOD prediction of low superimposition of spring-run redds may be unreliable.

Table 5.4-54. Mean Annual Spring-Run Chinook Salmon Mortality[1] (# of Fish/Year) Predicted by SALMOD

	Spawning, Egg Incubation, and Alevins							Fry and Juvenile Rearing									
	Temperature-Related Mortality			Flow-Related Mortality				Temperature-Related Mortality				Flow-Related Mortality					
Analysis Period	**Pre-Spawn**	**Eggs**	**Subtotal**	**Incubation**	**Super-imposition**	**Subtotal**	**Life Stage Total**	**Fry**	**Pre-smolt**	**Immature Smolt**	**Subtotal**	**Fry**	**Pre-smolt**	**Immature Smolt**	**Subtotal**	**Life Stage Total**	**Grand Total**
All Water Year Types2																	
NAA	46,032	124,013	170,045	1,905	0	1,905	171,950	1	0	0	1	2,265	0	0	2,265	2,265	174,215
PA	50,462	107,473	157,935	2,118	0	2,118	160,053	0	0	0	0	2,273	0	0	2,273	2,273	162,325
Difference	4,431	-16,540	-12,110	212	0	212	-11,898	-1	0	0	-1	8	0	0	8	7	-11,890
Percent Difference[3]	10	-13	-7	11	0	11	-7	-100	0	0	-100	0	0	0	0	0	-7
Water Year Types4																	
Wet (32.5%)																	
NAA	116	6,530	6,646	1,336	0	1,336	7,983	0	0	0	0	2,614	0	0	2,614	2,614	10,597
PA	117	5,835	5,952	1,748	0	1,748	7,699	0	0	0	0	2,815	0	0	2,815	2,815	10,514
Difference	1	-695	-695	411	0	411	-283	0	0	0	0	200	0	0	200	200	-83
Percent Difference	0	-11	-10	31	0	31	-4	0	0	0	NA5	8	0	0	8	8	-1
Above Normal (12.5%)																	
NAA	78	4,181	4,258	1,162	0	1,162	5,420	0	0	0	0	2,703	0	0	2,703	2,703	8,124
PA	65	3,888	3,953	1,509	0	1,509	5,463	0	0	0	0	2,354	0	0	2,354	2,354	7,816
Difference	-12	-293	-305	347	0	347	42	0	0	0	0	-350	0	0	-350	-350	-307
Percent Difference	-16	-7	-7	30	0	30	1	0	0	0	NA	-13	0	0	-13	-13	-4
Below Normal (17.5%)																	
NAA	154	34,929	35,084	1,300	0	1,300	36,384	0	0	0	0	2,634	0	0	2,634	2,634	39,018
PA	309	41,242	41,551	1,711	0	1,711	43,262	0	0	0	0	2,591	0	0	2,591	2,591	45,853
Difference	155	6,313	6,467	411	0	411	6,878	0	0	0	0	-43	0	0	-43	-43	6,835
Percent Difference	100	18	18	32	0	32	19	0	0	0	NA	-2	0	0	-2	-2	18
Dry (22.5%)																	
NAA	1,093	66,312	67,406	3,652	0	3,652	71,058	0	0	0	0	2,468	0	0	2,468	2,468	73,526
PA	995	64,050	65,045	3,422	0	3,422	68,467	0	0	0	0	2,438	0	0	2,438	2,438	70,905
Difference	-98	-2,263	-2,361	-230	0	-230	-2,591	0	0	0	0	-30	0	0	-30	-30	-2,621
Percent Difference	-9	-3	-4	-6	0	-6	-4	0	0	0	NA	-1	0	0	-1	-1	-4
Critical (15%)																	
NAA	304,677	671,412	976,089	1,670	0	1,670	977,759	3	0	0	3	408	0	0	408	411	978,170
PA	334,238	560,737	894,976	1,835	0	1,835	896,811	0	0	0	0	463	0	0	463	463	897,274
Difference	29,562	-110,675	-81,113	165	0	165	-80,949	-3	0	0	-3	55	0	0	55	52	-80,897
Percent Difference	10	-16	-8	10	0	10	-8	-100	0	0	-100	14	0	0	14	13	-8

[1] Mortality values do not include base mortality
[2] Based on the 80-year simulation period
[3] Relative difference of the Annual average
[4] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1995). Water years may not correspond to the biological years in SALMOD.
[5] NA = Unable to calculate because dividing by 0

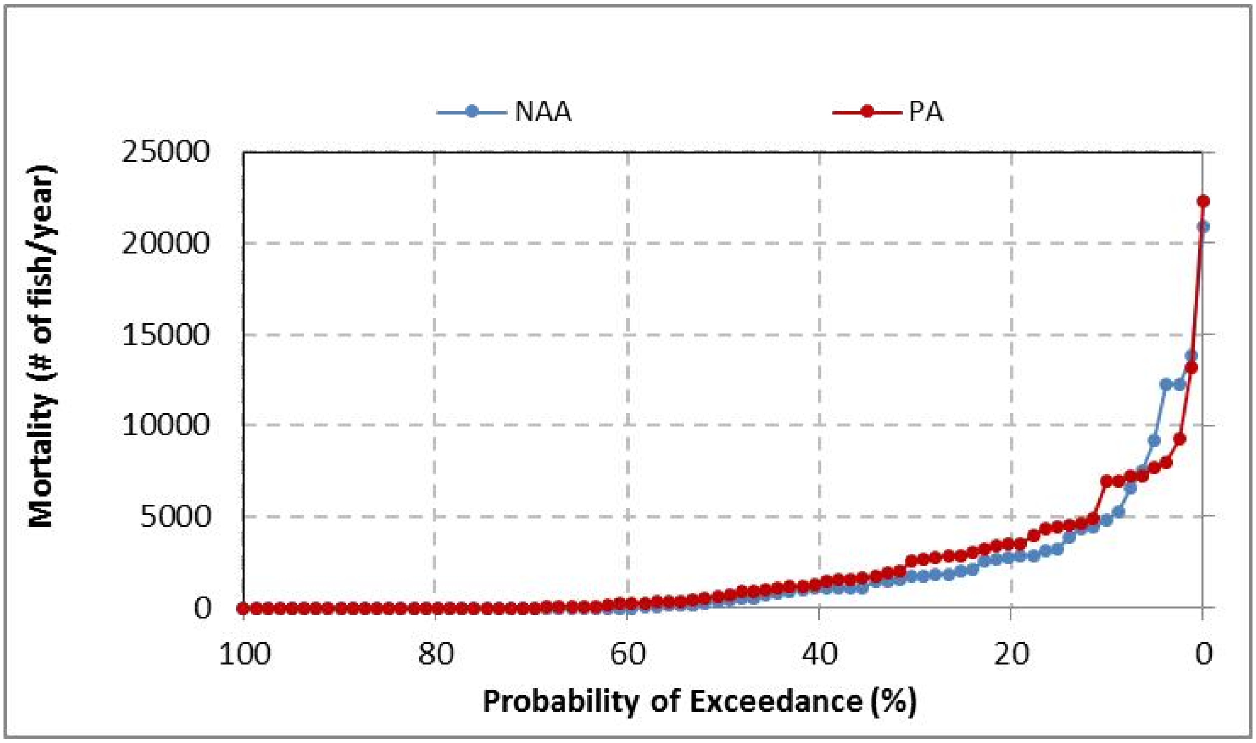

Figure 5.4-137. Exceedance Plot of Annual Flow-Based Mortality (#of Fish/Year) of Spring-Run Chinook Salmon Spawning, Egg Incubation, and Alevins

5.4.2.1.3.2.1.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the August through December spawning and incubation period for spring-run Chinook salmon (Table 5.4-27) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the spawning reach of Keswick Dam to Red Bluff in all months of the period and water year types. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.6°F, or up to 1.1%, and would occur at Red Bluff in above normal years during August, and above- and below normal years during September; and at Bend Bridge in below normal years during September. The increases during September would occur during the period of peak presence of spawners, eggs, and alevins.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of above normal water years during August (Figure 5.4-59) and September (
Figure 5.4-60) at Red Bluff, below normal years during September at Red Bluff (Figure 5.4-61), and below-normal years during September at Bend Bridge (Figure 5.4-62), where the largest increases in mean monthly water temperatures were seen, reveals that there is a general trend

towards higher temperatures under the PA but that the difference of 0.6°F in mean monthly temperatures between NAA and PA results in insignificant differences between curves for the NAA and PA in each exceedance plot.

To evaluate water temperature threshold exceedance during the spawning, egg incubation, and alevin life stages between Keswick Dam and Red Bluff, the USEPA's 7DADM threshold value of 55.4°F was used (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49) (U.S. Environmental Protection Agency 2003). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-80 through Table 5.D-84. At Keswick Dam, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-80). There would be two instances in which the percent of days exceeding the threshold would be lower under the PA relative to the NAA: November of wet (5.9%) and above normal (13.3%) years. However, in no case would there be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be biologically meaningful effect at Keswick Dam.

At Clear Creek, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during August (7.6%) and September (6.4%) of below normal years, and October (7.3%) and November (5.3%) of dry years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-81). There would also be a reduction of 8.9% in the percent of days exceeding the threshold in August of above normal water years. However, in no month or water year type would there be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect at Clear Creek.

At Balls Ferry, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during August (7.4%) and September (16.7%) of above normal water years (Appendix 5.D,, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-82). There would also be an increase in the percent of days exceeding the threshold in wet (8.5%) and above normal (13.9%) water years for August and September, respectively. However, in no case would there be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect at Balls Ferry.

At Bend Bridge, the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during September of above normal years (8.2%), and the percent of days exceeding the 55.4°F 7DADM threshold under the PA would be more than 5% lower than under the NAA during November of wet (7.1%) and above normal (12.2%) water years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-83). However, in none of these situations would there also be a more-than-0.5°F difference in the magnitude of average daily exceedance. There was only one month/water year type combination in which the average daily exceedance would be more than 0.5°F, which was September of below normal water years (0.6°F), but there was no concurrent difference in the percent of days exceeding the threshold. Therefore, it was concluded that there would be no biologically meaningful effect at Bend Bridge.

At Red Bluff, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-84). There would be two water year types (wet and above normal) during November in which there would be 10.1% and 11.4% reductions, respectively, in the percent of days exceeding the threshold, but there was no concurrent difference in the magnitude of average daily exceedance. . Therefore, it was concluded that there would be no biologically meaningful effect at Red Bluff.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could have lethal or sublethal effects on spawning, egg incubation, and alevins, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further, this analysis does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival. This process may result in refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. Although the process targets winter-run Chinook salmon, these changes are expected to benefit other races of Chinook salmon. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

The Reclamation Egg Mortality Model provides temperature-related estimates of spring-run egg mortality in the Sacramento River (see Appendix 5.D, Attachment 1, *Reclamation Egg Mortality Model*, for full model description). As noted in Appendix 5.D, Section 5.D.2.1. *Water Temperature Analysis Methods*, NMFS believes this model underestimates temperature related mortality and likely is not sensitive enough to capture small differences in scenarios or temperature related mortality experienced by recent winter-run brood years and, as a result, should be viewed with caution until a more accurate model is developed or there is better understanding of temperature effects on juvenile production. Because of this and the fact that the egg life stage has the highest potential effect on the propagation of population size in a life cycle context, a conservative value of a more-than-2% change in percent of total individuals (on a raw scale) was defined as a biologically meaningful effect for Reclamation Egg Mortality Model results (see Appendix 5.D, Section 5.D.2.1.2.3, *Reclamation Egg Mortality Model*, for details). Results of the model are presented in Table 5.4-55 and Figure 5.4-138 through Figure 5.4-143.

The results indicate that there would be no large increases in egg mortality under the PA relative to the NAA. The largest increase in mean egg mortality would be 1.9% (raw difference) in below-normal water years. There would be a biologically meaningful reduction in egg mortality of 6.7% in critical water years, although this difference in means is driven largely by 2 years in which egg mortality would be substantially (35% to 45%) reduced under the PA relative to the NAA (Figure 5.4-142).

Table 5.4-55. Spring-run Chinook Salmon Egg Mortality (Percent of Total Individuals) and Differences (Percent Differences) between Model Scenarios, Reclamation Egg Mortality Model

WYT	NAA	PA	PA vs. NAA
Wet	6.3	6.3	0.1 (1%)
Above Normal	5.0	5.4	0.4 (9%)
Below Normal	13.3	15.2	1.9 (14%)
Dry	19.0	19.1	0.1 (0.4%)
Critical	86.3	79.7	-6.7 (-8%)
All	22.0	21.4	-0.6 (-3%)

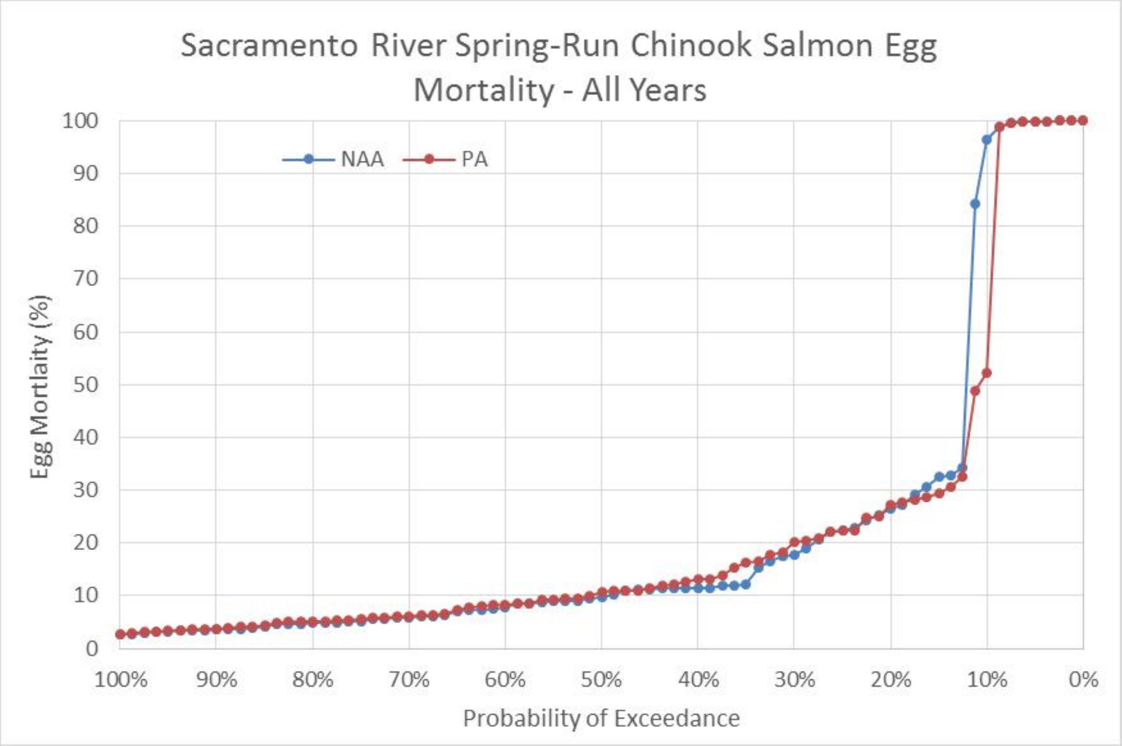

Figure 5.4-138. Exceedance Plot of Spring-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, All Water Years

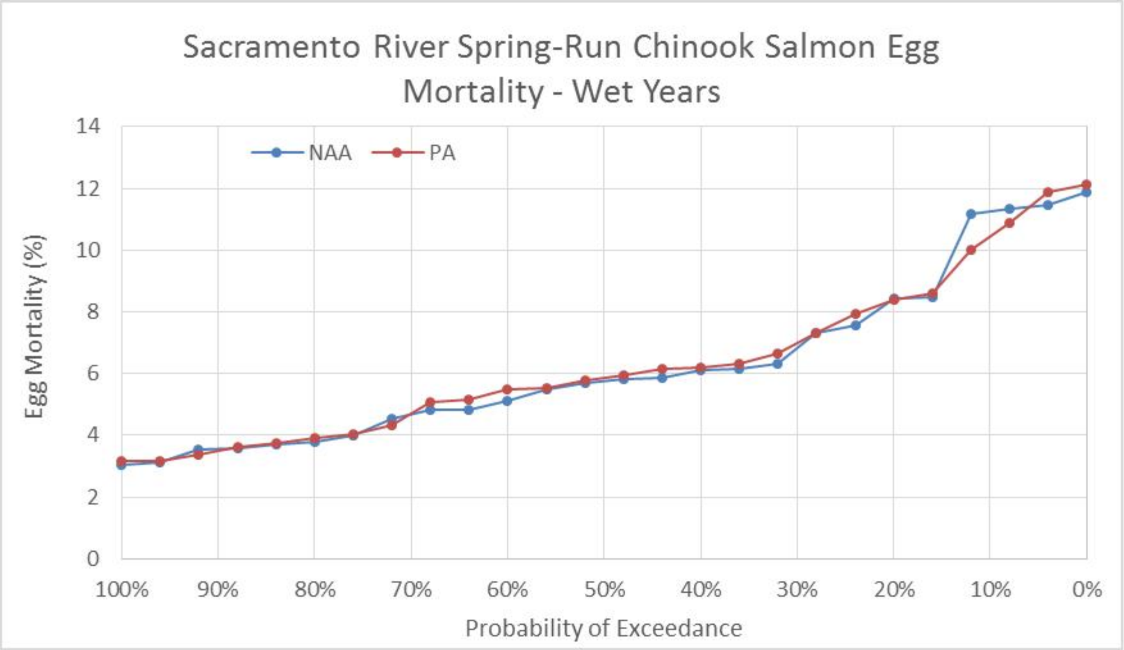

Figure 5.4-139. Exceedance Plot of Spring-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Wet Water Years

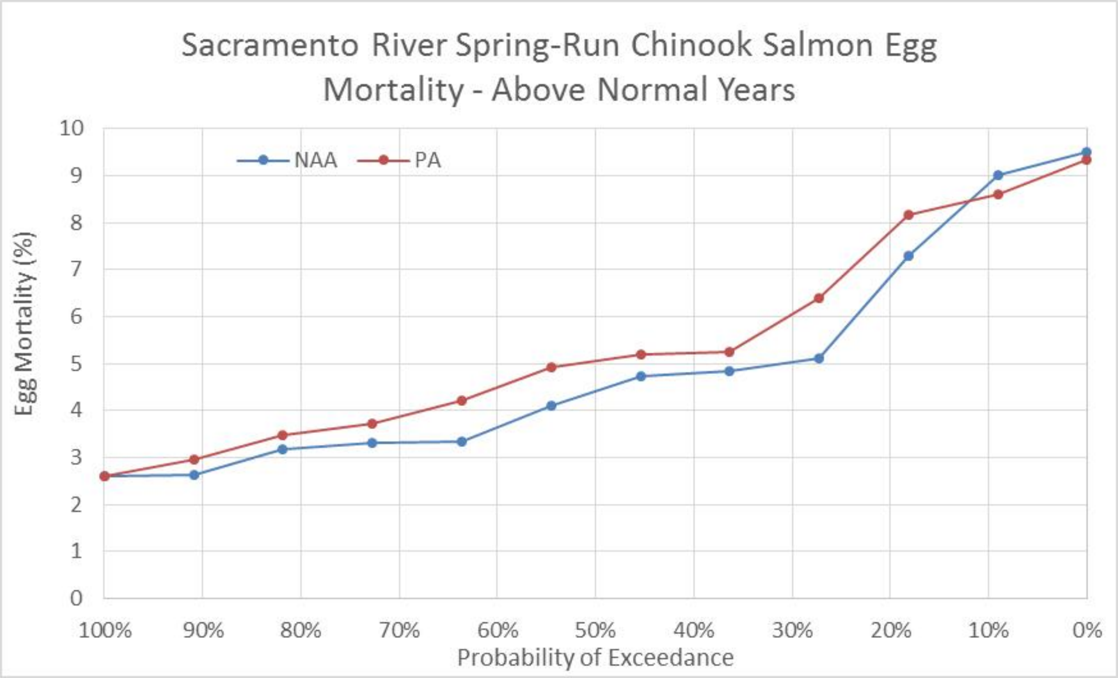

Figure 5.4-140. Exceedance Plot of Spring-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Above Normal Water Years

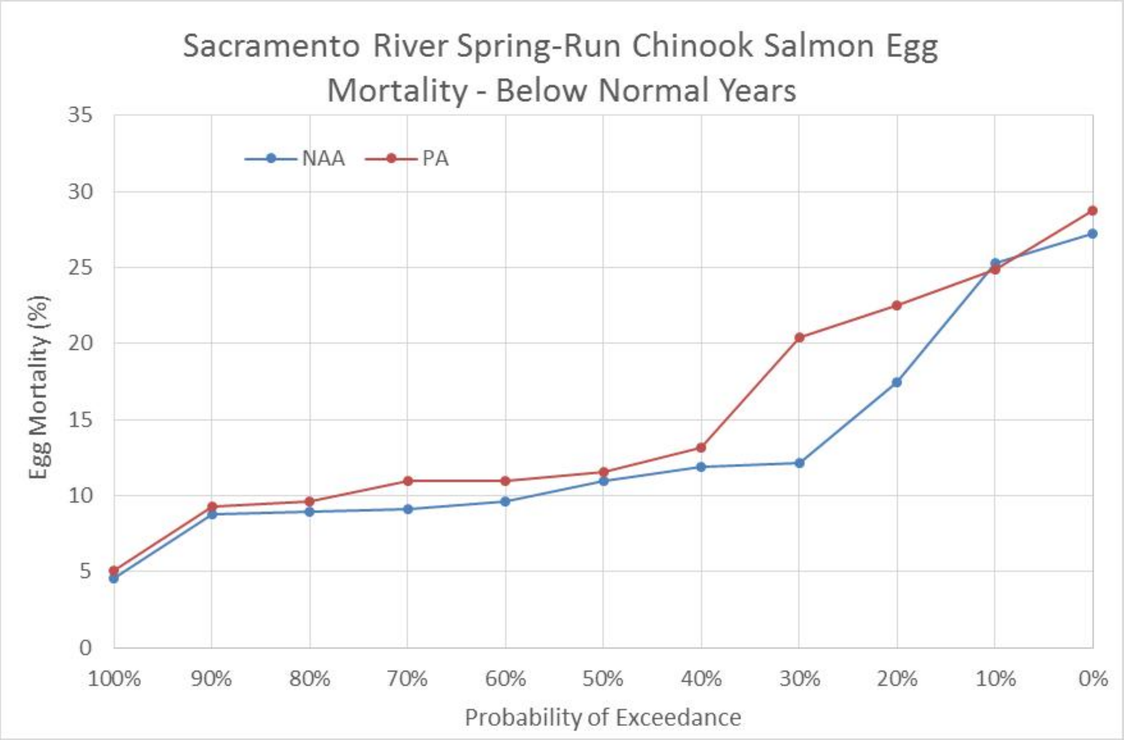

Figure 5.4-141. Exceedance Plot of Spring-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Below Normal Water Years

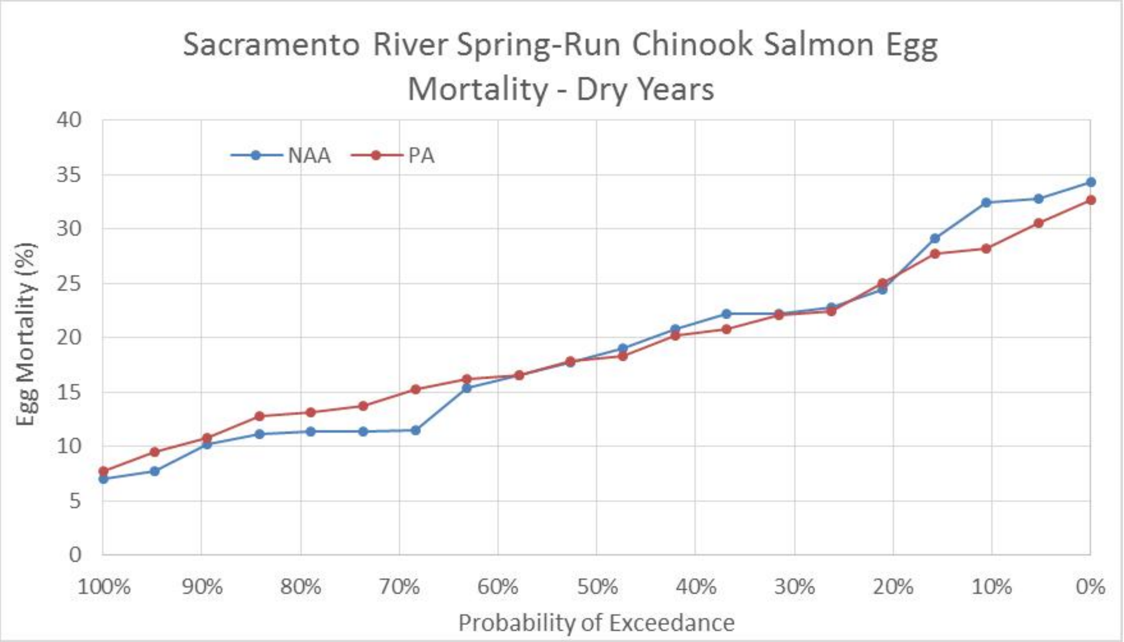

Figure 5.4-142. Exceedance Plot of Spring-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Dry Water Years

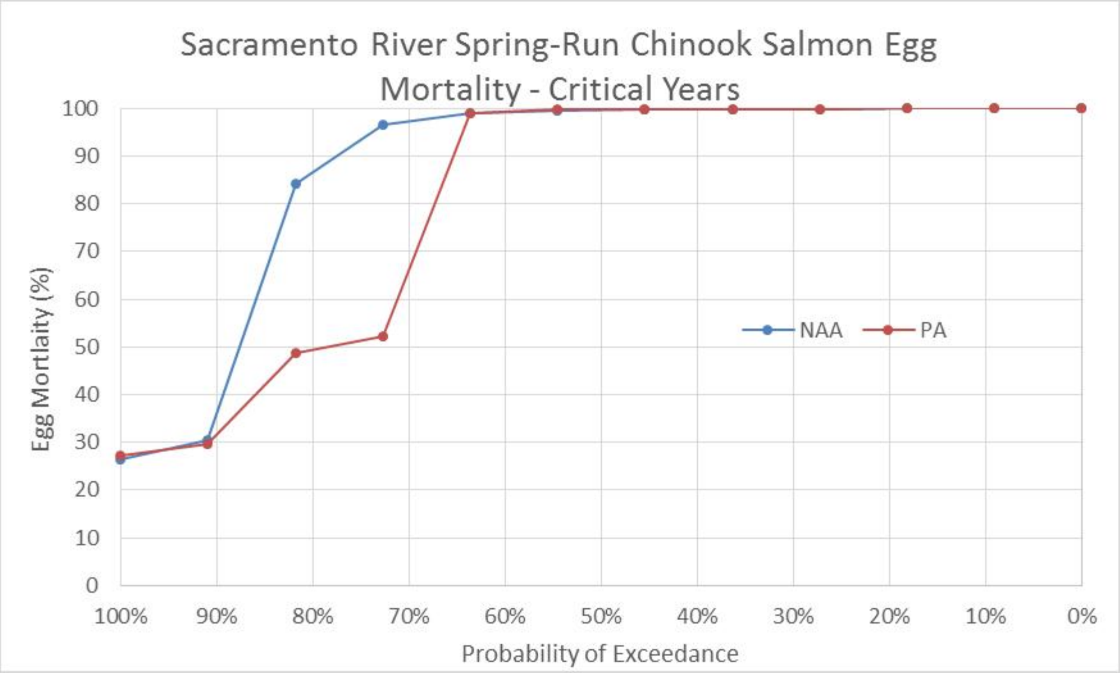

Figure 5.4-143. Exceedance Plot of Spring-Run Chinook Salmon Egg Mortality for NAA and PA Model Scenarios, Reclamation Egg Mortality Model, Critical Water Years

The SALMOD model provides predicted water temperature-related mortality of spring-run Chinook salmon spawning, eggs, and alevins the Sacramento River. This water temperature-related mortality of the combined spring-run Chinook salmon “spawning, eggs, and alevins” life stage is split up as *pre-spawn* (in vivo, or in the mother before spawning) and *egg* (in the gravel) mortality (see Attachment 5.D.2, *SALMOD Model,* for a full description). Results are presented in Table 5.4-54. The annual exceedance plot of temperature-related mortality of spring-run Chinook salmon spawning, eggs, and alevins is presented in Figure 5.4-144. The model indicates that, combining all water year types, water temperature-related mortality of the spawning, egg, and alevin life stage would decrease by 12,110 fish (7%) under the PA relative to the NAA. Within the combined spawning, egg, and alevin life stage, there would be an increase in pre-spawn mortality of 4,431 eggs in the mother (10%) under the PA, but a decrease in egg mortality of 16,540 eggs (13%). Water temperature-related mortality of this combined spawning, egg, and alevin life stage would comprise the large majority (more than 95%) of overall spring-run Chinook salmon mortality and, therefore, can be considered an important source of mortality to early life stages of spring-run Chinook salmon. Individual water year types largely follow the same patterns as for all water year types combined, with few exceptions. Most notably, in below normal years, there would be an overall increase in water temperature-related mortality under the PA in both pre-spawn (100%) and egg (18%) mortality, and an overall increase in water temperature-related mortality under the PA (18%).

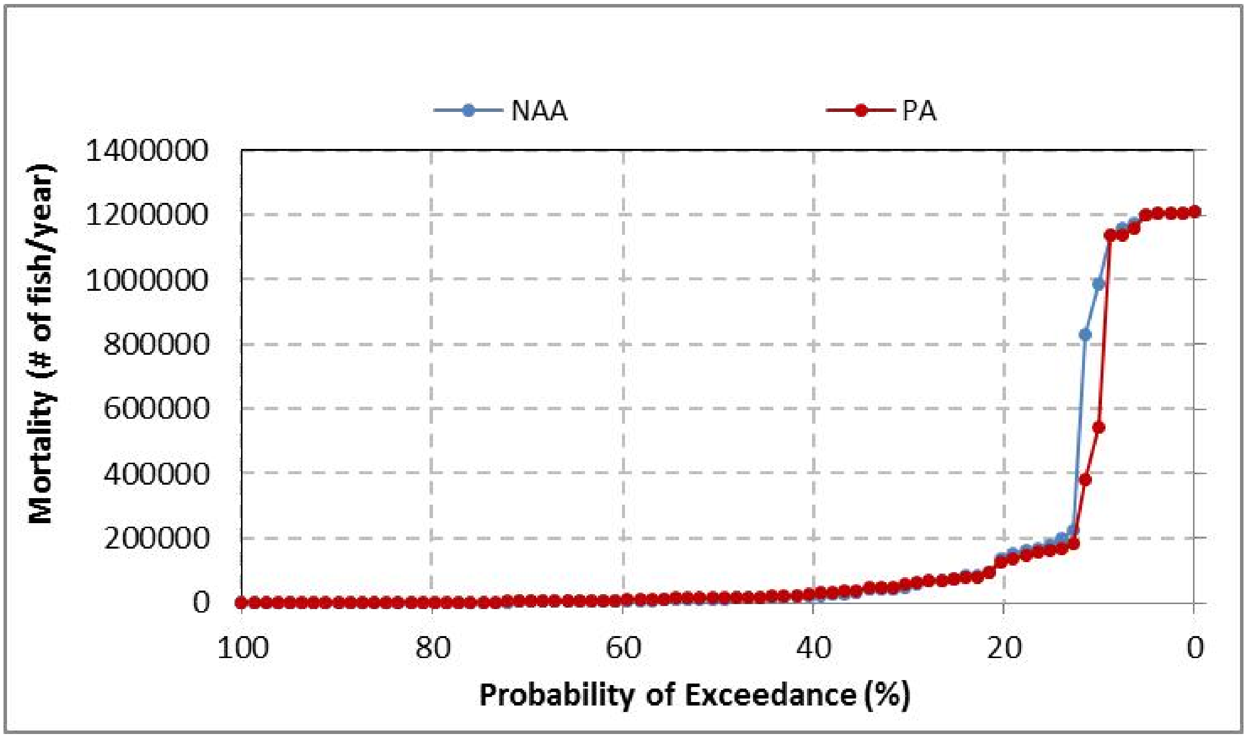

Figure 5.4-144. Exceedance Plot of Annual Water Temperature-Based Mortality (#of Fish/Year) of Spring-Run Chinook Salmon Spawning, Egg Incubation, and Alevins

5.4.2.1.3.2.2 Fry and Juvenile Rearing

5.4.2.1.3.2.2.1 Flow-Related Effects

As discussed above in the winter-run fry and juvenile rearing section and in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* the stranding of juvenile salmonids is not evaluated in the effects analysis due to limitations of CALSIM modeling. However, current operations of the Sacramento River include ramping rate restrictions, designed to minimize juvenile stranding, that limit the rate at which river flow can be changed. These restrictions would be kept in place for the PA.

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at the Keswick to Red Bluff locations during the year-round fry and juvenile rearing period for spring-run Chinook salmon, with peak occurrence during November and December (Table 5.4-25). Changes in flow can affect the instream area available for rearing, along with habitat quality, and can affect stranding of fry and juveniles, especially in side-channel habitats. Shasta Reservoir storage volumes at the end of May and the end of September influence flow rates in the Sacramento River. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-3). Mean Shasta September storage under the PA would also be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA.

In general, mean flow due to the PA at the Keswick and Red Bluff locations in the Sacramento River flow would be similar to (less than 5% difference) or higher than flow due to the NAA during winter, spring, and summer months and would be similar to or lower than flow due to the NAA during the fall, with exceptions (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-10, Table 5.A.6-35). Flows under the PA during December through August would be similar to (less than 5% difference) or greater than those under the NAA for all months and water year types, except for 13% and 7% lower flow during February of critical water years at Keswick and Red Bluff, respectively, and 10% lower flow during August of below normal years at both locations. Flow increases during the same months would range up to 18% for January of critical years. During June, flows would be greater than 5% higher under the PA than the NAA in all water year types except wet years. Flows under the PA during September through November would be similar to (less than 5% difference) or lower than those under the NAA in all months and water year types, except for flows up to 17% greater during October of below normal and dry years and up to 13% greater during November of critical years. During September, flow would be up to 11% lower under the PA than the NAA for all water year types except wet years. The largest flow reductions would occur in November of wet and above normal year, with reductions of 26% at Keswick and 21% at Red Bluff for both year types. The November reductions coincide with the period of peak occurrence of spring-run fry. The results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

Because, as described in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods*, rearing habitat WUA for spring-run Chinook salmon was not estimated directly by USFWS (2005b) but was modeled using the rearing habitat WUA curves obtained for fall-run Chinook salmon in Segments 4, 5 and 6 (U.S. Fish and Wildlife Service 2003a, 2006), the fall-run WUA curves for these three segments were also used in this effects analysis to model spring-run Chinook salmon rearing habitat. The rearing WUA curves for fall-run Chinook salmon were used because the fry rearing period of fall-run is similar to that of spring-run, and because this substitution follows previous practice (Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods).* However, as noted by USFWS (2005b), the validity of using the fall-run Chinook salmon rearing WUA curves to characterize spring-run Chinook salmon rearing habitat is uncertain. To estimate changes in rearing WUA that would result from the PA, the fall-run Chinook salmon WUA curves developed for each of the river segments was used with mean monthly CALSIM II flow estimates for the midpoint of each segment under the PA and the NAA during the rearing periods for spring-run fry (November through February) and juveniles (year-round) (Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* Table RFM-1). Fry were defined in this analysis as fish less than 60 mm, and juveniles were those greater than 60 mm. Further information on the rearing WUA analysis methods is provided in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods*.

Differences under the PA and NAA in rearing WUA for spring-run fry and juveniles were examined using exceedance plots of mean monthly WUA for the spring-run fry (Figure 5.4-145–Figure 5.4-162) and juvenile (Figure 5.4-163–Figure 5.4-180) rearing periods in each of the river segments for each water year type and all water year types combined. The PA exceedance curves for both fry and juvenile rearing WUA for all water years combined are similar to those for the NAA for all three river segments (Figure 5.4-145, Figure 5.4-151, Figure 5.4-154 Figure 5.4-153, Figure 5.4-163, Figure 5.4-169, and Figure 5.4-175). With the curves broken out by water year type, increases in fry rearing habitat WUA under the PA are evident in Segments 5 and 4 during above normal years (Figure 5.4-153 and Figure 5.4-155), and increases in juvenile rearing WUA under the PA are evident in Segment 4 during wet and above normal years (Figure 5.4-176 and Figure 5.4-177).

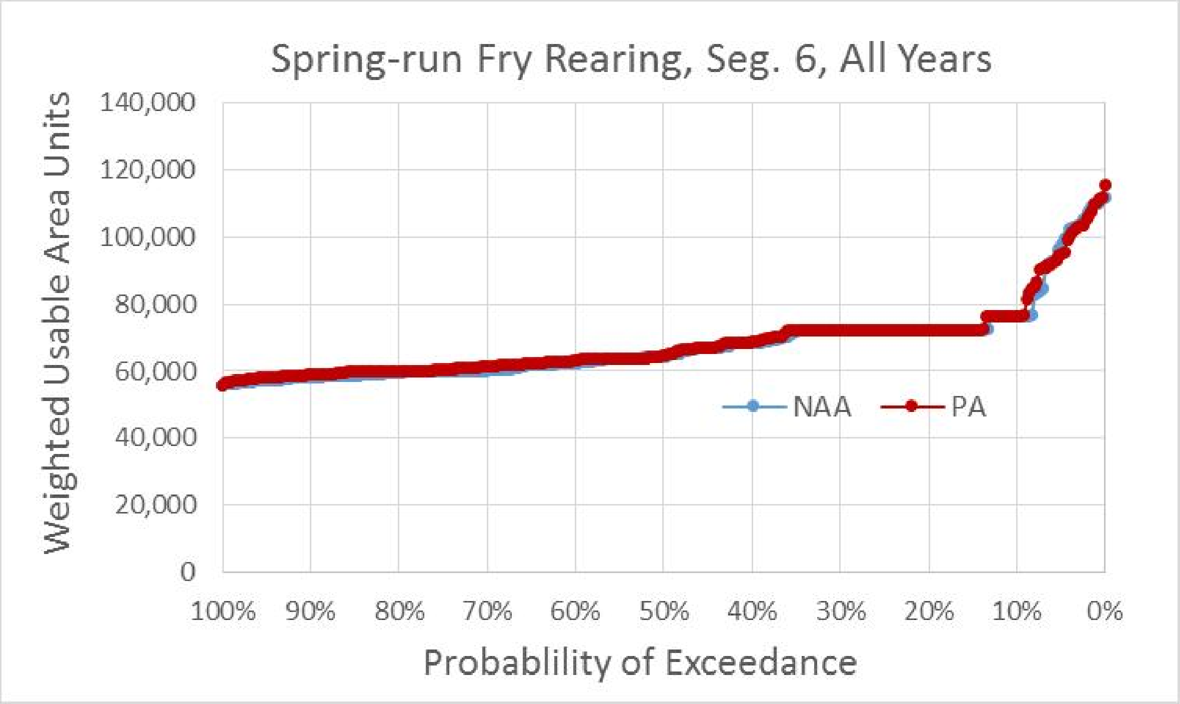

Figure 5.4-145. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

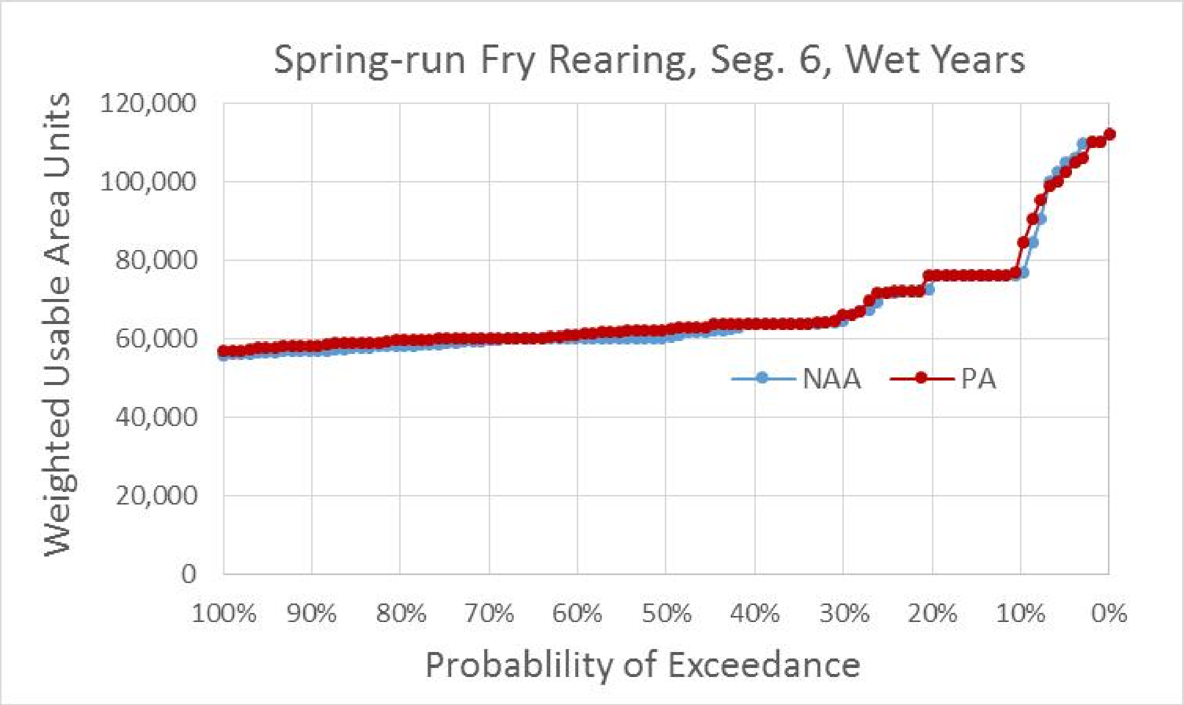

Figure 5.4-146. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

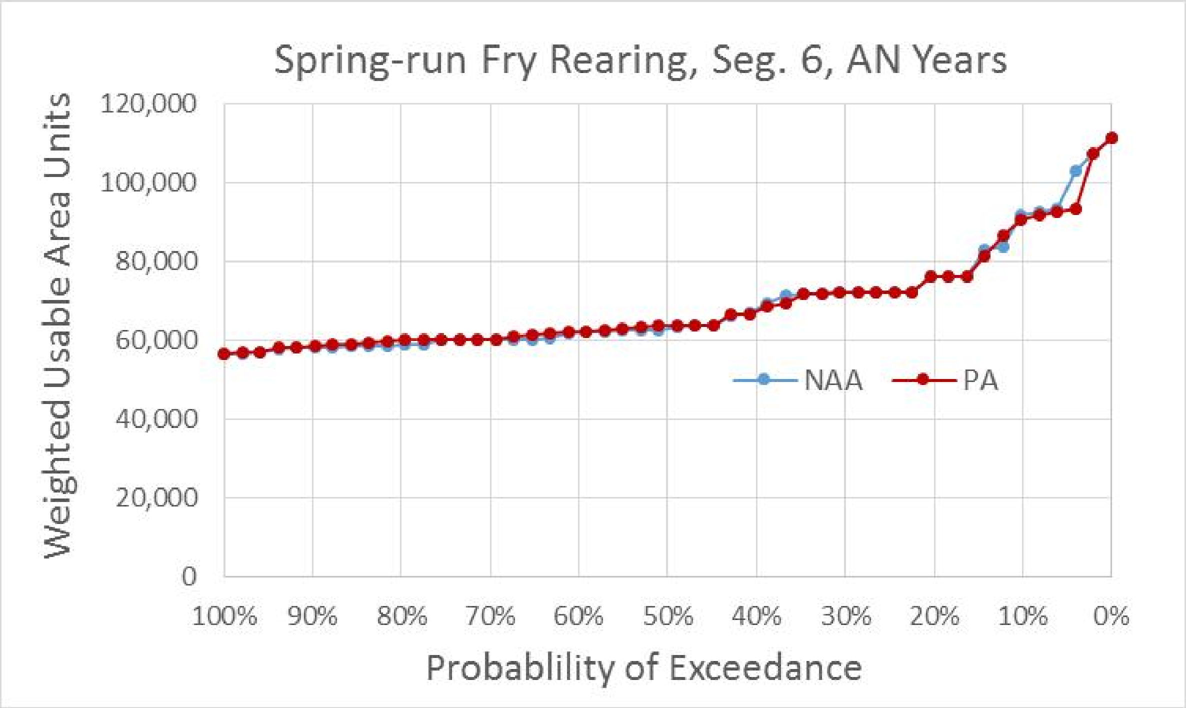

Figure 5.4-147. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

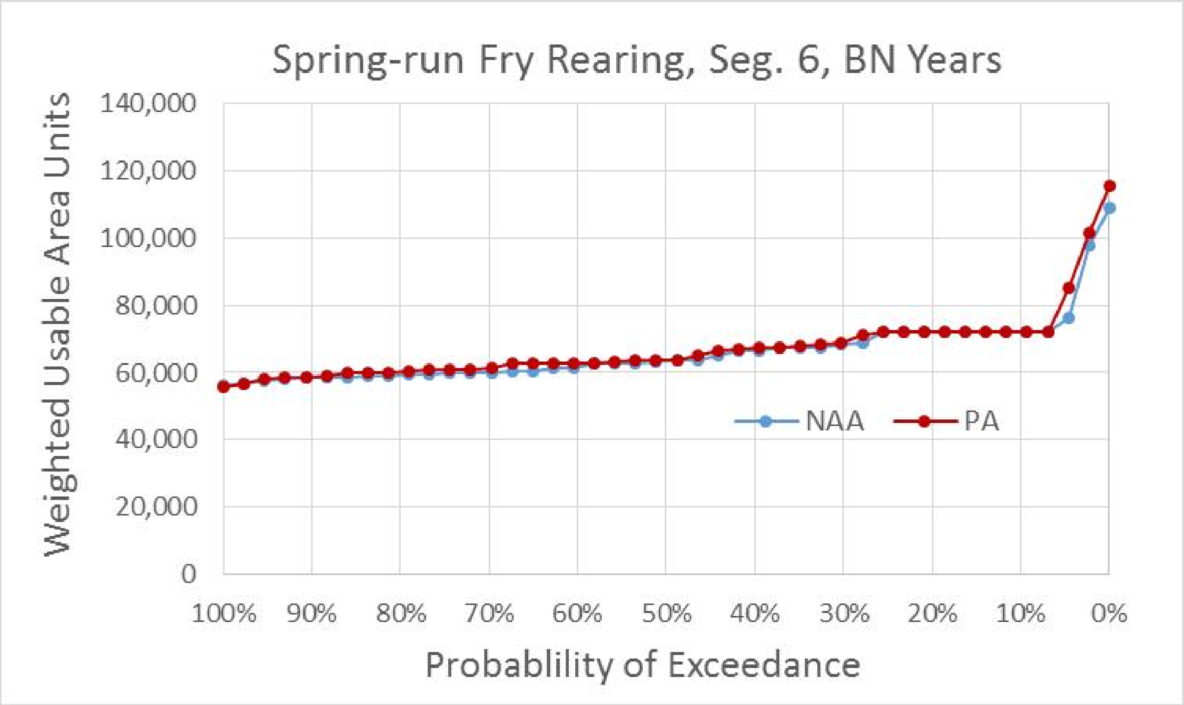

Figure 5.4-148. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

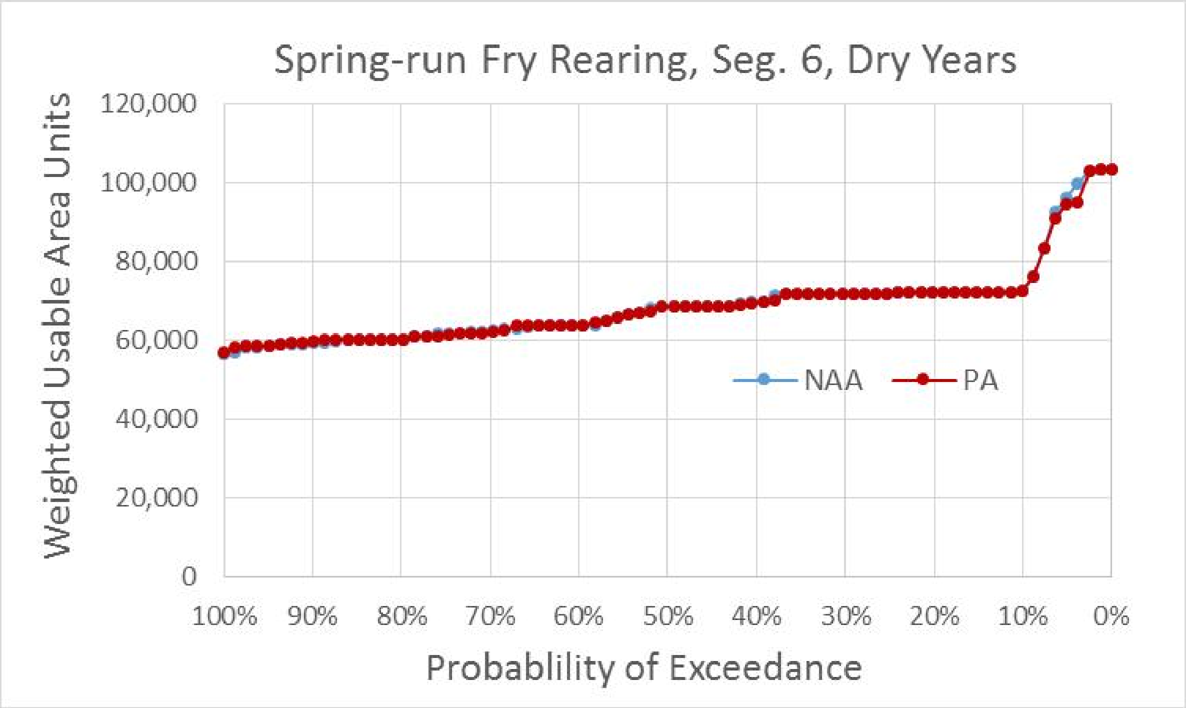

Figure 5.4-149. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

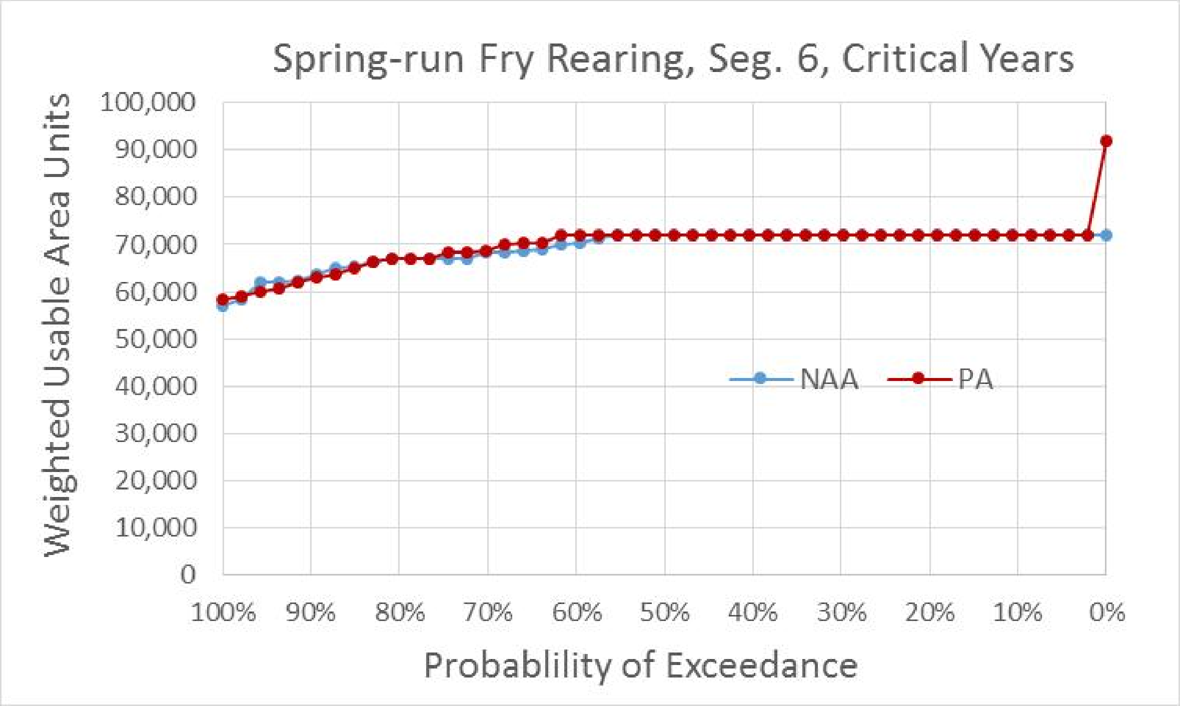

Figure 5.4-150. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

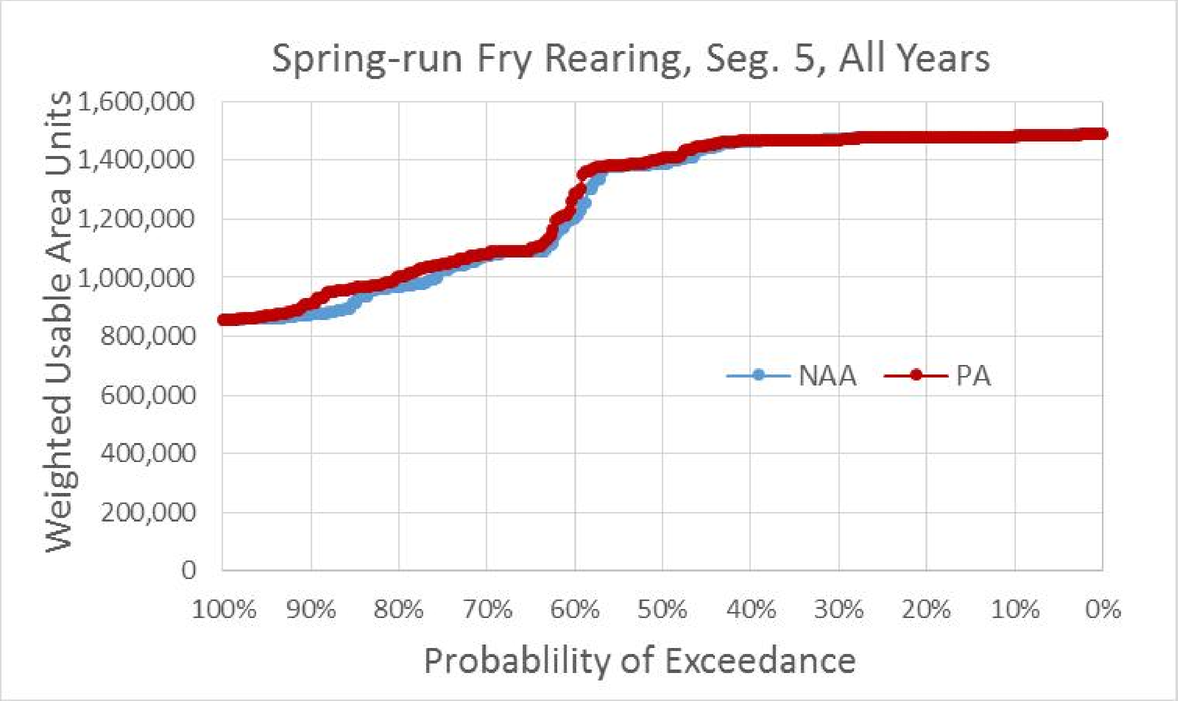

Figure 5.4-151. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

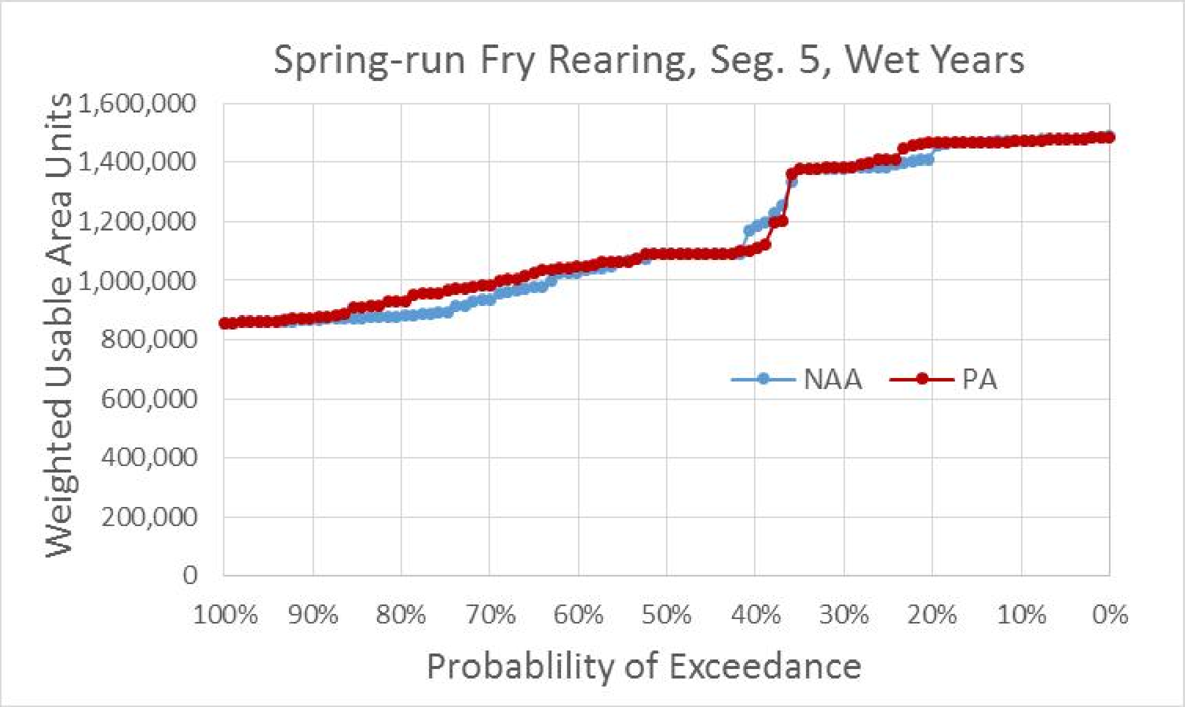

Figure 5.4-152. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

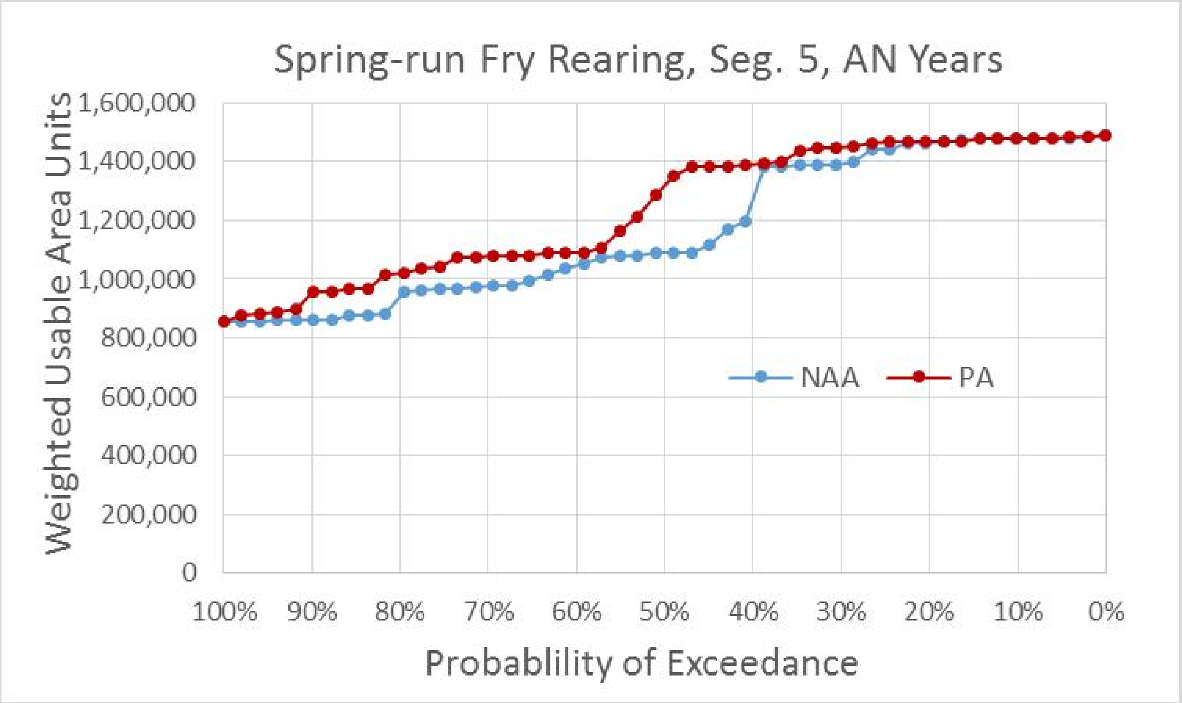

Figure 5.4-153. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

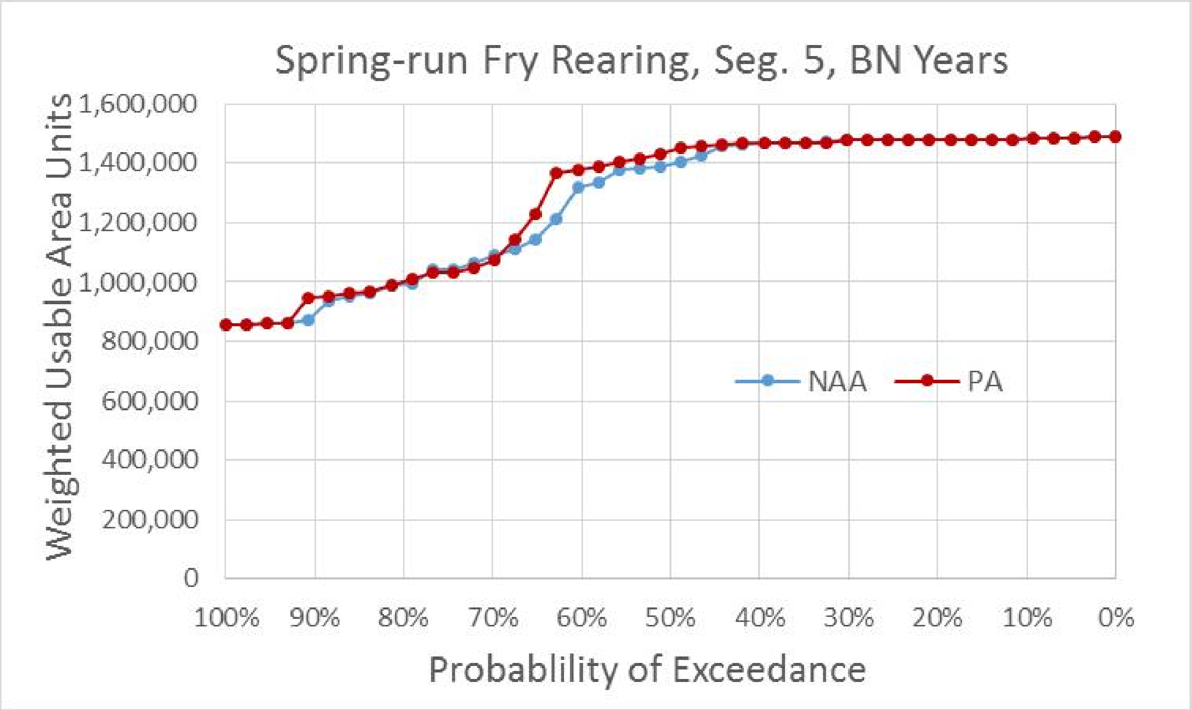

Figure 5.4-154. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

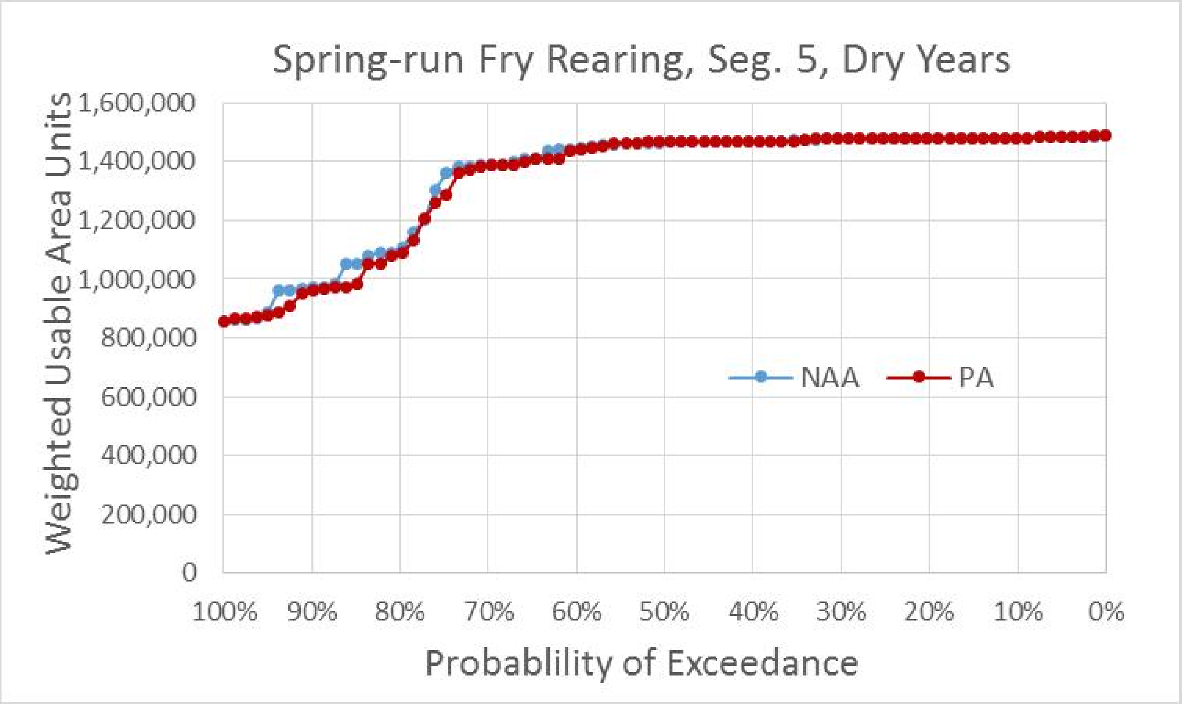

Figure 5.4-155. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

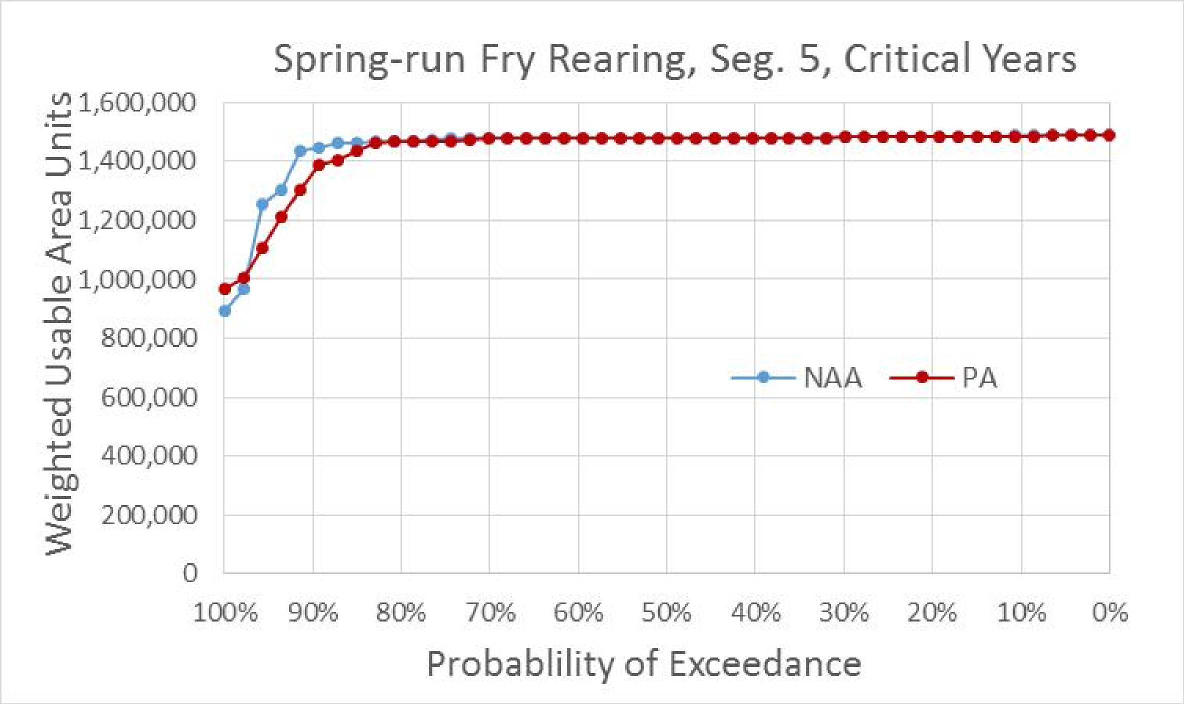

Figure 5.4-156. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

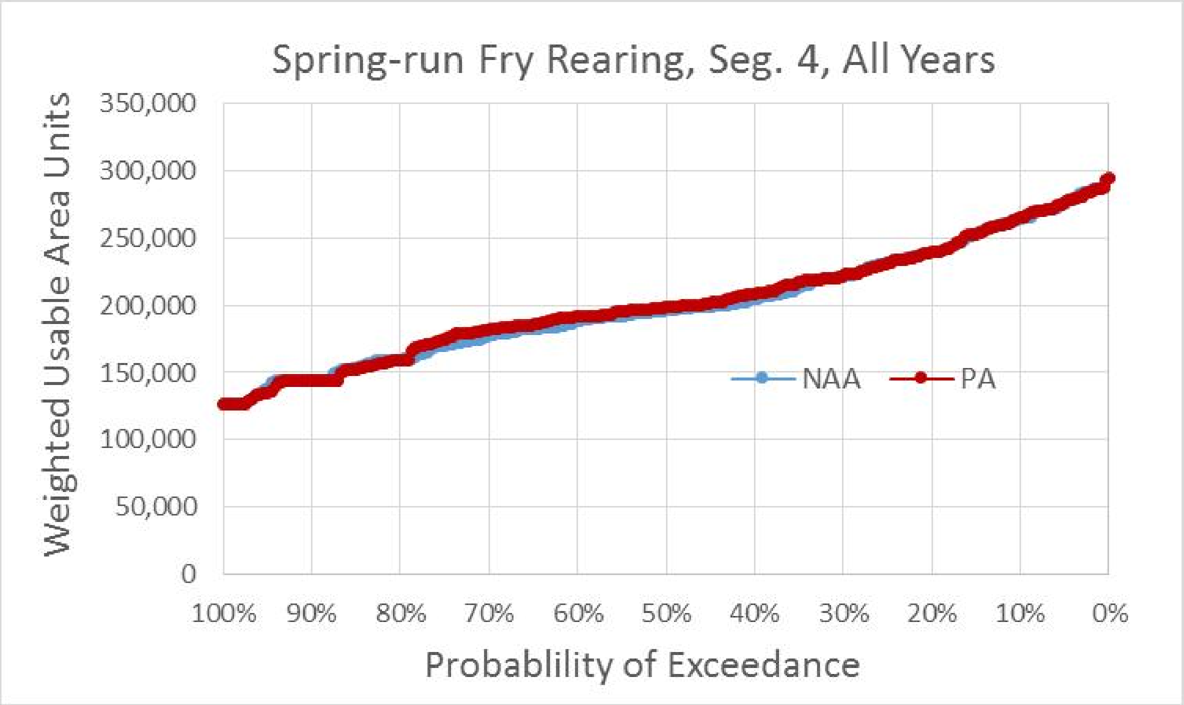

Figure 5.4-157. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

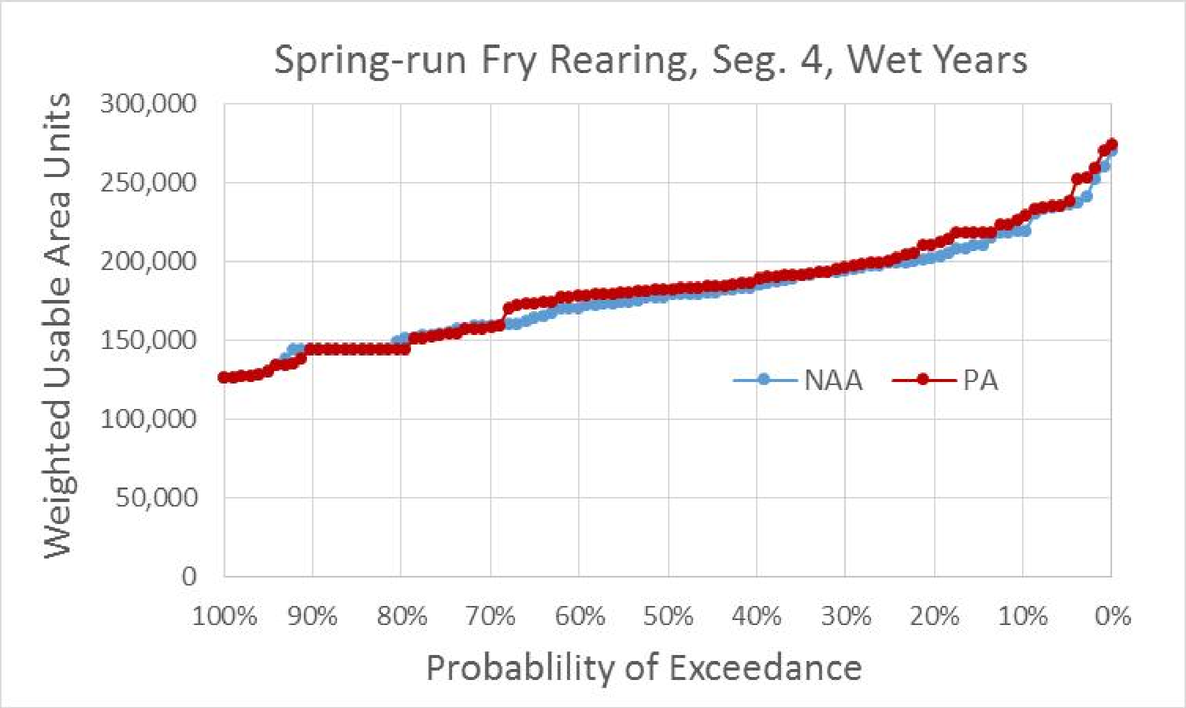

Figure 5.4-158. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

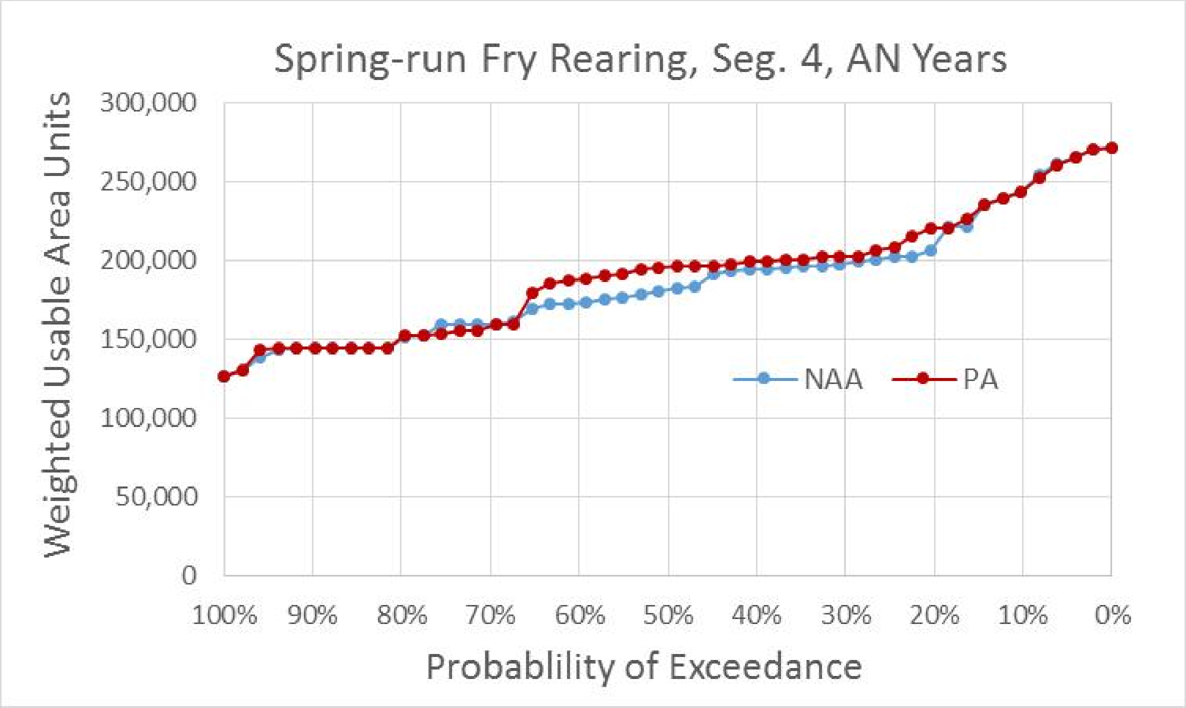

Figure 5.4-159. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

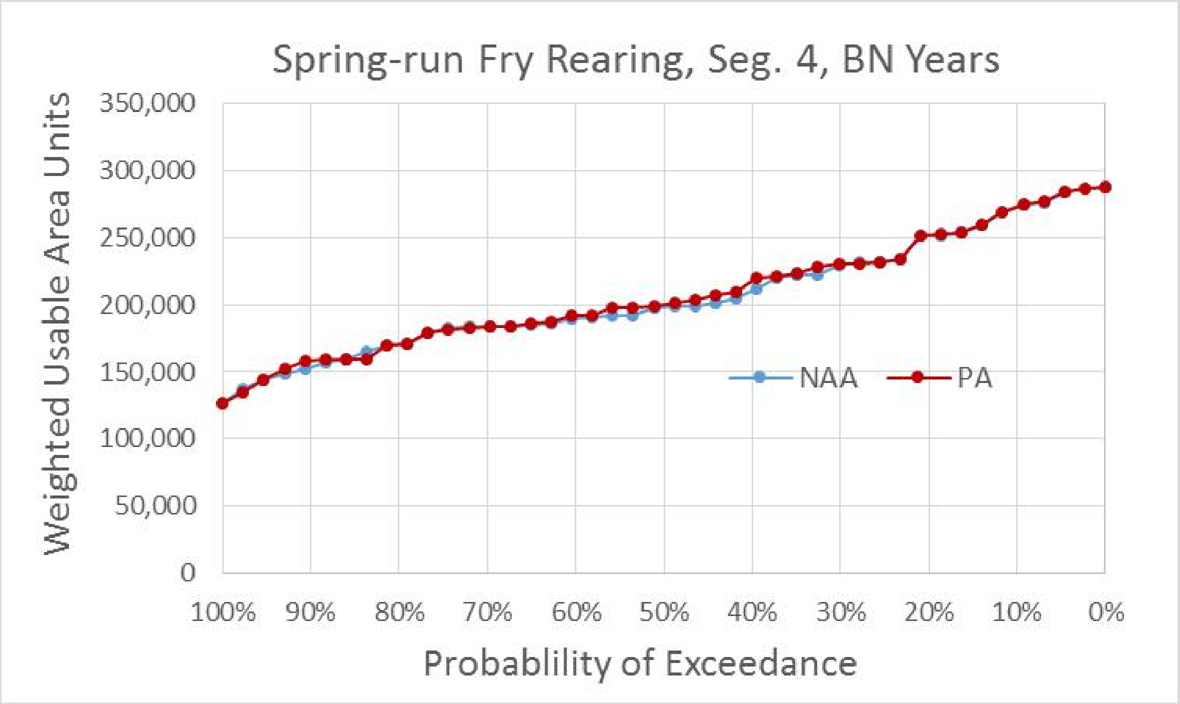

Figure 5.4-160. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

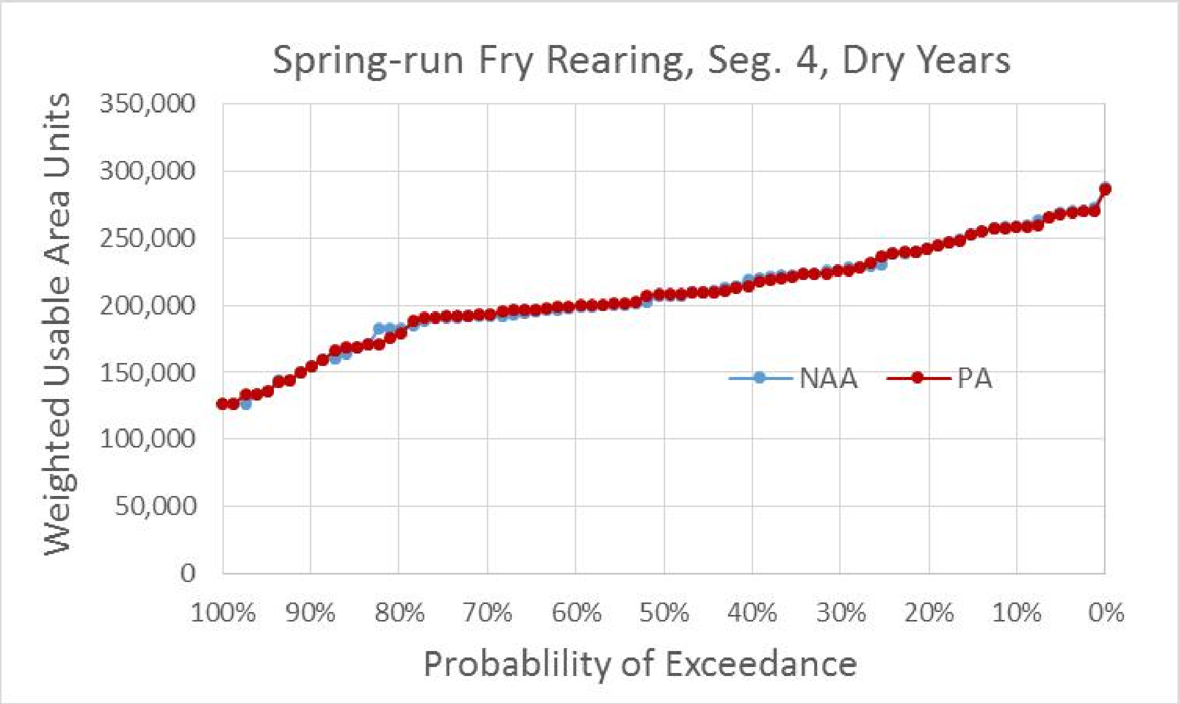

Figure 5.4-161. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

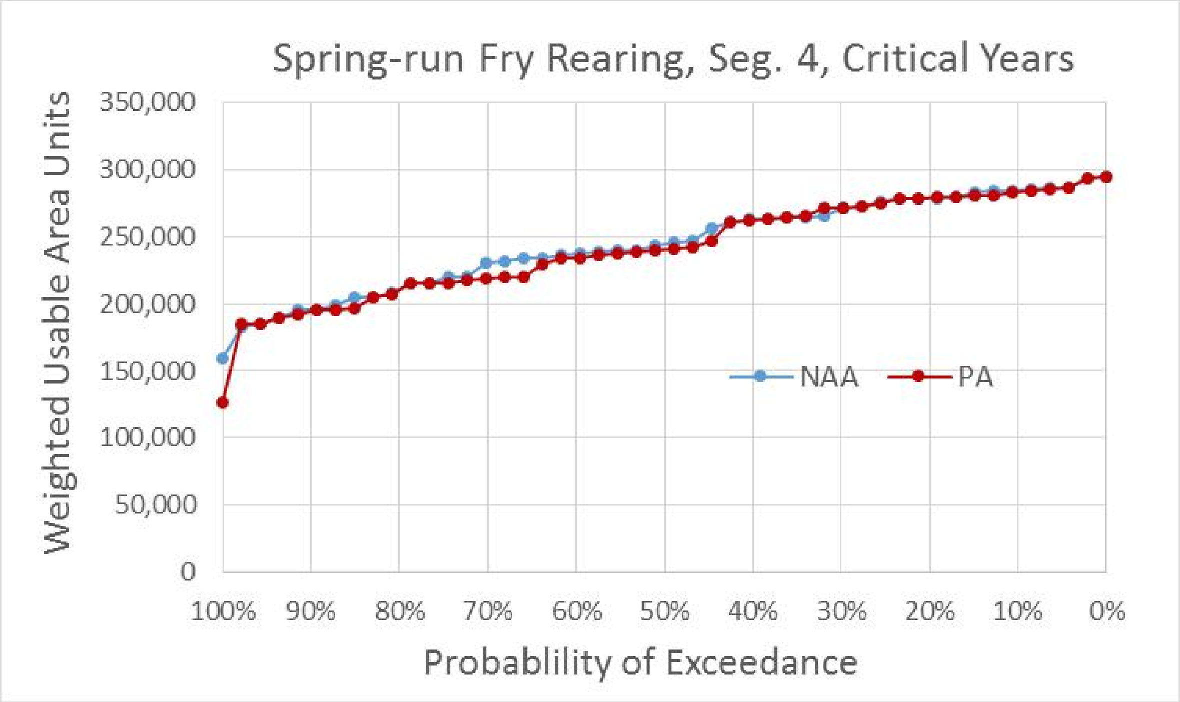

Figure 5.4-162. Exceedance Plot of Spring-Run Chinook Salmon Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

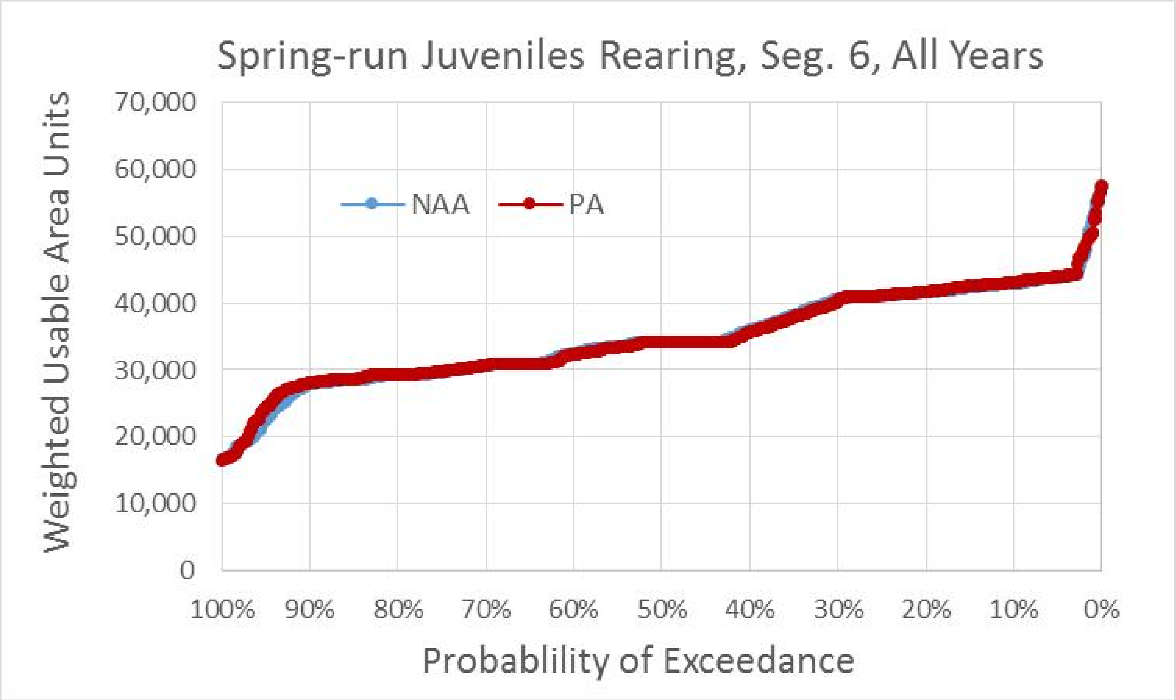

Figure 5.4-163. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

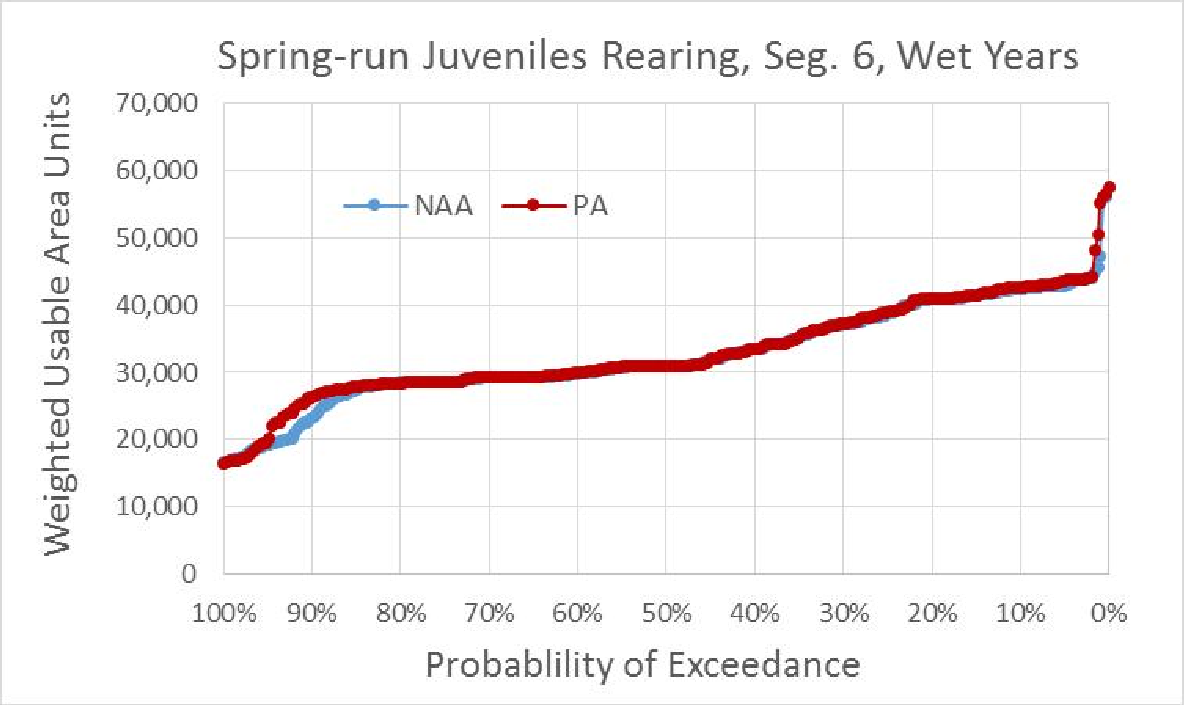

Figure 5.4-164. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

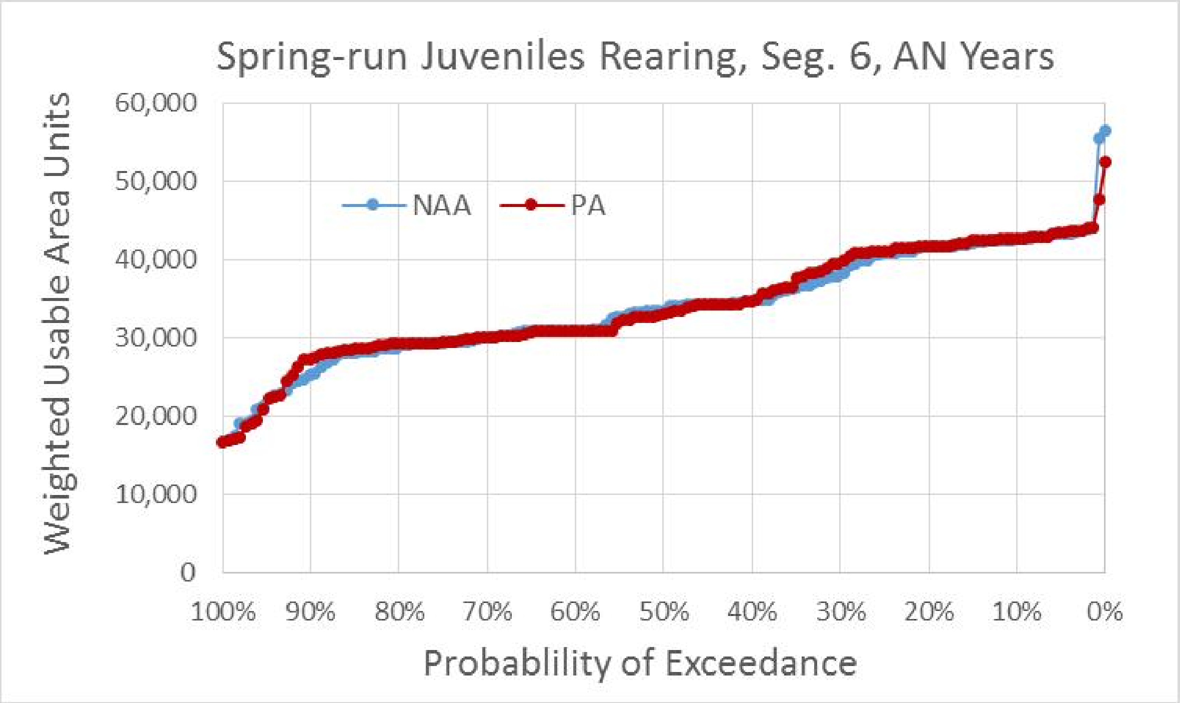

Figure 5.4-165. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

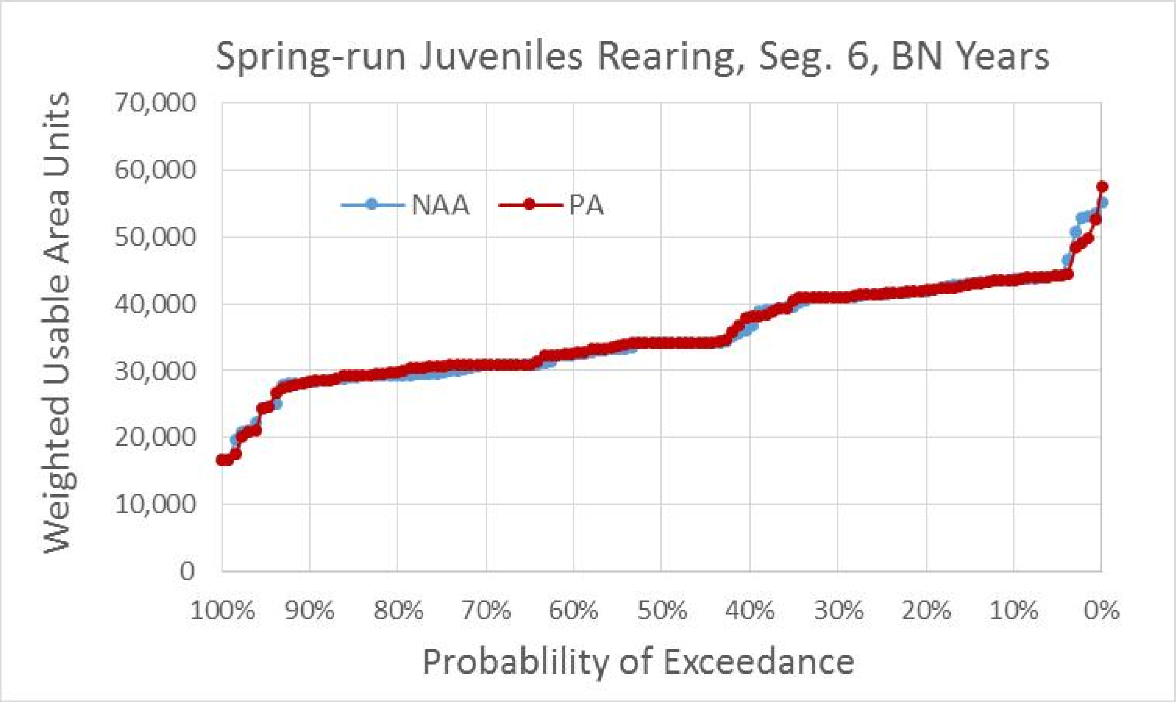

Figure 5.4-166. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

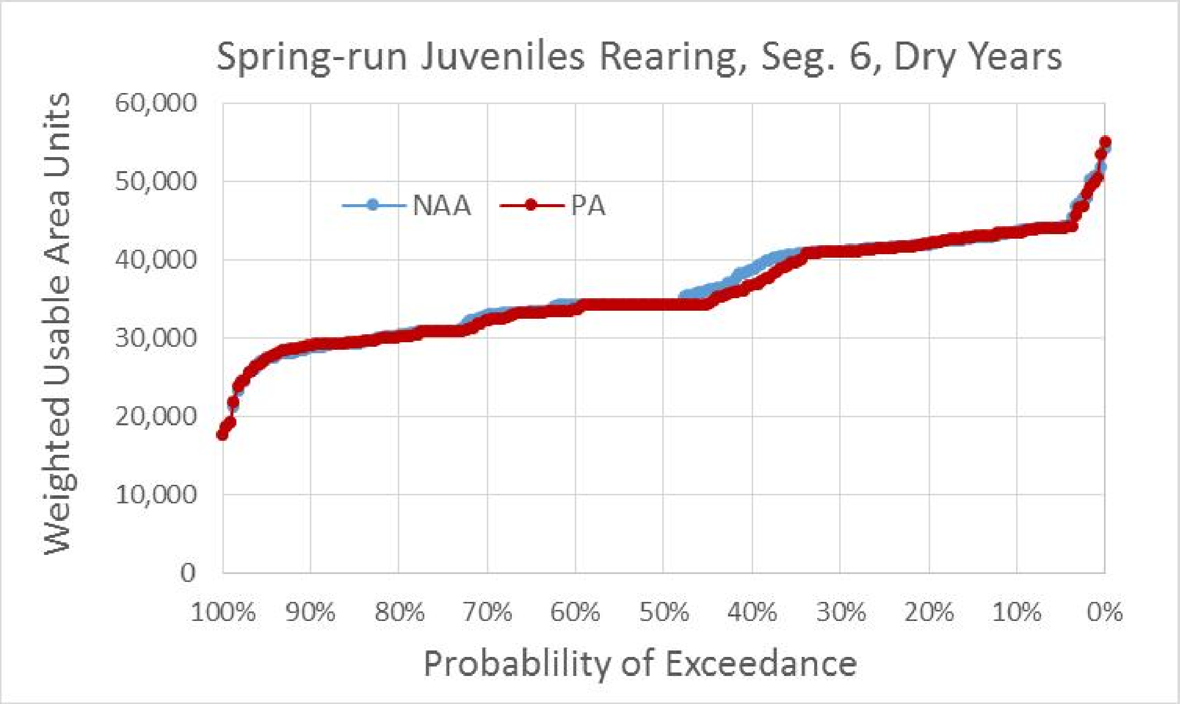

Figure 5.4-167. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

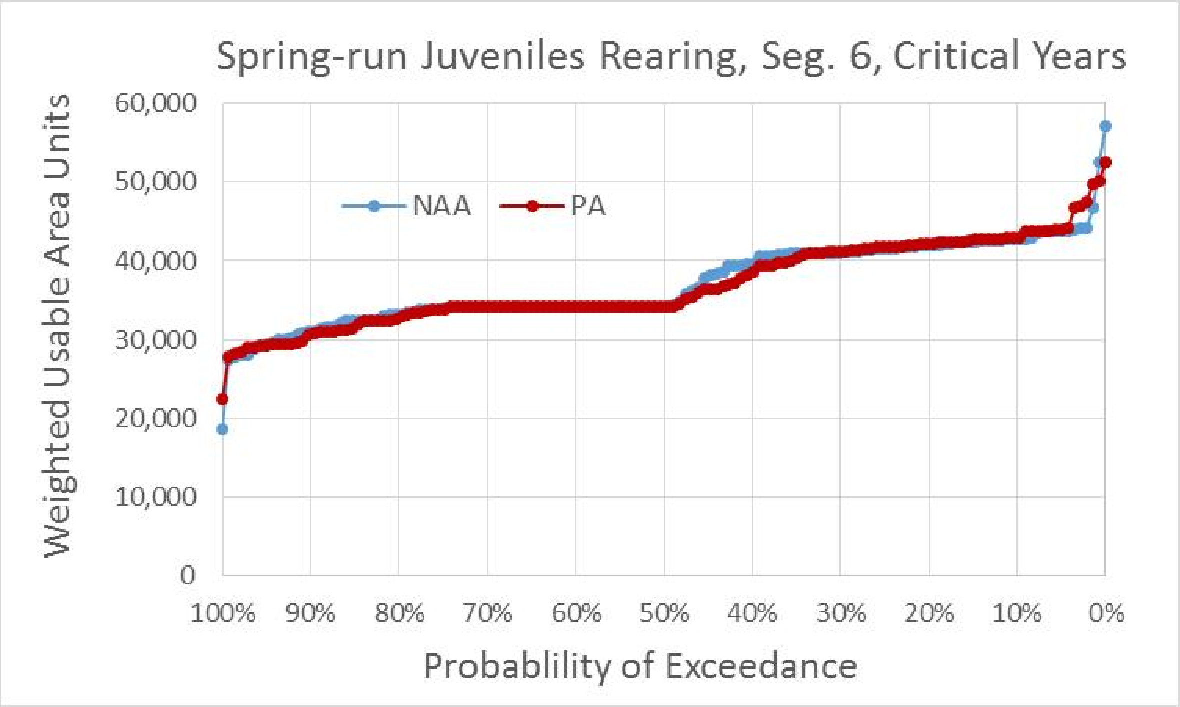

Figure 5.4-168. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

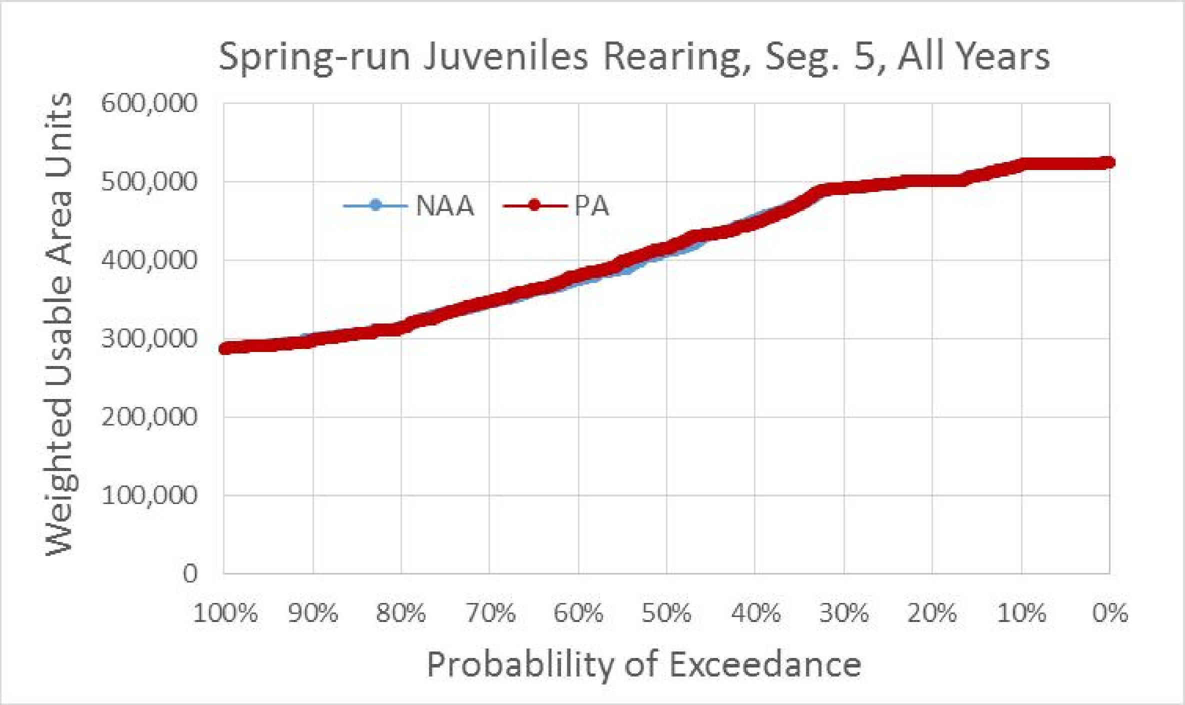

Figure 5.4-169. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

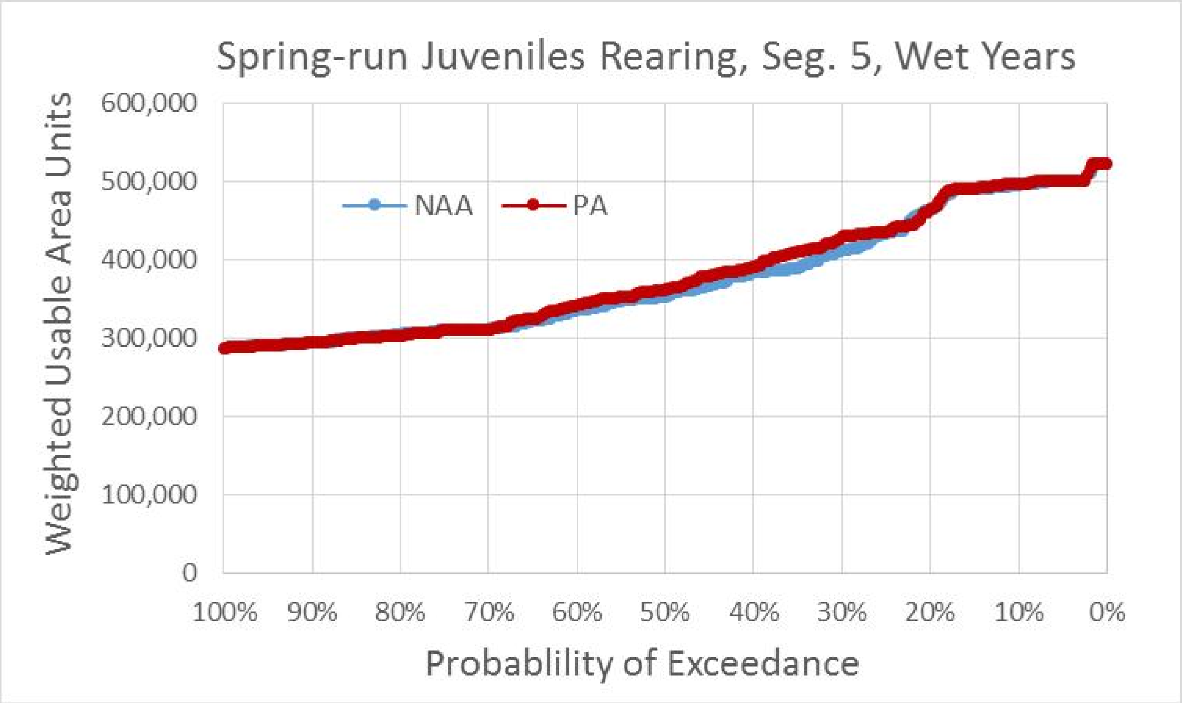

Figure 5.4-170. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

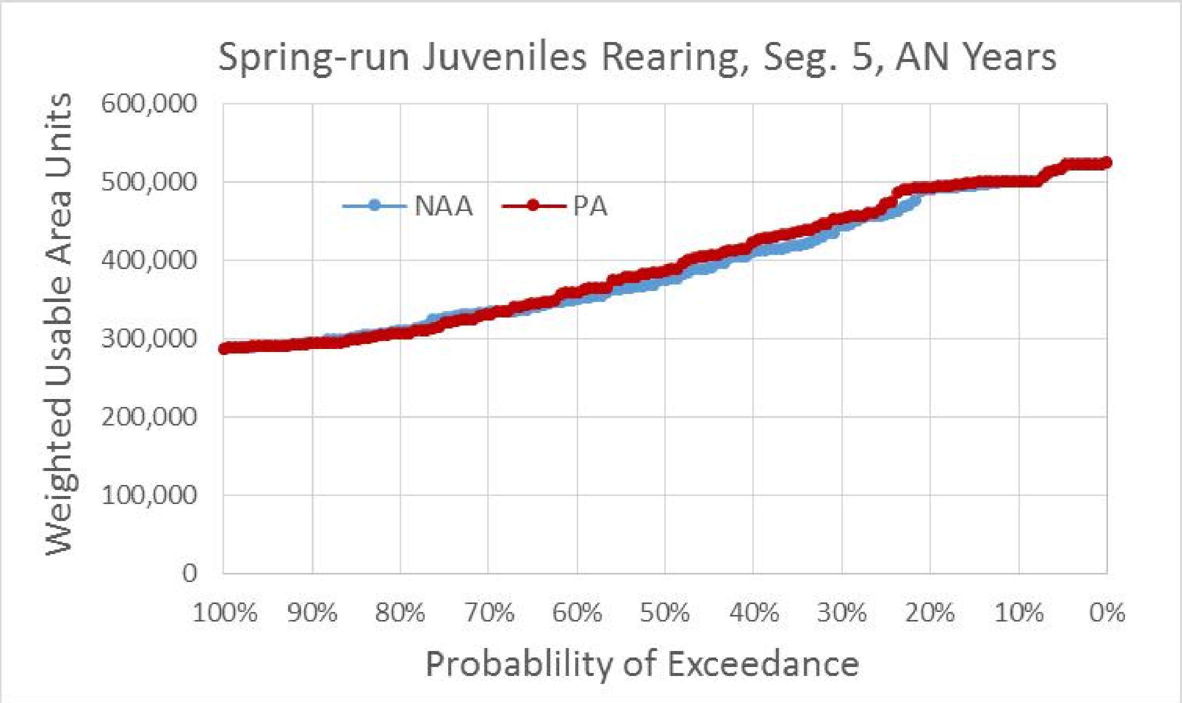

Figure 5.4-171. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

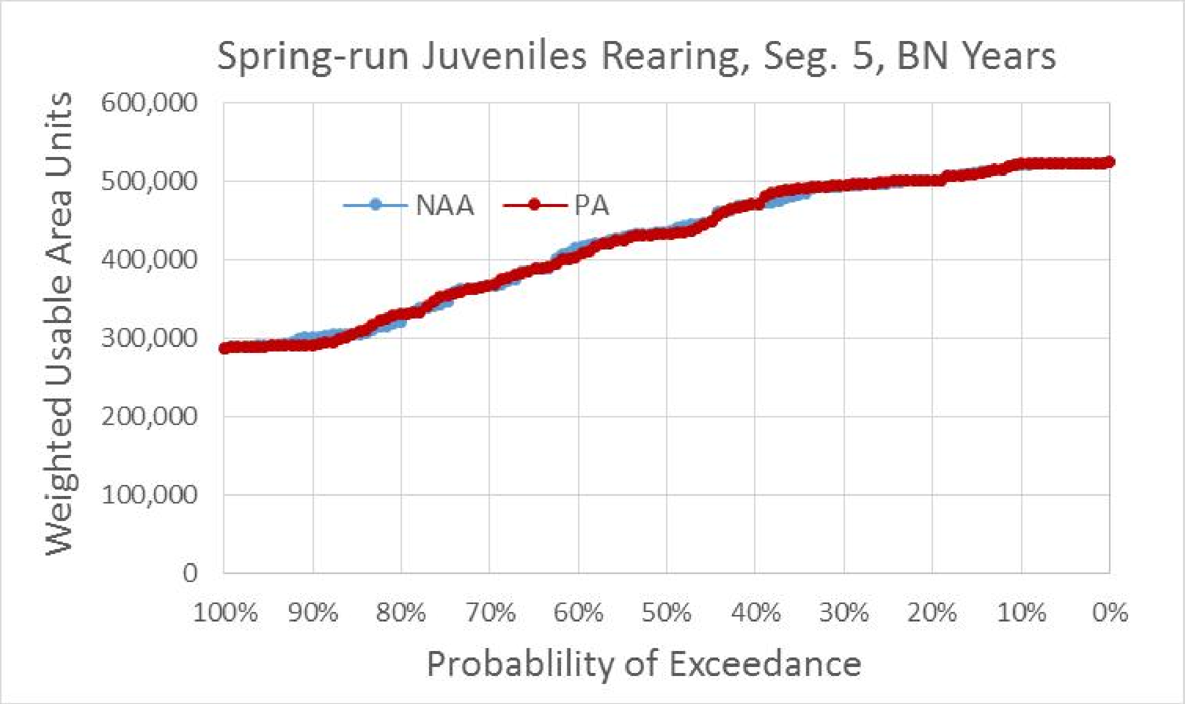

Figure 5.4-172. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

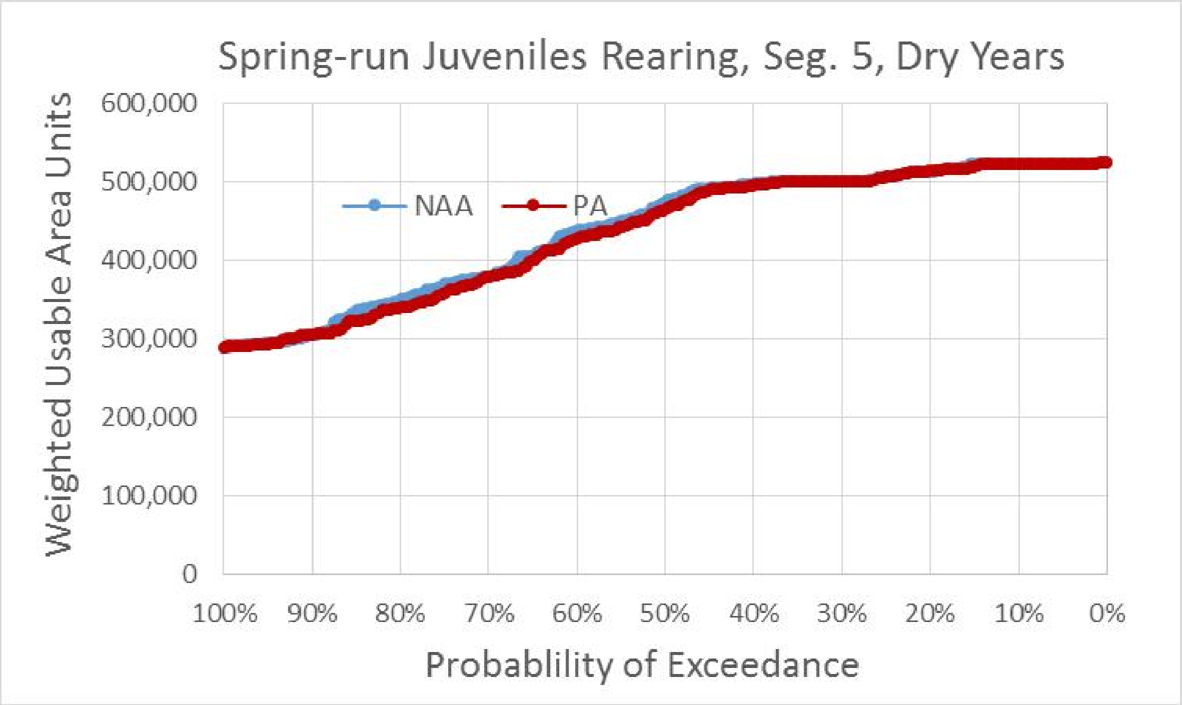

Figure 5.4-173. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

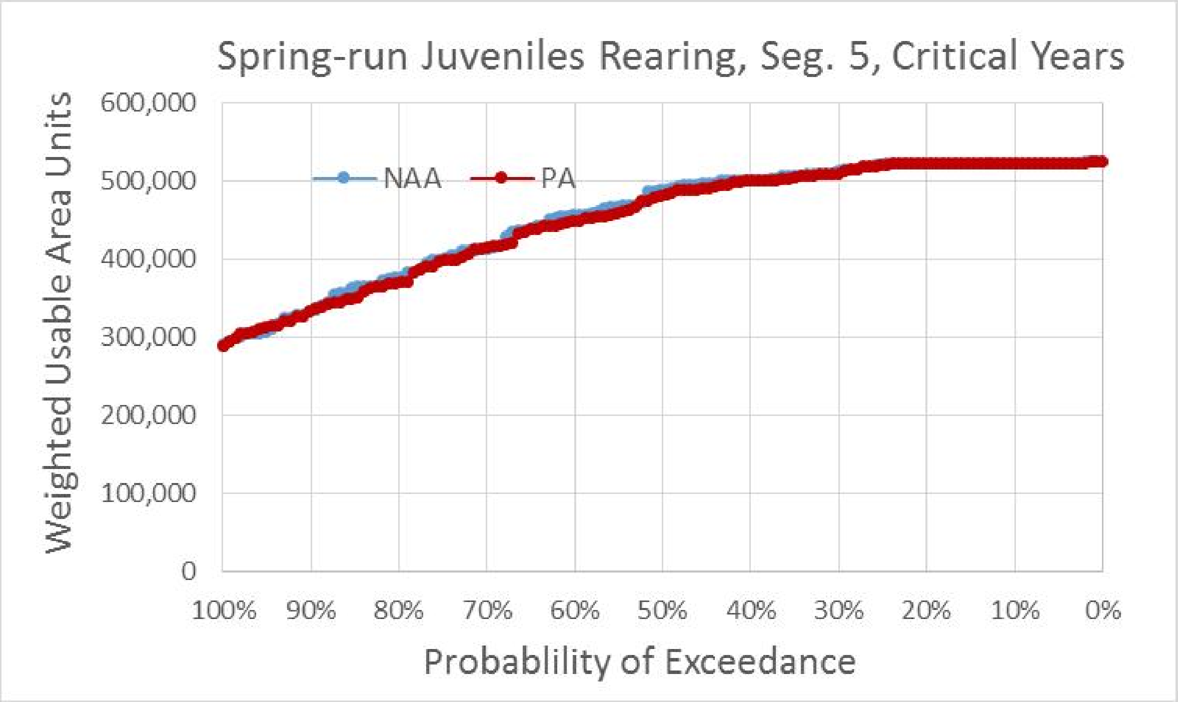

Figure 5.4-174. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

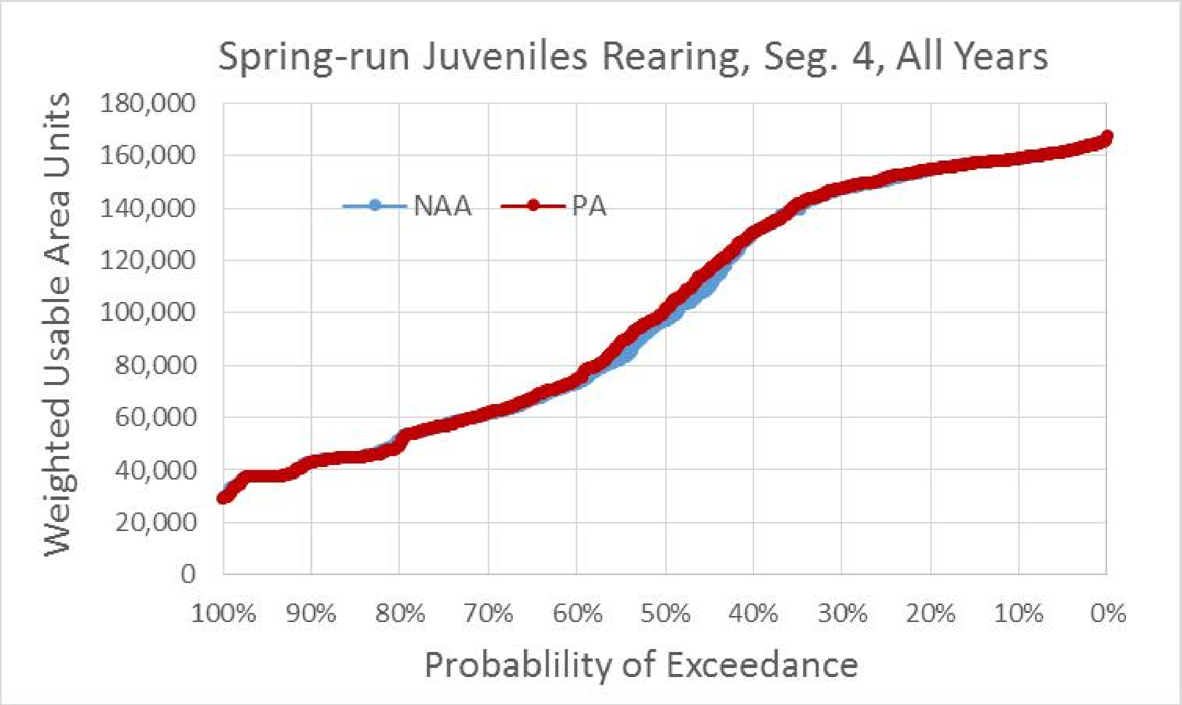

Figure 5.4-175. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

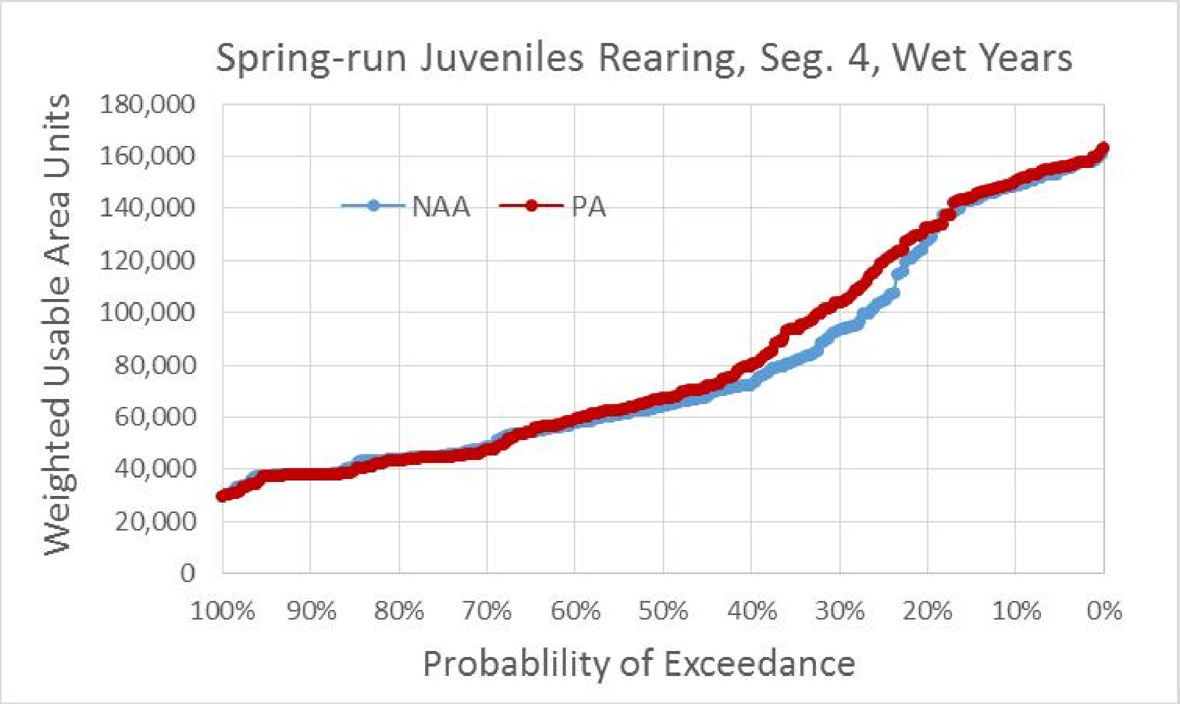

Figure 5.4-176. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

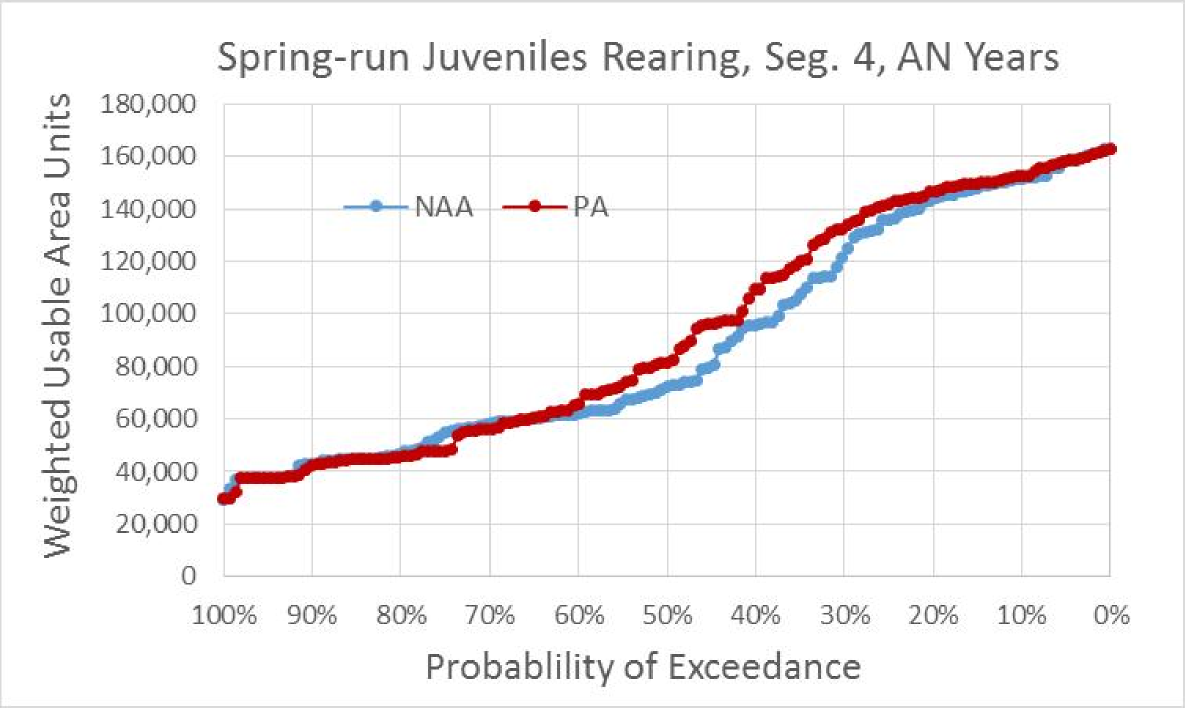

Figure 5.4-177. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

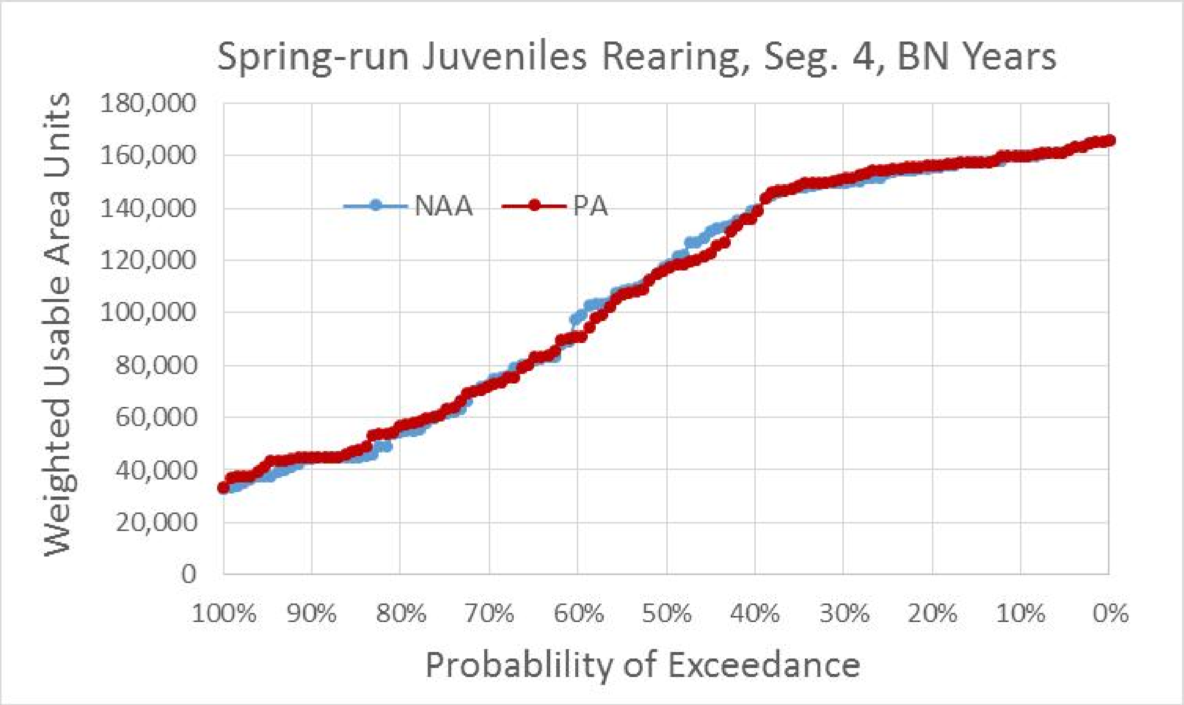

Figure 5.4-178. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

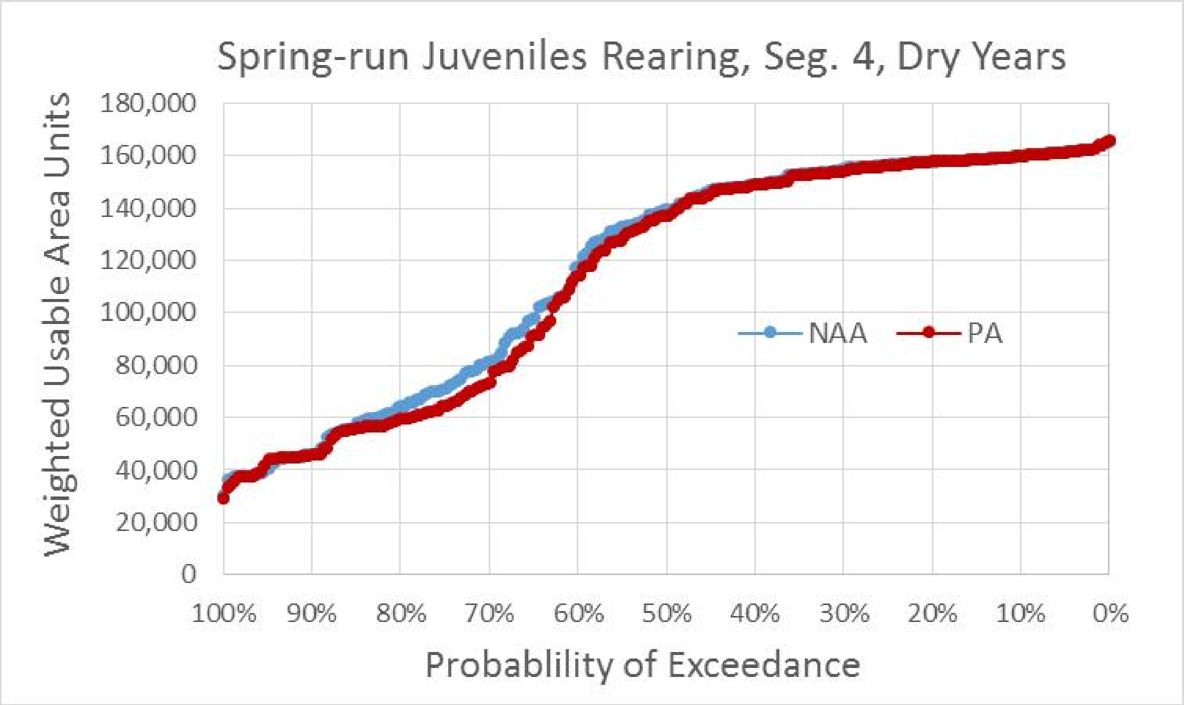

Figure 5.4-179. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

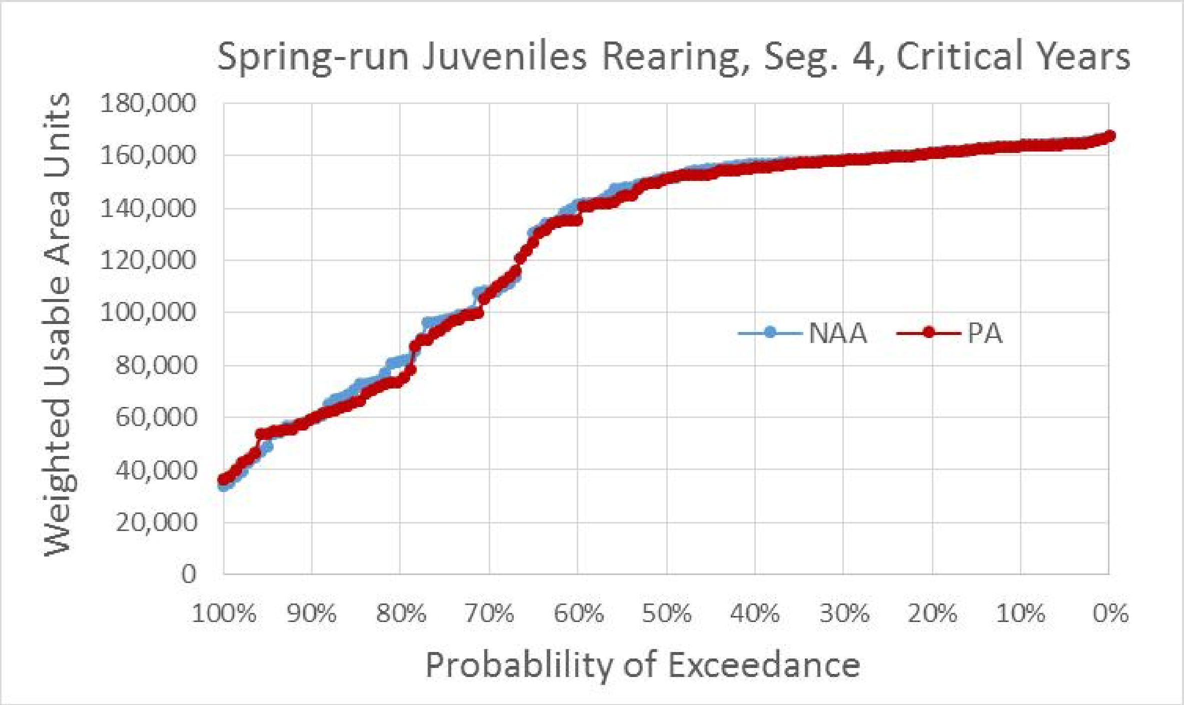

Figure 5.4-180. Exceedance Plot of Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in spring-run Chinook salmon fry and juvenile rearing WUA in each segment under the PAA and NAA were also examined using the grand mean rearing WUA for each month of the fry and juvenile rearing periods under each water year type and all water year types combined (Table 5.4-56 to Table 5.4-57). The means for fry rearing WUA differed by less than 5% for all months and water year types in Segment 6 and for most months and water year types in the other two segments. However, mean fry rearing WUA during November in Segment 5 was 27% higher under the PA than under the NAA in above normal water years and 12% higher in wet years (Table 5.4-57). In Segment 4, mean fry rearing WUA during November was 7% and 9% higher under the PA in wet and above normal years, respectively, but was 6% lower in critical years (Table 5.4-58). The means for juvenile rearing WUA also differed by less than 5% for most months and water year types in Segments 6 and 5 (Table 5.4-59, Table 5.4-60), but differences were greater and more frequent in Segment 4 (Table 5.4-61). In Segments 6 and 5, mean juvenile rearing WUA under the PA was up to 6% lower than that under the NAA during October of below normal years, 6% higher during September of above normal years, and up to 18% higher than that under the NAA during November of wet and above normal years. In Segment 4, mean juvenile rearing habitat WUA under the PA was 8% lower in January of wet years, 6% lower in March of above normal years, 5% lower in May of dry years, 13% and 8% lower in June of dry and critical years, 6% lower in August of dry years, and 14% lower in October of below normal years (Table 5.4-61). Also in Segment 4, mean juvenile WUA under the PA was 5% and 6% higher than that under the NAA in July of dry and critical years, 14% higher during August of below normal years, 19% and 7% higher in September of above normal and below normal years, 16% higher in October of wet years, and 51% and 63% higher in November of wet and above normal years. The WUA modeling indicates that the PA would reduce spring-run Chinook salmon rearing habitat during several months and water year types, especially in Segment 4. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

Table 5.4-56. Spring-Run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 6 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
November	Wet	58,557	60,764	2,207 (4%)
	Above Normal	61,618	62,370	752 (1%)
	Below Normal	60,551	61,282	731 (1%)
	Dry	62,562	62,588	26 (0.04%)
	Critical	66,986	64,682	-2,303 (-3%)
	All	61,519	62,103	584 (0.9%)
December	Wet	65,548	66,992	1,444 (2%)
	Above Normal	66,635	66,829	194 (0.3%)
	Below Normal	65,809	66,446	637 (1%)
	Dry	72,907	72,256	-651 (-0.9%)
	Critical	70,121	70,661	540 (0.8%)
	All	68,239	68,737	498 (0.7%)
January	Wet	68,569	68,470	-100 (-0.1%)
	Above Normal	68,778	68,771	-6 (-0.01%)
	Below Normal	69,865	70,433	568 (0.8%)
	Dry	70,819	70,945	126 (0.2%)
	Critical	70,170	72,298	2,128 (3%)
	All	69,559	69,945	386 (0.6%)
February	Wet	74,671	74,615	-56 (-0.1%)
	Above Normal	78,836	77,904	-932 (-1%)
	Below Normal	68,593	70,799	2,205 (3%)
	Dry	69,051	69,175	124 (0.2%)
	Critical	70,032	71,994	1,963 (3%)
	All	72,466	72,914	448 (0.6%)

Table 5.4-57. Spring-Run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 5 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
November	Wet	926,011	1,041,104	115,093 (12%)
	Above Normal	933,140	1,181,900	248,760 (27%)
	Below Normal	1,253,988	1,314,002	60,014 (5%)
	Dry	1,352,099	1,359,639	7,540 (0.6%)
	Critical	1,459,455	1,393,442	-66,013 (-5%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	All	1,155,843	1,229,872	74,029 (6%)
December	Wet	1,279,311	1,299,436	20,126 (2%)
	Above Normal	1,235,383	1,272,981	37,598 (3%)
	Below Normal	1,285,634	1,284,178	-1,457 (-0.1%)
	Dry	1,302,331	1,284,844	-17,487 (-1%)
	Critical	1,478,631	1,478,842	211 (0.01%)
	All	1,308,875	1,316,421	7,546 (0.6%)
January	Wet	1,243,402	1,184,743	-58,659 (-5%)
	Above Normal	1,315,155	1,315,630	475 (0.04%)
	Below Normal	1,270,988	1,269,935	-1,053 (-0.1%)
	Dry	1,284,618	1,275,452	-9,167 (-0.7%)
	Critical	1,432,288	1,399,043	-33,245 (-2%)
	All	1,296,173	1,270,407	-25,766 (-2%)
February	Wet	1,129,301	1,109,445	-19,856 (-2%)
	Above Normal	1,180,418	1,181,957	1,539 (0.1%)
	Below Normal	1,283,450	1,283,647	197 (0.02%)
	Dry	1,454,111	1,441,233	-12,879 (-0.9%)
	Critical	1,418,711	1,480,899	62,188 (4%)
	All	1,279,658	1,279,592	-66 (0%)

Table 5.4-58. Spring-Run Chinook Salmon Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 4 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
November	Wet	170,587	183,246	12,659 (7%)
	Above Normal	174,232	189,361	15,129 (9%)
	Below Normal	199,855	204,797	4,942 (2%)
	Dry	208,079	209,412	1,334 (0.6%)
	Critical	258,353	242,021	-16,332 (-6%)
	All	197,361	202,247	4,885 (2%)
December	Wet	197,730	203,064	5,334 (3%)
	Above Normal	198,735	200,701	1,967 (1%)
	Below Normal	212,080	211,503	-576 (-0.3%)
	Dry	200,937	202,090	1,153 (0.6%)
	Critical	241,605	243,986	2,380 (1%)
	All	207,119	209,682	2,563 (1%)
January	Wet	188,718	184,053	-4,666 (-2%)
	Above Normal	205,594	205,565	-28 (-0.01%)
	Below Normal	204,395	204,175	-220 (-0.1%)
	Dry	198,053	196,521	-1,532 (-0.8%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	Critical	230,927	219,761	-11,166 (-5%)
	All	201,950	198,429	-3,521 (-2%)
February	Wet	162,338	161,481	-857 (-0.5%)
	Above Normal	167,556	168,140	584 (0.3%)
	Below Normal	209,012	210,031	1,020 (0.5%)
	Dry	224,619	224,143	-476 (-0.2%)
	Critical	245,154	259,482	14,328 (6%)
	All	196,736	198,675	1,939 (1%)

Table 5.4-59. Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 6 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
January	Wet	28,944	27,904	-1,041 (-4%)
	Above Normal	29,751	29,740	-11 (-0.04%)
	Below Normal	29,628	29,571	-57 (-0.2%)
	Dry	29,921	29,966	45 (0.1%)
	Critical	32,677	32,493	-184 (-0.6%)
	All	29,948	29,593	-355 (-1%)
February	Wet	28,792	28,607	-186 (-0.6%)
	Above Normal	28,233	28,133	-100 (-0.4%)
	Below Normal	29,268	29,101	-166 (-0.6%)
	Dry	33,062	33,018	-44 (-0.1%)
	Critical	33,245	34,224	978 (3%)
	All	30,460	30,496	35 (0.1%)
March	Wet	25,414	25,390	-24 (-0.1%)
	Above Normal	27,393	26,663	-731 (-3%)
	Below Normal	31,873	31,373	-500 (-2%)
	Dry	32,863	32,806	-58 (-0.2%)
	Critical	33,622	32,647	-975 (-3%)
	All	29,612	29,265	-347 (-1%)
April	Wet	39,471	39,526	55 (0.1%)
	Above Normal	41,850	41,523	-327 (-0.8%)
	Below Normal	42,342	43,080	738 (2%)
	Dry	42,862	43,323	461 (1%)
	Critical	42,321	42,262	-59 (-0.1%)
	All	41,478	41,646	168 (0.4%)
May	Wet	40,927	40,990	63 (0.2%)
	Above Normal	41,545	41,674	129 (0.3%)
	Below Normal	43,144	42,896	-248 (-0.6%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	Dry	43,171	41,734	-1,437 (-3%)
	Critical	42,326	42,435	108 (0.3%)
	All	42,074	41,747	-328 (-0.8%)
June	Wet	37,291	36,889	-402 (-1%)
	Above Normal	34,123	32,682	-1,441 (-4%)
	Below Normal	34,136	34,230	94 (0.3%)
	Dry	35,461	33,581	-1,880 (-5%)
	Critical	37,656	36,318	-1,338 (-4%)
	All	35,973	34,975	-998 (-3%)
July	Wet	30,648	30,478	-169 (-0.6%)
	Above Normal	30,536	30,212	-324 (-1%)
	Below Normal	30,240	30,586	346 (1%)
	Dry	30,969	31,366	397 (1%)
	Critical	32,998	34,171	1,173 (4%)
	All	30,998	31,207	210 (0.7%)
August	Wet	36,130	35,871	-258 (-0.7%)
	Above Normal	35,711	35,907	196 (0.5%)
	Below Normal	35,227	37,372	2,144 (6%)
	Dry	39,218	38,279	-939 (-2%)
	Critical	39,446	38,559	-887 (-2%)
	All	37,181	37,059	-122 (-0.3%)
September	Wet	31,672	31,609	-63 (-0.2%)
	Above Normal	39,161	41,403	2,242 (6%)
	Below Normal	42,904	43,765	861 (2%)
	Dry	43,006	42,872	-134 (-0.3%)
	Critical	41,419	43,050	1,631 (4%)
	All	38,557	39,214	657 (2%)
October	Wet	41,662	43,027	1,365 (3%)
	Above Normal	43,615	42,822	-792 (-2%)
	Below Normal	45,982	43,621	-2,361 (-5%)
	Dry	42,941	43,409	468 (1.1%)
	Critical	43,397	42,174	-1,223 (-3%)
	All	43,111	43,045	-66 (-0.2%)
November	Wet	23,266	27,516	4,249 (18%)
	Above Normal	25,892	29,210	3,318 (13%)
	Below Normal	29,302	29,654	352 (1%)
	Dry	29,992	30,160	168 (0.6%)
	Critical	32,175	31,239	-936 (-3%)
	All	27,456	29,262	1,806 (7%)
December	Wet	28,523	29,190	668 (2%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	Above Normal	29,402	28,844	-558 (-2%)
	Below Normal	29,969	29,906	-62 (-0.2%)
	Dry	30,546	30,190	-356 (-1%)
	Critical	33,603	33,786	183 (0.5%)
	All	30,101	30,164	62 (0.2%)

Table 5.4-60. Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 5 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
January	Wet	432,112	413,583	-18,529 (-4%)
	Above Normal	445,682	445,658	-24 (-0.01%)
	Below Normal	443,727	443,611	-115 (-0.03%)
	Dry	445,606	444,111	-1,495 (-0.3%)
	Critical	502,981	493,596	-9,384 (-2%)
	All	449,484	441,851	-7,632 (-2%)
February	Wet	373,821	368,986	-4,834 (-1%)
	Above Normal	378,117	377,920	-197 (-0.1%)
	Below Normal	450,190	445,515	-4,674 (-1%)
	Dry	513,604	510,977	-2,627 (-0.5%)
	Critical	508,642	522,494	13,852 (3%)
	All	438,570	437,765	-805 (-0.2%)
March	Wet	366,405	366,379	-26 (-0.01%)
	Above Normal	424,177	410,918	-13,258 (-3%)
	Below Normal	497,733	487,596	-10,137 (-2%)
	Dry	506,508	505,929	-579 (-0.1%)
	Critical	519,295	512,383	-6,912 (-1%)
	All	449,727	445,104	-4,623 (-1%)
April	Wet	420,914	420,134	-780 (-0.2%)
	Above Normal	443,907	443,595	-311 (-0.1%)
	Below Normal	456,425	459,248	2,823 (0.6%)
	Dry	478,483	474,249	-4,234 (-0.9%)
	Critical	436,575	433,844	-2,731 (-0.6%)
	All	445,656	444,306	-1,350 (-0.3%)
May	Wet	394,060	394,839	779 (0.2%)
	Above Normal	413,996	413,087	-909 (-0.2%)
	Below Normal	413,934	415,744	1,810 (0.4%)
	Dry	427,754	416,004	-11,750 (-3%)
	Critical	432,727	429,645	-3,082 (-0.7%)
	All	413,763	410,792	-2,971 (-0.7%)

Month	Water Year Type	NAA	PA	PA vs. NAA
June	Wet	353,610	350,912	-2,698 (-0.8%)
	Above Normal	333,162	323,726	-9,436 (-3%)
	Below Normal	335,110	328,009	-7,101 (-2%)
	Dry	339,645	326,841	-12,804 (-4%)
	Critical	359,134	348,083	-11,051 (-3%)
	All	345,289	337,245	-8,044 (-2%)
July	Wet	304,401	303,147	-1,255 (-0.4%)
	Above Normal	292,543	293,527	983 (0.3%)
	Below Normal	295,515	295,330	-186 (-0.1%)
	Dry	309,237	309,588	351 (0.1%)
	Critical	326,040	332,004	5,964 (2%)
	All	305,675	306,367	692 (0.2%)
August	Wet	346,188	344,506	-1,682 (-0.5%)
	Above Normal	343,345	343,179	-166 (-0.05%)
	Below Normal	338,449	353,968	15,519 (5%)
	Dry	371,310	363,110	-8,200 (-2%)
	Critical	379,657	375,652	-4,006 (-1%)
	All	355,724	354,660	-1,064 (-0.3%)
September	Wet	311,968	313,612	1,644 (0.5%)
	Above Normal	373,342	394,735	21,392 (6%)
	Below Normal	470,407	489,201	18,793 (4%)
	Dry	486,797	495,488	8,691 (2%)
	Critical	485,334	489,551	4,217 (0.9%)
	All	410,964	420,135	9,171 (2%)
October	Wet	402,160	422,695	20,535 (5%)
	Above Normal	428,233	426,672	-1,562 (-0.4%)
	Below Normal	456,276	429,635	-26,640 (-6%)
	Dry	460,804	448,849	-11955 (-3%)
	Critical	478,293	467,689	-10603 (-2%)
	All	439,131	437,350	-1780 (-0.4%)
November	Wet	359,835	417,002	57167 (16%)
	Above Normal	375,328	443,072	67744 (18%)
	Below Normal	467,852	477,774	9922 (2%)
	Dry	481,554	484,303	2749 (0.6%)
	Critical	505,551	493,755	-11796 (-2%)
	All	428,441	457,106	28665 (7%)

Month	Water Year Type	NAA	PA	PA vs. NAA
December	Wet	444,484	446,185	1701 (0.4%)
	Above Normal	446,543	443,261	-3282 (-0.7%)
	Below Normal	453,829	450,779	-3051 (-0.7%)
	Dry	444,837	442,933	-1904 (-0.4%)
	Critical	517,248	518,823	1575 (0.3%)
	All	456,925	456,334	-591 (-0.1%)

Table 5.4-61. Spring-Run Chinook Salmon Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 4 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
January	Wet	105,561	96,786	-8774 (-8%)
	Above Normal	120,006	120,026	19 (0.02%)
	Below Normal	111,312	111,317	5 (0.004%)
	Dry	113,748	113,146	-602 (-0.5%)
	Critical	142,557	137,324	-5233 (-4%)
	All	116,033	112,342	-3691 (-3%)
February	Wet	72,975	70,412	-2563 (-4%)
	Above Normal	82,159	82,191	32 (0.04%)
	Below Normal	115,508	114,052	-1456 (-1%)
	Dry	150,024	148,480	-1,544 (-1%)
	Critical	154,053	160,903	6,850 (4%)
	All	110,794	110,417	-377 (-0.3%)
March	Wet	74,330	74,044	-287 (-0.4%)
	Above Normal	101,342	95,175	-6,167 (-6%)
	Below Normal	146,884	139,687	-7,197 (-5%)
	Dry	145,837	145,714	-123 (-0.1%)
	Critical	160,506	157,978	-2,528 (-1.6%)
	All	118,397	115,963	-2,434 (-2%)
April	Wet	100,706	100,259	-447 (-0.4%)
	Above Normal	114,559	114,471	-87 (-0.1%)
	Below Normal	125,936	128,216	2,281 (2%)
	Dry	141,034	137,514	-3,520 (-2%)
	Critical	123,099	121,151	-1,948 (-2%)
	All	119,400	118,406	-993 (-0.8%)
May	Wet	84,773	85,296	522 (0.6%)
	Above Normal	103,129	102,211	-918 (-0.9%)
	Below Normal	102,810	103,712	901 (0.9%)
	Dry	113,644	107,550	-6,093 (-5%)
	Critical	120,533	117,678	-2,855 (-2%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	All	102,378	100,615	-1,763 (-2%)
June	Wet	64,501	63,511	-990 (-2%)
	Above Normal	55,834	54,584	-1,250 (-2%)
	Below Normal	55,813	58,223	2,411 (4%)
	Dry	61,880	53,985	-7,895 (-13%)
	Critical	72,830	66,683	-6,147 (-8%)
	All	62,541	59,527	-3,014 (-5%)
July	Wet	47,124	45,954	-1,170 (-2%)
	Above Normal	44,779	43,791	-988 (-2%)
	Below Normal	43,578	44,027	449 (1%)
	Dry	48,479	50,945	2,466 (5%)
	Critical	55,578	60,078	4,500 (8%)
	All	47,844	48,637	793 (2%)
August	Wet	64,888	64,007	-881 (-1%)
	Above Normal	65,342	64,175	-1,167 (-2%)
	Below Normal	61,595	70,346	8,750 (14%)
	Dry	81,374	76,801	-4,573 (-6%)
	Critical	86,051	84,560	-1,491 (-2%)
	All	71,636	71,012	-624 (-0.9%)
September	Wet	52,473	51,421	-1,052 (-2%)
	Above Normal	80,500	95,548	15,049 (19%)
	Below Normal	146,125	155,660	9,534 (7%)
	Dry	154,899	158,005	3,105 (2%)
	Critical	156,031	158,501	2,470 (2%)
	All	109,616	114,066	4,450 (4%)
October	Wet	95,915	111,740	15,824 (16%)
	Above Normal	115,276	113,689	-1,586 (-1%)
	Below Normal	134,904	116,236	-18,667 (-14%)
	Dry	137,405	131,516	-5,889 (-4%)
	Critical	152,604	151,355	-1,249 (-0.8%)
	All	122,721	123,391	670 (0.5%)
November	Wet	68,272	103,228	34,956 (51%)
	Above Normal	75,596	122,916	47,320 (63%)
	Below Normal	137,638	143,452	5,814 (4%)
	Dry	140,893	142,968	2,075 (1%)
	Critical	160,501	156,188	-4,313 (-3%)
	All	110,372	129,266	18,894 (17%)
December	Wet	120,552	119,449	-1,103 (-0.9%)
	Above Normal	117,007	114,999	-2,008 (-2%)
	Below Normal	120,260	119,003	-1,257 (-1%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	Dry	118,140	117,090	-1,050 (-0.9%)
	Critical	157,336	157,833	496 (0.3%)
	All	124,841	123,833	-1,008 (-0.8%)

5.4.2.1.3.2.2.1.1 SALMOD flow-related outputs

The SALMOD model provides predicted flow-related fry and juvenile spring-run Chinook salmon mortality, which is presented as mortality of the fry, pre-smolt, and immature smolt life stages (see Attachment 5.D.2, *SALMOD Model*, for a full description). Results for flow-related mortality of these life stages are presented in Table 5.4-54 and the annual exceedance plot for all water year types combined is presented in Figure 5.4-181. These results show no mortality for the pre-smolt and immature smolt life stages and low mortality (in terms of numbers of fish) for the fry. Flow-related mortality of spring-run Chinook salmon fry would increase moderately under the PA relative to the NAA in wet years (8% or 200 fish) and critical years (14% or 55 fish) and would decrease moderately in above normal years (13% or 350 fish). The flow-related mortality of fry for all water year types combined would be almost the same (difference = 0.4%) between the NAA and PA. Accordingly, the model predicts that there would be no biologically meaningful[52] effect of the PA on flow-related mortality of spring-run Chinook salmon fry and juveniles.

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[52] For purposes of flow-related effects, a "biologically meaningful" effect is defined as an effect that would alter one or more biological processes to the extent that it affects the fish population.

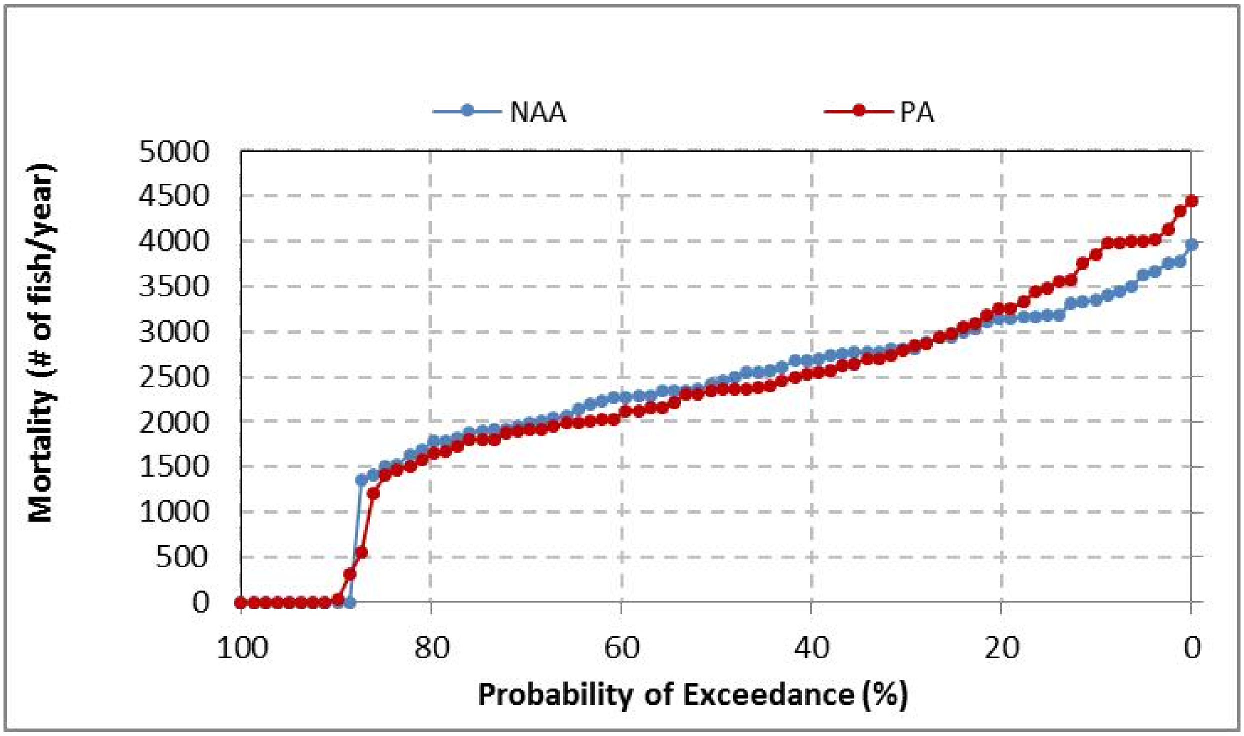

Figure 5.4-181. Exceedance Plot of Annual Flow-Based Mortality (# of Fish/Year) of Spring-Run Chinook Salmon Fry and Juveniles, SALMOD

5.4.2.1.3.2.2.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the year-round fry and juvenile rearing period for spring-run Chinook salmon in the Sacramento River upstream of the Delta (Table 5.4-27) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-10[53]. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the juvenile rearing reach of Keswick Dam to Knights Landing in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 1.0°F (1.4%), and would occur at Knights Landing in below normal years during August.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the juvenile rearing period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.10-7[54]). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of below normal water years in August at Knights Landing, where the largest increase in mean monthly water temperature was seen, indicates that water temperatures under

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[53] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

[54] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

the PA would be higher than those under NAA for most of the exceedance range by up to approximately 2.2°F, particularly in the colder end of the range (Figure 5.4-108). As indicated below in the threshold analysis, temperatures predicted for Knights Landing during August of below normal water years would be greater than the 64°F 7DADM threshold on 100% of days under both the NAA and PA, although there is low certainty that modeled values are comparable to actual values. Therefore, this suggests that, with low certainty, conditions would already be unsuitable for spring-run Chinook salmon fry and juvenile rearing for reasons that are independent of the PA.

For purposes of this analysis, the water temperature thresholds analysis for juvenile rearing and emigration were combined and the year-round period was evaluated. For juvenile rearing and emigration, the thresholds used were from the USEPA's 7DADM value of 61°F for core juvenile rearing reach from Keswick Dam to Red Bluff and 64°F for the non-core juvenile rearing reach at Knights Landing (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49). The 7DADM values were converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-85 through 5.D-90. At Keswick Dam, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-85). There would be two instances in which average daily exceedance would be 0.5°F: September of critical years and September for all water year types combined (reflecting that the only differences in threshold exceedance among water year types during September would occur during critical years). However, there would be no concurrent increase in the percent of days exceeding the threshold in these instances. This indicates that the frequency of days above the threshold be would similar under the PA, but exceedances would be higher on average.

At Clear Creek, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold, and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-86). However, the percent of days exceeding the threshold under the PA would be more than 5% lower than under the NAA during September and October of critical water years (6.7% and 11.8%, respectively). Despite this reduction during September of critical water years, the difference in mean daily exceedance would increase by 0.7°F. This indicates that the frequency of days above the threshold would decrease under the PA, but exceedances per day would be higher on average.

At Balls Ferry, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the 61°F 7DADM threshold, and no more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-87). Therefore, it was concluded that there would be no biologically meaningful effect. There are two situations at Balls Ferry during which the percent of days exceeding the threshold under the PA would be more than 5% lower than under the NAA during September and October of critical water years (10% and 14%, respectively). Despite this reduction during September of critical water years, the difference in mean daily exceedance would increase by 0.7°F. This indicates that the frequency of days above the threshold would decrease under the PA, but exceedances per day would be higher on average.

At Bend Bridge, the percent of days exceeding the 61°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during July of critical water years (7.8%), August (5.9%) and September of below normal (15.8%) years, and September of dry (8.0%) water years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-88). There would also be a reduction of 8.4% and 11.6% in the percent of days exceeding the threshold in August of dry and critical water years, respectively, and of 11% in October of critical water years. There would not be an increase in average daily exceedance except in August of critical water years. This indicates that the frequency of days above the threshold would decrease under the PA, but exceedances per day would be higher on average.

At Red Bluff, the percent of days exceeding the 61°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during July of critical water years (6.5%), August of below normal years (9.4%), and September of above normal (7.7%), below normal (10.3%), and dry (5.5%) water years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-89). However, in no month or water year type would there be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect at Red Bluff.

At Knights Landing, the percent of days exceeding the 64°F 7DADM threshold for non-core rearing and emigration habitat under the PA would be more than 5% higher than under the NAA during October of wet water years (6.9%) (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-90). There would also be a 7.9% reduction in the percent of days exceeding the threshold during October of below normal water years. However, in neither of these situations would there also be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect. There would be >0.5F increases in the magnitude of average daily exceedance in 3 cases: September of above normal water years (0.8°F), and August (1.0°F) and September (0.8°F) of below normal water years. Temperatures predicted for Knights Landing during August of below normal water years would be greater than the 64°F 7DADM threshold on 100% of days under both the NAA and PA, although there is low certainty that modeled values are comparable to actual values. Therefore, this suggests that, with low certainty, conditions would already be unsuitable for spring-run Chinook salmon fry and juvenile rearing for reasons that are independent of the PA.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could have lethal or sublethal effects on spring-run Chinook salmon fry and juvenile rearing, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. This analysis also does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival. This process may result in refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. Although the process targets winter-run Chinook salmon, these changes are expected to benefit other races of Chinook salmon. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

The SALMOD model provides predicted water temperature-related fry and juvenile spring-run Chinook salmon mortality, which is a combination of mortality of the fry, pre-smolt, and immature smolt life stages (see Attachment 5.D.2, *SALMOD Model*, for a full description). Results for water temperature-related mortality of these life stages are presented in Table 5.4-55 and the annual exceedance plot is presented in Figure 5.4-182. These results indicate that there would be very little water temperature-related mortality to these life stages. Therefore, there would be no biologically meaningful effect of the PA.

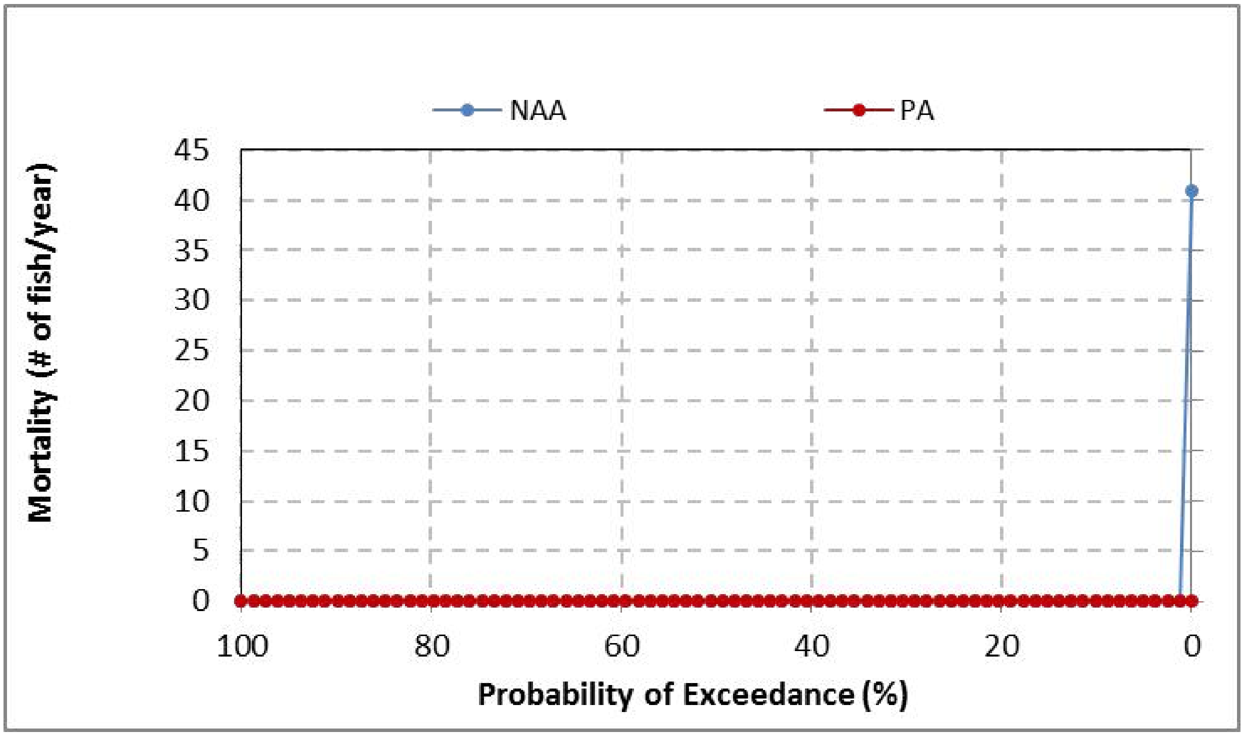

Figure 5.4-182. Exceedance Plot of Annual Water Temperature-Based Mortality (# of Fish/Year) of Spring-Run Chinook Salmon Fry and Juveniles, SALMOD

5.4.2.1.3.2.3 *Juvenile Emigration*

5.4.2.1.3.2.3.1 Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at four locations along the downstream migration corridor of juvenile spring-run Chinook salmon (i.e., Keswick, Red Bluff, Wilkins Slough and Verona) during the October through May emigration period, with peak migration from October through December and in April (Table 5.4-27). Changes in flow potentially affect emigration of juveniles, including the timing and rate of emigration, as well as conditions for feeding, protective cover, resting, temperature, turbidity, and other habitat factors. Crowding and stranding, especially in side-channel habitats, can also be affected (Quinn 2005; Williams 2006; del Rosario et al. 2013). As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* quantitative relationships between flow and downstream migration generally are highly variable and poorly understood, but on balance, except under very high flows, benefits of increased flow generally outweigh the costs. Therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for the emigration of juvenile spring-run Chinook salmon. Milner et al. (2012) and del Rosario et al. (2013) have found that migration cues for anadromous fish species are often the result of natural pulse flows, or pulse flows caused by natural events, such as an extensive rainfall event, which will not be affected by the PA.

Shasta Reservoir storage volume at the end of September influences flows in the Sacramento River during much of the juvenile emigration period. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-3).

In general, mean flow under the PA would be similar to (less than 5% difference) or greater than flow under the NAA during most months and water year types of the spring-run juvenile emigration period (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-10, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During November of wet and above normal water years, however, flow under the PA would be 26% lower than it would be under the NAA at Keswick Dam, 21% lower at Red Bluff, up to 24% lower at Wilkins Slough, and up to 17% lower at Verona. In November of critical water years, flow would be greater at all the locations (up to 13% greater in Keswick). Flow would also be lower in October of wet years (7% to 9% lower, depending on location) and 6% to 13% lower in February of critical years, except at Verona. The largest increases in flow under the PA would occur during October of below normal and dry years, with increases in ranging from 6% in dry years at Red Bluff to 17% in below normal years at Keswick. The large flow differences during October and November coincide with the peak of the juvenile emigration period. During January, mean flow under the PA at Keswick would be 18% greater than it would be under the NAA in critical water year types and 8% greater in wet years. At Red Bluff, the mean January flow in critical years would be 7% greater under the PA; at the other two locations, all differences in January flow would be less than 5%. During February, in addition to the flow reductions described above, flow would be 8% greater in below normal years but only at Keswick. During March, flow under the PA at Keswick would be 9% greater in above normal and below normal years and 8% greater in critical years, but there would be no differences greater than 5% at the other locations. During May, flow would be 5% to 8% greater in dry years, except at Verona.

The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.1.3.2.3.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the Sacramento River in the reach from Keswick Dam to Knights Landing during the October through May juvenile emigration period for spring-run Chinook salmon (Table 5.4-27) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-10[55]. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the Sacramento River upstream of the Delta in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 1.0°F (1.4%), and would occur at Knights Landing in below normal years during August.

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[55] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

Exceedance plots of monthly mean water temperatures were examined during each month throughout the spring-run Chinook salmon juvenile emigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.10-7[56]). Values in the exceedance plots for PA generally match those of the NAA, except in below normal water years in August at Knights Landing, for which water temperatures under the PA would be higher than those under NAA for most of the range by up to approximately 2.2°F, particularly at the colder end of the range (Figure 5.4-108). As indicated above, temperatures predicted for Knights Landing during August of below normal water years would be greater than the 64°F 7DADM threshold on 100% of days under both the NAA and PA although there is low certainty that modeled values are comparable to actual values. Therefore, this suggests that, with low certainty, conditions would already be unsuitable for spring-run Chinook salmon juvenile emigration for reasons that are independent of the PA.

Please see the discussion of water temperature thresholds for juvenile spring-run Chinook salmon emigration in Section 5.4.2.1.3.1.2, *Fry and Juvenile Rearing,* which concludes that that there would be no water temperature-related effects of the PA on spring-run Chinook salmon juvenile rearing and emigration

5.4.2.1.3.2.4 Adult Immigration

5.4.2.1.3.2.4.1 Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at four locations along the upstream migration corridor of adult spring-run Chinook salmon (i.e., Keswick, Red Bluff, Wilkins Slough and Verona) during the March through September immigration period, with peak migration during May and June (Table 5.4-27). Changes in flow potentially affect conditions for upstream migration of adults, including bioenergetic cost, water quality, crowding, cues for locating natal streams, and passage conditions, but the quantitative relationship between flow and upstream migration is poorly understood (Quinn 2005; Milner et al. 2012). As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* on balance, except under very high flows, the benefits of increased flow generally outweigh the costs and, therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for upstream migration of adult spring-run Chinook salmon. Milner et al. (2012) and del Rosario et al. (2013) have found that migration cues for anadromous fish species are often the result of natural pulse flows, or pulse flows caused by natural events, such as an extensive rainfall event, which will not be affected by the PA.

Shasta Reservoir storage volume at the end of May influences flows in the Sacramento River during the second half of the immigration period. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-3).

In general, mean flows under the PA at the four river locations during the 4 months of the adult immigration period for spring-run Chinook salmon would be similar to (less than 5% difference)

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[56] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

or greater than those under the NAA, whereas mean flows during the last 3 months would be similar (less than 5% difference) between the PA and the NAA or would be lower under the PA (Appendix 5.A, *CALSIM Methods and Results,* Table 5.A.6-10, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During March, mean flow under the PA at Keswick would be 9% greater in above normal and below normal years and 8% greater in critical years, but there would be no differences greater than 5% at the other locations. During May, flow under the PA would be greater (up to 8% greater at Wilkins Slough) at all the locations, except Verona. During June, flow under the PA would be greater at all the locations, including all water year types at Verona and all water year types, except wet years at the other locations. The increases for all water year types would be greater at Wilkins Sough and Verona (up to 25% greater in above normal years) than those at Keswick and Red Bluff. The flow differences during May and June, all of which are positive for the PA, would occur during the peak immigration period. During July of critical water years, mean flow under the PA would be up to 13% lower at Wilkins Slough and Verona. During August, mean flow in below normal years would be lower at all four locations (up to 18% lower flow at Wilkins Slough). During August of dry and critical years, flow under the PA would be greater (up to 10% greater) at Wilkins Slough and Verona. Mean flow during September would be lower for most water year types at all the locations (up to 24% lower in below normal years at Verona).

The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*. As described in Appendix 5.D, Section 5.D.2.4*, Migration Flows Methods,* mean monthly flow below about 3,250 cfs is considered to have potentially adverse effects on Chinook salmon, CCV steelhead, and green sturgeon adult immigration conditions in the Sacramento River. The effect of the PA on the frequency of flows below this threshold was evaluated by comparing CALSIM flows between the PA and the NAA at three of the migration corridor locations in the river: Keswick, Red Bluff, and Wilkins Slough. Of the 574 months within the spring-run Chinook salmon migration period, only one has a mean flow less than 3,250 cfs under both the PA and the NAA at Keswick and Wilkins Slough, and none has a mean flow less than 3,250 cfs at Red Bluff. The one month with mean flow less than 3,250 cfs for both scenarios and locations was September of 1934, a critically dry water year.

5.4.2.1.3.2.4.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the Sacramento River at Keswick Dam, Bend Bridge, and Red Bluff during the March through September adult immigration period for spring-run Chinook salmon (Table 5.4-27) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-7, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.6°F (0.9% to 1.1%), and would occur at Red Bluff in below normal years during August and in above- and below normal water years during September.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the adult immigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The curves for the PA generally match those of the NAA. For below normal water years in August at Red Bluff, where the largest increase in mean monthly water temperature was seen, the PA curve is consistently higher than the NAA curve by approximately 0.5°F (Figure 5.4-111). During September of above normal and below normal water years, water temperatures are more variable between the two scenarios, but those under the PA are higher in nearly all years (Figure 5.4-60, Figure 5.4-61).

To evaluate water temperature threshold exceedance during the adult immigration life stage at Keswick Dam, Bend Bridge, and Red Bluff, the USEPA's 7DADM threshold value of 68°F was used (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D.2-49). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D.2-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-91 through 5.D-93. At Keswick Dam and Red Bluff, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold, and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-91 and Table 5.D-93).

At Bend Bridge, there are two instances during which the percent of days exceeding the 68°F DADM under the PA would be more than 5% higher than under the NAA: August of critical water years (5.1% higher under the PA) and September of critical water years (5.3% higher) (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-92). However, there would be an insignificant (less than 0.1°F) difference in average daily exceedance in these instances. Therefore, it was concluded that there would be no biologically meaningful effect on spring-run adult immigration.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could have lethal or sublethal effects on winter-run Chinook salmon adult immigration, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

5.4.2.1.3.2.5 Adult Holding

5.4.2.1.3.2.5.1 Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at the Keswick Dam and Red Bluff locations during the April through September holding period, with peak occurrence during May through August, for spring-run

Chinook salmon (Table 5.4-27). Changes in flow likely affect holding habitat for spring-run Chinook salmon, with higher flows potentially providing greater depths and improved water quality in pools. Shasta Reservoir storage volume at the end of May influences flow rates below the dam during much of the spring-run holding period. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A*, CALSIM Methods and Results*, Table 5.A.6-3). During the majority of months and water year types of the spring-run holding period, the PA would result in minor (less than 5% difference) changes in mean flow in the Sacramento River at the Keswick Dam and Red Bluff locations (Appendix 5.A*, CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35). However, at both locations, flows under the PA would be 5% to 7% higher during May of dry years and June of all water year types except wet years. Mean flow during August of below normal years would be 10% lower under the PA than under the NAA and mean flows during September would range from 5% to 11% lower under the PA for all water year types except wet years. The flow increases during May and June and the decrease during August occur within the peak spring-run holding period (May through August).

5.4.2.1.3.2.5.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the Sacramento River at Keswick Dam, Balls Ferry, and Red Bluff during the April through September adult holding period for spring-run Chinook salmon (Table 5.4-27) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results.* Table 5.C.7-3, Table 5.C.7-5, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.6°F, or up to 1.1%, and would occur at Red Bluff in above normal years during August and above- and below normal years during September. This 0.6°F increase during August would occur during the last month of the peak adult holding period (May through August).

Exceedance plots of monthly mean water temperatures were examined during each month throughout the adult holding period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.5-7, Figure 5.C.7.8-7). The curves for PA generally match those of the NAA. For below normal water years in August at Red Bluff, where the largest increase in mean monthly water temperature was seen, the PA curve is consistently higher than the NAA curve by approximately 0.5°F (Figure 5.4-111).

To evaluate water temperature threshold exceedance during the spring-run Chinook salmon adult holding life stage at Keswick Dam, Balls Ferry, and Red Bluff, the USEPA's 7DADM threshold value of 61°F was used (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49) (U.S. Environmental Protection Agency 2003). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-94 through 5.D-96. At Keswick Dam and Balls Ferry, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold, and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-94 and Table 5.D-95). Also at Balls Ferry, there would be a 10% reduction under the PA in the percent of days above the threshold in September of critical water years and a concurrent increase in average daily exceedance above the threshold of 0.7°F.

At Red Bluff, the percent of days exceeding the 61°F 7DADM threshold for adult holding habitat under the PA would be more than 5% higher than under the NAA during July (6.5%) of critical water years, August of below normal water years (9.4%), and September of above normal (7.7%), below normal (10.3%) and critical (5.5%) water years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-96). There would also be reductions in the percent of days exceeding the threshold in June of critical years (5.8%) and August of dry (6.1%) and critical (6.5%) water years. However, in none of these situations would there also be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could have lethal or sublethal effects on holding adults, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. In addition, this analysis does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival. This process may result in refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. Although the process targets winter-run Chinook salmon, these changes are expected to benefit other races of Chinook salmon. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

5.4.2.1.3.2.6 SALMOD

The SALMOD model integrates all early life stages of spring-run Chinook salmon race on an annual basis and provides an *Annual Potential Production* value (Attachment 5.D.2, *SALMOD Model*). This value represents all individuals that survive from the pre-spawn egg stage to the end of the year in each year of the 80-year simulation period. Individual years are independent of one another and, therefore, effects through time cannot be evaluated as a time series.

Mean spring-run Chinook salmon annual potential production values and differences between scenarios are presented in Table 5.4-62 and an exceedance plot is provided in Figure 5.4-183. Overall, these results indicate that changes in spring-run Chinook salmon annual potential production under the PA relative to the NAA would be insignificant. This result is consistent among water year types and when all water year types are combined, except in critical years, in which there would be a 20,164 fish (8%) increase in annual potential production under the PA, indicating a beneficial effect of the PA to spring-run Chinook salmon annual potential production.. However, as a model that integrates early life stages, but not all life stages, SALMOD does not provide a basis to evaluate the subsequent impacts of in-Delta effects on the predicted annual potential production.

Table 5.4-62. Mean Annual Potential Production of Spring-Run Chinook Salmon and Differences between Model Scenarios, SALMOD

Analysis Period	Annual Potential Production (# of Fish/year)
All Water Year Types Combined	
Full Simulation Period1	
NAA	401,814
PA	407,082
Difference	5,269
Percent Difference2	1
Water Year Types3	
Wet (32.5%)	
NAA	442,361
PA	457,069
Difference	14,708
Percent Difference	3
Above Normal (12.5%)	
NAA	376,362
PA	379,324
Difference	2,963
Percent Difference	1
Below Normal (17.5%)	
NAA	464,026
PA	463,493
Difference	-533
Percent Difference	0
Dry (22.5%)	
NAA	412,383
PA	401,490
Difference	-10,894
Percent Difference	-3
Critical (15%)	
NAA	268,146
PA	288,311
Difference	20,164
Percent Difference	8

[1] Based on the 80-year simulation period

[2] Relative difference of the annual average

[3] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (State Water Resources Control Board 1995). Water years may not correspond to the biological years in SALMOD.

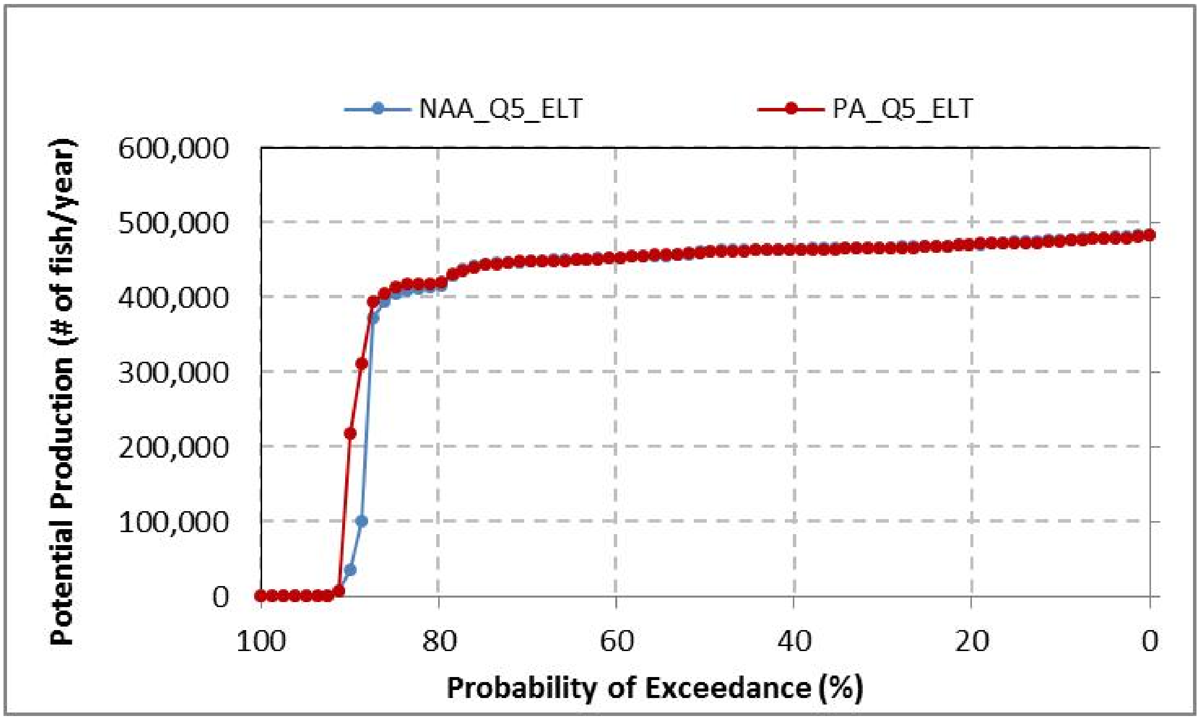

Figure 5.4-183. Exceedance Plot for Annual Potential Production (# of Fish/Year) of Spring-Run Chinook Salmon, SALMOD

The frequency at which annual production was below minimum production thresholds was evaluated as a measure of a worst-case scenario for spring-run Chinook salmon. Thresholds were determined as 5% and 10% of the number of eggs used as inputs into the model (see Attachment 5.D.2, *SALMOD* for details). The initial egg value was 1,210,000 for both NAA and PA and, therefore, the 5% and 10% values were 60,500 fish per year and 121,000 fish per year, respectively. Results are presented in Table 5.4-63. There would be 1 year fewer (11% lower) under the PA compared to the NAA during which production would be below the 5% (60,000 fish) threshold. There would be 2 fewer years (20% lower) under the PA compared to the NAA during which production would be below the 10% (591,300 fish) threshold. Therefore, the PA would have no biologically meaningful negative effects on the frequency of worst-case scenario years for spring-run Chinook salmon.

Table 5.4-63. Number of Years during which Winter-Run Chinook Salmon Production Would be Lower than Production Thresholds and Differences (Percent Differences) between Model Scenarios, SALMOD

Production Threshold (# of Fish)	NAA (# of Years)	PA (# of Years)	PA vs. NAA (# of Years [%])
60,500 (based on 5% of eggs)	9	8	-1 (-11%)
121,000 (based on 10% of eggs)	10	8	-2 (-20%)

5.4.2.1.3.3 California Central Valley Steelhead

5.4.2.1.3.3.1 Spawning, Egg Incubation, and Alevins

5.4.2.1.3.3.1.1 Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA during the November through April spawning and incubation period for Central Valley (CV) Steelhead (Table 5.4-29). Changes in flow can affect the instream area available for spawning and egg incubation, along with the quality of the habitat, and can result in dewatering or scour of the redds. Shasta Reservoir storage volume at the end of September influences flow rates below the dam during some of the steelhead spawning and egg incubation period in some years. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A*, CALSIM Methods and Results*, Table 5.A.6-3). Under the PA, mean flow at the Keswick Dam and Red Bluff locations in the Sacramento River would be lower than flow under the NAA during November of all except critical water year types, with 26% lower flows under the PA than under the NAA for wet and above normal water year types at Keswick Dam and 21% lower flows at Red Bluff (Appendix 5.A*, CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35). During most of the remaining months and water year types of the spawning period, changes in mean flow would be minor (less than 5% difference). However, flows under the PA at Keswick Dam would be 13% higher during November of critical water years, up to 18% higher during January of critical years, and 13% lower in February of critical years than flows under the NAA. Differences at Red Bluff would generally be similar but smaller. The results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.1.3.3.1.1.1 Spawning WUA

Spawning WUA for Central Valley steelhead in the Sacramento River was determined by USFWS (2003a, 2006) in the same manner that it was determined for winter-run Chinook salmon, except that habitat suitability criteria (HSC) previously determined for Central Valley steelhead in the American River (U.S. Fish and Wildlife Service 2003b) were used in developing the Sacramento River steelhead WUA curves (Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*). HSC data were not collected by USFWS for steelhead in the Sacramento River because very few steelhead redds were observed and because the steelhead redds could not be distinguished from those of resident rainbow trout. The validity of this substitution could not be tested and is uncertain (U.S. Fish and Wildlife Service 2003a). To evaluate the effects of the PA on steelhead spawning habitat, steelhead spawning WUA was estimated for flows during the November through April spawning period under the NAA and the PA in the same three segments of the Sacramento River that were used for winter-run and spring-run Chinook salmon: Segment 4 (Battle Creek to the confluence with Cow Creek), Segment 5 (Cow Creek to the A.C.I.D. Dam), and Segment 6 (A.C.I.D. Dam to Keswick Dam). Further information on WUA analysis methods is provided in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*. Differences in steelhead spawning WUA under the PA and NAA were examined using exceedance plots of monthly mean WUA for the steelhead spawning period in each of the river segments for each water year type and all water year types combined (Figure 5.4-180 – Figure 5.4-197). The exceedance curves with all water years combined (Figure 5.4-184, Figure 5.4-190, and Figure 5.4-196) and those broken out by water year type (Figure 5.4-181 through Figure 5.4-189, Figure 5.4-191 through Figure 5.4-195, and Figure 5.4-197 through Figure 5.4-201) are largely similar between the PA and the NAA for all three river segments.

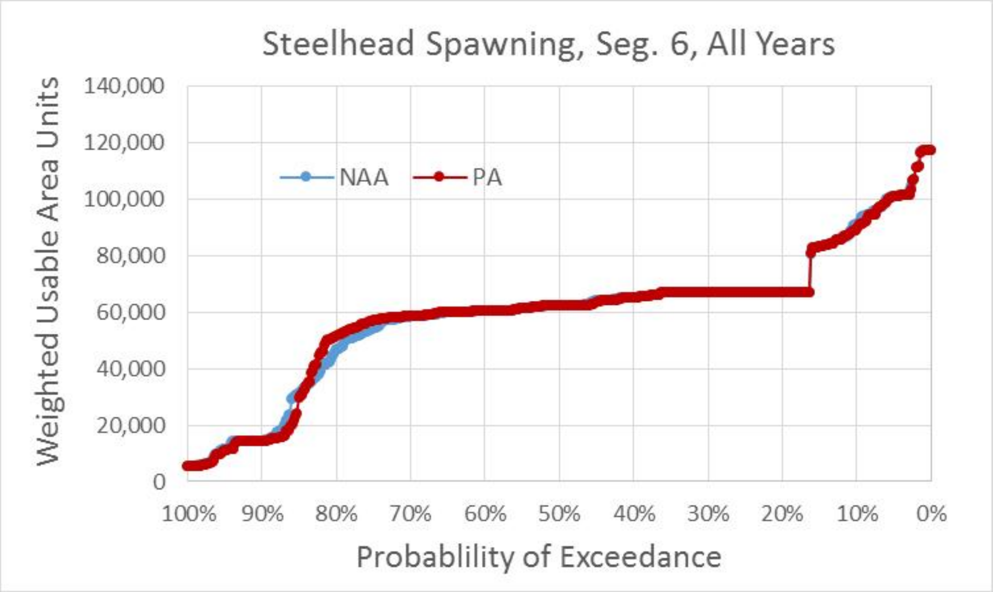

Figure 5.4-184. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

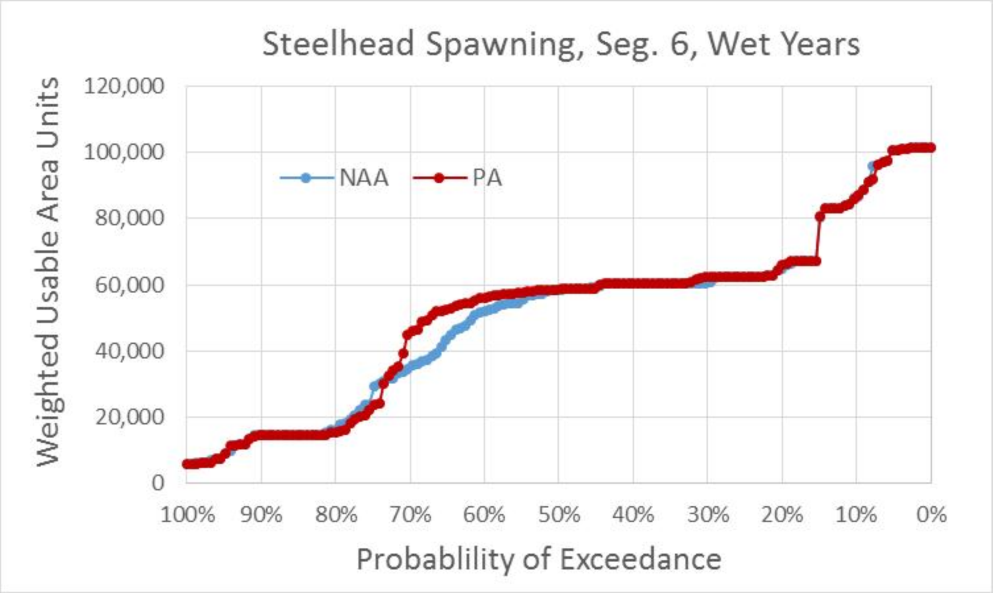

Figure 5.4-185. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

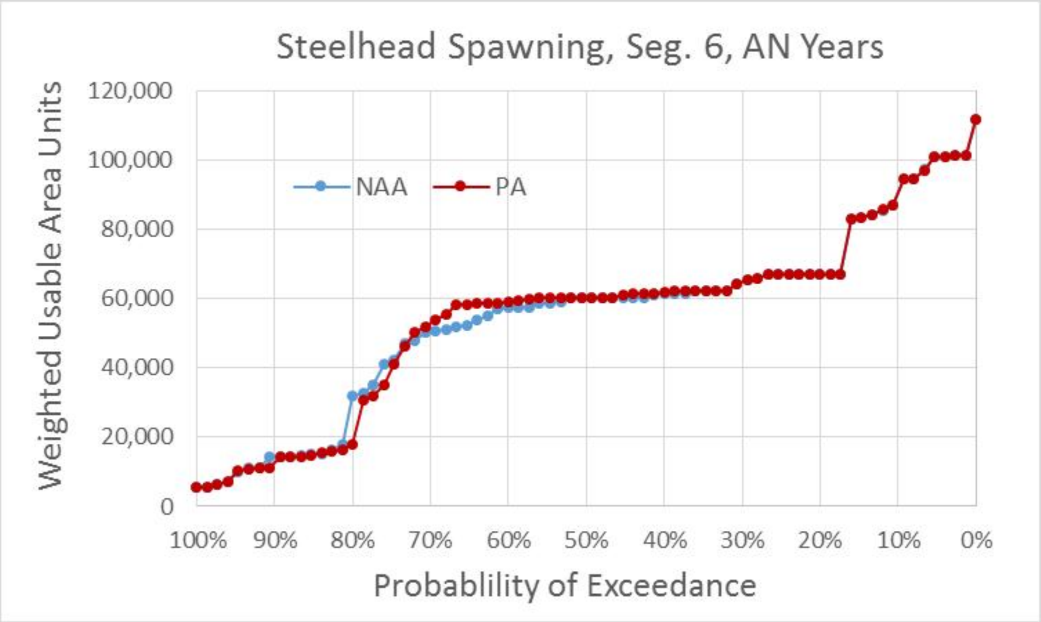

Figure 5.4-186. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

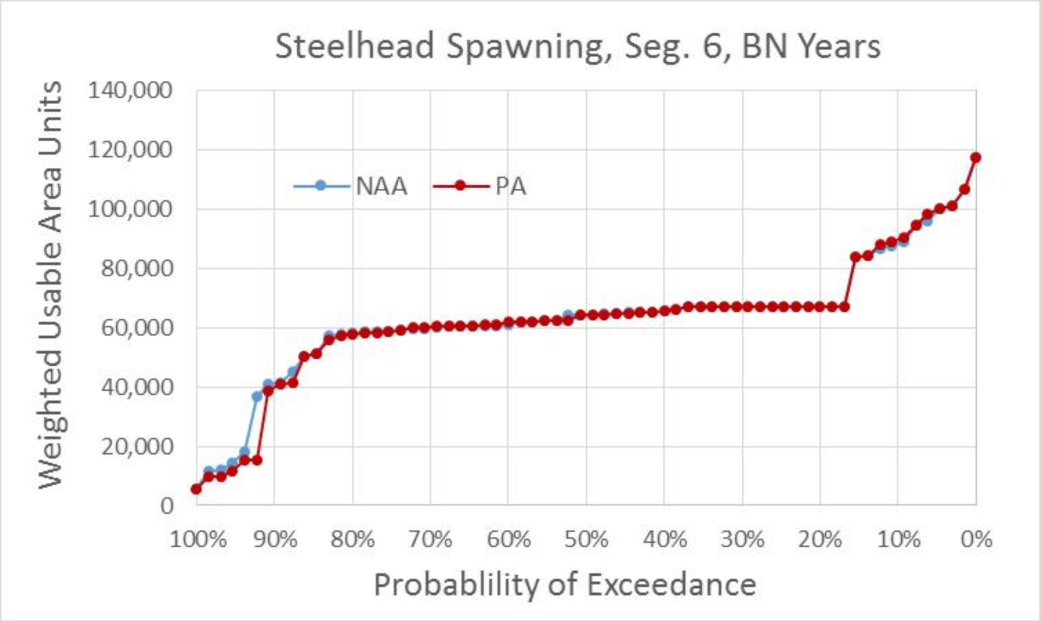

Figure 5.4-187. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

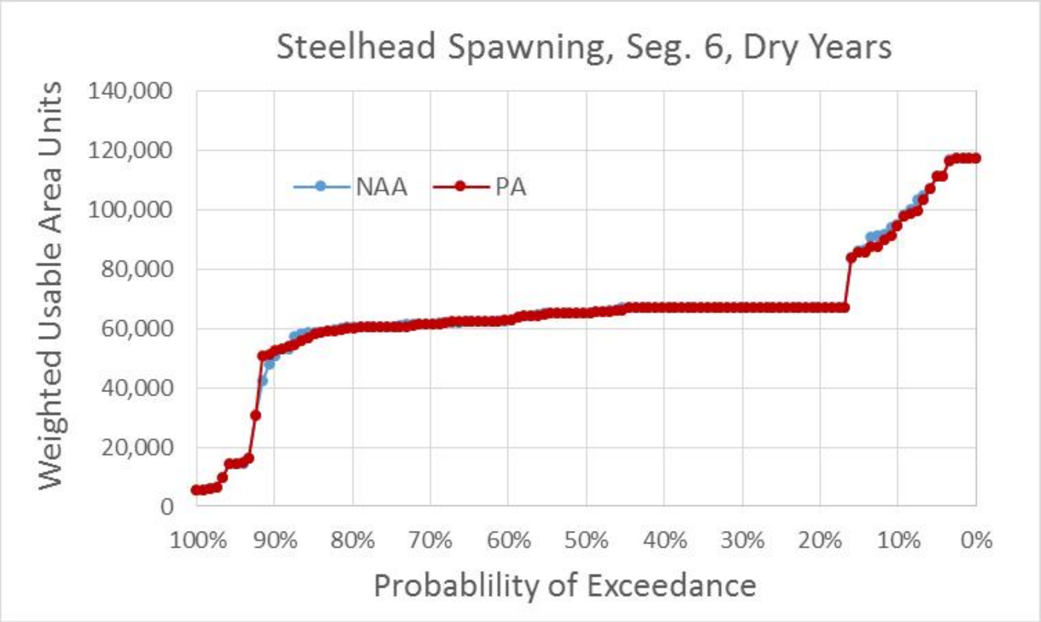

Figure 5.4-188. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

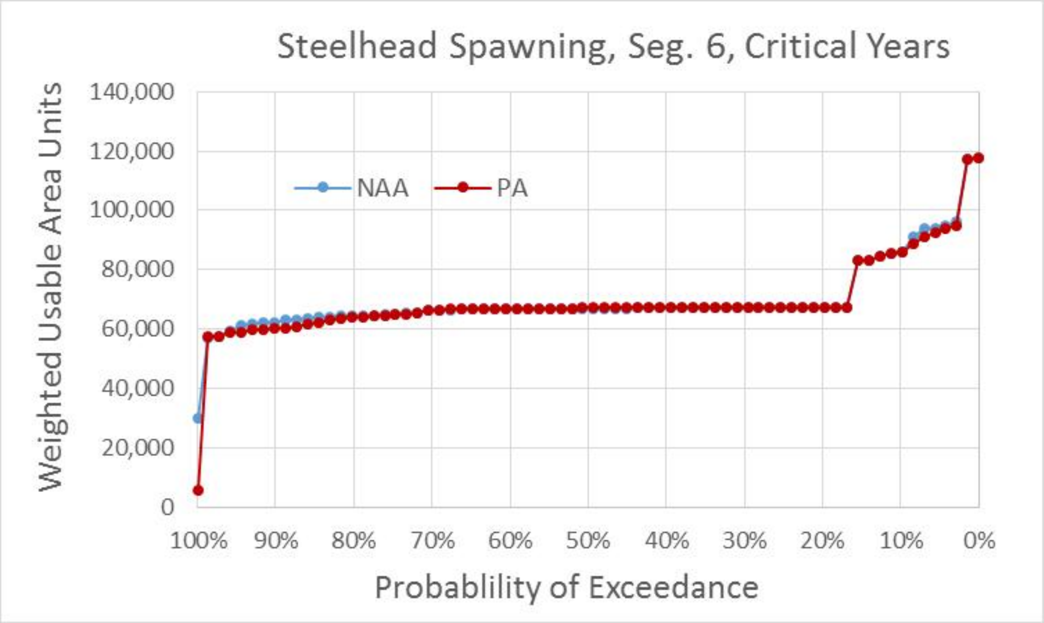

Figure 5.4-189. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

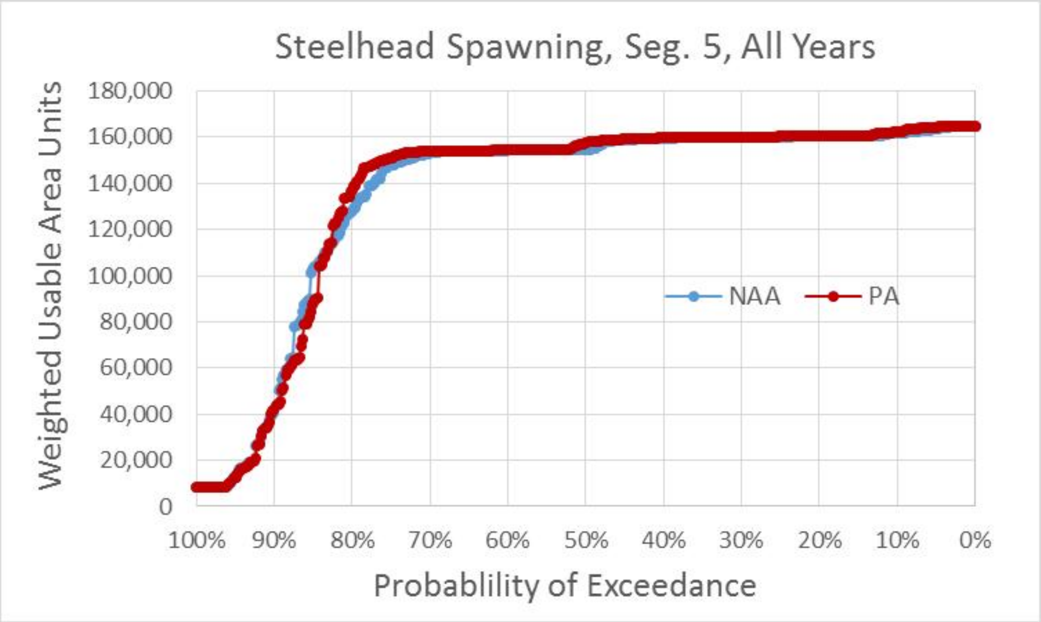

Figure 5.4-190. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

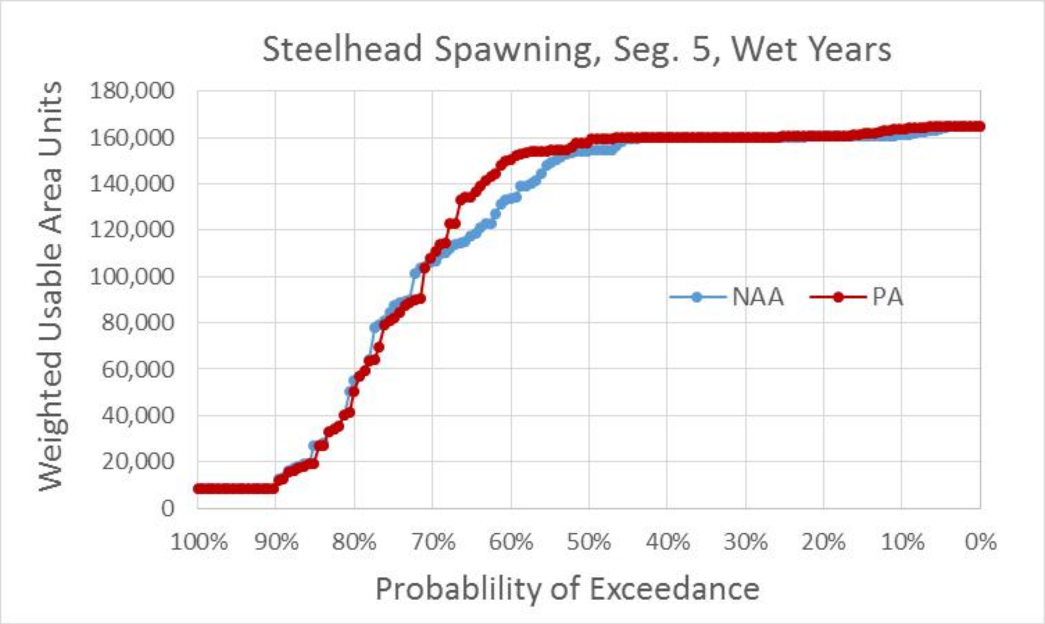

Figure 5.4-191. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

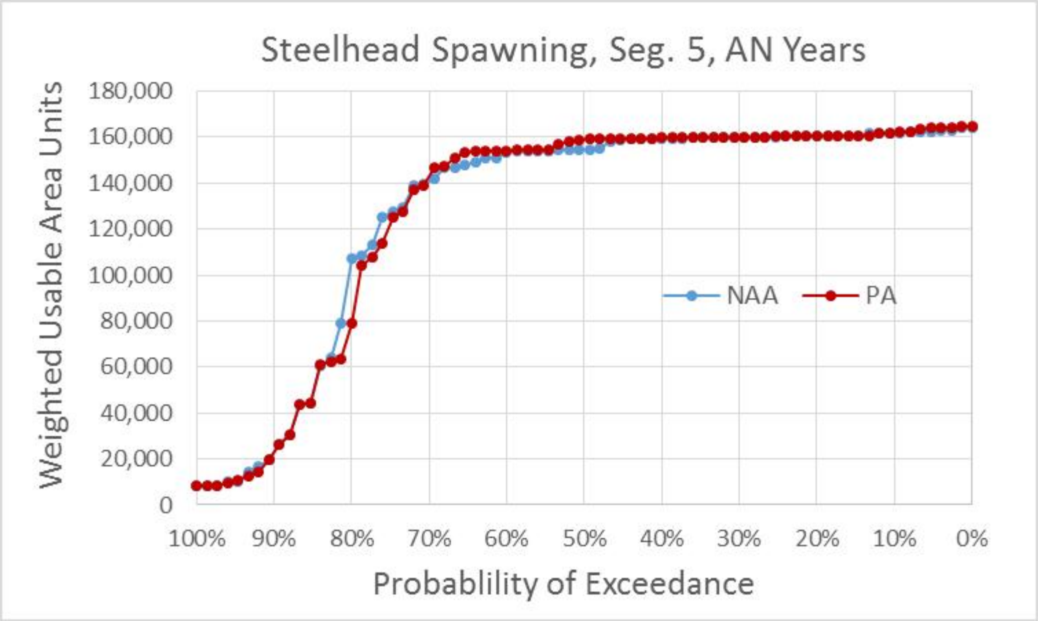

Figure 5.4-192. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

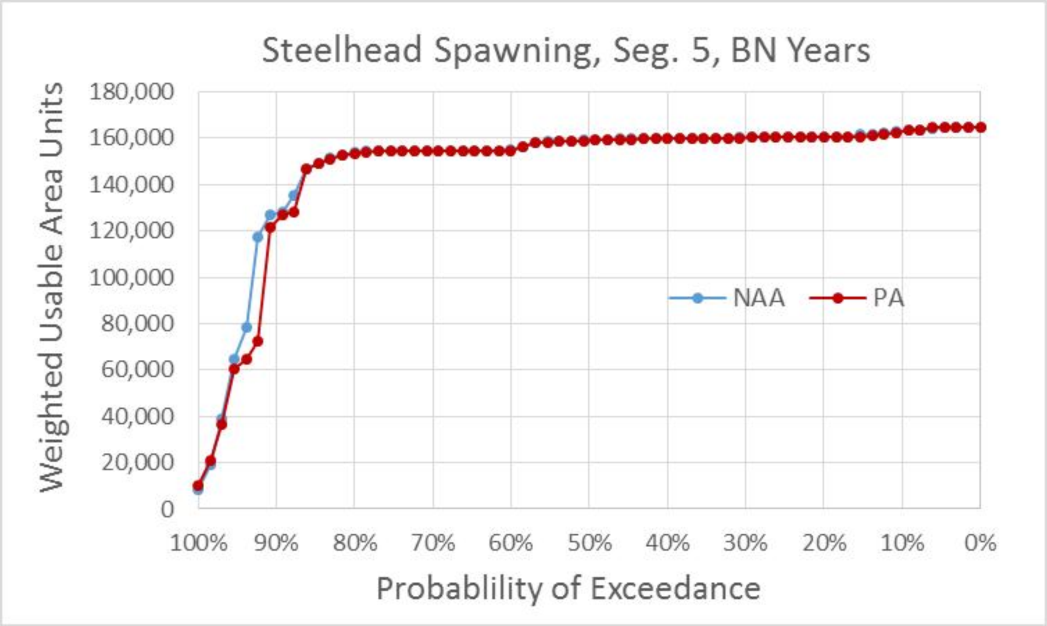

Figure 5.4-193. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

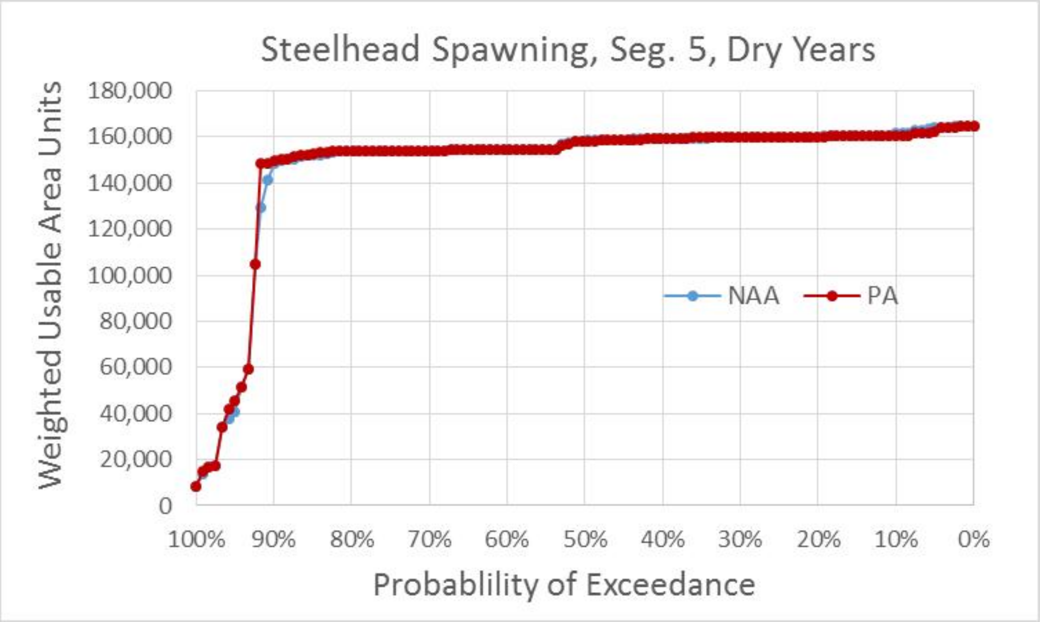

Figure 5.4-194. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

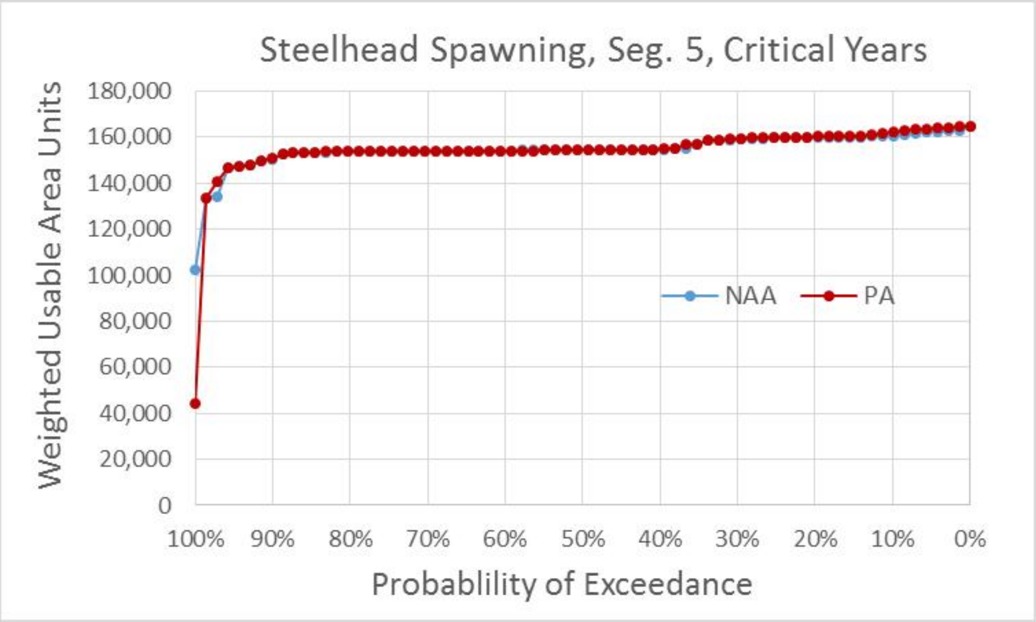

Figure 5.4-195. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

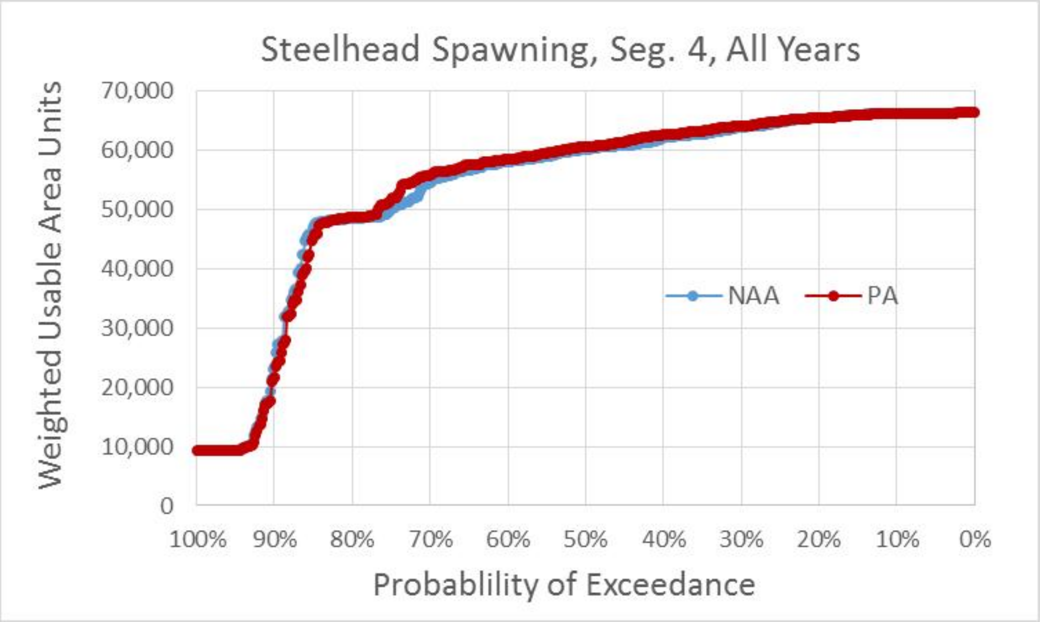

Figure 5.4-196. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

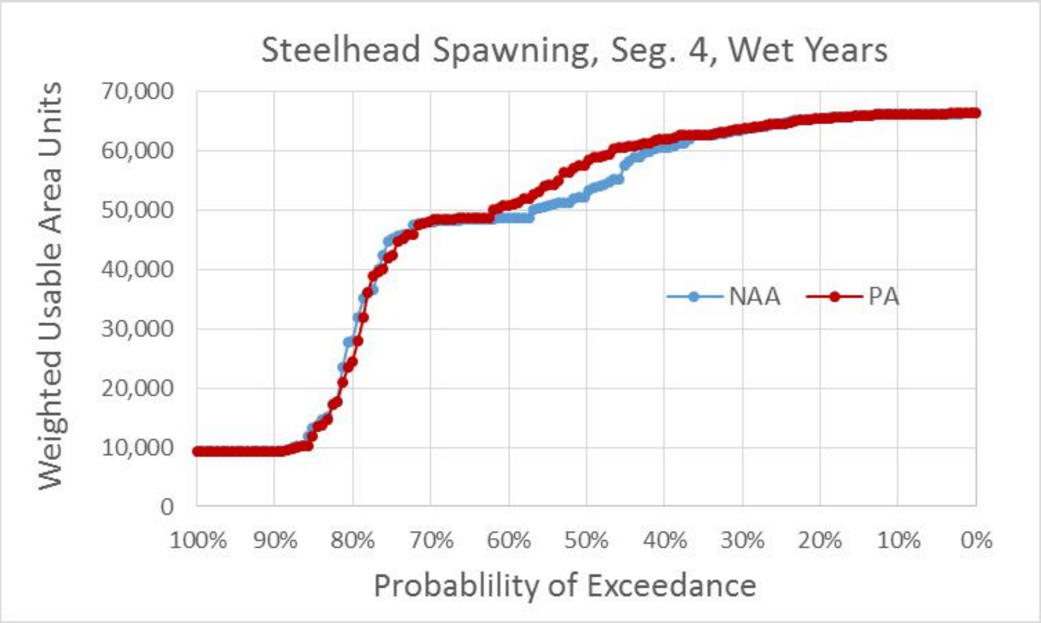

Figure 5.4-197. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

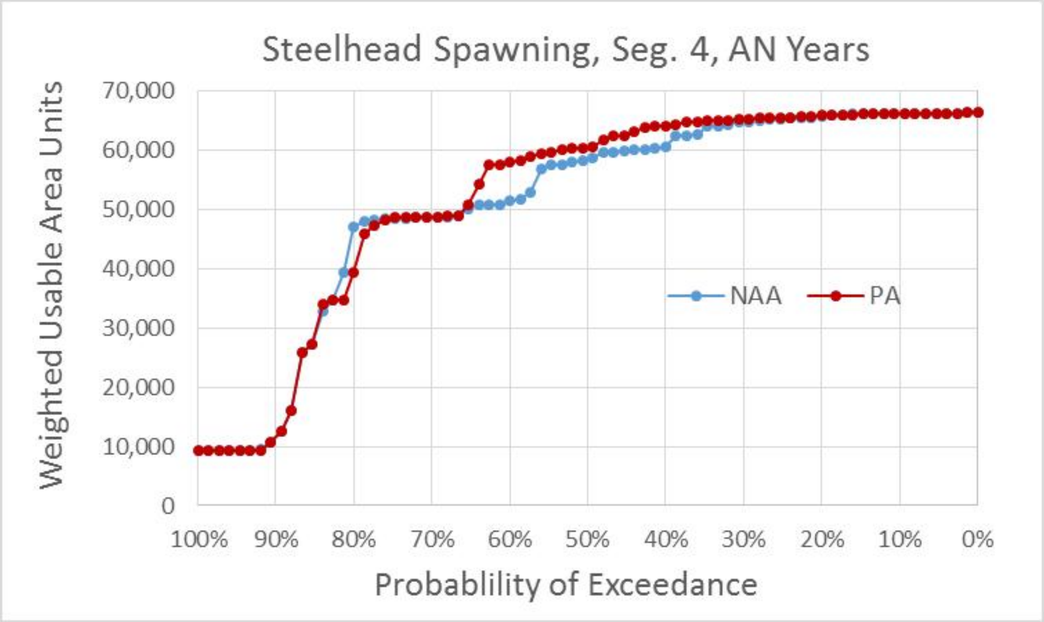

Figure 5.4-198. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

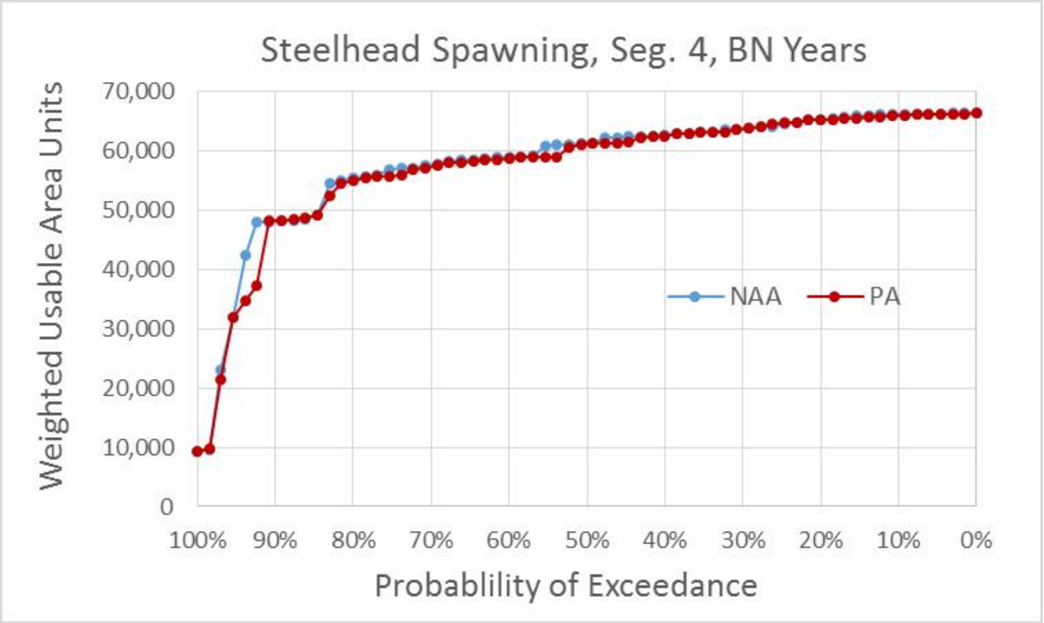

Figure 5.4-199. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

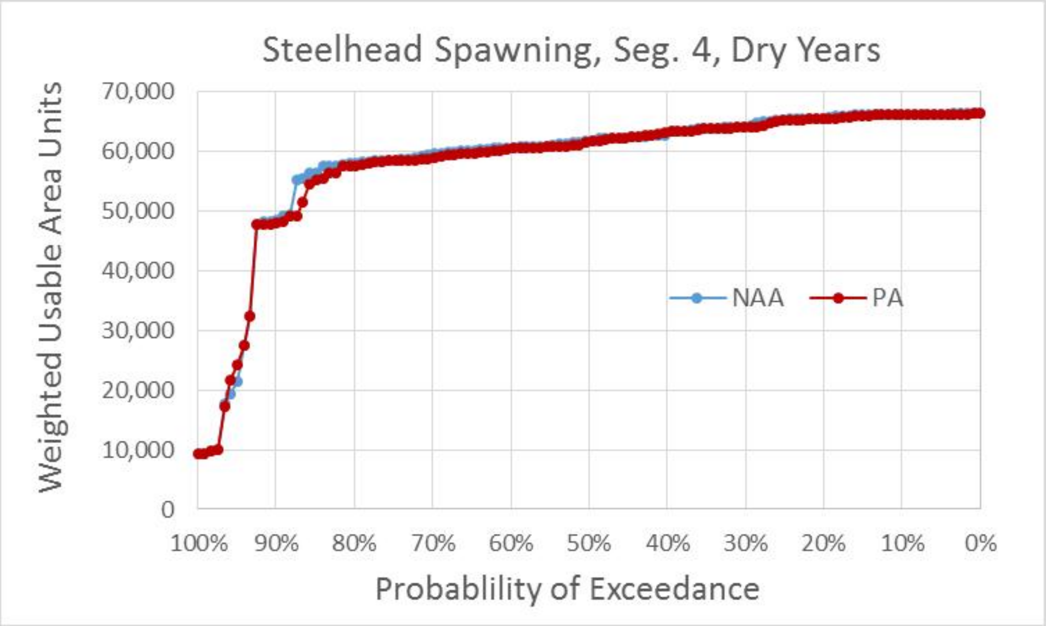

Figure 5.4-200. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

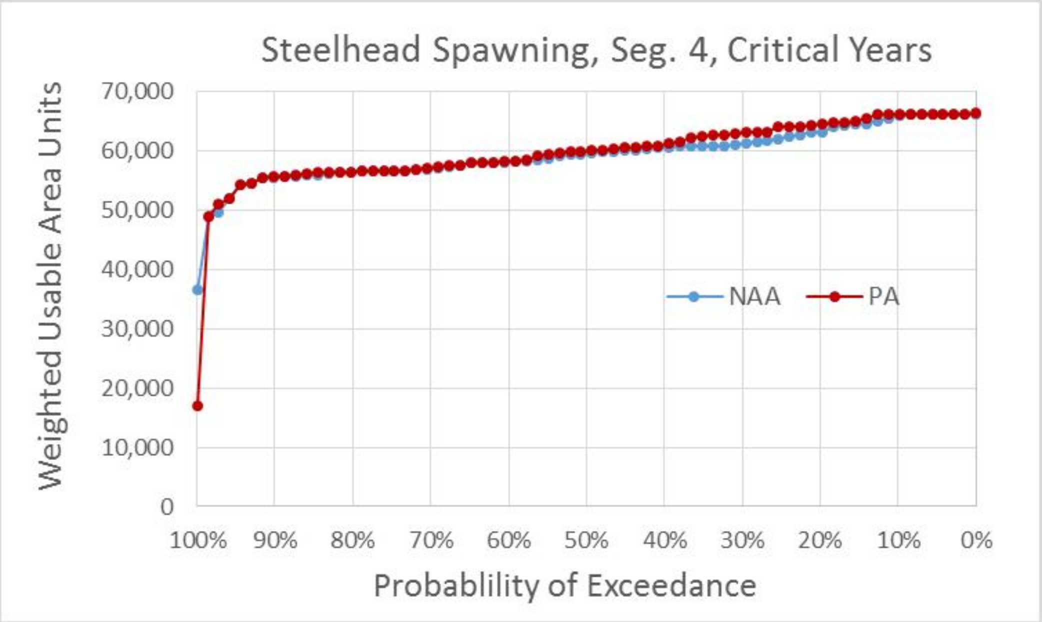

Figure 5.4-201. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in the mean spawning WUA in each river segment for the months of the spawning period under each water year type and all water year types combined also indicate that spawning WUA would be little affected by the PA, except for moderate increases in mean WUA during November of wet and above normal water year types (Table 5.4-64 through Table 5.4-66). As noted for spring-run Chinook salmon, mean flows in the Sacramento River are expected to be up to 26% lower under the PA during November of wet and above normal years.

Table 5.4-64. Central Valley Steelhead Spawning Weighted Usable Area (WUA) and Differences (Percent Differences) in River Segment 6 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
November	Wet	44,934	55,001	10,066 (22%)
	Above Normal	48,791	55,559	6,769 (14%)
	Below Normal	59,665	60,346	681 (1%)
	Dry	60,619	61,097	478 (0.8%)
	Critical	63,815	62,426	-1,389 (-2.2%)
	All	54,176	58,415	4,239 (8%)
December	Wet	90,427	90,302	-125 (-0.1%)
	Above Normal	94,408	94,374	-35 (-0.04%)
	Below Normal	95,154	95,754	600 (0.6%)
	Dry	102,175	101,105	-1,069 (-1%)
	Critical	93,937	93,146	-791 (-0.8%)
	All	95,071	94,730	-341 (-0.4%)
January	Wet	47,991	44,845	-3,146 (-7%)
	Above Normal	50,103	50,084	-19 (-0.04%)
	Below Normal	52,093	51,860	-233 (-0.4%)
	Dry	50,880	50,762	-119 (-0.2%)
	Critical	63,630	60,825	-2,806 (-4%)
	All	51,870	50,398	-1,471 (-3%)
February	Wet	34,241	33,861	-380 (-1%)
	Above Normal	30,811	30,982	172 (0.6%)
	Below Normal	52,430	49,679	-2,752 (-5%)
	Dry	65,457	65,318	-139 (-0.2%)
	Critical	65,625	67,129	1,504 (2%)
	All	48,344	48,067	-276 (-0.6%)
March	Wet	33,522	33,502	-20 (-0.06%)
	Above Normal	49,551	46,630	-2,921 (-6%)
	Below Normal	63,098	62,275	-823 (-1%)
	Dry	64,981	64,880	-101 (-0.2%)
	Critical	66,249	64,918	-1,331 (-2%)
	All	52,493	51,694	-799 (-2%)

Month	WYT	NAA	PA	PA vs. NAA
April	Wet	90,427	90,302	-125 (-0.1%)
	Above Normal	94,408	94,374	-35 (-0.04%)
	Below Normal	95,154	95,754	600 (0.6%)
	Dry	102,175	101,105	-1,069 (-1%)
	Critical	93,937	93,146	-791 (-0.8%)
	All	95,071	94,730	-341 (-0.4%)

Table 5.4-65. Central Valley Steelhead Spawning Weighted Usable Area (WUA) and Differences (Percent Differences) in River Segment 5 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
November	Wet	134,237	155,266	21,029 (16%)
	Above Normal	138,183	149,145	10,962 (8%)
	Below Normal	161,674	161,250	-424 (-0.3%)
	Dry	158,686	159,625	939 (0.6%)
	Critical	155,106	156,314	1,208 (0.8%)
	All	147,676	156,404	8,727 (6%)
December	Wet	136,651	136,947	296 (0.2%)
	Above Normal	155,557	155,489	-69 (-0.04%)
	Below Normal	160,300	160,244	-56 (-0.04%)
	Dry	158,725	158,764	39 (0%)
	Critical	156,285	157,203	918 (0.6%)
	All	151,078	151,297	219 (0%)
January	Wet	124,886	119,593	-5,293 (-4%)
	Above Normal	123,962	123,959	-4 (0%)
	Below Normal	133,040	133,226	186 (0.1%)
	Dry	128,093	127,825	-268 (-0.2%)
	Critical	150,023	145,948	-4,075 (-3%)
	All	130,294	127,979	-2,316 (-2%)
February	Wet	82,820	82,314	-506 (-0.6%)
	Above Normal	78,150	78,049	-101 (-0.1%)
	Below Normal	135,596	129,547	-6,049 (-4%)
	Dry	156,252	156,270	18 (0.01%)
	Critical	155,460	154,255	-1,205 (-0.8%)
	All	117,700	116,540	-1,160 (-1%)
March	Wet	95,020	94,955	-65 (-0.07%)
	Above Normal	135,184	129,848	-5,336 (-4%)
	Below Normal	153,621	153,491	-130 (-0.08%)
	Dry	155,629	155,434	-194 (-0.1%)
	Critical	154,823	155,886	1,064 (0.7%)

Month	WYT	NAA	PA	PA vs. NAA
	All	132,783	132,007	-776 (-0.6%)
April	Wet	136,651	136,947	296 (0.2%)
	Above Normal	155,557	155,489	-69 (-0.04%)
	Below Normal	160,300	160,244	-56 (-0.04%)
	Dry	158,725	158,764	39 (0%)
	Critical	156,285	157,203	918 (0.6%)
	All	151,078	151,297	219 (0%)

Table 5.4-66. Central Valley Steelhead Spawning Weighted Usable Area (WUA) and Differences (Percent Differences) in River Segment 4 between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
November	Wet	52,447	60,623	8,176 (16%)
	Above Normal	50,951	59,956	9,005 (18%)
	Below Normal	64,550	64,154	-397 (-0.6%)
	Dry	62,752	62,372	-380 (-0.6%)
	Critical	57,853	59,809	1,956 (3%)
	All	57,214	61,315	4,101 (7%)
December	Wet	55,269	55,379	110 (0.2%)
	Above Normal	60,368	60,356	-12 (-0.02%)
	Below Normal	62,831	63,159	328 (0.5%)
	Dry	62,828	62,480	-348 (-0.6%)
	Critical	60,694	60,845	151 (0.2%)
	All	59,730	59,744	14 (0.02%)
January	Wet	49,096	46,930	-2,166 (-4%)
	Above Normal	50,530	50,530	0 (0%)
	Below Normal	51,290	51,312	22 (0.04%)
	Dry	51,204	51,213	9 (0.02%)
	Critical	58,708	57,821	-887 (-2%)
	All	51,538	50,727	-812 (-2%)
February	Wet	34,859	34,368	-491 (-1%)
	Above Normal	35,645	35,721	76 (0.2%)
	Below Normal	54,283	51,867	-2,416 (-4%)
	Dry	61,860	61,407	-453 (-0.7%)
	Critical	59,546	58,465	-1,082 (-2%)
	All	47,788	47,051	-736 (-2%)
March	Wet	41,811	41,715	-96 (-0.2%)
	Above Normal	54,345	51,949	-2,396 (-4%)
	Below Normal	60,258	59,189	-1,069 (-2%)
	Dry	61,160	61,074	-86 (-0.1%)

Month	WYT	NAA	PA	PA vs. NAA
	Critical	58,799	60,354	1,555 (3%)
	All	53,478	53,131	-347 (-0.6%)
April	Wet	55,269	55,379	110 (0.2%)
	Above Normal	60,368	60,356	-12 (-0.02%)
	Below Normal	62,831	63,159	328 (0.5%)
	Dry	62,828	62,480	-348 (-0.6%)
	Critical	60,694	60,845	151 (0.2%)
	All	59,730	59,744	14 (0.02%)

5.4.2.1.3.3.1.1.2 Redd Scour

The probability of flows occurring under the PA and the NAA that would be high enough to mobilize sediments and scour Central Valley steelhead redds was estimated from CALSIM II estimates of mean monthly flows, using a relationship determined from the historical record between actual mean monthly flow and maximum daily flow (Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*). The actual monthly and daily flow data used in the analysis are from gage records just below Keswick Dam and at Bend Bridge, and the CALSIM II estimates used to compare probabilities of redd scour for the PA and the NAA are for the Keswick Dam and Red Bluff locations. As discussed in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*, 40,000 cfs is treated as the minimum daily flow at which redd scour occurs in the Sacramento River. The analysis of the Keswick Dam gage data shows that for months with a mean monthly flow of at least 27,300 cfs, the maximum daily flow in that month is always at least 40,000 cfs. The Bend Bridge gage data show that for months with a mean flow of at least 21,800 cfs, the maximum daily flow in that month is always 40,000 cfs. Therefore, redd scour probabilities for the PA and the NAA were evaluated by comparing frequencies of CALSIM II flows greater than 27,300 cfs at Keswick Dam or greater than 21,800 cfs at Red Bluff during the steelhead November through April spawning and incubation period. Further information on the redd scour analysis methods is provided in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*.

Table 5.4-32 shows that about 5% of months at Keswick Dam and about 15% of months at Red Bluff would have flows above the redd scouring thresholds during the November through April spawning and incubation period of Central Valley steelhead. The relatively high percentage of scouring flows in the steelhead spawning and incubation period is expected, given that the period encompasses the wettest months of the year. There would be little difference between the PA and the NAA in the percentage of scouring flows at Keswick Dam. The percentage under the PA at Red Bluff would be about 7% greater than under the NAA on a relative scale, but the difference is 1% on a raw scale. Water years and months with mean monthly flow greater than 27,300 cfs predicted at Keswick Dam for the Central Valley spawning and incubation period (under either the PA or the NAA or both) are listed in Table 5.4-67, and those with mean monthly flow greater than 21,800 cfs predicted at Red Bluff are listed in Table 5.4-68.

Table 5.4-67. Water Years and Months with Mean Flow > 27,300 cfs at Keswick Dam for the PA and/or the NAA during the Central Valley Steelhead Spawning and Incubation Period

Water Year	Month	WYT	Flow (cfs) NAA	Flow (cfs) PA
1927	February	Above Normal	29,347	28,705
1938	February	Wet	37,196	37,196
1938	March	Wet	35,340	35,340
1940	February	Above Normal	25,084	27,865
1942	February	Wet	30,876	30,876
1945	December	Below Normal	31,540	29,102
1952	January	Wet	31,940	31,940
1955	December	Dry	27,318	26,935
1956	January	Wet	34,001	34,001
1958	February	Wet	60,491	60,491
1963	April	Wet	30,893	30,893
1969	January	Wet	58,978	58,978
1973	January	Above Normal	39,202	39,202
1973	November	Above Normal	29,514	29,913
1974	March	Wet	34,994	34,994
1975	March	Wet	27,693	28,273
1980	February	Above Normal	32,212	32,212
1983	February	Wet	41,920	41,920
1983	March	Wet	50,123	50,123
1983	December	Wet	33,201	33,201
1986	February	Wet	43,792	45,287
1995	March	Wet	47,351	47,351
1996	January	Wet	36,776	36,776
1996	February	Wet	36,796	37,081
1998	February	Wet	51,790	51,790
1999	February	Wet	27,798	27,798
2000	February	Above Normal	30,989	36,419

Table 5.4-68. Water Years and Months with Mean Flow > 21,800 cfs at Red Bluff for the NAA and/or the NAA during the Central Valley Steelhead Spawning and Incubation Period

Water Year	Month	WYT	Flow (cfs)	
			NAA	PA
1925	February	Dry	24,070	24,071
1927	February	Above Normal	49,417	48,776
1928	March	Above Normal	19,932	23,602
1937	December	Dry	30,649	30,029
1938	February	Wet	56,909	56,909
1938	March	Wet	55,120	55,119
1940	January	Above Normal	43,491	43,477
1940	February	Above Normal	38,879	41,661
1940	March	Above Normal	33,599	33,586
1940	December	Above Normal	20,610	22,620
1941	January	Wet	28,155	28,141
1941	February	Wet	43,074	43,074
1941	March	Wet	26,178	26,178
1941	April	Wet	24,464	24,464
1941	December	Wet	21,964	23,292
1942	February	Wet	47,744	47,741
1945	December	Below Normal	44,541	42,119
1950	December	Dry	24,773	24,789
1951	January	Above Normal	22,521	22,497
1951	February	Above Normal	26,705	26,702
1951	December	Above Normal	20,624	23,775
1952	January	Wet	48,541	48,511
1952	February	Wet	31,265	31,264
1953	January	Wet	15,670	22,115
1954	February	Above Normal	26,779	26,734
1955	January	Dry	55,945	55,949
1955	December	Dry	43,925	43,545
1956	February	Wet	34,257	34,258
1957	January	Above Normal	24,267	24,280
1958	February	Wet	95,921	95,922
1958	March	Wet	31,825	31,825
1958	April	Wet	22,228	22,228
1959	February	Below Normal	21,419	23,042
1962	February	Below Normal	28,659	29,188
1963	April	Wet	42,184	42,182
1964	January	Dry	36,532	36,546
1964	December	Dry	34,329	32,345

Water Year	Month	WYT	Flow (cfs)	
			NAA	PA
1968	January	Below Normal	42,219	41,417
1968	February	Below Normal	21,477	24,587
1969	January	Wet	88,102	88,084
1969	February	Wet	43,254	43,259
1969	December	Wet	26,013	28,454
1970	January	Wet	25,837	25,840
1971	March	Wet	23,009	23,007
1972	January	Below Normal	26,964	26,965
1973	January	Above Normal	58,571	58,570
1973	February	Above Normal	31,982	31,983
1973	November	Above Normal	38,394	38,789
1973	December	Above Normal	33,753	33,749
1974	March	Wet	46,485	46,485
1975	March	Wet	41,124	41,672
1978	February	Above Normal	25,264	25,041
1978	March	Above Normal	26,406	26,407
1979	January	Dry	27,900	29,149
1980	February	Above Normal	46,641	46,636
1981	December	Dry	38,173	38,204
1982	January	Wet	31,549	31,548
1982	February	Wet	33,563	33,566
1982	March	Wet	21,927	21,929
1982	April	Wet	33,884	33,885
1982	December	Wet	23,928	23,927
1983	February	Wet	63,449	63,448
1983	March	Wet	81,583	81,583
1983	December	Wet	53,169	53,169
1986	February	Wet	65,637	67,131
1986	March	Wet	33,295	33,286
1994	January	Critical	38,785	44,227
1995	March	Wet	71,080	71,088
1996	January	Wet	53,792	53,761
1996	February	Wet	47,831	48,105
1996	December	Wet	30,177	34,956
1997	January	Wet	29,572	32,414
1998	February	Wet	85,109	85,090
1998	March	Wet	29,700	29,701
1999	February	Wet	37,943	37,942
2000	February	Above Normal	46,308	51,728

Water Year	Month	WYT	Flow (cfs)	
			NAA	PA
2002	January	Dry	28,842	28,849
2002	December	Dry	22,758	21,248

5.4.2.1.3.3.1.1.3 Redd Dewatering

The percentage of steelhead redds dewatered by reductions in Sacramento River flow was estimated from CALSIM II estimates of monthly mean flows during the 3 months following each of the months that steelhead spawn (Section 5.D.2.2, *Spawning Flows Methods*, Table SFM-1). This analysis employed functional relationships developed in field studies by USFWS (2006) that predicted percentages of redds dewatered from an array of paired spawning and dewatering flows. Segment 5 CALSIM II flows were used for the effects analysis to estimate redd dewatering under the PA and NAA. Because the CALSIM II flows for Segments 4 and 6 are similar to those for Segment 5, redd dewatering estimates using the Segment 4 and Segment 6 flows differ little from those for Segment 5 (Appendix 5.D, Section 5.D.2.6, *Redd Dewatering Results, Sacramento River Segments 4 and 6*). Further information on the redd dewatering analysis methods is provided in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*.

Differences in steelhead redd dewatering under the PA and NAA were examined using exceedance plots of mean monthly percent of redds dewatered for the months that steelhead spawn (November through February) (Figure 5.4-202 through Figure 5.4-207). The exceedance curves for wet and above normal water years indicate that frequencies of dewatering in the middle of the range of redd dewatering percentages would be lower under the PA than under the NAA, but that the frequencies would be similar under the two scenarios for the high and low portions of the range. For the other water year types, the frequencies would be similar throughout the range of percentages.

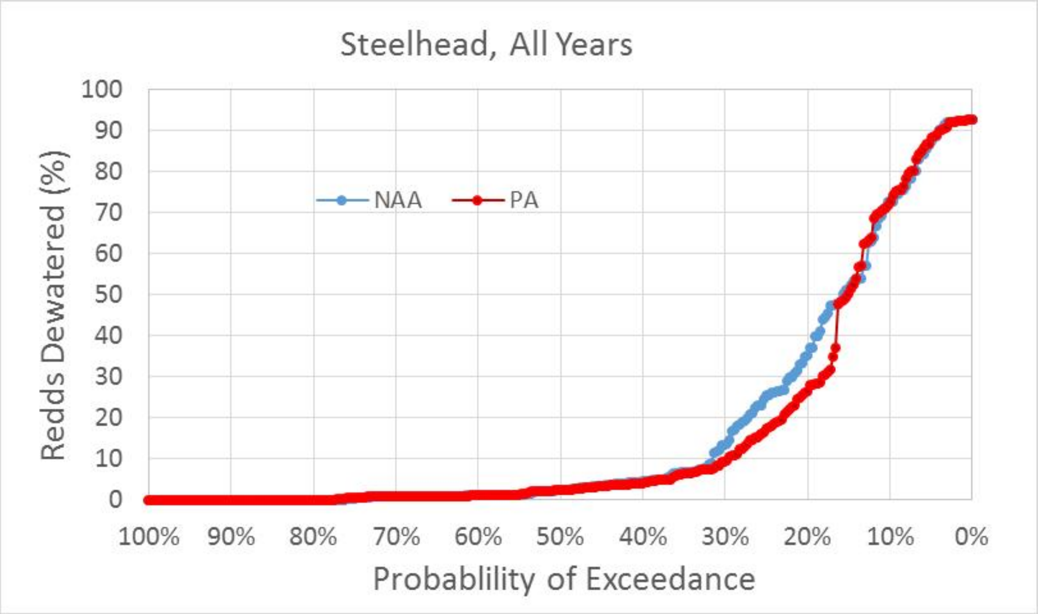

Figure 5.4-202. Exceedance Plot of Central Valley Steelhead Percent of Redds Dewatered for NAA and PA Model Scenarios, All Water Years

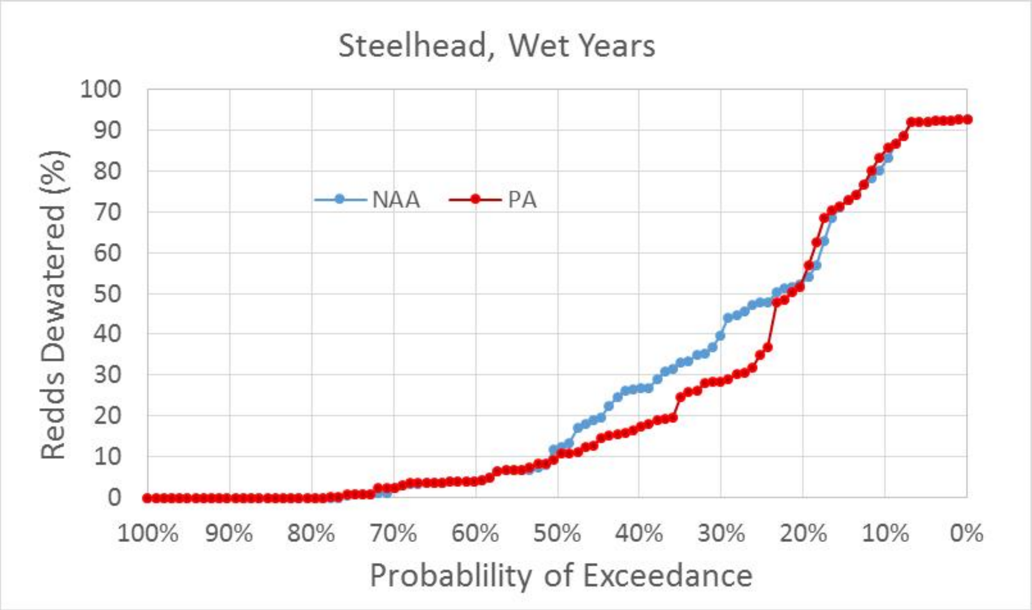

Figure 5.4-203. Exceedance Plot of Central Valley Steelhead Percent of Redds Dewatered for NAA and PA Model Scenarios, Wet Water Years

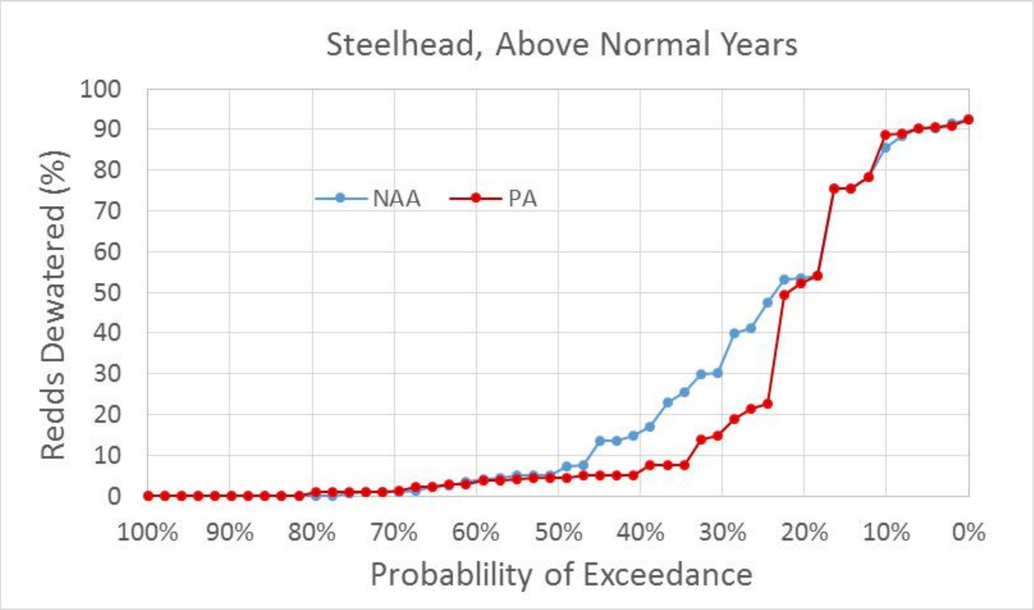

Figure 5.4-204. Exceedance Plot of Central Valley Steelhead Percent of Redds Dewatered for NAA and PA Model Scenarios, Above Normal Water Years

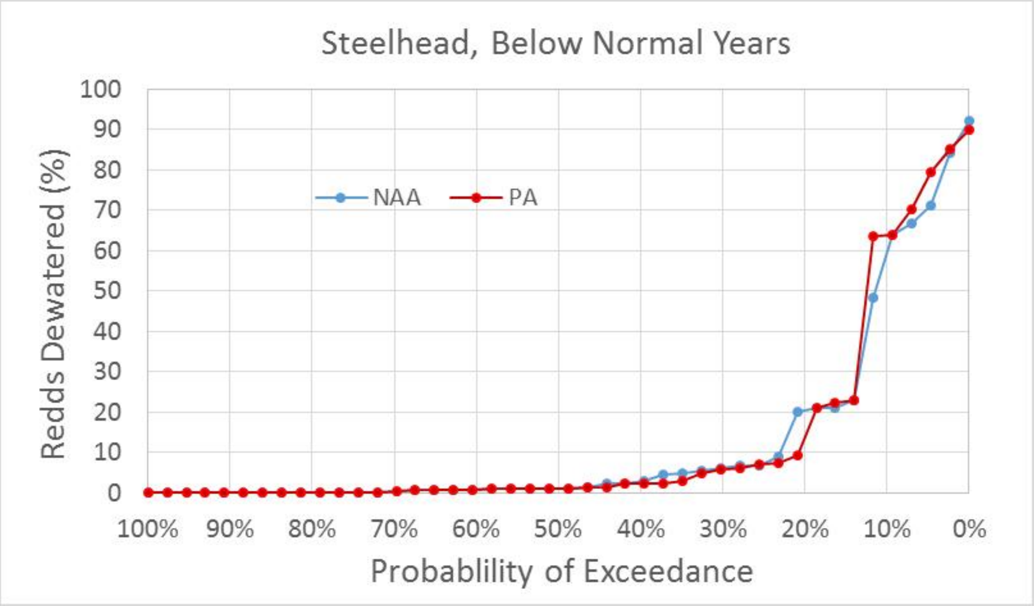

Figure 5.4-205. Exceedance Plot of Central Valley Steelhead Percent of Redds Dewatered for NAA and PA Model Scenarios, Below Normal Water Years

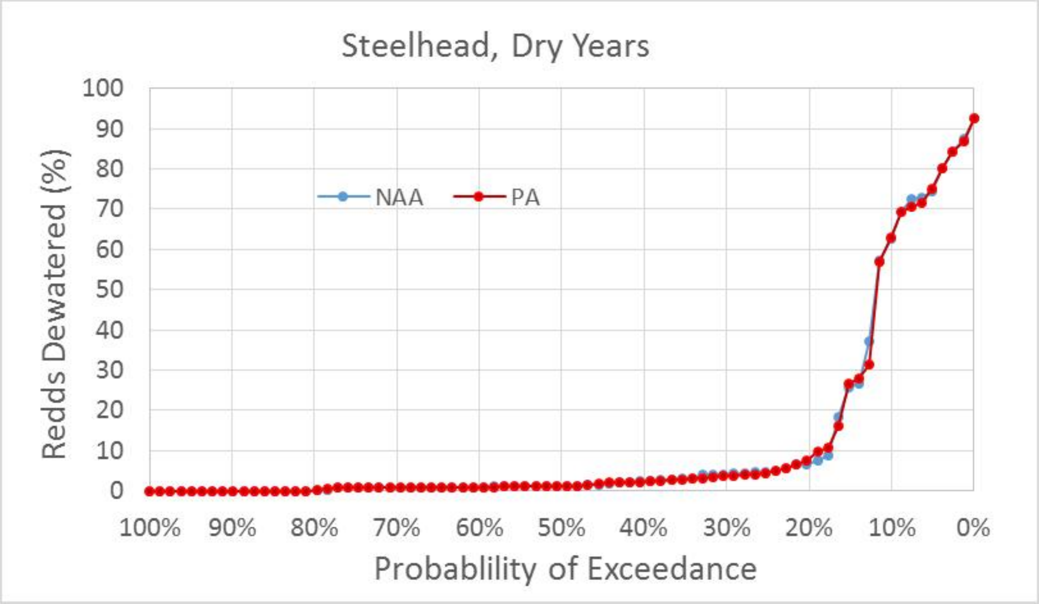

Figure 5.4-206. Exceedance Plot of Central Valley Steelhead Percent of Redds Dewatered for NAA and PA Model Scenarios, Dry Water Years

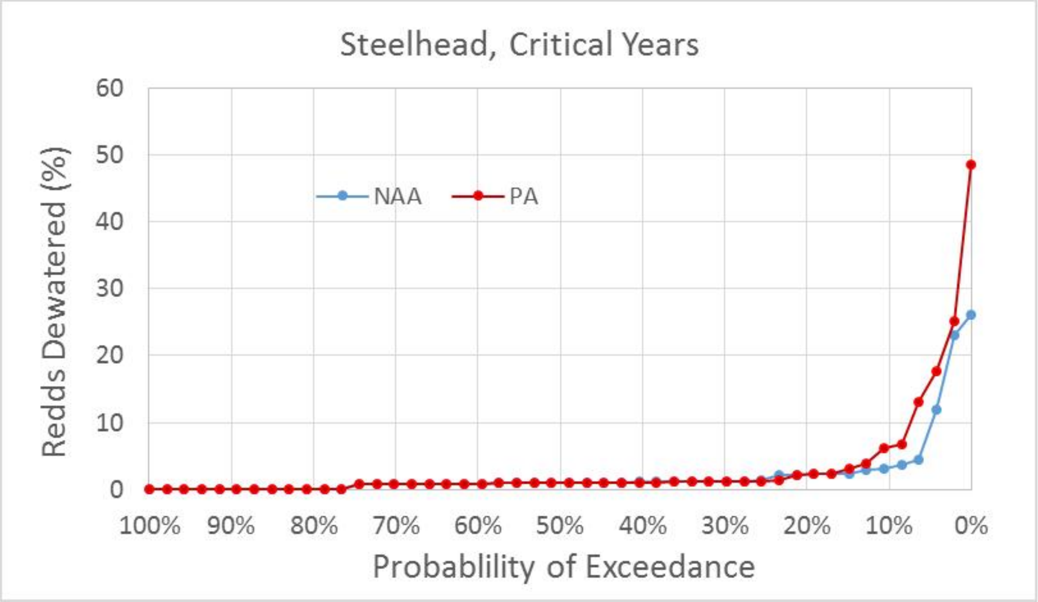

Figure 5.4-207. Exceedance Plot of Central Valley Steelhead Percent of Redds Dewatered for NAA and PA Model Scenarios, Critical Water Years

Differences in the mean percentage of redds dewatered in each river segment for each month of spawning under each water year type and all water year types combined also indicate that the PA would insignificantly affect steelhead redd dewatering, except for reductions in the mean percent of redds dewatered during November of wet and above normal water year types (Table 5.4-69). The percent differences between the PA and the NAA in the percent of redds dewatered range up to a 158% increase under the PA for January of critical water years, but this increase and many of the large relative changes in percent of redds dewatered are artifacts of the low percentages of redds dewatered under both scenarios that were used in computing the percent changes.

Table 5.4-69. Central Valley Steelhead Percent of Redds Dewatered (Percent of Total Redds) and Differences (Percent Differences) between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)

Month	WYT	NAA	PA	PA vs. NAA
November	Wet	29.4	15.6	-13.8 (-47%)
	Above Normal	29.1	15.5	-13.55 (-47%)
	Below Normal	6.6	5.0	-1.6 (-24%)
	Dry	4.5	3.4	-1.1 (-24%)
	Critical	1.9	4.7	2.8 (153%)
	All	16.0	9.5	-6.5 (-41%)
December	Wet	14.0	14.7	0.7 (5%)
	Above Normal	10.2	8.9	-1.3 (-13%)
	Below Normal	11.8	11.7	-0.1 (-1%)
	Dry	22.2	22.3	0.1 (1%)
	Critical	1.1	1.0	-0.1 (-11%)
	All	13.3	13.3	0 (0%)
January	Wet	22.6	26.0	3.5 (15%)
	Above Normal	14.2	14.3	0.1 (1%)
	Below Normal	14.7	14.2	-0.6 (-4%)
	Dry	21.5	21.9	0.4 (2%)
	Critical	2.6	6.7	4.1 (158%)
	All	17.0	18.8	1.8 (10%)
February	Wet	43.5	44.2	0.8 (1.8%)
	Above Normal	47.7	47.9	0.1 (0%)
	Below Normal	18.8	21.8	3 (16%)
	Dry	1.0	1.1	0.1 (12%)
	Critical	3.6	0.6	-3.1 (-84.1%)
	All	24.6	24.9	0.2 (1%)

5.4.2.1.3.3.1.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the November through April spawning and egg/alevins incubation period for steelhead in the Sacramento River reach of Keswick Dam to Red Bluff (Table 5.4-29) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the reach in all months and water year types of the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.2°F, or 0.4%, and would occur at Bend Bridge and Red Bluff in critical water years during February. Despite the increase, water temperatures would remain less than 52°F in both locations under both scenarios during this time, which is well below a temperature range of concern (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49).

Exceedance plots of monthly mean water temperatures were examined during each month throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The values for the PA in these exceedance plots generally match those of the NAA. For critical years during February at Bend Bridge and Red Bluff, where the largest increase in mean monthly water temperature was seen, curves would be nearly identical between the NAA and PAA, except for 2 years in which the PA would be approximately 1°F higher (Figure 5.4-208, Figure 5.4-209). However, water temperatures would not differ in the large majority of years at both locations. These results suggest that the differences in water temperature between NAA and PA in February of critical water years would be insignificant at both locations.

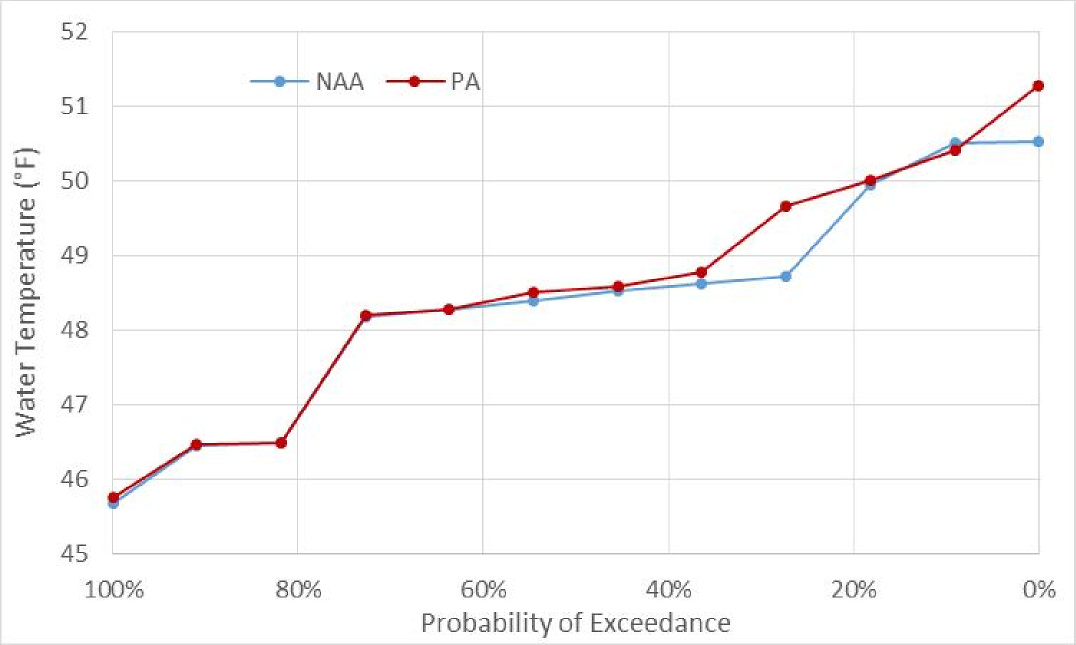

Figure 5.4-208. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Bend Bridge in February of Critical Water Years

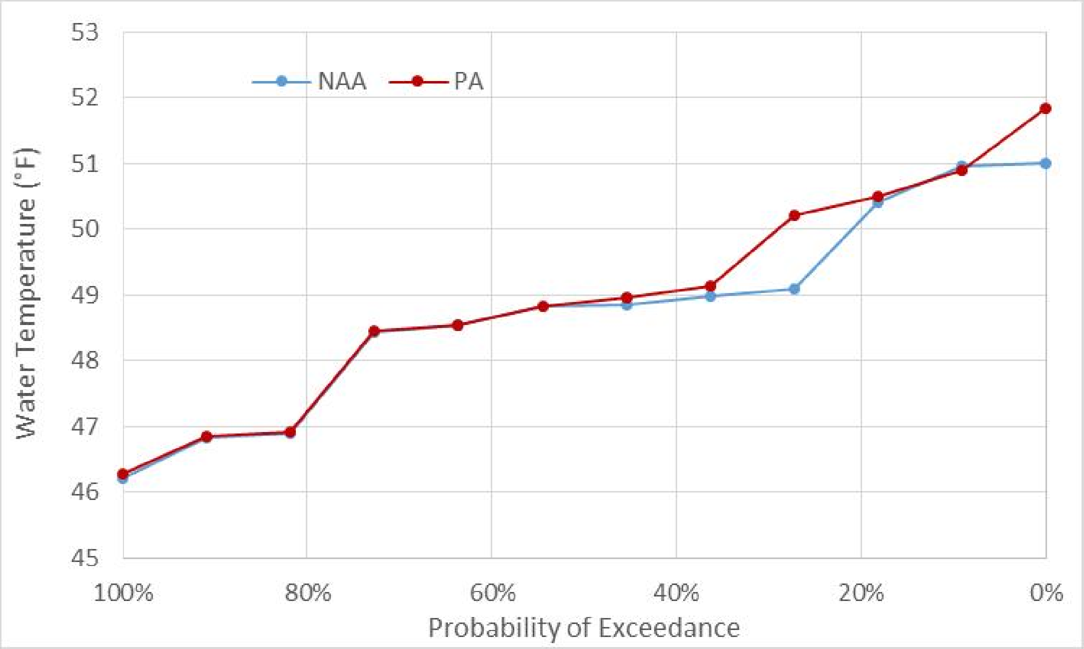

Figure 5.4-209. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Red Bluff in February of Critical Water Years

The exceedance of temperature thresholds in the Sacramento River presented in Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49 by modeled daily water temperatures was evaluated based on thresholds identified from the literature. For steelhead spawning and egg/alevin incubation, the thresholds used were 53°F (McCullough et al. 2001) and 56°F (McEwan and Jackson 1996) (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-97 through Table 5.D-106. At Keswick Dam, for both temperature thresholds, there would be no months or water year types in which there would be 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-97, Table 5.D-98). There would be one instance in which the percent of days exceeding the 53°F threshold would be lower under the PA relative to the NAA: November of above normal years (8.3% reduction). There would be two instances in which the percent of days exceeding the 56°F threshold would be lower under the PA relative to the NAA: November of above normal (6.7% reduction) and below normal (5.8% reduction) years. However, in no case would there be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect at Keswick Dam.

At Clear Creek, for both temperature thresholds, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature*

Threshold Analysis Results, Table 5.D-99, Table 5.D-100). There would be 1 month and water year type, November of above normal water years, during which the percent exceedance would be lower under the PA relative to the NAA by 6.9% and 5.8% for the 53°F and 56°F thresholds, respectively. However, there would be no concurrent increase in magnitude of average daily exceedance that is more than 0.5°F for either instance. Therefore, it was concluded that there would be no biologically meaningful effect at Clear Creek.

At Balls Ferry, for both temperature thresholds, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-101, Table 5.D-102). There would be 1 water year type during November for each threshold during which the percent exceedance would be lower under the PA relative to the NAA by (53°F threshold: above normal water years, 11.7% lower under PA; 56°F threshold: below normal water years, 5.2% lower under PA). In addition, there would be no increase in magnitude of average daily exceedance that is more than 0.5°F for either instance. Therefore, it was concluded that there would be no biologically meaningful effect at Balls Ferry.

At Bend Bridge, for both temperature thresholds, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-103, Table 5.D-104). For the 53°F threshold, there would be two instances, November of wet (8.8% reduction) and above normal (16.1% reduction) water years, in which there would be a reduction in the percent exceedance above the threshold under the PA relative to the NAA. However, there would be no concurrent increase in magnitude of average daily exceedance that is more than 0.5°F for either instance. Therefore, it was concluded that there would be no biologically meaningful effect at Bend Bridge.

At Red Bluff, for both temperature thresholds, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold, and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-105, Table 5.D-106). For the 53°F threshold, there would be three instances, November of wet (8.3% reduction) and above normal (15.6% reduction) water years and March of below normal water years (6.7% reduction), in which there would be a reduction in the percent exceedance above the threshold under the PA relative to the NAA. However, there would be no concurrent increase in magnitude of average daily exceedance that is more than 0.5°F for any of these three instances. Therefore, it was concluded that there would be no biologically meaningful effect at Red Bluff.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA which could have lethal or sublethal effects on spawning, egg incubation, and alevins, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further, these results do not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival. This process may result in refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates, some of which may benefit steelhead spawning, egg incubation, and alevins. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

5.4.2.1.3.3.2 Kelt Emigration

5.4.2.1.3.3.2.1 Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at Keswick, Red Bluff, Wilkins Slough, and Verona during the February through May emigration period for Central Valley steelhead kelts (Table 5.4-29). Changes in flow potentially affect conditions for emigrating kelts, including bioenergetic cost, water quality, crowding, and passage conditions, but the quantitative relationship between flow and downstream migration is poorly understood. As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* on balance, except under very high flows, the benefits of increased flow generally outweigh the costs and, therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for emigration of steelhead kelts. Milner et al. 2012 and del Rosario et al. 2013 have found that migration cues for anadromous fish species are often the result of natural pulse flows, or pulse flows caused by natural events, such as an extensive rainfall event, which will not be affected by the PA.

Shasta Reservoir storage volume at the end of September may influence flows in the Sacramento River during the kelt emigration period in some years. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3).

In general, mean flow under the PA would be similar to (less than 5% difference) or greater than flow under the NAA at the four Sacramento River locations during most months and water year types of the kelt emigration period (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). However, flow would be lower under the PA during February of critical years (up to 13% lower at Keswick) at all the locations, except Verona. During February of below normal years, flow under the PA would be 8% greater at Keswick. During March, flow under the PA at Keswick would be 9% greater in above normal and below normal years and 8% greater in critical years, but there would be no differences greater than 5% at the other locations. During May, flow would be 5% to 8% greater in dry years, except at Verona.

The CALSIM modeling results given here indicate that the PA would result in increases and decreases in flow during the kelt migration period , but that, on balance, the differences would be insignificant.

5.4.2.1.3.3.2.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the February through May kelt emigration period for steelhead in the Sacramento River upstream of the Delta (Table 5.4-29) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-10[57]. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the kelt emigration reach of Keswick Dam to Knights Landing in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 1.0°F (1.4%), and would occur at Knights Landing in below normal water years during August.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the kelt emigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.10-7[58]). The curves for PA generally match those of the NAA. At Knights Landing in below normal water years during August, where the largest increase in mean monthly water temperature was seen, the difference between PA and NAA would be larger at the lower end of the temperatures range by nearly 2°F in 2 of the 11 years (Figure 5.4-108).

There have been no known studies evaluating specific temperature effects on emigrating kelts. Therefore, adult immigration thresholds of 68°F 7DADM and 70°F were used for kelt emigration thresholds, with an assumption that kelts emigrating downstream would be affected by water temperatures similarly to adults immigrating upstream (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49). The 68°F 7DADM threshold was taken from USEPA (2003) and the 70°F threshold represents the average of the studies cited in Richter and Kolmes (2005) for the upper end of the suboptimal temperature range. The 7DADM threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-107 through Table 5.D-112. At all three locations, Keswick Dam, Bend Bridge, and Red Bluff, there would be no months or water year types with both a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA and a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful water temperature-related effects on CCV steelhead kelt emigration.

5.4.2.1.3.3.3 Juvenile Rearing

5.4.2.1.3.3.3.1 Flow-Related Effects

As discussed above in the winter-run fry and juvenile rearing section and in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* the stranding of juvenile salmonids is not evaluated in

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[57] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

[58] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

the effects analysis due to limitations of CALSIM modeling. However, current operations of the Sacramento River include ramping rate restrictions, designed to minimize juvenile stranding, that limit the rate at which river flow can be changed. These restrictions would be kept in place for the PA.

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at the Keswick to Red Bluff locations during the Central Valley steelhead year-round fry and juvenile rearing period (Table 5.4-29). Changes in flow can affect the instream area available for rearing, along with habitat quality, and stranding of fry and juveniles, especially in side-channel habitats. Shasta Reservoir storage volume at the end of May and the end of September influences flow rates in the Sacramento River. Mean Shasta May storage under the PA would be similar to (less than 5% difference) storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3). Mean Shasta September storage under the PA would also be similar to (less than 5% difference) storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA.

Mean flow under the PA at the Keswick and Red Bluff locations in the Sacramento River flow would generally be similar to (less than 5% difference) or higher than flow under the NAA during winter, spring and summer months and would be similar to or lower than flow under the NAA during the fall, with exceptions (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35). Flows under the PA during December through August would be similar to (less than 5% difference) or greater than those under the NAA for all months and water year types, except for 13% and 7% lower flow during February of critical water years at Keswick and Red Bluff, respectively, and 10% lower flow during August of below normal years at both locations. Flow increases during the same months would range up to 18% for January of critical years. During June, flows would be more than 5% higher under the PA than the NAA in all water year types, except wet years. Flows under the PA during September through November would be similar to (less than 5% difference) or lower than those under the NAA in all months and water year types, except for flows up to 17% greater during October of below normal and dry years and up to 13% greater during November of critical years. During September, flow would be up to 11% lower under the PA than the NAA for all water year types except wet years. The largest flow reductions would occur in November of wet and above normal year, with reductions of 26% at Keswick and 21% at Red Bluff for both year types. The results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

As described in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods*, rearing habitat WUA for Central Valley steelhead was not estimated directly by USFWS (2005b), but was modeled using the rearing WUA curves obtained for late fall-run Chinook salmon, in the same three Sacramento River segments that were used for the winter-run Chinook salmon rearing habitat WUA studies (USFWS 2005b). The rearing WUA curves for late fall-run Chinook salmon were used because the fry rearing period of late fall-run Chinook salmon is similar to that of Central Valley steelhead, and because this substitution follows previous practice (Appendix 5.D, Section

5.D.2.3, *Rearing Flows Methods)*. However, the validity of using the late fall-run Chinook salmon WUA curves to characterize Central Valley steelhead rearing habitat is uncertain. To estimate changes in rearing WUA that would result from the PA, the late fall-run Chinook salmon WUA curves developed for each of the river segments was used with mean monthly CALSIM II flow estimates for the midpoint of each segment under the PA and the NAA during the rearing periods for CCV steelhead fry (February through May) and juveniles (year-round) (Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* Table RFM-1). Fry were defined as fish less than 60 mm and juveniles were those greater than 60 mm. Further information on the WUA analysis methods is provided in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods*.

Differences under the PA and NAA in rearing WUA for CCV steelhead fry and juveniles were examined using exceedance plots of mean monthly WUA for the CCV steelhead fry (Figure 5.4-210–Figure 5.4-227) and juvenile (Figure 5.4-228-Figure 5.4-245) rearing periods in each of the river segments for each water year type and all water year types combined. The PA exceedance curves for both fry and juvenile rearing WUA for all water years combined are similar to those for the NAA for all three river segments (Figure 5.4-210, Figure 5.4-216, Figure 5.4-222, Figure 5.4-228, Figure 5.4-234, and Figure 5.4-240). With the curves broken out by water year type, reductions in fry rearing habitat WUA under the PA compared to the NAA are evident in Segment 6 during dry and critical water years (Figure 5.4-214 and Figure 5.4-215) and in Segment 5 during dry years (Figure 5.4-220), while increases in juvenile rearing WUA under the PA are evident in Segment 4 during wet and above normal years (Figure 5.4-241 and Figure 5.4-242). The WUA modeling indicates that the PA would reduce CCV steelhead salmon rearing habitat during several months and water year types. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

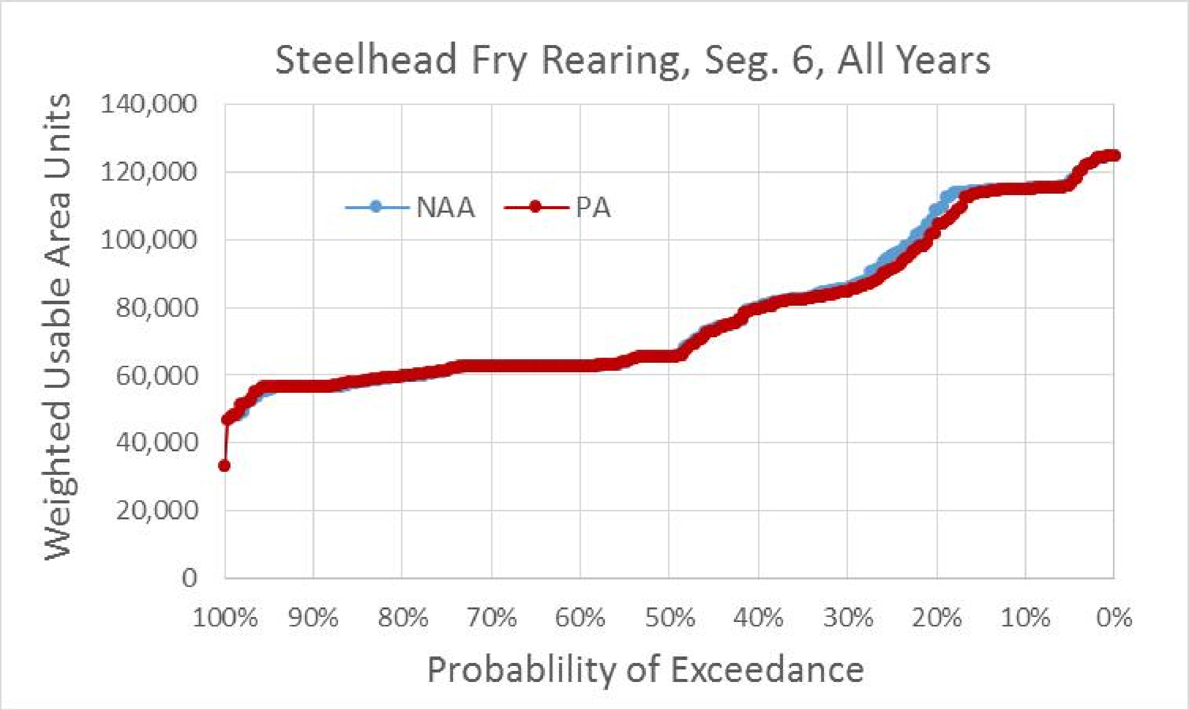

Figure 5.4-210. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

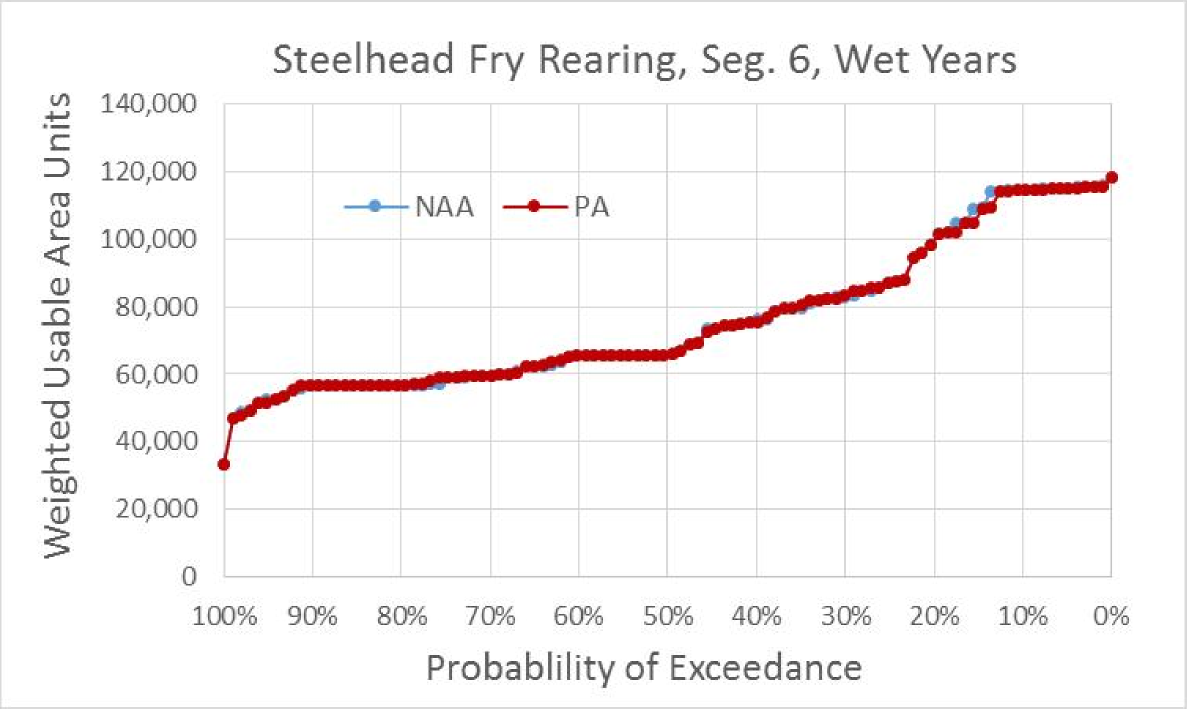

Figure 5.4-211. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

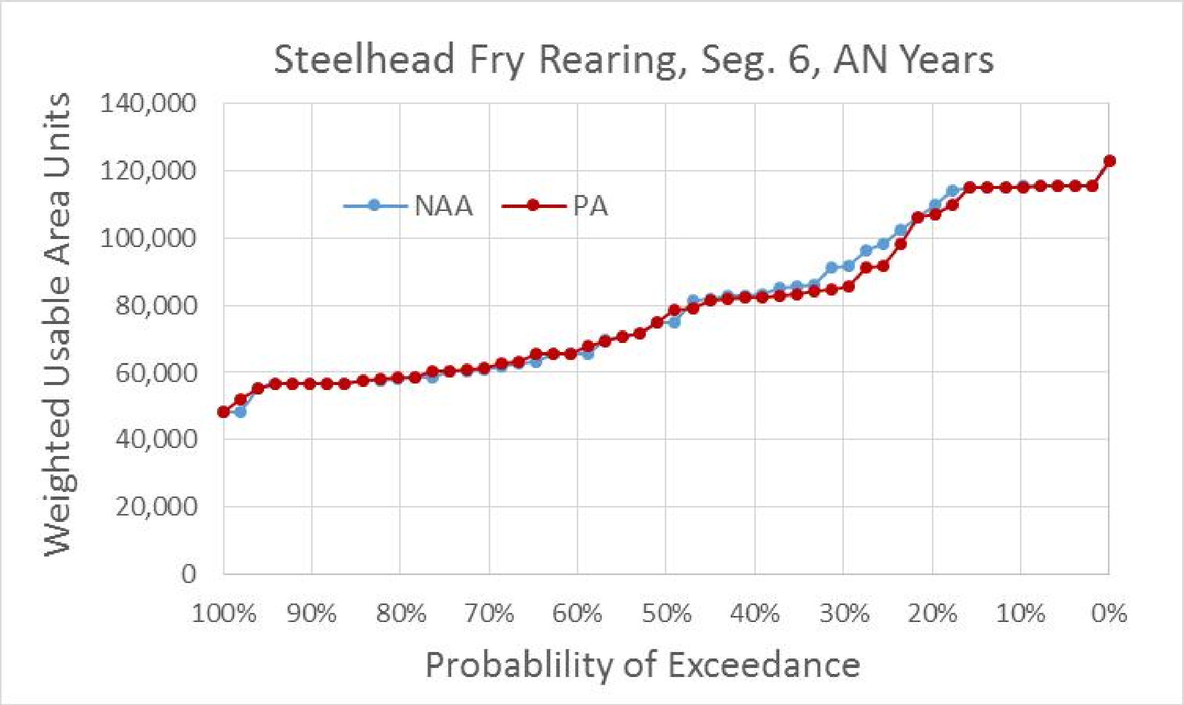

Figure 5.4-212. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

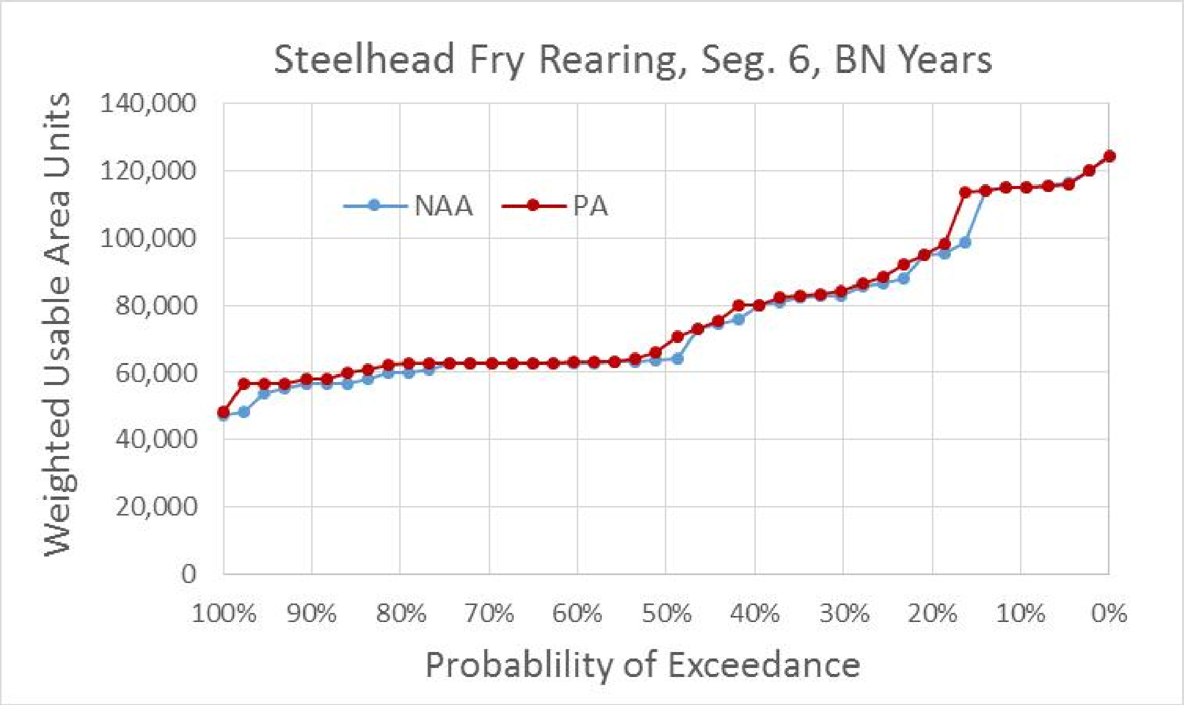

Figure 5.4-213. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

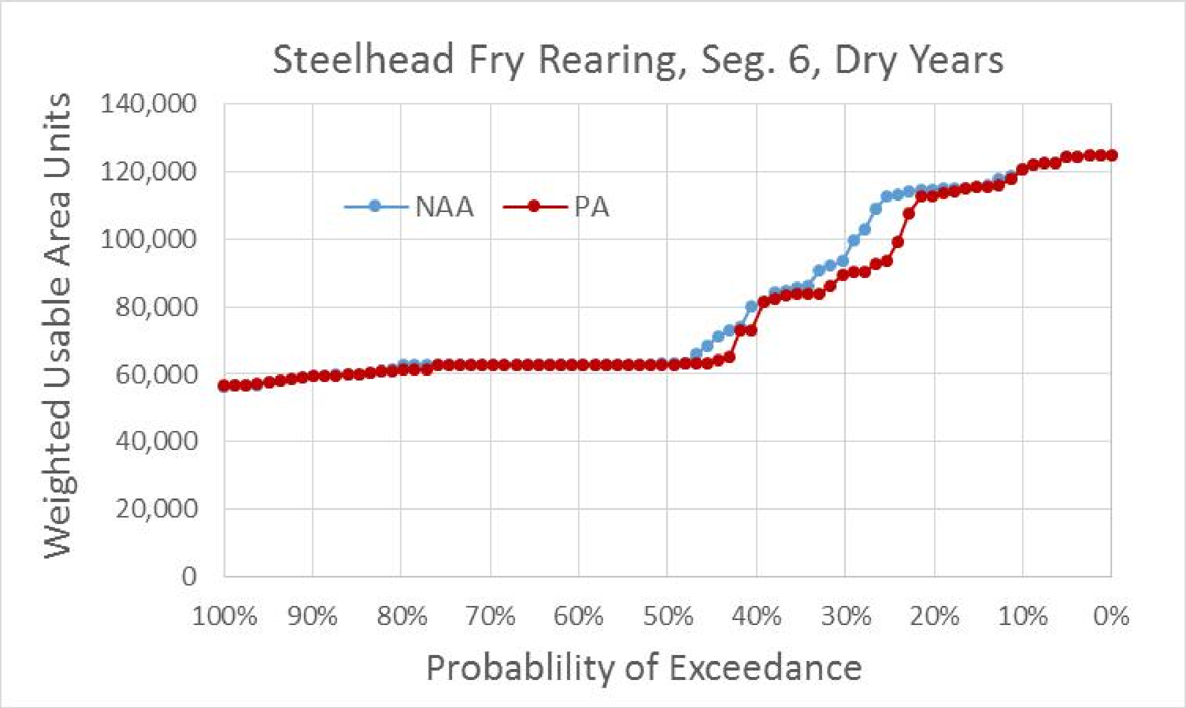

Figure 5.4-214. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

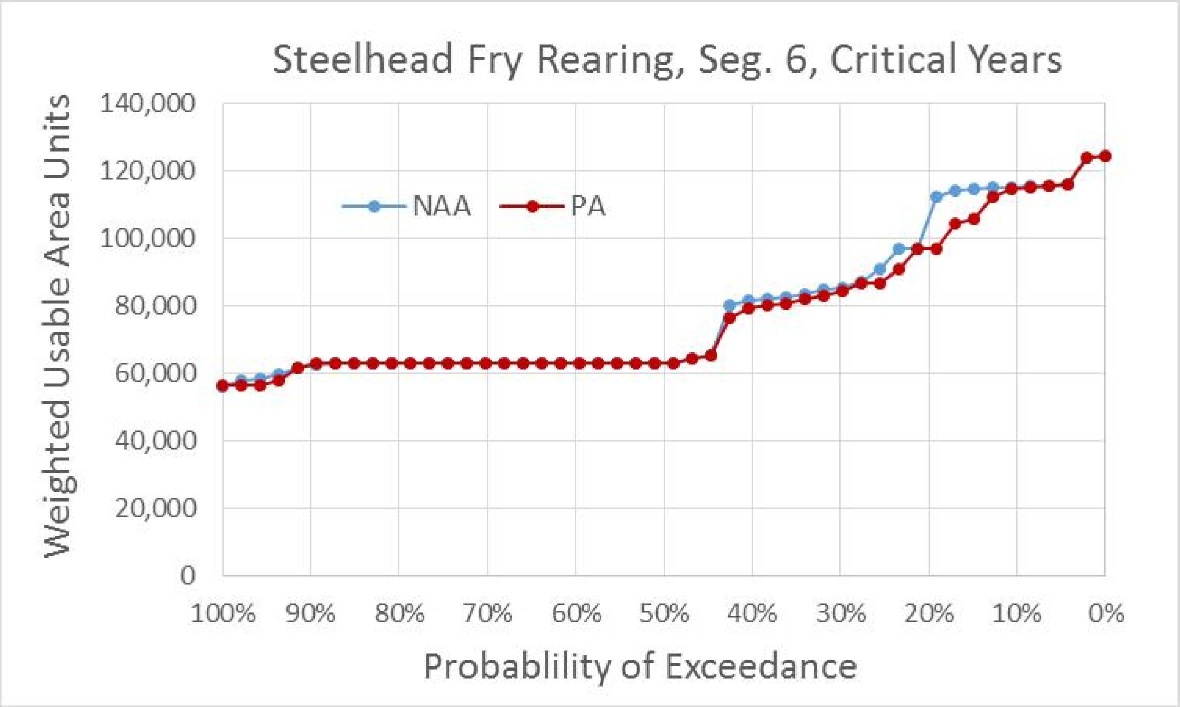

Figure 5.4-215. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

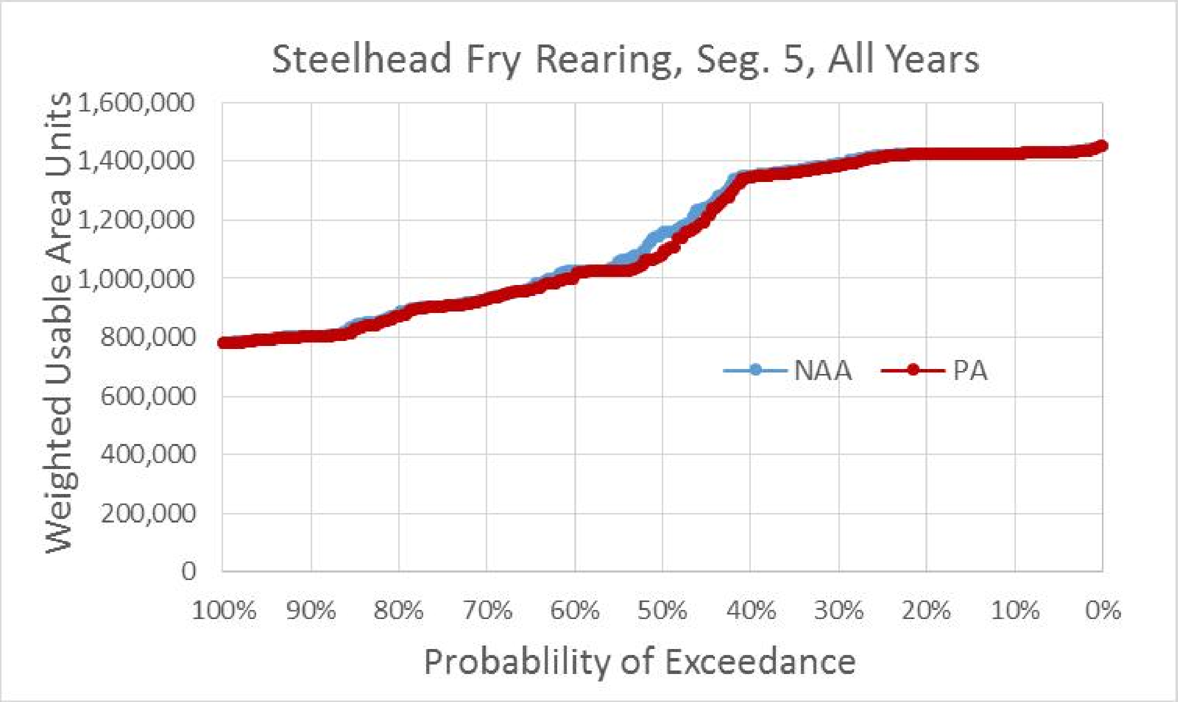

Figure 5.4-216. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

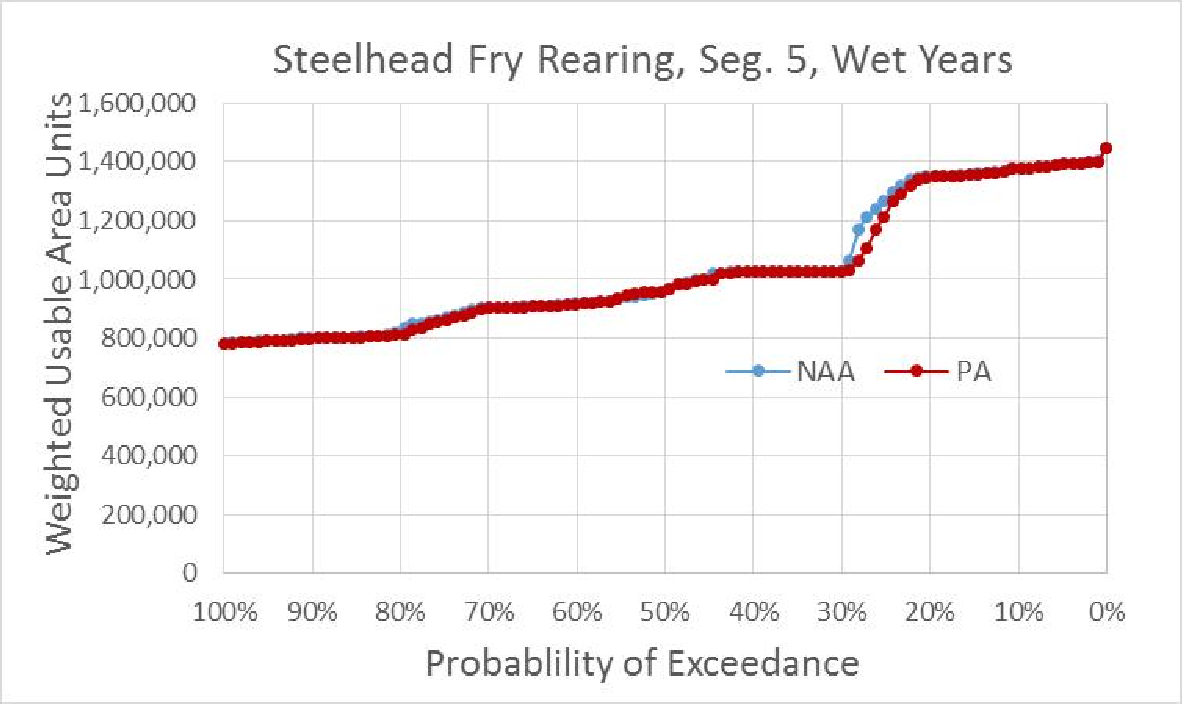

Figure 5.4-217. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

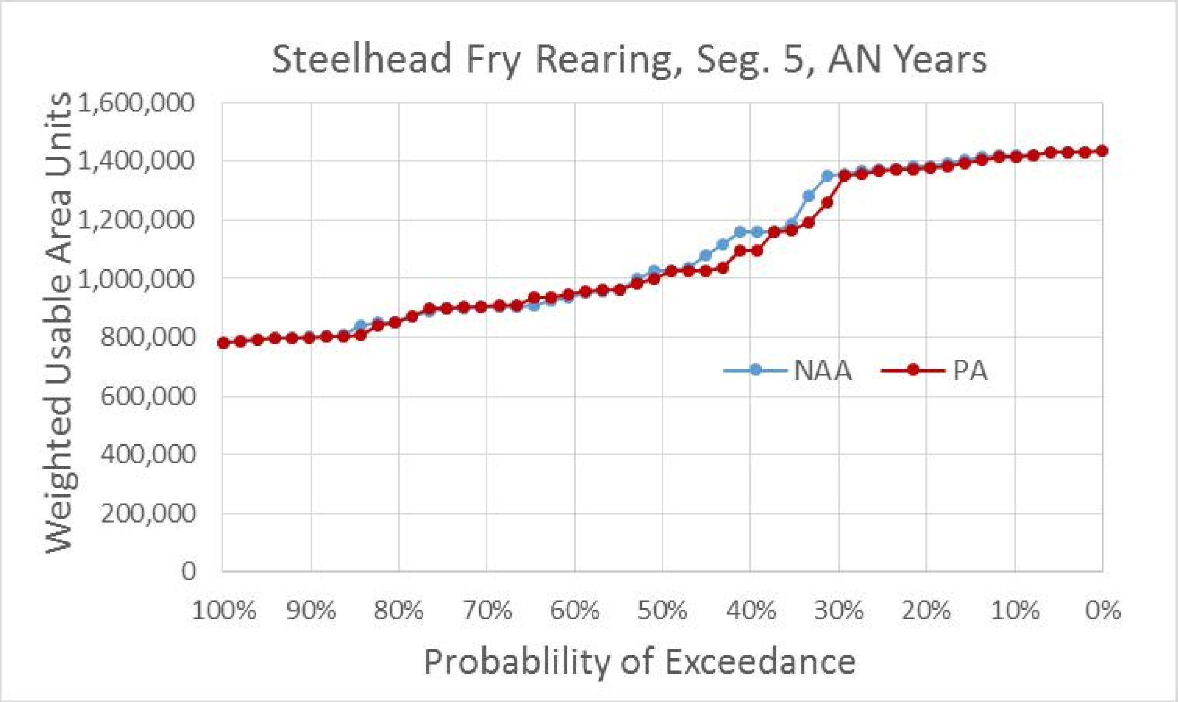

Figure 5.4-218. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

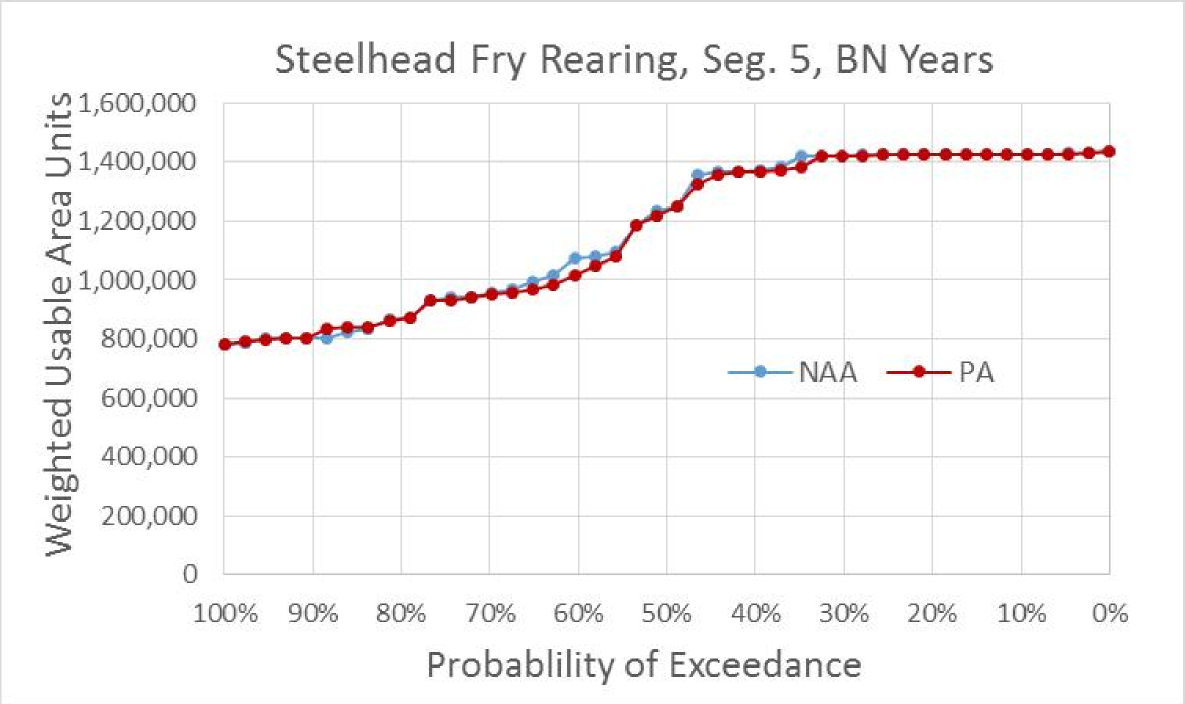

Figure 5.4-219. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

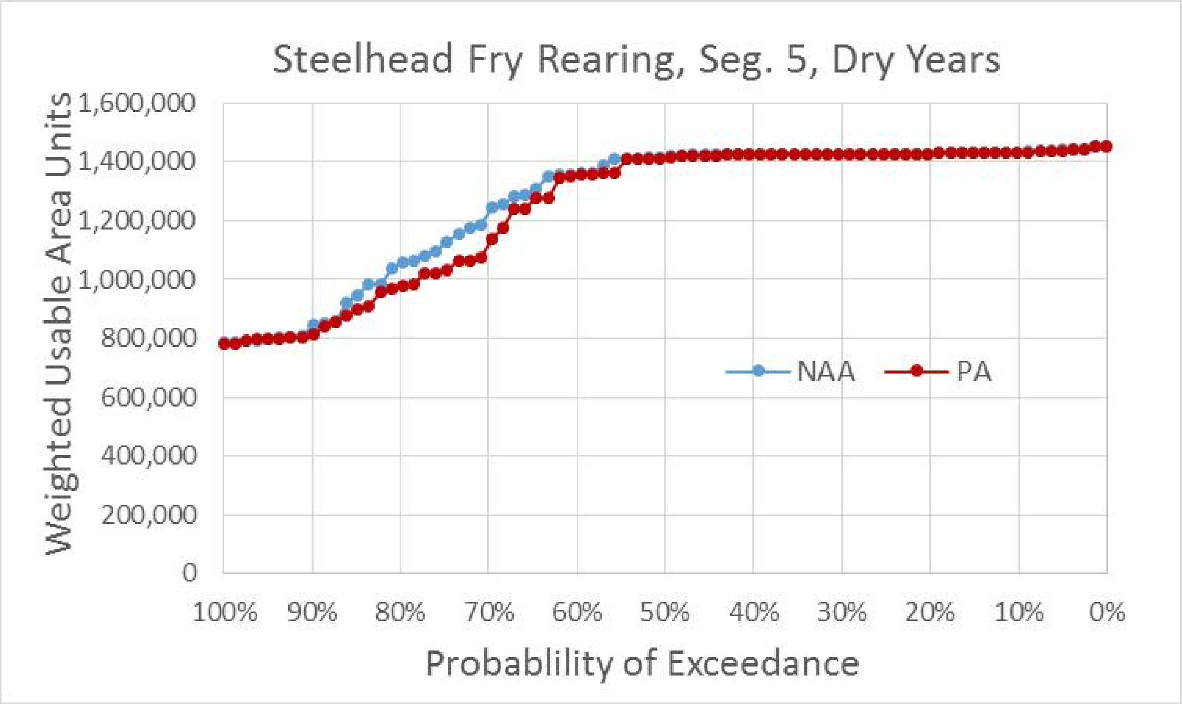

Figure 5.4-220. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

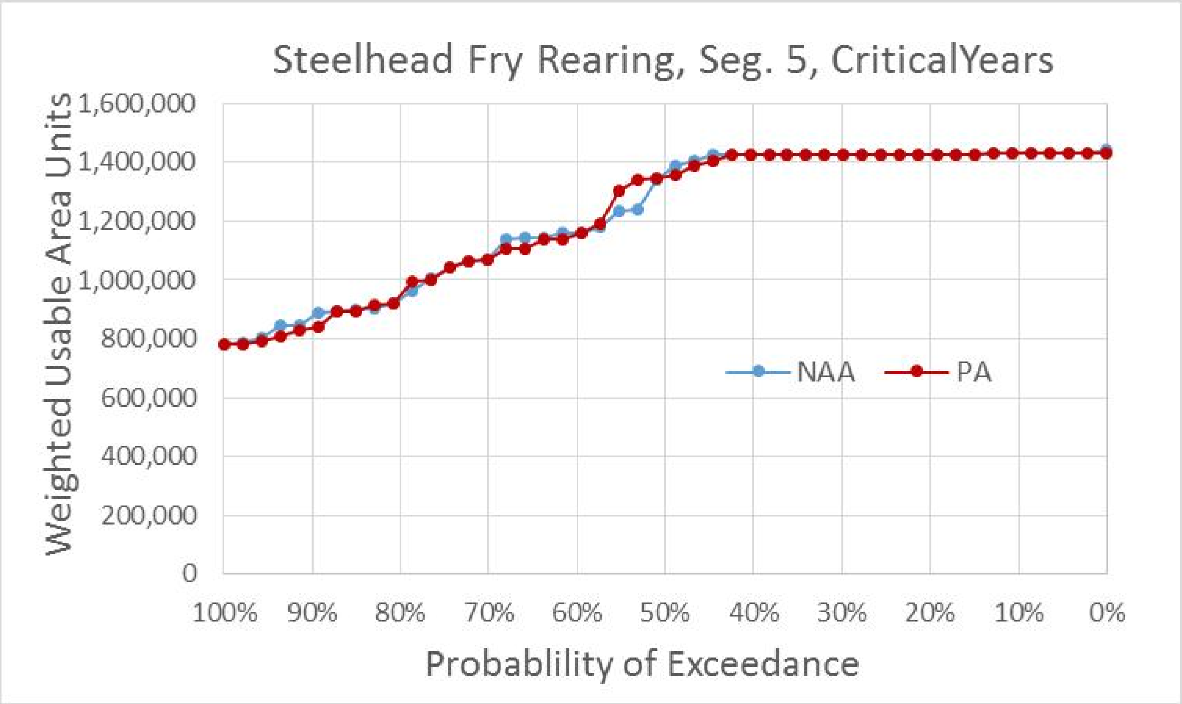

Figure 5.4-221. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

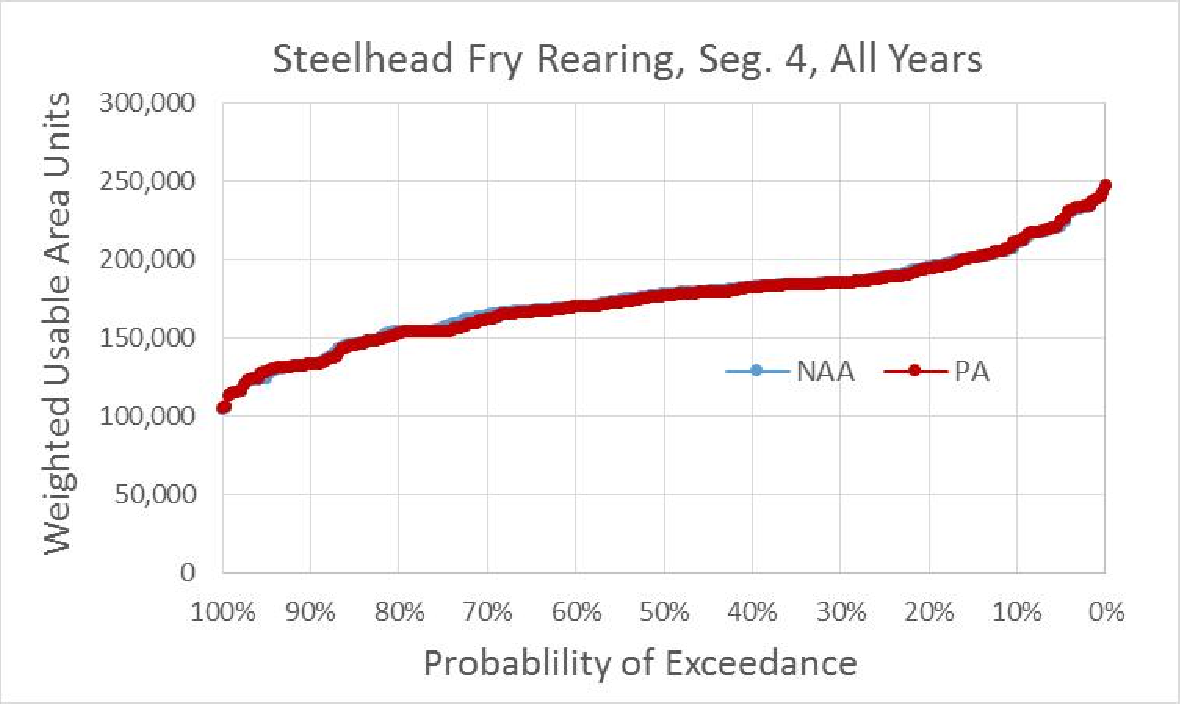

Figure 5.4-222. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

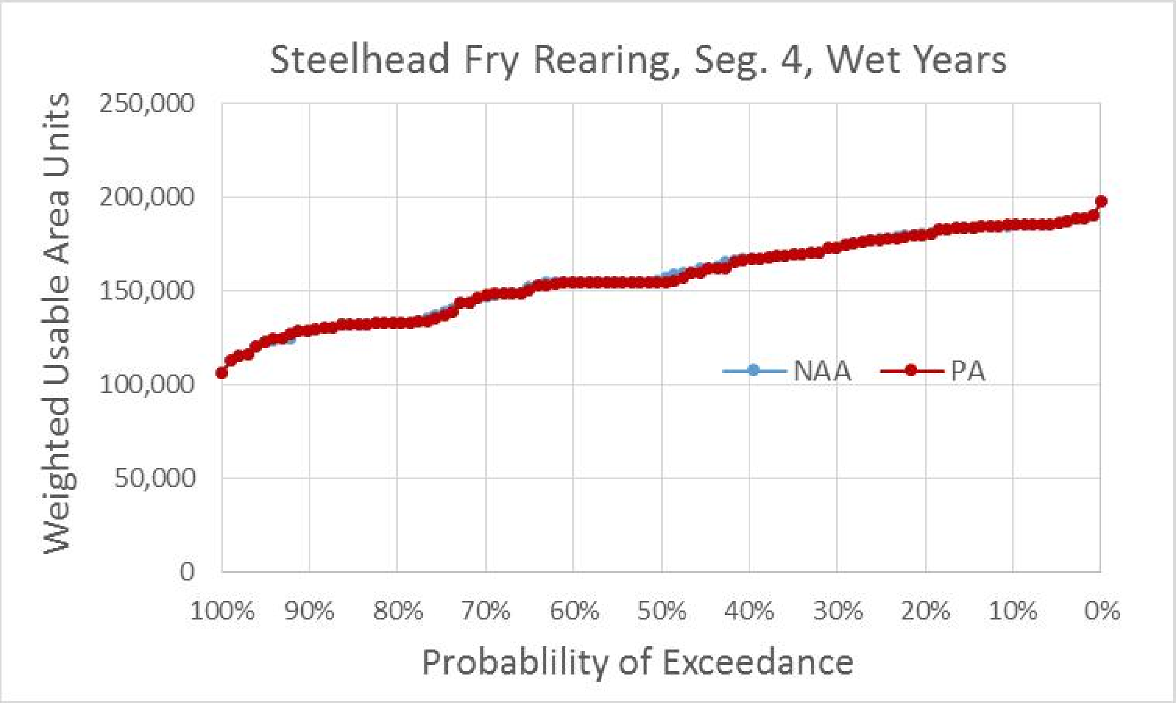

Figure 5.4-223. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

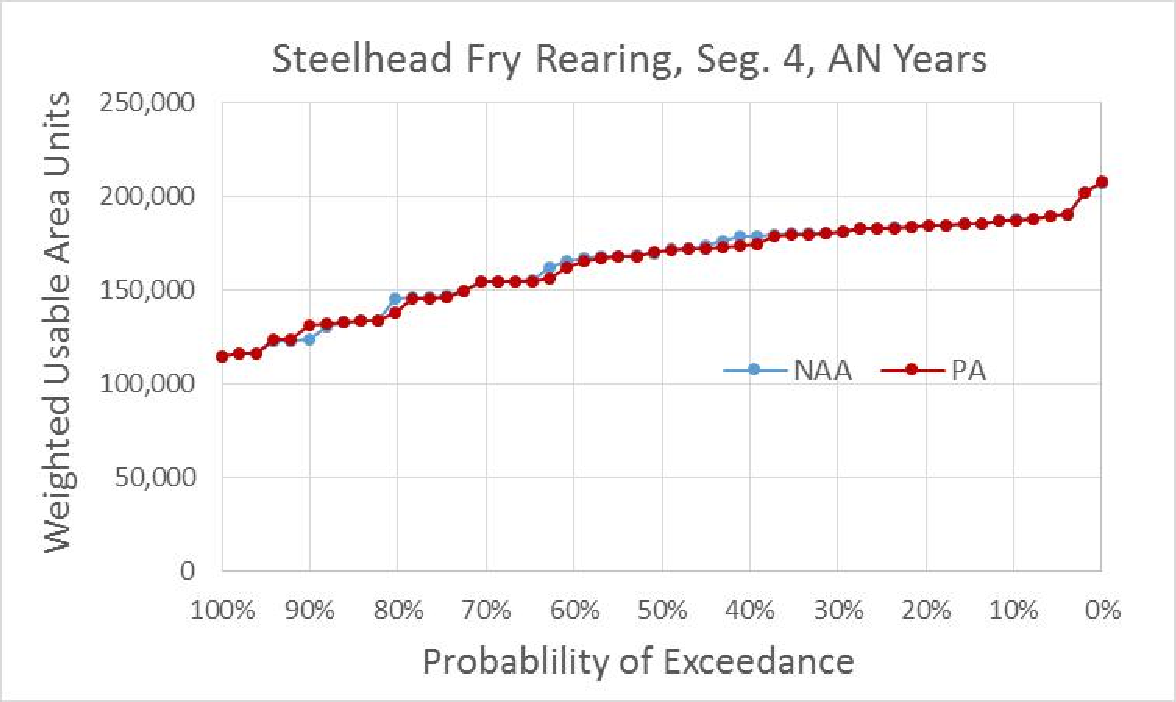

Figure 5.4-224. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

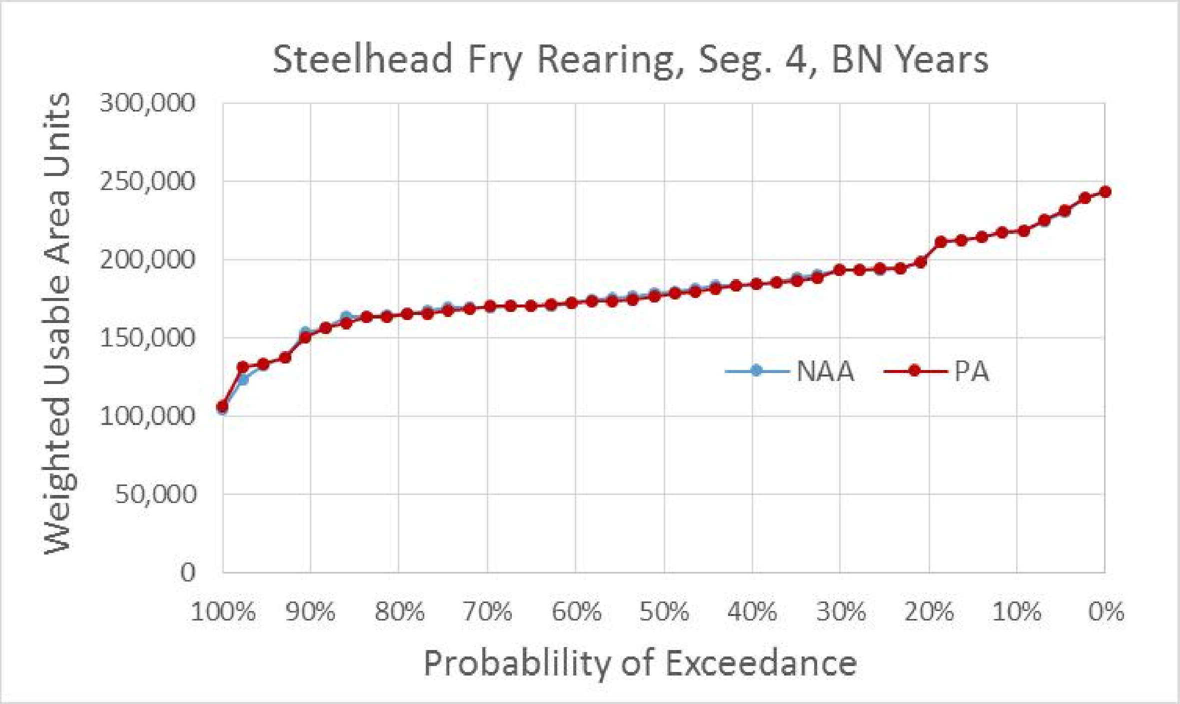

Figure 5.4-225. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

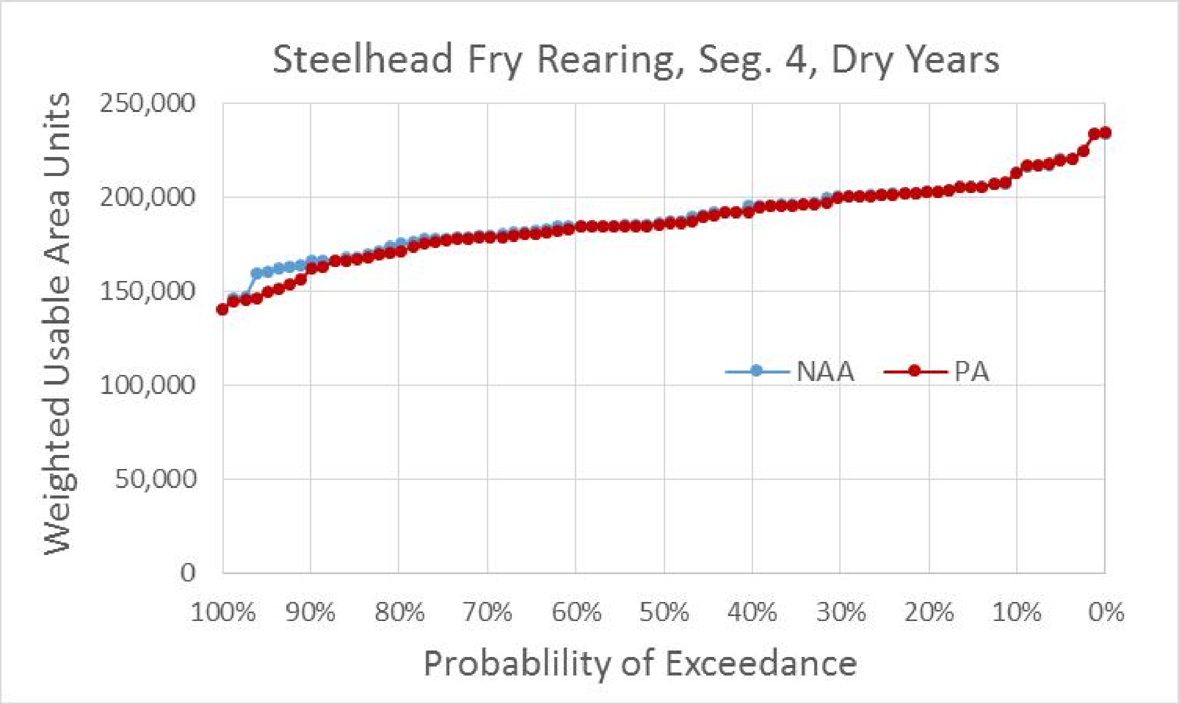

Figure 5.4-226. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

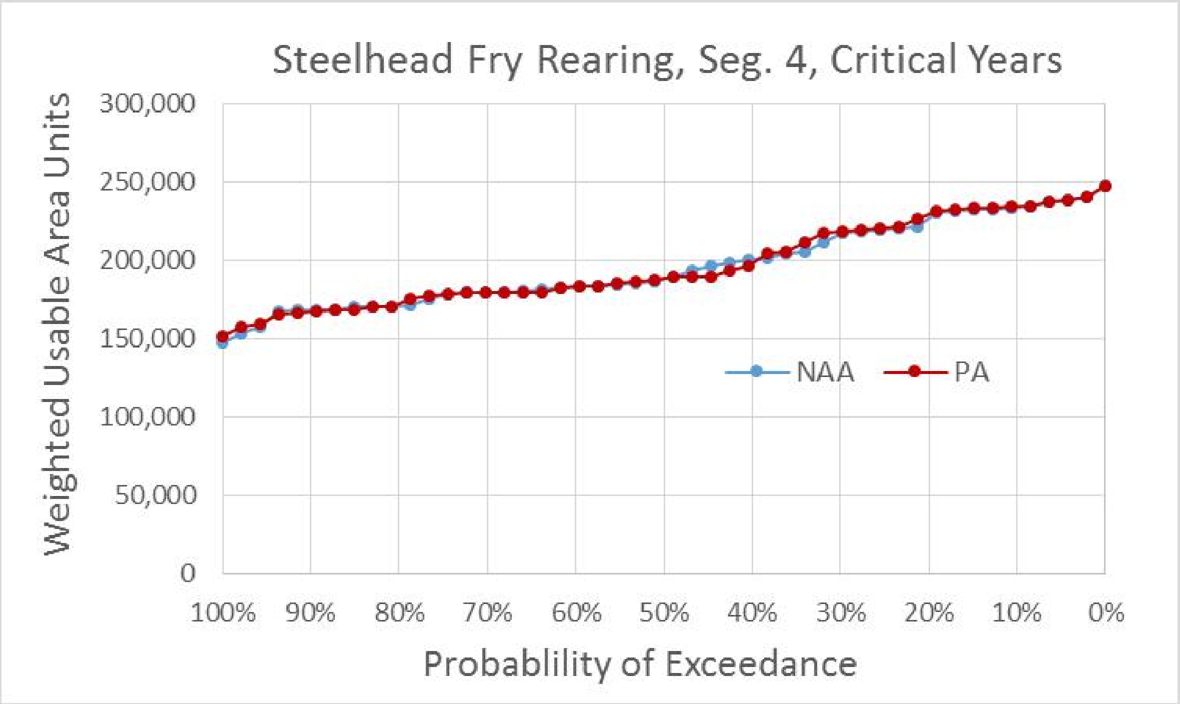

Figure 5.4-227. Exceedance Plot of CCV Steelhead Fry Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

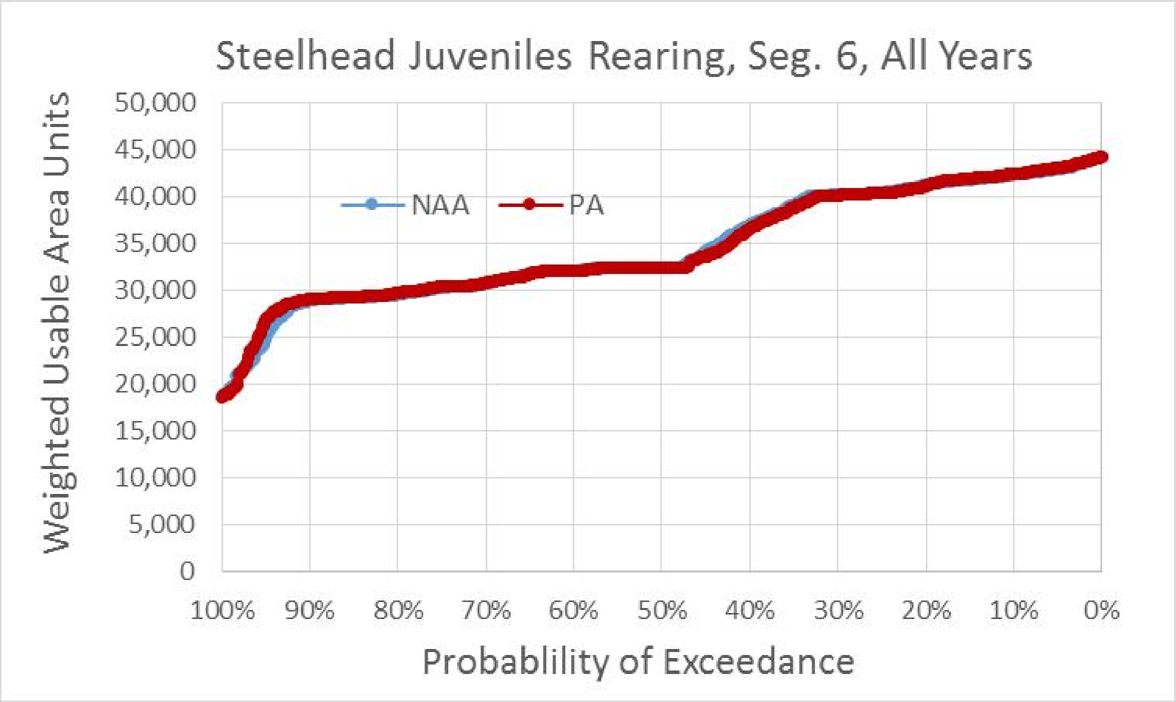

Figure 5.4-228. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, All Water Years

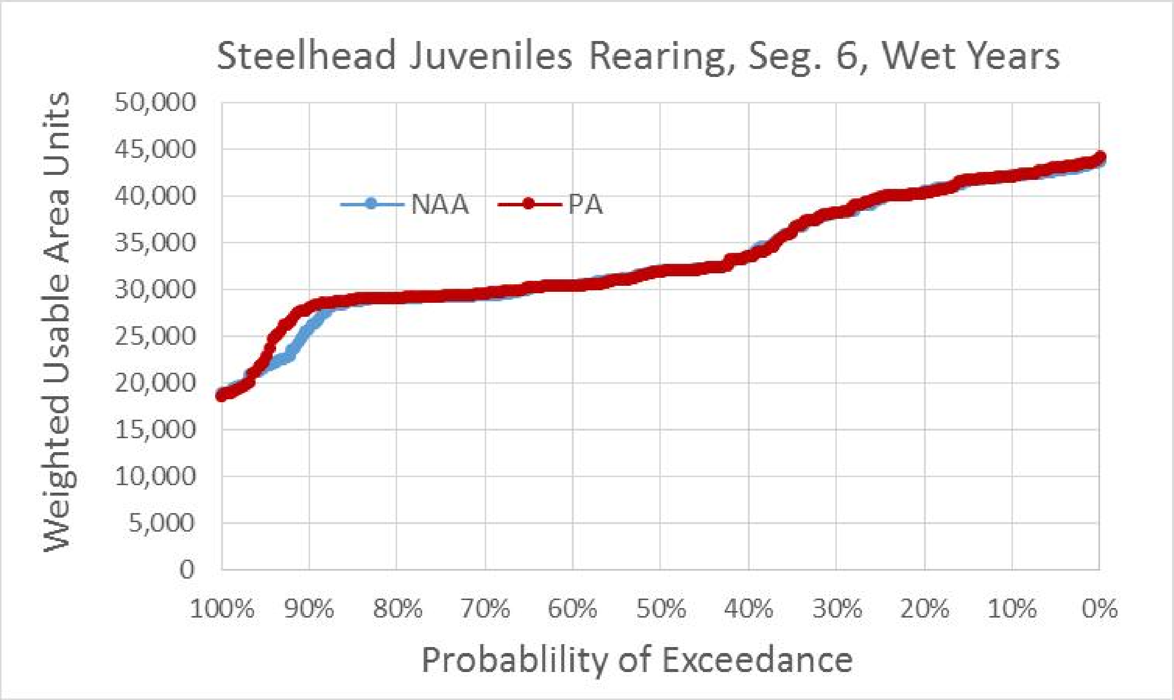

Figure 5.4-229. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Wet Water Years

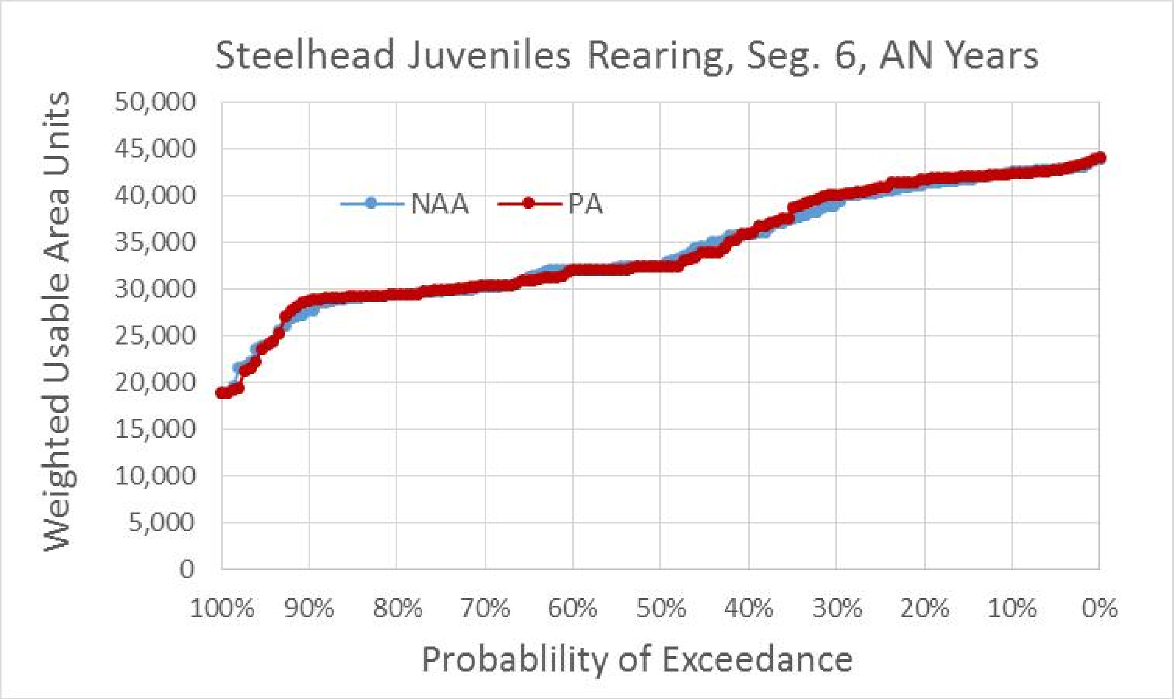

Figure 5.4-230. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Above Normal Water Years

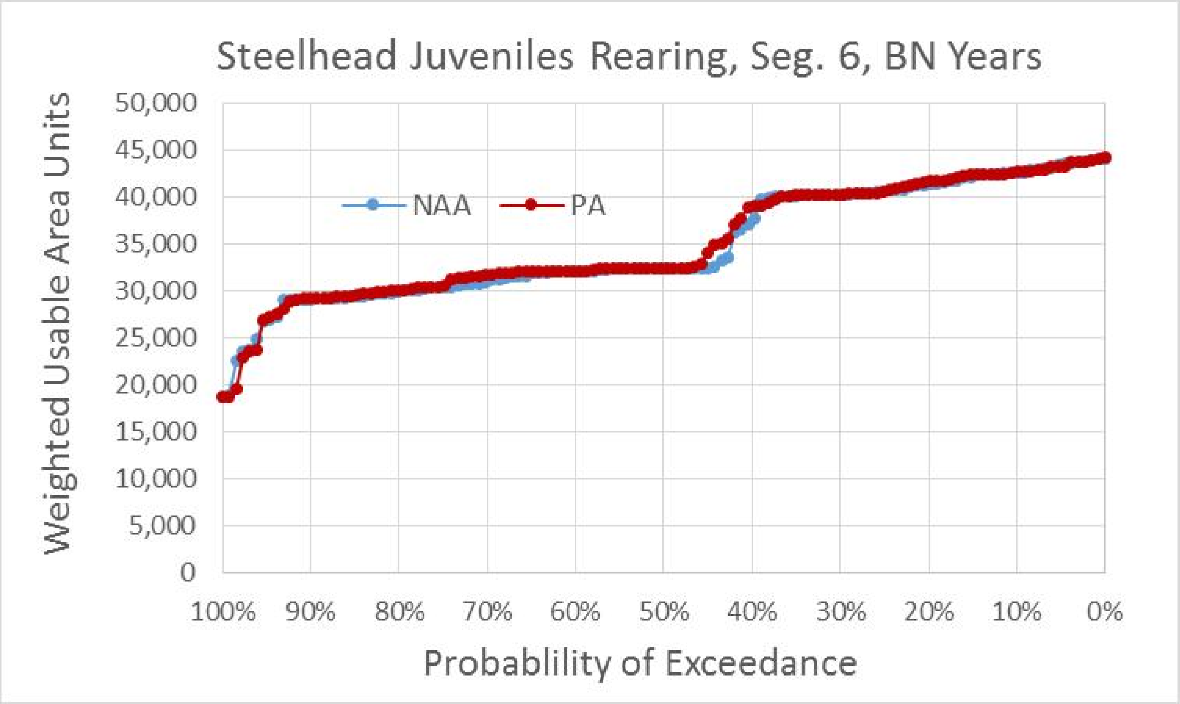

Figure 5.4-231. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Below Normal Water Years

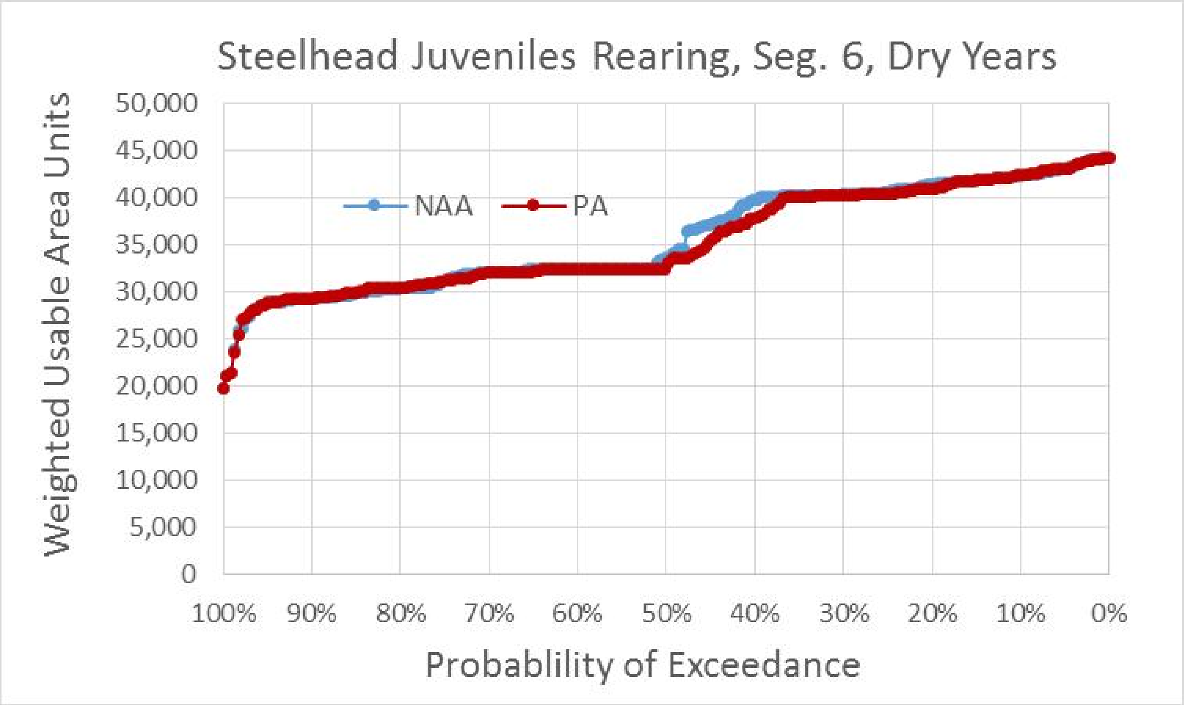

Figure 5.4-232. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Dry Water Years

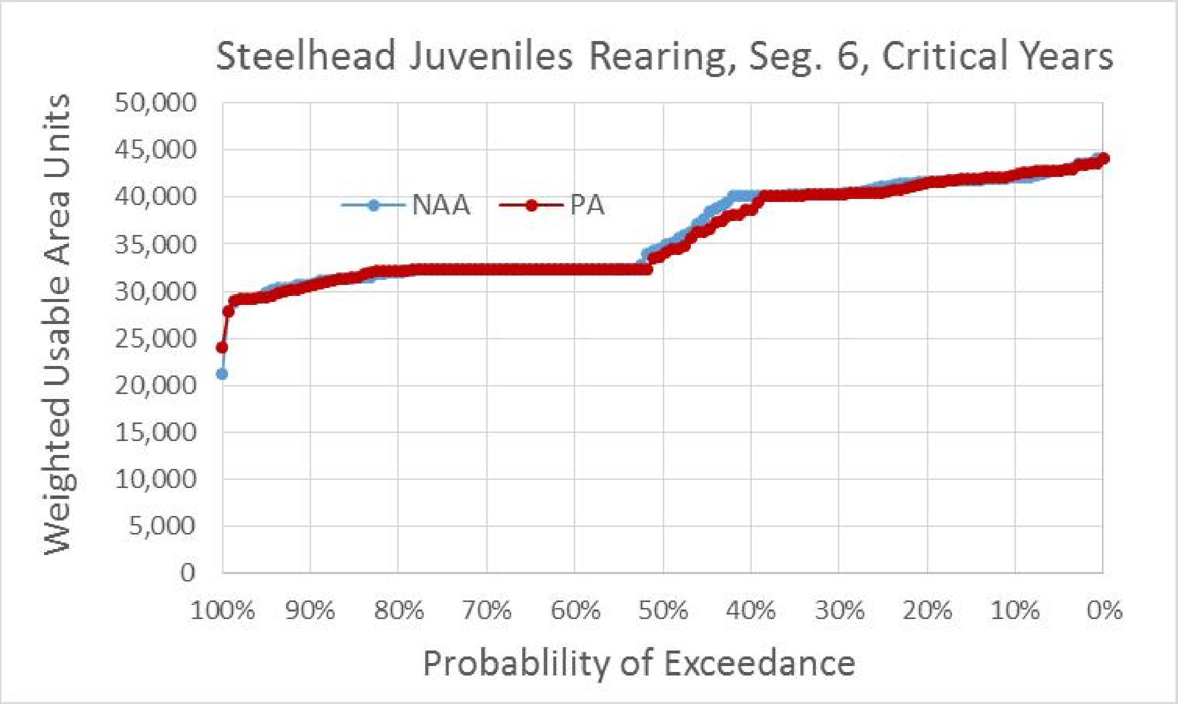

Figure 5.4-233. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 6, Critical Water Years

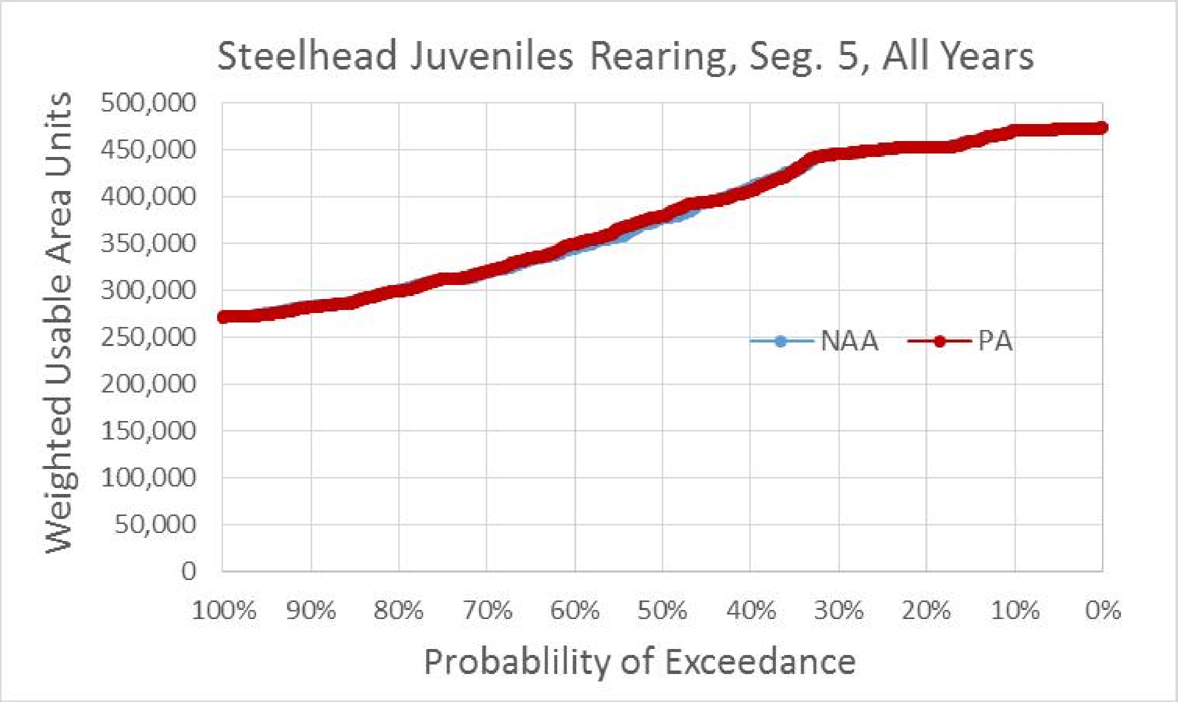

Figure 5.4-234. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, All Water Years

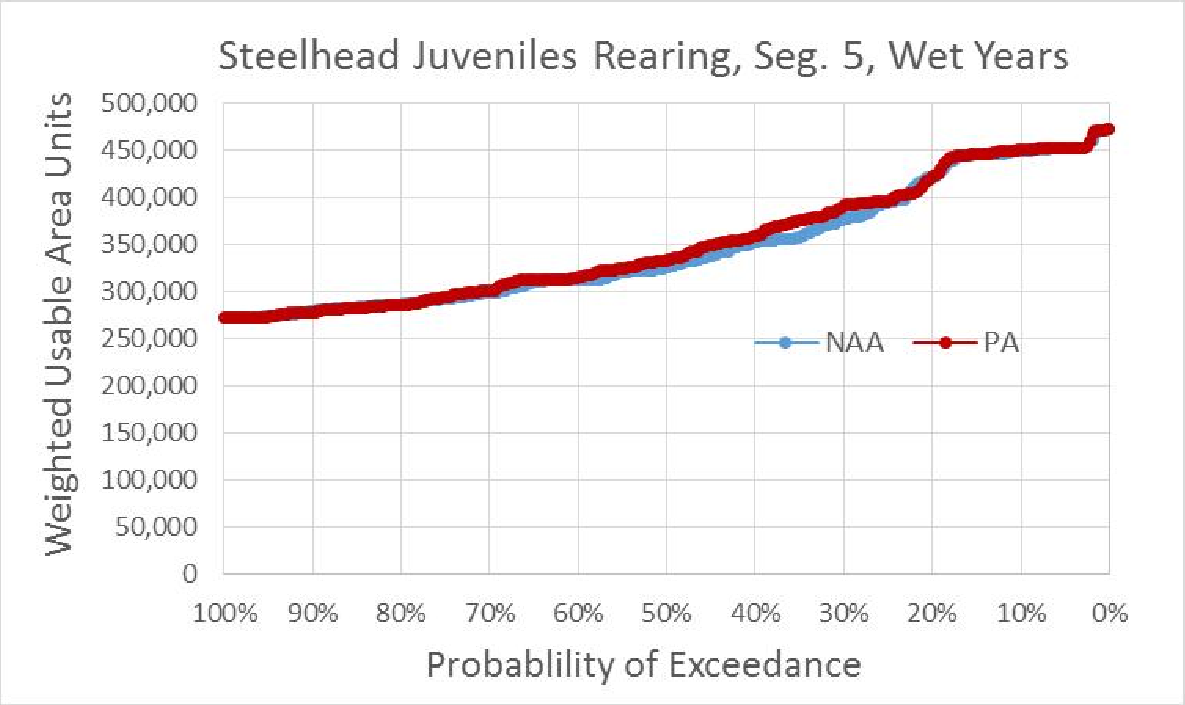

Figure 5.4-235. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Wet Water Years

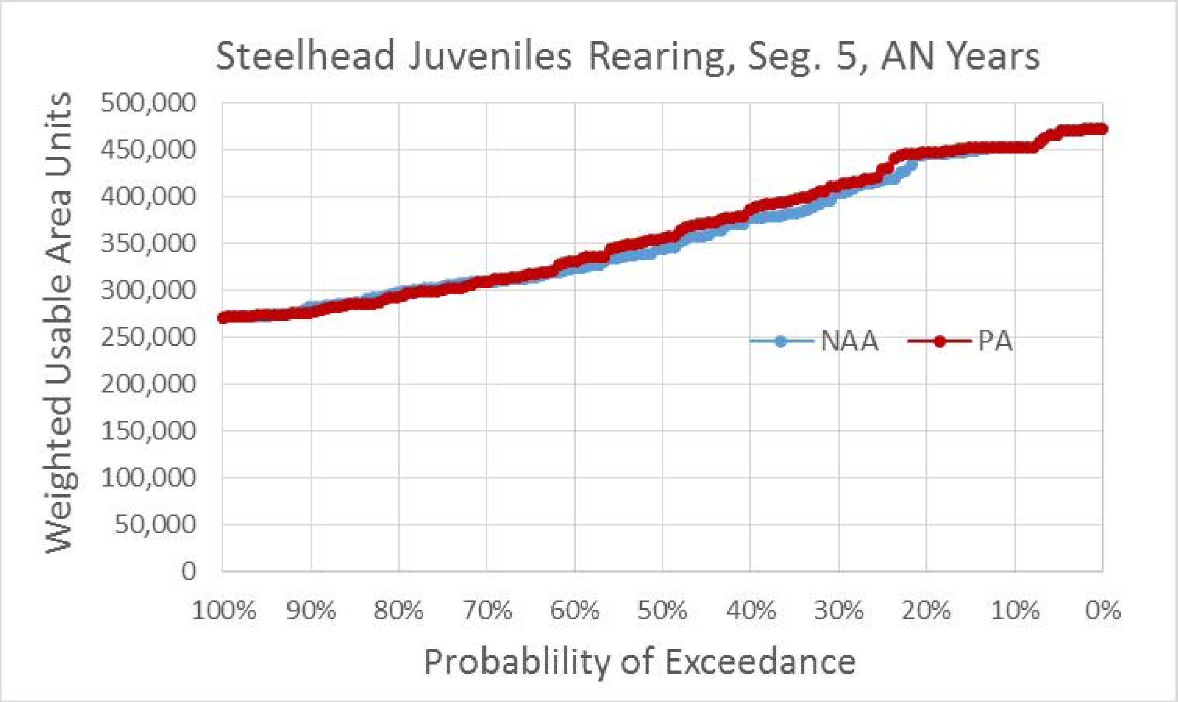

Figure 5.4-236. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Above Normal Water Years

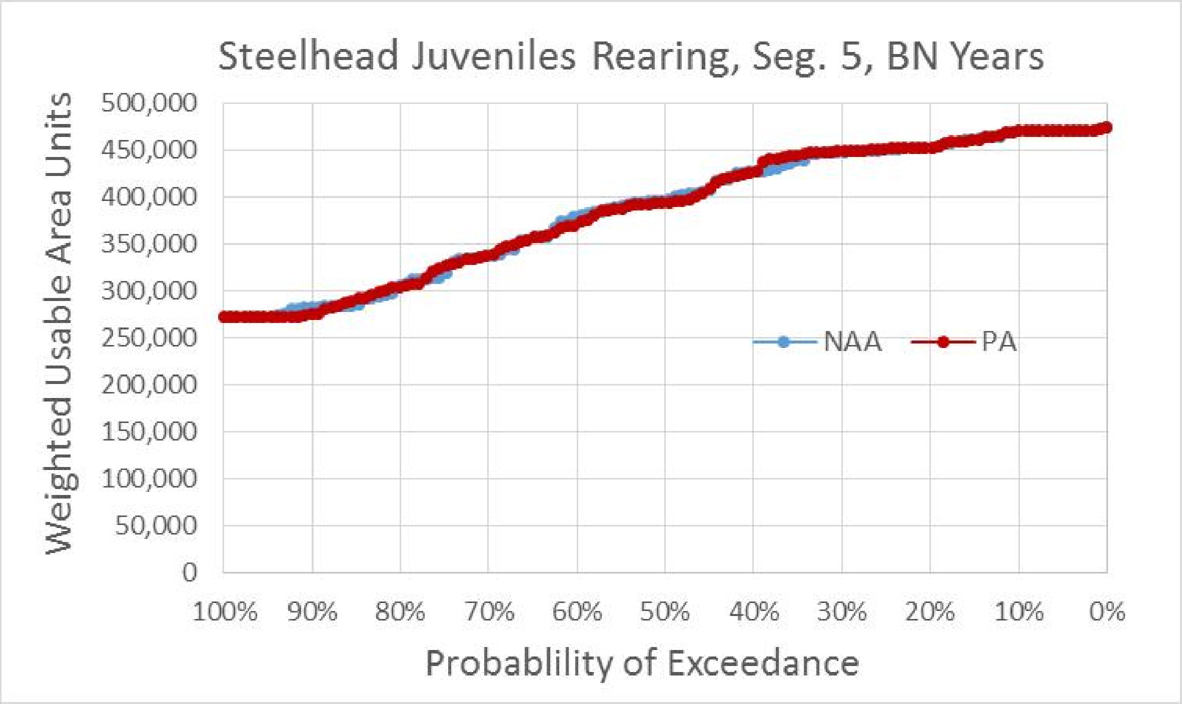

Figure 5.4-237. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Below Normal Water Years

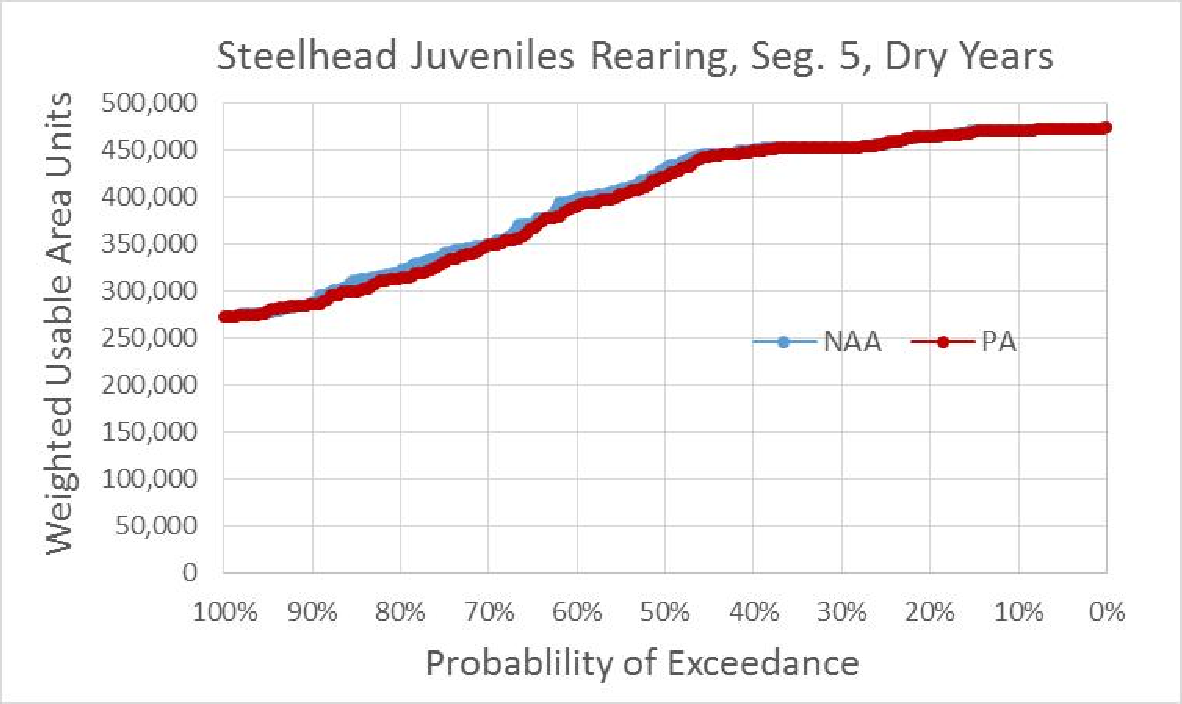

Figure 5.4-238. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Dry Water Years

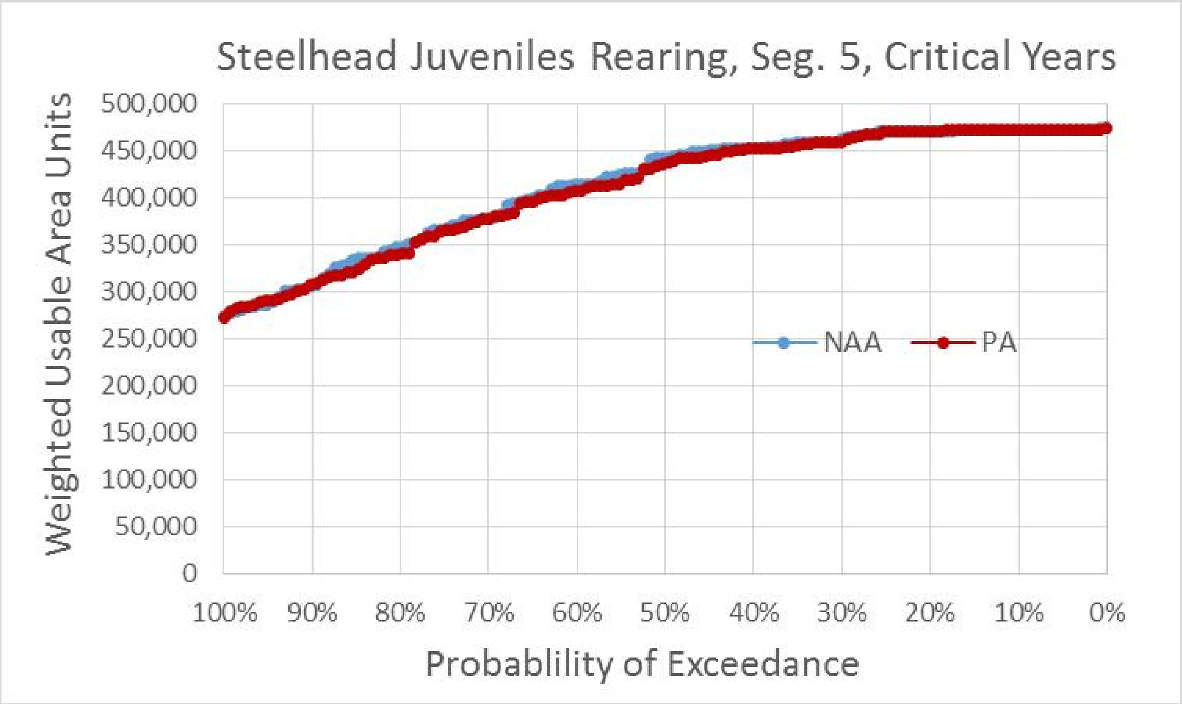

Figure 5.4-239. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 5, Critical Water Years

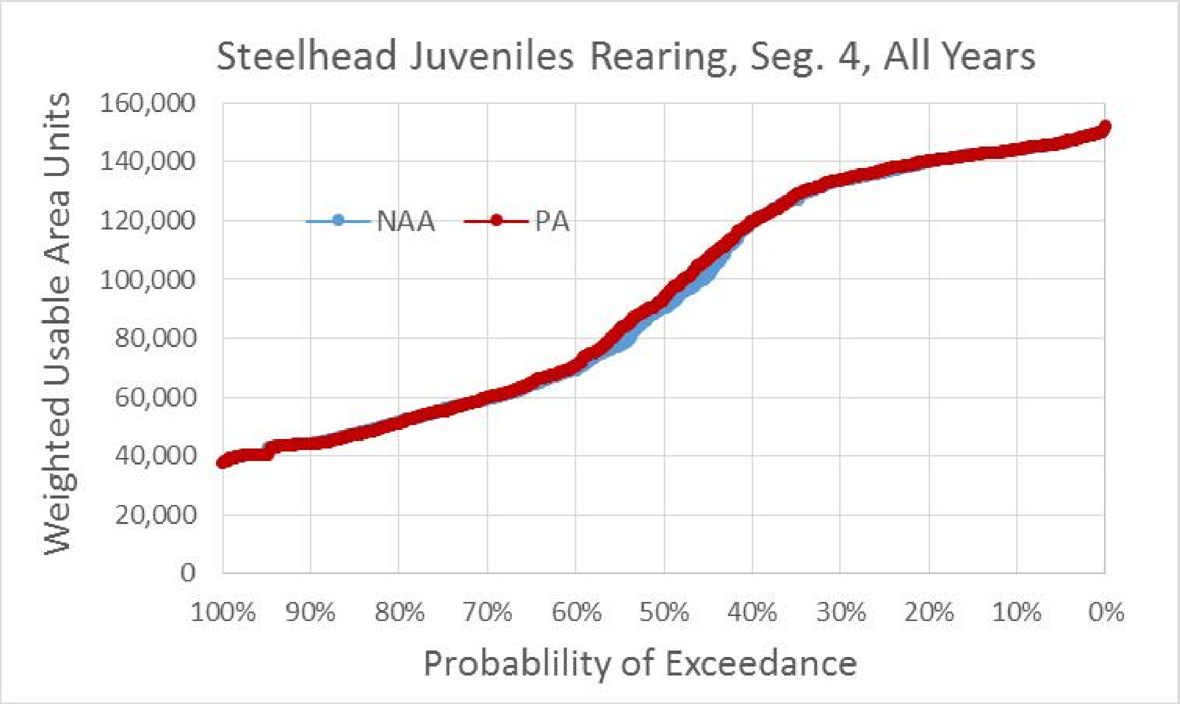

Figure 5.4-240. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, All Water Years

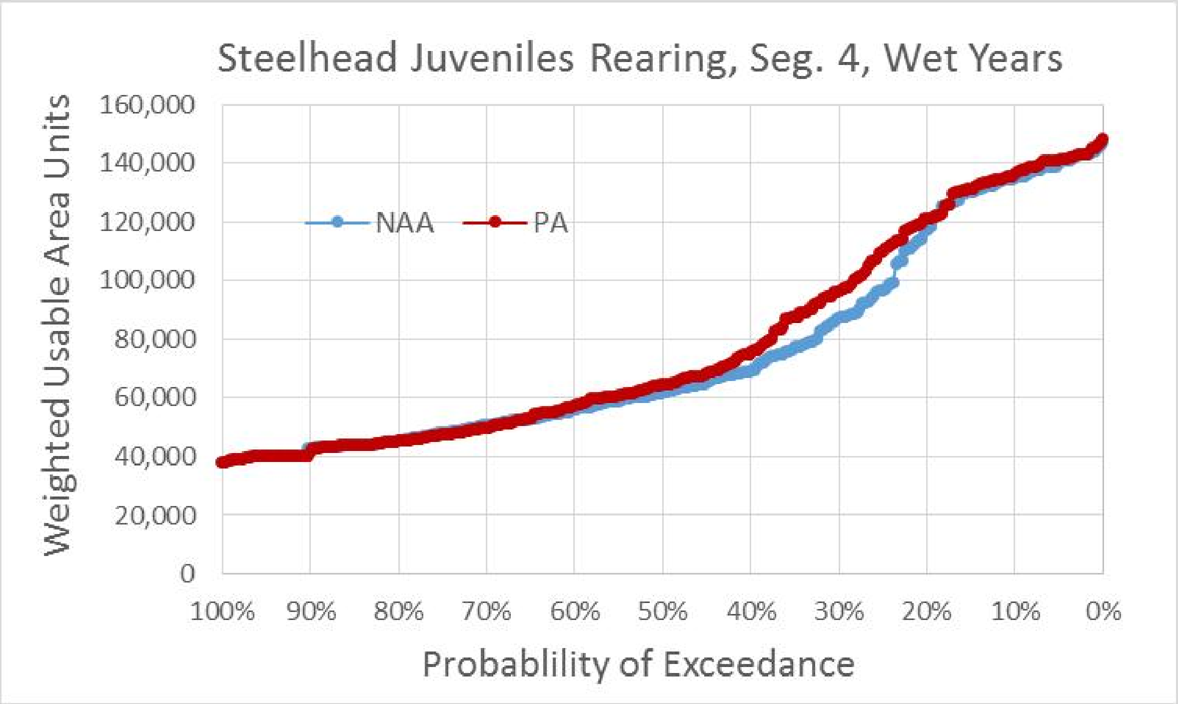

Figure 5.4-241. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Wet Water Years

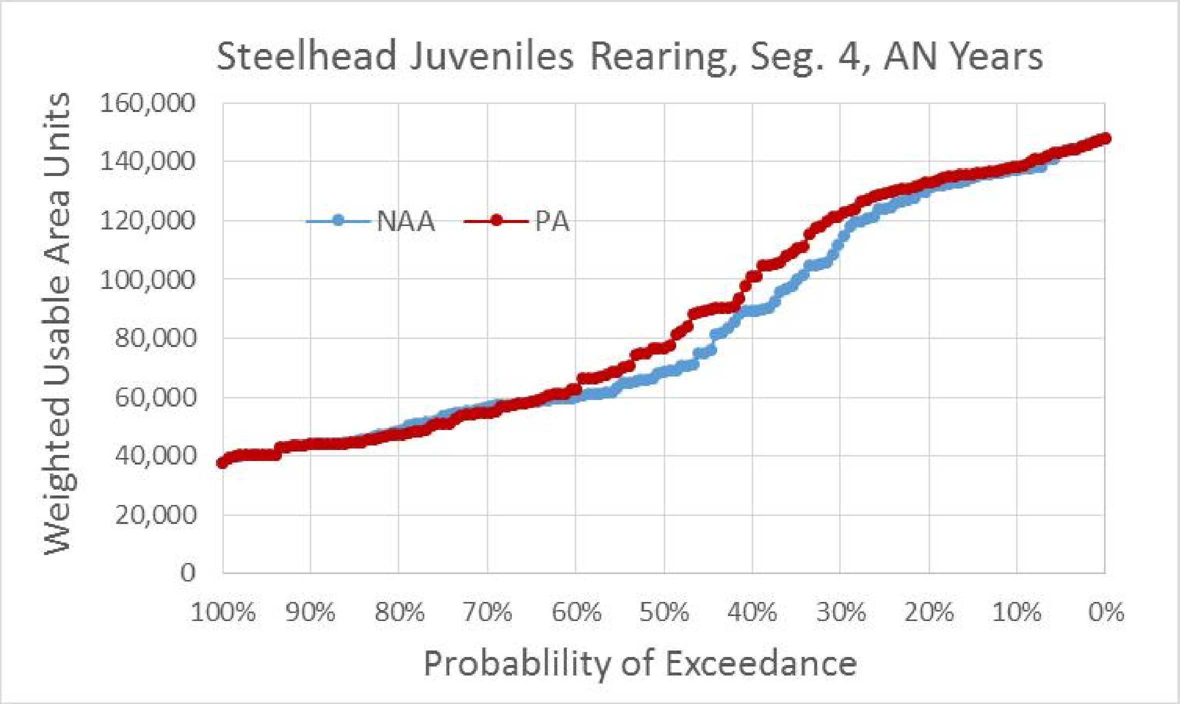

Figure 5.4-242. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Above Normal Water Years

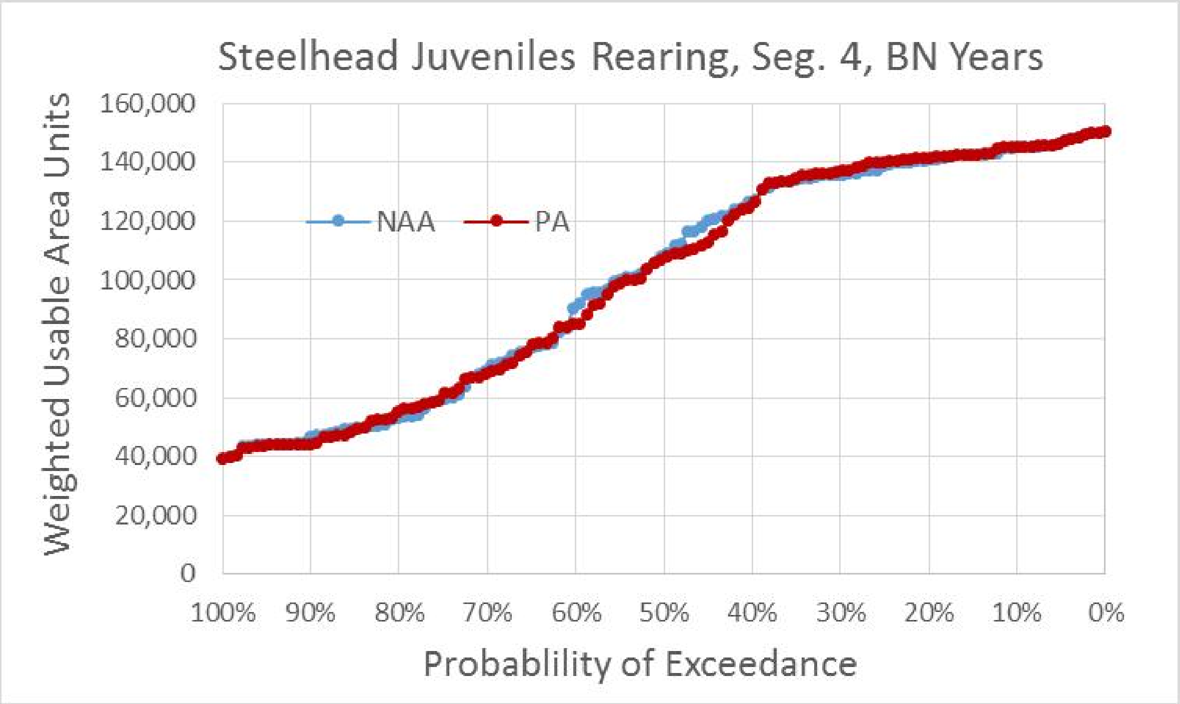

Figure 5.4-243. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Below Normal Water Years

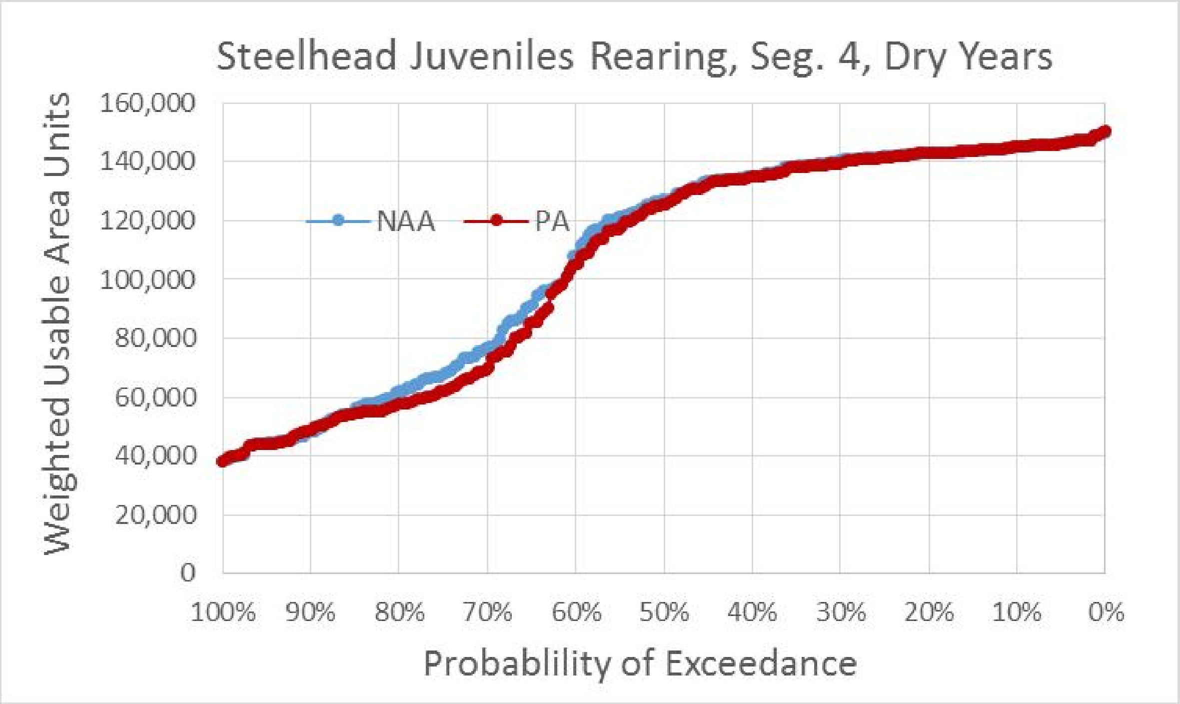

Figure 5.4-244. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Dry Water Years

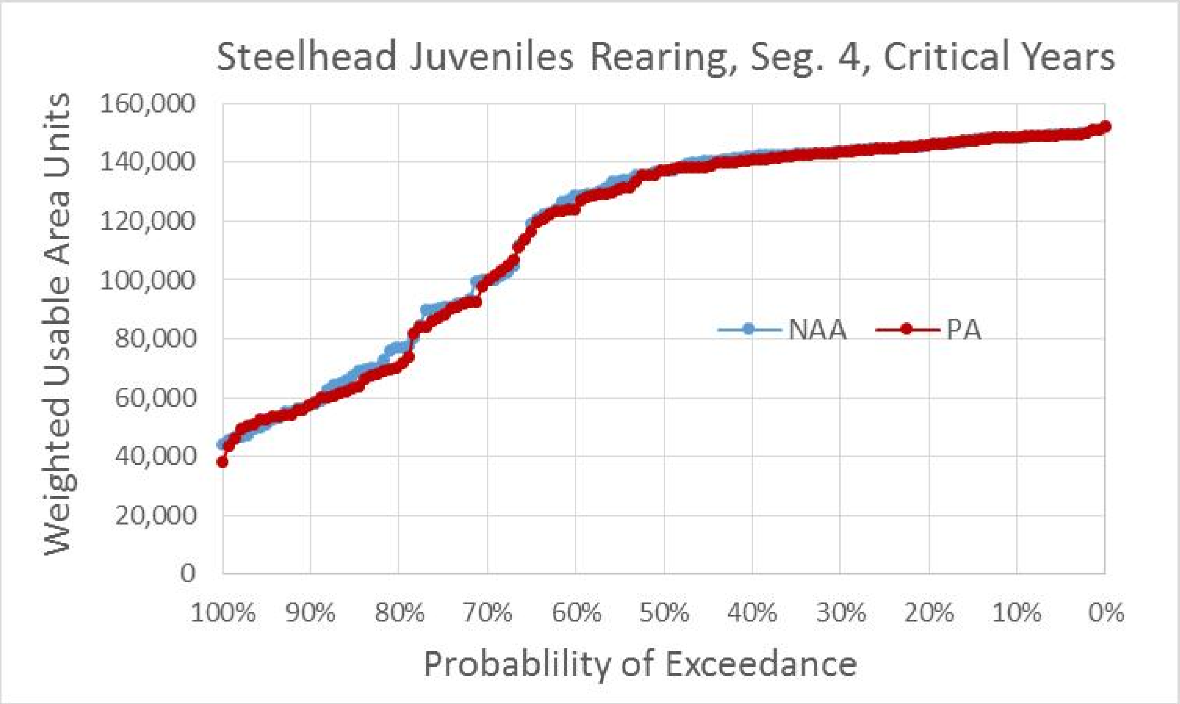

Figure 5.4-245. Exceedance Plot of CCV Steelhead Juvenile Rearing Weighted Usable Area (WUA) for NAA and PA Model Scenarios in River Segment 4, Critical Water Years

Differences in CCV steelhead fry and juvenile rearing WUA in each segment under the PAA and NAA were also examined using the grand mean rearing WUA for each month of the fry and juvenile rearing periods under each water year type and all water year types combined (Table 5.4-66 to Table 5.4-75). The means for fry rearing WUA differed by less than 5% for all months and water year types in Segments 5 and 4 (Table 5.4-71 and Table 5.4-72). In Segment 6, means differed by 5% or more only for February of below normal water years (6% increase) and May of dry years (5% reduction) (Table 5.4-70). The means for juvenile rearing WUA differed by less than 5% for most months and water year types in Segments 6 and 5 (Table 5.4-73 and Table 5.4-74), but differences were greater and more frequent in Segment 4 (Table 5.4-75). In Segment 6, the mean WUA for juvenile rearing under the PA was 5% lower than that under the NAA during June of dry years (Table 5.4-73), and in Segment 5 it was 6% lower during October of below normal years (Table 5.4-74). The mean juvenile rearing WUA was 6% higher under the PA than under the NAA in Segment 6 during August of below normal years and in Segment 5 during September of above normal years, and it was up to 15% and 17% greater in both segments during November of wet and above normal years, respectively (Table 5.4-73 and Table 5.4-74). In Segment 4, mean juvenile rearing habitat WUA under the PA was 8% lower in January of wet years, 6% lower in March of above normal years, 5% lower in May of dry years, 7% and 8% lower in June of dry and critical years, 6% lower in August of dry years, and 13% lower in October of below normal years (Table 5.4-75). Also in Segment 4, mean juvenile WUA under the PA was 10% higher than that under the NAA during August of below normal years, 17% and 6% higher in September of above normal and below normal years, 15% higher in October of wet years, and 44% and 57% higher in November of wet and above normal years. As indicated above for the WUA exceedance plot results, the WUA modeling indicates that the PA would reduce CCV steelhead rearing habitat in several months and water year types, especially for juveniles in Segment 4.

Table 5.4-70. CCV Steelhead Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 6 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
February	Wet	69,319	69,315	-5 (-0.01%)
	Above Normal	73,692	72,500	-1,192 (-2%)
	Below Normal	61,965	65,693	3,728 (6%)
	Dry	61,294	61,669	375 (0.6%)
	Critical	62,526	62,940	414 (0.7%)
	All	66,074	66,536	462 (0.7%)
March	Wet	64,102	64,136	34 (0.1%)
	Above Normal	60,879	62,045	1,165 (2%)
	Below Normal	59,793	60,116	322 (0.5%)
	Dry	61,619	61,505	-114 (-0.2%)
	Critical	62,082	60,942	-1,140 (-2%)
	All	62,112	62,156	44 (0.1%)
April	Wet	91,860	91,331	-529 (-0.6%)
	Above Normal	98,286	98,308	22 (0.02%)
	Below Normal	101,393	102,071	678 (0.7%)
	Dry	110,620	107,689	-2,931 (-3%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	Critical	98,133	95,152	-2,981 (-3%)
	All	99,651	98,427	-1,224 (-1%)
May	Wet	78,212	78,465	253 (0.3%)
	Above Normal	88,580	86,221	-2,359 (-3%)
	Below Normal	83,535	85,377	1,842 (2%)
	Dry	92,012	87,286	-4,726 (-5%)
	Critical	94,167	92,417	-1,750 (-2%)
	All	86,270	84,815	-1,455 (-2%)

Table 5.4-71. CCV Steelhead Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 5 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
February	Wet	1,065,995	1,044,266	-21,729 (-2%)
	Above Normal	1,124,562	1,132,598	8,036 (0.7%)
	Below Normal	1,238,453	1,238,610	156 (0.01%)
	Dry	1,407,760	1,392,412	-15,347 (-1%)
	Critical	1,366,240	1,427,481	61,240 (4%)
	All	1,225,710	1,225,334	-376 (-0.03%)
March	Wet	1,046,678	1,046,819	141 (0.01%)
	Above Normal	1,149,168	1,110,060	-39,108 (-3%)
	Below Normal	1,358,136	1,303,846	-54,290 (-4%)
	Dry	1,371,907	1,371,289	-618 (-0.05%)
	Critical	1,429,713	1,405,462	-24,251 (-2%)
	All	1,240,086	1,222,948	-17,138 (-1%)
April	Wet	1,123,545	1,118,918	-4,627 (-0.4%)
	Above Normal	1,140,259	1,138,996	-1,263 (-0.1%)
	Below Normal	1,144,277	1,164,535	20,258 (2%)
	Dry	1,259,182	1,230,999	-28,183 (-2%)
	Critical	1,065,349	1,040,715	-24,634 (-2%)
	All	1,153,542	1,144,113	-9,429 (-0.8%)
May	Wet	906,548	908,702	2,154 (0.2%)
	Above Normal	958,558	948,654	-9,904 (-1%)
	Below Normal	941,548	951,632	10,083 (1%)
	Dry	1,039,173	1,005,901	-33,272 (-3%)
	Critical	1,027,540	1,009,911	-17,630 (-2%)
	All	969,542	959,313	-10,230 (-1%)

Table 5.4-72. CCV Steelhead Fry Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 4 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
February	Wet	156,731	155,422	-1,310 (-0.8%)
	Above Normal	156,421	157,078	657 (0.4%)
	Below Normal	179,947	180,611	663 (0.4%)
	Dry	197,086	196,371	-715 (-0.4%)
	Critical	210,670	219,778	9,108 (4%)
	All	177,532	178,469	936 (0.5%)
March	Wet	150,795	151,042	247 (0.2%)
	Above Normal	161,121	158,569	-2,552 (-2%)
	Below Normal	197,140	194,502	-2,638 (-1%)
	Dry	195,232	195,162	-70 (-0.04%)
	Critical	215,950	209,421	-6,530 (-3%)
	All	179,022	177,370	-1,653 (-0.9%)
April	Wet	163,985	163,897	-88 (-0.1%)
	Above Normal	172,564	172,563	-1 (-0.001%)
	Below Normal	180,540	181,257	717 (0.4%)
	Dry	189,289	187,614	-1,674 (-0.9%)
	Critical	184,159	183,685	-474 (-0.3%)
	All	176,690	176,280	-410 (-0.2%)
May	Wet	159,078	159,267	189 (0.1%)
	Above Normal	167,272	166,856	-417 (-0.2%)
	Below Normal	168,883	168,866	-18 (-0.01%)
	Dry	173,321	169,780	-3,541 (-2%)
	Critical	174,839	174,413	-426 (-0.2%)
	All	167,473	166,538	-935 (-0.6%)

Table 5.4-73. CCV Steelhead Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 6 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
January	Wet	29,129	28,400	-729 (-3%)
	Above Normal	29,434	29,426	-8 (-0.03%)
	Below Normal	29,509	29,473	-36 (-0.1%)
	Dry	29,713	29,790	77 (0.3%)
	Critical	31,261	31,292	31 (0.1%)
	All	29,683	29,469	-214 (-0.7%)
February	Wet	29,438	29,351	-88 (-0.3%)
	Above Normal	28,607	28,520	-86 (-0.3%)
	Below Normal	29,040	28,867	-174 (-0.6%)
	Dry	31,689	31,676	-13 (-0.04%)
	Critical	31,838	32,374	536 (2%)
	All	30,153	30,164	11 (0.04%)
March	Wet	26,562	26,542	-20 (-0.1%)
	Above Normal	28,066	27,525	-541 (-2%)
	Below Normal	30,923	30,542	-381 (-1%)
	Dry	31,654	31,609	-46 (-0.1%)
	Critical	32,015	31,400	-615 (-2%)
	All	29,426	29,181	-244 (-0.8%)
April	Wet	38,038	38,143	106 (0.3%)
	Above Normal	40,355	40,351	-4 (-0.01%)
	Below Normal	41,781	41,831	51 (0.1%)
	Dry	41,581	41,620	39 (0.1%)
	Critical	41,408	41,830	422 (1%)
	All	40,265	40,376	111 (0.3%)
May	Wet	40,564	40,642	77 (0.2%)
	Above Normal	41,482	41,616	133 (0.3%)
	Below Normal	42,164	41,799	-365 (-0.9%)
	Dry	41,111	40,807	-304 (-0.7%)
	Critical	42,067	42,348	281 (0.7%)
	All	41,278	41,241	-36 (-0.1%)
June	Wet	38,289	37,899	-390 (-1%)
	Above Normal	35,211	33,831	-1,380 (-4%)
	Below Normal	35,207	35,327	120 (0.3%)
	Dry	36,548	34,685	🟥 -1,863 (-5%)
	Critical	38,428	37,290	-1,137 (-3%)
	All	36,983	36,036	-947 (-3%)
July	Wet	31,828	31,661	-167 (-0.5%)

Month	Water Year Type	NAA	PA	PA vs. NAA
	Above Normal	31,739	31,436	-303 (-1%)
	Below Normal	31,399	31,770	371 (1%)
	Dry	32,171	32,536	365 (1%)
	Critical	34,132	35,246	1,115 (3%)
	All	32,177	32,378	201 (0.6%)
August	Wet	37,184	36,932	-252 (-0.7%)
	Above Normal	36,724	36,975	252 (0.7%)
	Below Normal	36,295	38,389	2,094 (6%)
	Dry	39,998	39,116	-882 (-2%)
	Critical	40,084	39,070	-1,014 (-3%)
	All	38,102	37,980	-122 (-0.3%)
September	Wet	32,778	32,739	-39 (-0.1%)
	Above Normal	39,868	41,822	1,954 (5%)
	Below Normal	41,223	40,536	-687 (-2%)
	Dry	41,051	40,512	-539 (-1%)
	Critical	40,210	40,006	-204 (-0.5%)
	All	38,141	38,184	44 (0.1%)
October	Wet	41,526	41,903	377 (0.9%)
	Above Normal	42,223	41,934	-289 (-0.7%)
	Below Normal	41,700	42,635	936 (2%)
	Dry	41,478	42,091	613 (1%)
	Critical	40,175	39,012	-1,163 (-3%)
	All	41,441	41,625	184 (0.4%)
November	Wet	25,367	28,636	3,269 (13%)
	Above Normal	27,841	29,694	1,854 (7%)
	Below Normal	29,693	29,802	108 (0.4%)
	Dry	29,877	29,958	81 (0.3%)
	Critical	30,961	30,451	-510 (-2%)
	All	28,263	29,546	1,283 (5%)
December	Wet	28,705	29,188	483 (2%)
	Above Normal	29,674	29,032	-642 (-2%)
	Below Normal	29,987	29,928	-59 (-0.2%)
	Dry	30,308	30,029	-280 (-0.9%)
	Critical	32,077	32,168	91 (0.3%)
	All	29,918	29,914	-4 (-0.01%)

Table 5.4-74. CCV Steelhead Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 5 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
January	Wet	397,419	381,586	-15,833 (-4%)
	Above Normal	408,747	408,732	-15 (-0.004%)
	Below Normal	405,140	404,956	-184 (-0.05%)
	Dry	407,975	406,745	-1,230 (-0.3%)
	Critical	454,578	447,163	-7,415 (-2%)
	All	411,190	404,758	-6,432 (-2%)
February	Wet	353,152	348,966	-4,186 (-1%)
	Above Normal	355,755	355,646	-109 (-0.03%)
	Below Normal	409,987	406,555	-3,432 (-0.8%)
	Dry	463,795	461,569	-2,226 (-0.5%)
	Critical	459,496	471,382	11,886 (3%)
	All	403,738	403,129	-608 (-0.2%)
March	Wet	342,746	342,757	10 (0.003%)
	Above Normal	387,907	376,683	-11,223 (-3%)
	Below Normal	450,055	441,394	-8,661 (-2%)
	Dry	457,711	457,191	-520 (-0.1%)
	Critical	468,699	462,847	-5,852 (-1.2%)
	All	410,773	406,852	-3,921 (-1%)
April	Wet	385,647	384,916	-731 (-0.2%)
	Above Normal	403,753	403,471	-282 (-0.1%)
	Below Normal	414,776	417,162	2,386 (0.6%)
	Dry	433,537	429,955	-3,582 (-0.8%)
	Critical	397,226	394,890	-2,336 (-0.6%)
	All	405,800	404,628	-1,172 (-0.3%)
May	Wet	360,972	361,641	669 (0.2%)
	Above Normal	378,137	377,364	-773 (-0.2%)
	Below Normal	378,041	379,629	1,589 (0.4%)
	Dry	389,954	379,530	-10,424 (-3%)
	Critical	394,079	391,549	-2,530 (-0.6%)
	All	377,897	375,287	-2,610 (-0.7%)
June	Wet	325,990	323,761	-2,229 (-0.7%)
	Above Normal	307,768	299,977	-7,791 (-3%)
	Below Normal	309,967	304,453	-5,514 (-2%)
	Dry	313,749	302,796	-10,953 (-3%)
	Critical	330,817	321,164	-9,653 (-3%)
	All	318,673	311,907	-6,766 (-2%)

Month	Water Year Type	NAA	PA	PA vs. NAA
July	Wet	284,079	283,073	-1,006 (-0.4%)
	Above Normal	274,903	275,756	853 (0.3%)
	Below Normal	277,076	277,024	-53 (-0.02%)
	Dry	288,136	288,370	234 (0.1%)
	Critical	302,335	307,296	4,961 (2%)
	All	285,346	285,938	592 (0.2%)
August	Wet	319,088	317,603	-1,486 (-0.5%)
	Above Normal	316,379	316,213	-166 (-0.1%)
	Below Normal	312,933	326,036	13,103 (4%)
	Dry	341,252	334,031	-7,221 (-2%)
	Critical	348,461	344,745	-3,716 (-1%)
	All	327,537	326,493	-1,045 (-0.3%)
September	Wet	290,880	292,099	1,219 (0.4%)
	Above Normal	342,762	361,634	18,872 (6%)
	Below Normal	426,776	443,066	16,290 (4%)
	Dry	440,826	448,417	7,591 (2%)
	Critical	439,491	442,949	3,458 (0.8%)
	All	375,655	383,577	7,921 (2%)
October	Wet	368,056	385,654	17,597 (5%)
	Above Normal	390,535	389,160	-1,375 (-0.4%)
	Below Normal	414,535	391,634	-22,902 (-6%)
	Dry	418,469	408,088	-10,381 (-2%)
	Critical	433,106	423,427	-9,678 (-2%)
	All	399,783	398,121	-1,662 (-0.4%)
November	Wet	331,245	380,767	49,522 (15%)
	Above Normal	346,354	404,807	58,454 (17%)
	Below Normal	424,548	433,126	8,578 (2%)
	Dry	436,339	438,833	2,494 (0.6%)
	Critical	456,650	446,478	-10,172 (-2%)
	All	390,682	415,511	24,830 (6%)
December	Wet	406,003	407,769	1,765 (0.4%)
	Above Normal	407,216	404,525	-2,691 (-0.7%)
	Below Normal	414,355	411,388	-2,967 (-0.7%)
	Dry	407,378	405,710	-1,669 (-0.4%)
	Critical	466,877	468,226	1,349 (0.3%)
	All	416,675	416,228	-447 (-0.1%)

Table 5.4-75. CCV Steelhead Juvenile Rearing Weighted Usable Areas (WUA) and Differences (Percent Differences) between Model Scenarios in River Segment 4 (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	Water Year Type	NAA	PA	PA vs. NAA
January	Wet	97,853	90,372	-7,480 (-8%)
	Above Normal	110,447	110,464	17 (0.02%)
	Below Normal	103,601	103,579	-22 (-0.02%)
	Dry	104,950	104,456	-494 (-0.5%)
	Critical	129,995	125,378	-4,616 (-4%)
	All	107,055	103,887	-3,168 (-3%)
February	Wet	69,936	68,146	-1,790 (-3%)
	Above Normal	77,689	77,735	46 (0.1%)
	Below Normal	106,251	105,096	-1,155 (-1%)
	Dry	136,350	135,011	-1,339 (-1%)
	Critical	139,995	146,033	6,038 (4%)
	All	102,488	102,329	-158 (-0.2%)
March	Wet	71,476	71,581	105 (0.1%)
	Above Normal	94,398	89,099	-5,299 (-6%)
	Below Normal	133,584	127,354	-6,229 (-5%)
	Dry	132,709	132,598	-111 (-0.1%)
	Critical	145,643	143,338	-2,305 (-2%)
	All	109,230	107,223	-2,007 (-2%)
April	Wet	94,253	93,866	-387 (-0.4%)
	Above Normal	105,842	105,770	-72 (-0.1%)
	Below Normal	115,424	117,414	1,990 (2%)
	Dry	128,546	125,460	-3,086 (-2%)
	Critical	113,038	111,395	-1,643 (-1%)
	All	110,044	109,183	-860 (-0.8%)
May	Wet	79,767	80,228	461 (0.6%)
	Above Normal	95,889	95,087	-802 (-0.8%)
	Below Normal	95,374	96,155	782 (0.8%)
	Dry	104,706	99,470	-5,236 (-5%)
	Critical	110,769	108,284	-2,485 (-2%)
	All	95,036	93,519	-1,517 (-2%)
June	Wet	63,094	62,254	-840 (-1%)
	Above Normal	56,914	54,112	-2,802 (-5%)
	Below Normal	58,642	56,280	-2,362 (-4%)
	Dry	59,726	55,659	-4,067 (-7%)
	Critical	70,307	64,770	-5,537 (-8%)
	All	61,751	58,921	-2,830 (-5%)

Month	Water Year Type	NAA	PA	PA vs. NAA
July	Wet	48,887	48,468	-419 (-0.9%)
	Above Normal	44,821	45,170	349 (0.8%)
	Below Normal	46,166	45,746	-421 (-0.9%)
	Dry	50,575	50,839	263 (0.5%)
	Critical	57,109	59,671	2,562 (4%)
	All	49,492	49,798	305 (0.6%)
August	Wet	63,617	62,843	-774 (-1%)
	Above Normal	62,801	61,796	-1,005 (-2%)
	Below Normal	61,174	67,131	5,957 (10%)
	Dry	77,174	72,790	-4,384 (-6%)
	Critical	80,766	79,494	-1,272 (-2%)
	All	68,976	68,115	-861 (-1%)
September	Wet	52,839	52,636	-202 (-0.4%)
	Above Normal	75,962	89,045	13,083 (17%)
	Below Normal	132,906	141,161	8,255 (6%)
	Dry	140,636	143,342	2,706 (2%)
	Critical	141,499	143,750	2,251 (2%)
	All	101,634	105,741	4,107 (4%)
October	Wet	89,341	103,106	13,764 (15%)
	Above Normal	106,157	104,776	-1,381 (-1%)
	Below Normal	123,137	107,044	-16,093 (-13%)
	Dry	125,338	120,272	-5,066 (-4%)
	Critical	138,530	137,326	-1,204 (-0.9%)
	All	112,597	113,196	599 (0.5%)
November	Wet	66,553	96,003	29,450 (44%)
	Above Normal	71,954	112,909	40,955 (57%)
	Below Normal	125,535	130,529	4,994 (4%)
	Dry	128,334	130,106	1,773 (1%)
	Critical	145,622	141,785	-3,837 (-3%)
	All	102,331	118,399	16,068 (16%)
December	Wet	110,968	110,752	-216 (-0.2%)
	Above Normal	107,891	108,500	609 (0.6%)
	Below Normal	110,687	110,366	-320 (-0.3%)
	Dry	108,714	107,759	-955 (-0.9%)
	Critical	142,796	143,253	457 (0.3%)
	All	114,633	114,442	-191 (-0.2%)

5.4.2.1.3.3.3.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the year-round juvenile rearing period for steelhead in the Sacramento River between Keswick Dam and Red Bluff (Table 5.4-29) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) throughout the juvenile rearing reach in all months and water year types. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.6°F, or up to 1.1%, and would occur at Red Bluff in above normal years during August and above- and below normal years during September, and at Bend Bridge in below normal years during September.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the juvenile rearing period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of August (Figure 5.4-59) and September (Figure 5.4-60) during above normal years at Red Bluff, September of below normal years at Red Bluff (Figure 5.4-61), and September during below normal years at Bend Bridge (Figure 5.4-62), where the largest increases in mean monthly water temperatures were seen, reveals that there is a general trend towards marginally higher temperatures under the PA but that the difference of 0.6°F in mean monthly temperatures between NAA and PA, the largest throughout the juvenile rearing period, would cause little change to the curves.

Water temperature thresholds of 63°F and 69°F (7DADM) were used to evaluate water temperature threshold exceedances during the steelhead juvenile rearing life stage in the Sacramento River between Keswick Dam and Red Bluff (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49). The 63°F threshold was derived by taking the intermediate value of the ranges of optimal growth from several studies (Grabowski 1973; Wurtsbaugh and Davis 1977; Hokanson et al 1977; Myrick and Cech 2005; and Beakes et al. 2014). The 69°F 7DADM used was based on Sullivan (2000) and was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-113 through 5.D-122. At Keswick Dam, for both thresholds, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold, and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-113, Table 5.D-114). There would be 1 month and water year type in which the percent of days exceeding the threshold would be 7.8% lower under the PA relative to the NAA, but the magnitude of average daily exceedance above the threshold would be 0.9°F higher under the PA.

At Clear Creek, for both thresholds, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold, and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-115, Table 5.D-116). There would be one instance in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the 69°F threshold (September of critical water years, 5.3% increase), and two instances in which there would be a more-than-0.5°F increase in the magnitude of average daily exceedance above the 63°F threshold (September of critical years and all water year types combined, 0.6°F for both), but no instances would have both conditions met concurrently. Therefore, it is concluded that there would be no biologically meaningful effect at Clear Creek.

At Balls Ferry, for both thresholds, with one exception, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-117, Table 5.D-118). The one exception would occur under the 69°F 7DADM threshold in September of critical water years (6.7% increase). However, there would not be a concurrent more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect.

At Bend Bridge, for both temperature thresholds, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-119, Table 5.D-120). There would be one instance for the 63°F threshold in which the percent of days exceeding the threshold would be lower under the PA relative to the NAA, September of critical water years (6.4% reduction), but there would be a 0.5°F increase in the magnitude of average daily exceedance.

At Red Bluff for both thresholds, with one exception, there would be no months or water year types in which there would be both 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-121, Table 5.D-122). The one exception would occur under the 69°F 7DADM threshold in September of critical water years (9.4% increase in frequency of exceedance). However, there would not be a concurrent more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect.

An additional threshold analysis was conducted to determine how the PA would affect steelhead smoltification. A 54°F threshold was used and was based on an average of temperatures from Zaugg and Wagner (1973), Adams et al (1975), Zaugg (1981), and Hoar (1988), above which smoltification can be impaired. This analysis was conducted for January through March in the reach from Keswick Dam to Red Bluff.

Results of the water temperature thresholds analysis for steelhead smoltification are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-123 through Table 5.D-127. At all locations analyzed, Keswick Dam, Clear Creek, Balls Ferry, Bend Bridge, and Red Bluff, there would be no months or water year types with a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA or with a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful water temperature-related effects on CCV steelhead smoltification.

5.4.2.1.3.3.4 Smolt Emigration

This section refers specifically to emigrating smolts and does not include migrant parr. Effects to migrant parr would be similar to those presented in Section 5.4.2.1.3.3.3, *Juvenile Rearing*.

5.4.2.1.3.3.4.1 Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at four locations along the downstream migration corridor of CCV steelhead smolts (i.e., Keswick, Red Bluff, Wilkins Slough and Verona) during the November through June emigration period, with peak migration during January through March (Table 5.4-29). Changes in flow potentially affect emigration of smolts, including the timing and rate of emigration, as well as conditions for feeding, protective cover, resting, temperature, turbidity, and other habitat factors. Crowding and stranding, especially in side-channel habitats, can also be affected (Moyle 2002; Quinn 2005; Williams 2006). As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* quantitative relationships between flow and downstream migration generally are highly variable and poorly understood, but on balance, except under very high flows, benefits of increased flow generally outweigh the costs. Therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for emigration of CCV steelhead smolts. Milner et al. (2012) and del Rosario et al. (2013) have found that migration cues for anadromous fish species are often the result of natural pulse flows, or pulse flows caused by natural events, such as an extensive rainfall event, which will not be affected by the PA.

Shasta Reservoir storage volume at the end of September may influence flows in the Sacramento River during much of the smolt emigration period, and Shasta storage volume at the end of May influences June flows. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3).

In general, mean flow under the PA would be similar to (less than 5% difference) or greater than flow under the NAA at the four Sacramento River locations during most months and water year types of the CCV steelhead smolt emigration period (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During November of wet and above normal water years, however, flow under the PA would be 26% lower than it would be under the NAA at Keswick Dam, 21% lower at Red Bluff, up to 24% lower at Wilkins Slough, and up to 17% lower at Verona. In November of critical water years, flow would be greater at all the locations (up to 13% greater in Keswick). Flow would also be lower in February of critical years (up to 13% lower at Keswick) at all the locations, except Verona. During

January, mean flow under the PA at Keswick would be 18% greater than it would be under the NAA in critical water year types and 8% greater in wet years. At Red Bluff, the mean January flow in critical years would be 7% greater under the PA; at the other two locations, all differences in January flow would be less than 5%. During February, in addition to the flow reductions described above, flow would be 8% greater in below normal years but only at Keswick. During March, flow under the PA at Keswick would be 9% greater in above normal and below normal years and 8% greater in critical years, but there would be no differences greater than 5% at the other locations. The flow differences during January through March occur during the peak smolt emigration period. During May, flow would be 5% to 8% greater in dry years, except at Verona. The greatest increases in flow would occur during June, when flow under the PA would be greater at all the locations, including all water year types at Verona and all water year types, except wet years, at the other locations. The increases for all water year types would be greater at Wilkins Sough and Verona (up to 25% greater in above normal years) than those at Keswick and Red Bluff.

The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.1.3.3.4.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the Sacramento River in the reach from Keswick Dam to Red Bluff during the November through June smolt emigration period, with a peak during January through March (Table 5.4-29) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-4, Table 5.C.7-5, Table 5.C.7-7, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) throughout the Sacramento River upstream of the Delta in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.3°F (0.5 to 0.7%), and would occur at Keswick Dam, above Clear Creek, Balls Ferry, and Bend Bridge in below normal years during May, which is outside the peak period of smolt emigration. Despite this increase, temperatures would be in the low- to mid-50s range (°F) under both scenarios, which is well below temperatures of concern. Despite the uncertainty caused by comparing modeled results to threshold values, it is not likely that this difference would cause a biologically meaningful effect, especially considering the small magnitude (0.3°F).

Exceedance plots of monthly mean water temperatures were examined during each month throughout the smolt emigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.4-7, Figure 5.C.7.5-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of below normal years during May at Keswick Dam (Figure 5.4-246), above Clear Creek (Figure 5.4-64), Balls Ferry (Figure 5.4-650), and Bend Bridge (Figure 5.4-247), where the largest increases in mean monthly water temperatures were seen, reveals that the curves were similar overall. The 0.3°F increase under the PA is the result of 1 year at Keswick Dam, above Clear Creek, and Balls

Ferry, and the result of 2 years at Bend Bridge. Further examination of these months and years reveals that this appears to be due to CALSIM II attempting to balance storage levels among the CVP reservoirs. There are no operational requirements, such as cold-water pool storage, temperature, or outflow requirements, that would cause these years to differ so widely in water temperatures. Therefore, there is no practical reason why real operations under the PA would be different from those under the NAA in these months and years.

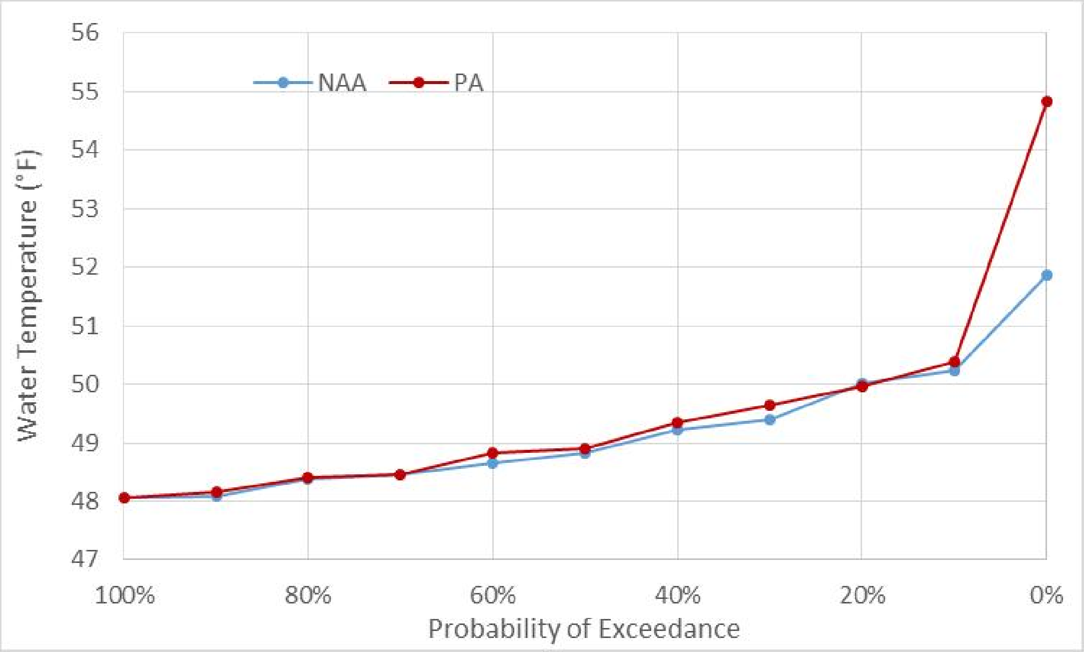

Figure 5.4-246. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Keswick Dam in May of Below Normal Water Years

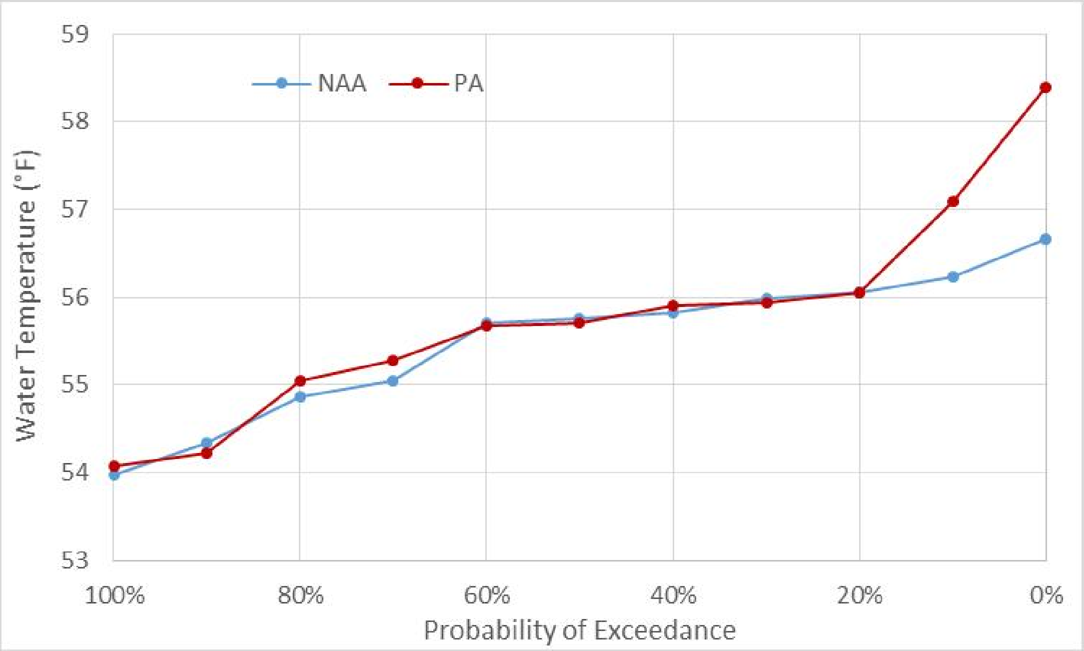

Figure 5.4-247. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Bend Bridge in May of Below Normal Water Years

The exceedance of temperature thresholds in the Sacramento River presented in Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49 by modeled daily water temperatures were evaluated based on thresholds identified in the USEPA's temperature water quality guidance (U.S. Environmental Protection Agency 2003). Two thresholds, 61°F 7DADM and 64°F 7DADM, were evaluated. The 61°F value corresponds to the upper end of the optimal smolt emigration range and represents each site as a core habitat location, and the 64°F value corresponds to the upper end of the suboptimal range and represents each site as a non-core habitat location. The 7DADM values were converted by month to function with daily model outputs (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51). Both thresholds were evaluated from Keswick Dam to Red Bluff.

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-128 through Table 5.D-137. At Keswick Dam, Clear Creek, Balls Ferry, Bend Bridge, and Red Bluff, there would be very few exceedances above either threshold. At all locations for both thresholds, there would be no months or water year types with both a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA and a more-than-0.5°F difference in the magnitude of average daily exceedance.

5.4.2.1.3.3.5 Adult Immigration

5.4.2.1.3.3.5.1 Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at four locations along the upstream migration corridor of adult CCV steelhead (i.e., Keswick, Red Bluff, Wilkins Slough and Verona) during the August through March immigration period, with peak migration from

September through November (Table 5.4-29). Changes in flow potentially affect conditions for upstream migration of adults, including bioenergetic cost, water quality, crowding, cues for locating natal streams, and passage conditions, but the quantitative relationship between flow and upstream migration is poorly understood (Quinn 2005; Milner et al. 2012). As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* on balance, except under very high flows, the benefits of increased flow generally outweigh the costs and, therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for upstream migration of adult CCV steelhead. Milner et al. (2012) and del Rosario et al. (2013) have found that migration cues for anadromous fish species are often the result of natural pulse flows, or pulse flows caused by natural events, such as an extensive rainfall event, which will not be affected by the PA.

Shasta Reservoir storage volume at the end of September influences flows in the Sacramento River during much of the immigration period. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3).

In general, mean flow under the PA at the Keswick, Red Bluff, Wilkins Slough, and Verona locations in the Sacramento River would be similar to (less than 5% difference) or lower than flow under the NAA during the first 4 months of the CCV steelhead adult migration period and would be similar (less than 5% difference) or higher than under the NAA during the last 4 months, with some exceptions (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During August, mean flow in below normal years would be lower at all four locations (up to 18% lower flow at Wilkins Slough). During dry and critical years in August, flow under the PA would be greater (up to 10% greater) at Wilkins Slough and Verona. Mean flow during September would be lower for most water year types at all the locations (up to 24% lower in below normal years at Verona). During October, flow under the PA would lower at all the locations in wet years, ranging from 7% to 11% lower, but would be up to 17% higher in below normal and dry years. During November of wet and above normal water years, flow would be 26% lower under the PA than it would be under the NAA at Keswick Dam, 21% lower at Red Bluff, up to 24% lower at Wilkins Slough, and up to 17% lower at Verona, but in critical water years, flow would be greater at all the locations (up to 13% greater in Keswick). The large differences in flow from September through November coincide with the peak of the adult immigration period. During January, mean flow under the PA at Keswick would be 18% greater than it would be under the NAA in critical water year types and 8% greater in wet years. At Red Bluff, the mean January flow in critical years would be 7% greater under the PA, but at the other two locations, all differences in January flow would be less than 5%. During February, mean flow would be lower (up to 13% lower at Keswick) under the PA compared with the NAA at all the locations, except Verona. During March, flow under the PA at Keswick would be 9% greater in above normal and below normal years and 8% greater in critical years, but there would be no differences greater than 5% at the other locations.

The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*.

As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* mean monthly flow below about 3,250 cfs is considered to have potentially adverse effects on Chinook salmon, CCV steelhead, and green sturgeon adult immigration conditions in the Sacramento River. The effect of the PA on the frequency of flows below this threshold was evaluated by comparing CALSIM flows between the PA and the NAA at three of the migration corridor locations in the river: Keswick, Red Bluff, and Wilkins Slough. Of the 656 months within the CCV steelhead migration period, mean flow at Keswick was less than 3,250 cfs for 6 months under the NAA and 5 months under the PA. Mean flow at Red Bluff was less than 3,250 cfs in 0 months under the NAA and 1 month under the PA, and mean flow at Wilkins Slough was less than 3,250 cfs in 2 months under both alternatives (Table 5.4-76). At all three locations, the months with flow less than 3,250 cfs were September, October or November of 1931, 1933, or 1934, except for November 1992 at Keswick Dam. All four of these years were critically dry. These results indicate that with respect to the frequency of flow below the 3,250 cfs threshold, differences between the PA and the NAA on adult CCV steelhead immigration conditions in the Sacramento River would be insignificant.

Table 5.4-76 Number and Percent of the 656 Months within the California Central Valley Steelhead Adult Immigration Period from the 82-year CALSIM Record with Flow < 3,250 cfs

	Months with Mean Flow < 3,250 cfs		**Percent with Mean Flow < 3,250 cfs**		**Difference in Months and Percent Difference**
Location	NAA	PA	NAA	PA	PA vs. NAA
Keswick	6	5	0.9	0.8	-1 (-17%)
Red Bluff	0	1	0.0	0.2	1 (NA1)
Wilkins Slough	2	2	0.3	0.3	0 (0%)

[1] NA = Could not calculate because dividing by 0

5.4.2.1.3.3.5.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the Sacramento River at Keswick Dam, Bend Bridge, and Red Bluff during the August through March adult immigration period for steelhead (Table 5.4-29) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-7, Table 5.C.7-8. Overall, mean water temperatures would change very little (predominantly less than 1°F, or approximately 1%) due to the PA at these locations in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.6°F, or up to 1.1%, and would occur at Red Bluff in above normal years during August and above- and below normal years during September, and at Bend Bridge in below normal years during September. These largest increases during September would occur during the period of peak adult immigration (September through November).

Exceedance plots of monthly mean water temperatures were examined during each month throughout the adult immigration period (Appendix 5.C, *Upstream Water Temperature Methods*

and Results, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.7-7, Figure 5.C.7.8-7). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of above normal water years during August at Red Bluff (Figure 5.4-59), above normal (
Figure 5.4-60) and below normal (Figure 5.4-61) water years during September at Red Bluff, and below normal water years during September at Bend Bridge (Figure 5.4-62), where the biggest water temperature increases of 0.6°F were seen, reveals that there is a general trend towards slightly higher temperatures under the PA but that the difference in mean monthly temperatures between NAA and PA has little effect on the values in the exceedance plots.

To evaluate water temperature threshold exceedance during the adult immigration life stage at Keswick Dam, Bend Bridge, and Red Bluff, the USEPA's 7DADM threshold value of 68°F (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49) was used. The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51). In addition, the threshold of 70°F, the average of studies cited in Richter and Kolmes (2005) for the upper end of the suboptimal temperature range, was used.

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-138 through Table 5.D-143. At Keswick Dam and Red Bluff, for both thresholds there would be no months or water year types with either a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA or a more-than-0.5°F difference in the magnitude of average daily exceedance.

At Bend Bridge, the percent of days exceeding the 68°F 7DADM threshold under the PA would be more than 5% higher than under the NAA during August (5.1%) and September (5.3%) of critical water years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-140 and Table 5.D-141). However, in no month or water year type would there be a more-than-0.5°F difference between NAA and PA in the magnitude of average daily exceedance above the threshold. Also, there would be no months or water year types with either a more-than-5% increase in the percent of total days exceeding the 70°F threshold under the PA relative to the NAA or a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect at Bend Bridge.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could have lethal or sublethal effects on immigrating adults, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

5.4.2.1.3.3.6 Adult Holding

5.4.2.1.3.3.6.1 Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at the Keswick Dam and Red Bluff locations during the September through November holding period for Central Valley steelhead (Table 5.4-29). Changes in flow likely affect holding habitat for steelhead, with higher flows potentially providing greater depths and improved water quality in pools. Shasta Reservoir storage volume at the end of September influences flow rates below the dam during much of the steelhead holding period. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA (Appendix 5.A*, CALSIM Methods and Results*, Table 5.A.6-3). The mean flows at the Keswick Dam and Red Bluff locations in the Sacramento River during September would range from 5% to 11% lower under the PA than the NAA for all water year types except wet years. During October, mean flow under the PA would be up to 11% lower in wet years and up to 17% higher in below normal and dry years. And during November, mean flow under the PA would be lower than flow under the NAA in all except critical water year types, with 26% lower flows under the PA than under the NAA for wet and above normal water year types at Keswick Dam and 21% lower flows at Red Bluff (Appendix 5.A*, CALSIM Methods and Results*, Table 5.A.6-10, Table 5.A.6-35). Flow would be 13% higher at Keswick Dam and 9% higher at Red Bluff during November of critical water years. The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*..

5.4.2.1.3.3.6.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the Sacramento River at Keswick Dam, Balls Ferry, and Red Bluff during the September through November CCV steelhead adult holding period (Table 5.4-29) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-3, Table 5.C.7-5, Table 5.C.7-8. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.6°F, or up to 1.1%, and would occur at Red Bluff in above- and below normal years during September.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the adult holding period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.3-7, Figure 5.C.7.5-7, Figure 5.C.7.8-7). The curves for PA generally match those of the NAA. Further examination of above normal (Figure 5.4-60) and below normal (Figure 5.4-61) years during September at Red Bluff, the month and water year types with the largest changes in water temperatures (0.6°F), reveals that there is a general trend towards marginally higher temperatures under the PA but that the difference of 0.6°F in mean monthly temperatures between NAA and PA would cause no substantial differences between curves for the NAA and PA in each exceedance plot.

To evaluate water temperature threshold exceedance during the steelhead adult holding life stage at Keswick Dam, Balls Ferry, and Red Bluff, the USEPA's 7DADM threshold value of 61°F was used Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49) (U.S. Environmental Protection Agency 2003). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-51).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-144 through 5.D-146. At Keswick Dam, there would be no months or water year types with both a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-144).

At Balls Ferry, there would be no months or water year types with a more-than-5% increase in the percent of total days exceeding either threshold under the PA relative to the NAA (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-145). However, there would be two more-than-5% reductions under the PA relative to the NAA in the percent of total days exceeding the 61°F 7DADM threshold: September (10% lower) and October (14% lower) of critical water years. During October of critical years, the difference in average daily exceedance above the threshold between the PA and NAA would be less than 0.5°F. In September, the average daily exceedance above the threshold under the PA would be 0.7°F higher than that under the NAA, indicating that the frequency of days above the threshold would decrease under the PA, but exceedances would be higher on average.

At Red Bluff for both thresholds, there would be no months or water year types with both a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA and a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-146). There would be some instances when there would be a more-than-5% increase in the percent of total days exceeding the 61°F 7DADM threshold under the PA relative to the NAA, including August of below normal water years (9.4% increase) and September of above normal (7.7% increase), below normal (10.3% increase), and dry (5.5% increase) water years, but under the PA, none of these would see a concurrent increase of at least 0.5°F in the magnitude of average daily exceedance above the threshold.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could have lethal or sublethal effects on holding adults, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further, this does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the*

Delta, to improve winter-run Chinook salmon egg-to-fry survival. This process may result in refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. Although the process targets winter-run Chinook salmon, some benefits to steelhead holding may arise. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

5.4.2.1.3.4 Green Sturgeon

5.4.2.1.3.4.1 Spawning and Egg Incubation

5.4.2.1.3.4.1.1 Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the Sacramento River at Red Bluff (Appendix 5.A, *CALSIM Methods and Results*) during the March through July spawning and incubation period, with peak occurrence during April to June, for green sturgeon (Table 5.4-30). Changes in flow can affect the instream area available for spawning and egg incubation, the quality of the spawning and egg incubation habitat, and the downstream dispersal of larvae to rearing habitat in the bay and Delta. There is some evidence that green sturgeon year class strength is positively correlated with Delta outflow, perhaps as a result in part of improved downstream dispersal. This potential effect is evaluated as part of Delta outflow in Section 5.4.1.3.2.2.2.1, *Delta Outflow*. Shasta Reservoir storage volume at the end of May influences flow rates in the Sacramento River during much of the green sturgeon spawning and egg incubation period. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A*, CALSIM Methods and Results*, Table 5.A.6-3). During the majority of months and water year types of the green sturgeon spawning period, the PA would result in minor (less than 5% difference) changes in mean flow in the Sacramento River at Red Bluff (Appendix 5.A*, CALSIM Methods and Results*, Table 5.A.6-35). However, flows under the PA would be 5% to 7% higher during May of dry years and June of all water year types except wet years. The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.1.3.4.1.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the March through July spawning and embryo incubation period for green sturgeon in the Sacramento River at Bend Bridge, Red Bluff, and Hamilton City (Table 5.4-30) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-9. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the reach in all months of the period and water year types. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.3°F (0.5%) at Bend Bridge in below normal water years during May and at Hamilton City in critical years during July. The largest change in May would coincide with peak spawning and egg incubation.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.9-7). The values for the PA in these exceedance plots generally match those of the NAA for all locations, months, and water year types. Further examination of water temperature patterns in below normal water years during May at Bend Bridge (Figure 5.4-247), where the largest increases in mean monthly water temperatures were seen, reveals that this appears to be due to CALSIM II attempting to balance storage levels among the CVP reservoirs and there are no operational requirements, such as cold water pool storage, temperature, or outflow requirements, that would cause these years to differ so widely in water temperatures. Therefore, there is no practical reason why real operations under the PA would be different from those under the NAA in these months and years. Further examination of critical years during July at Hamilton City (Figure 5.4-248), also where the largest increases in mean monthly water temperatures were seen, reveals that the curves were similar overall and that the difference of 0.3°F in mean monthly temperatures between NAA and PA would cause no substantial differences between curves for the NAA and PA in each exceedance plot. Regardless, green sturgeon are not likely to spawn this far downstream in critical water years in July.

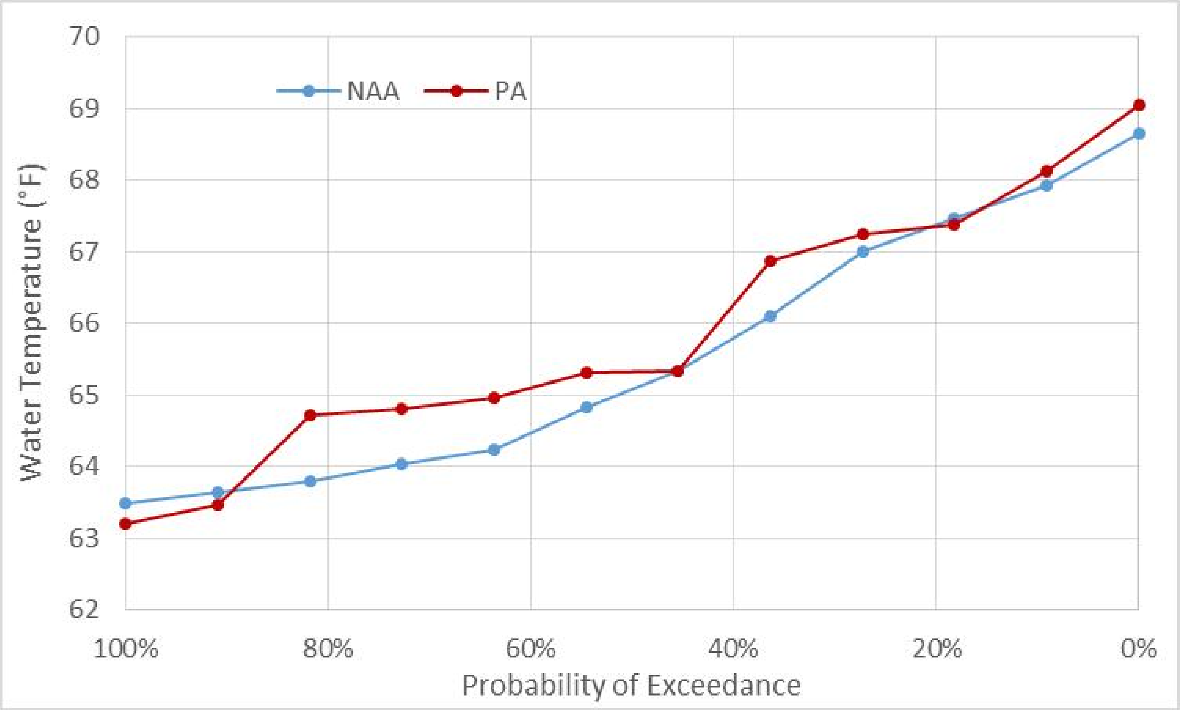

Figure 5.4-248. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Hamilton City in July of Critical Water Years

To evaluate water temperature threshold exceedance during the spawning and embryo incubation life stage at Bend Bridge, Red Bluff, and Hamilton City, the threshold value of 63°F for the upper end of the optimal range for embryonic development from Van Eenennaam et al. (2005) was used (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-147 through 5.D-149. At Bend Bridge and Red Bluff, there would be no months or water year types in which there would be either more than 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold or a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-147, Table 5.D-148).

At Hamilton City, there would be one instance with more than 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold: July of dry water years (5.3% higher) (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-149). There would be several instances in which the percent of days would decrease by more than 5% under the PA relative to the NAA: June of above normal (6.7% reduction), below normal (7.0% reduction), and dry (10.3% reduction) water years, and for all water year types in June combined (5.8% reduction). However, in no case would there be a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful effect at Hamilton City between the NAA and PA.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could have lethal or sublethal effects on green sturgeon spawning and egg incubation, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. This also does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival. This process may result in refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. Although the process targets improving winter-run Chinook salmon egg to fry survival, there may be benefits gained by green sturgeon as a result of some of these refinements. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management and RPA revisions is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

5.4.2.1.3.4.2 Pre- and Post-Spawn Adult Holding

Because adult green sturgeon hold near spawning areas both before and after spawning events, this section analyzes the pre-spawn and post-spawn adult holding periods combined.

5.4.2.1.3.4.2.1 Flow-Related Effects

Mean monthly flow rates and reservoir storage were evaluated during the March through December pre- and post-spawning adult holding period for green sturgeon in the Sacramento River at Red Bluff (Table 5.4-30). Changes in flow likely affect holding habitat for green sturgeon, with higher flows potentially providing greater depths and improved water quality in pools. Shasta Reservoir storage volumes at the end of May and end of September influence flow rates in the Sacramento River during much of the green sturgeon pre- and post-spawning holding period. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under the NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3), while mean Shasta September storage under the PA would be similar for all water year types except for 7% higher mean storage during critical water years. During the first several months of the green sturgeon holding period, changes in mean flow in the Sacramento River at Red Bluff due to the PA would be minor (less than 5% difference) or somewhat positive (less than 10% increase) (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-35). Flows under the PA would be 5% to 7% higher during May of dry years and June of all water year types except wet years. Greater changes in mean flow due to the PA would occur during August through November, including 9% to 10% reductions in flow during August of below normal years, September of above normal and below normal years, and October of wet years. During November, mean flows would be 21% lower under the PA for wet and above normal years. Increases in mean flow of 6% to 14% are expected during October of below normal and dry years and during November of critical years. Reductions in flow during the holding period would be somewhat greater than increases in flow, but they would occur during wetter year types when they would have less impact. The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.1.3.4.2.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the March through December pre- and post-spawning adult holding period for green sturgeon in the Sacramento River at Bend Bridge, Red Bluff, and Hamilton City (Table 5.4-30) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-9. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the spawning reach of Keswick Dam to Red Bluff in all months of the period and water year types. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.8°F (1.2% to 1.3%) and would occur at Hamilton City in below normal years during August and above normal and below normal years during September.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.9-7). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of below normal years during August (Figure 5.4-249) and above normal (Figure 5.4-250) and below normal (Figure 5.4-251) years during September at Hamilton City, where the largest increases in mean monthly water temperatures were seen, reveals that the curves were similar overall, although there were multiple differences of more than 1°F at the colder end of the range in below normal years during both August and September.

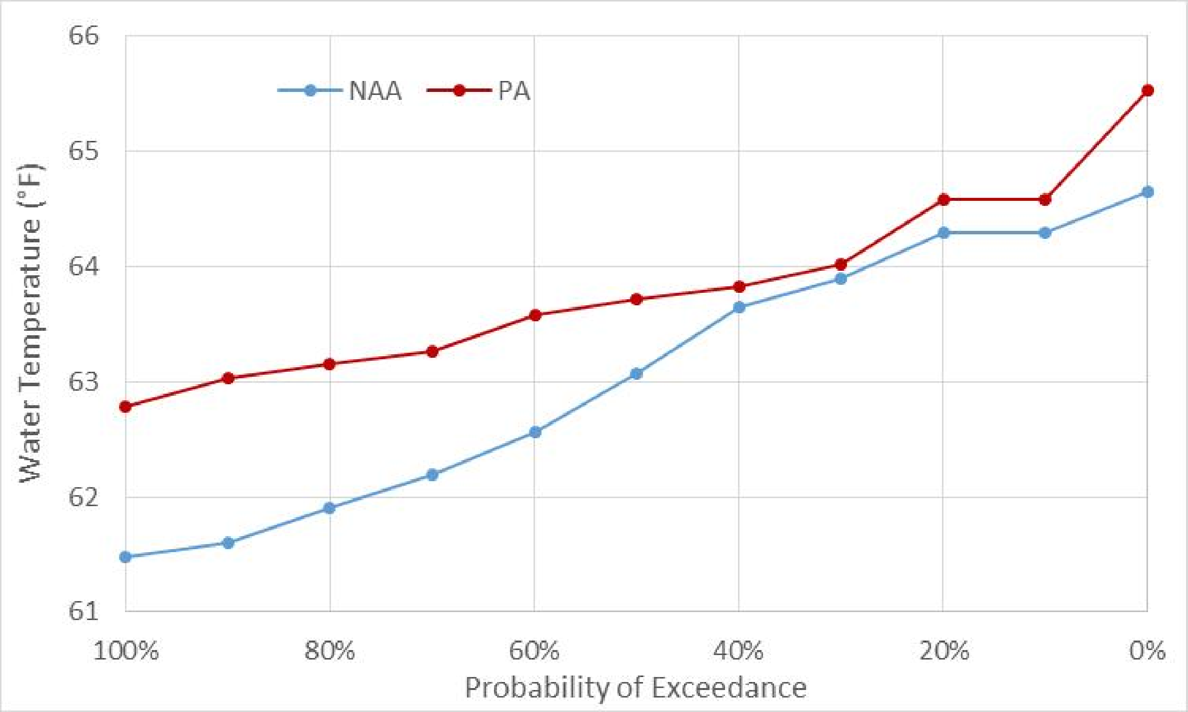

Figure 5.4-249. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Hamilton City in August of Below Normal Water Years

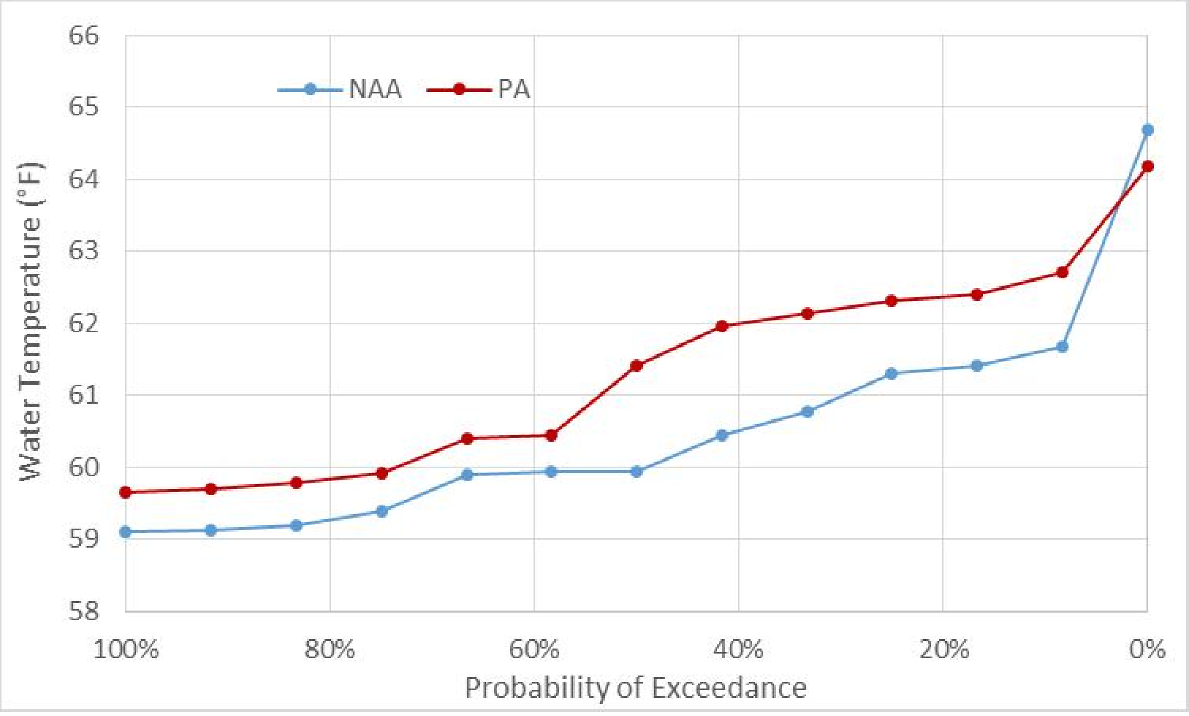

Figure 5.4-250. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Hamilton City in September of Above Normal Water Years

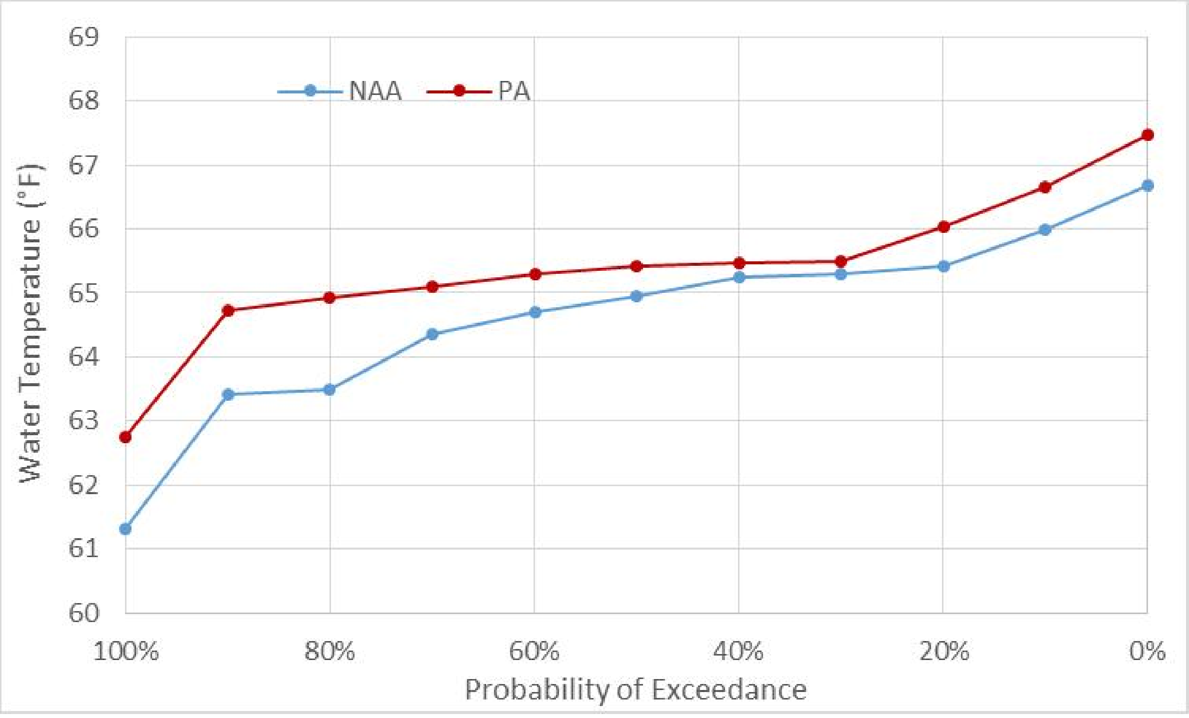

Figure 5.4-251. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the Sacramento River at Hamilton City in September of Below Normal Water Years

All non-spawning adult life stages, including pre-spawn and post-spawn holding and immigration and post-spawn emigration, were combined for the water temperature threshold analysis. Adult green sturgeon are present year-round at Bend Bridge, Red Bluff, and Hamilton City, although spawning adults are also present during March through July. A more conservative threshold evaluation specific to the spawning and egg incubation period is described above in Section 5.4.2.1.3.4.1, *Spawning and Egg Incubation*. The period of August through February, when green sturgeon are present but typically do not spawn, was evaluated here. Non-spawning green sturgeon adults are present year-round at Knights Landing. Therefore, all months were included in the threshold evaluation at this location.

For each location (Bend Bridge, Red Bluff, and Hamilton City, and Knights Landing), the exceedance of water temperature thresholds of 66°F and 73°F were used to evaluate potential effects of the PA (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49). The 66°F threshold was based on the conservative assumption that optimal temperatures for larvae and juveniles (from Mayfield and Cech 2004) would be sufficient for non-spawning adults. The 73°F threshold was based on Houston (1988) and Erickson et al. (2002).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-150 through Table 5.D-157. At Bend Bridge and Red Bluff, for both thresholds, there would be no months or water year types in which there would be either more than 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold or a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-150 through Table 5.D-153).

At Hamilton City, for the 66°F threshold, there would be one instance in which temperatures would exceed the threshold on more than 5% more days under the PA compared to the NAA: September of below normal water years (14.2% higher) (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-154). However, there would be no concurrent increase under the PA relative to the NAA of more than 0.5°F in the magnitude of average daily exceedance. There would also be two instances in which there would be a reduction under the PA in the percent of days exceeding the 66°F threshold: August of dry and critical water years (9.2% and 9.1% reductions, respectively). In dry years, there would be no difference between the PA and NAA in the magnitude of average daily exceedance above the threshold. In critical water years, there would be a 0.5°F increase in the magnitude of average daily exceedance above the threshold. This indicates that the frequency of days above the threshold would decrease under the PA, but exceedances would be higher on average. For the 73°F threshold, there would be no months or water year types in which there would be either more than 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold or a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-155).

At Knights Landing, for the 66°F threshold, there would be two instances in which temperatures would exceed the threshold on more than 5% more days under the PA compared to the NAA: September (18.7% higher) and October (5.6% higher) of above normal water years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-156). In September, there would be no difference of more than 5% in the magnitude of average daily exceedance above the threshold between the NAA and PA. However, for October, there would be a reduction of 1.1°F in the magnitude of average daily exceedance above the threshold. This indicates that, for October of above normal water years, the frequency of days above the threshold would increase under the PA, but exceedances would be lower on average. For the 73°F threshold, there would be more than 5% more days under the PA relative the NAA on which water temperature would exceed the threshold in July of critical water years (10.2% increase) and in August (11.4% higher) and September (5.2% higher) of below normal water years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-157). However, in no case would there be a more-than-0.5°F difference in the magnitude of average daily exceedance between the NAA and PA.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could cause lethal or sublethal effects to greens sturgeon pre- and post-spawners, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further, this does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival. This process may result in refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. Although the process targets improving winter-run Chinook salmon egg to fry survival, there may be benefits gained by green sturgeon as a result of some of these refinements. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management and RPA revisions is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

5.4.2.1.3.4.3 Post-Spawn Adult Emigration

5.4.2.1.3.4.3.1 Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River during the April through January green sturgeon post-spawn adult emigration period at Red Bluff, Wilkins Slough, and Verona, which are located along the adult emigration corridor (Table 5.4-30). As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* on balance, except under very high flows, the benefits of increased flow generally outweigh the costs and, therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for emigration of post-spawn adult green sturgeon.

Shasta Reservoir storage volume at the end of May influences flow rates in the Sacramento River early in the adult emigration period, and Shasta storage volume at the end of September influences flow rates later in the period. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3). Mean Shasta September storage under the PA would also be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA.

In general, mean flow under the PA at the Red Bluff, Wilkins Slough, and Verona locations in the Sacramento River would be similar to (less than 5% difference) or greater than flow under the NAA from April through June and during December and January but would be similar (less than 5% difference) or lower than flows under the NAA from July through November, with exceptions (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During May of dry years, flow would be 5% and 8% greater at Red Bluff and Wilkins Slough, respectively, but flow would be similar (less than 5% difference) at Verona. The greatest increases in flow would occur during June, when flow under the PA would be greater at all the locations, including all water year types at Verona and all water year types, except wet years, at Red Bluff and Wilkins Slough. The increases for all water year types would be greater at Wilkins Sough and Verona (up to 25% greater in above normal years at Verona) compared with those at Red Bluff. During July, mean flow in critical water years under the PA would be 10% and 13% lower than under the NAA at Wilkins Slough and Verona, but the flows would be similar (less than 5% difference) at Red Bluff. During August of below normal years, mean flow would be lower at all three locations (up to 18% lower flow at Wilkins Slough). During August of dry and critical years, flow under the PA would be greater (up to 10% greater) at Wilkins Slough and Verona. Mean flow during September would be lower for most water year types at all the locations (up to 24% lower in below normal years at Verona). During October, flow under the PA would be lower in wet years at all the locations, ranging from 7% to 11% lower, but would be up to 17% higher in below normal and dry years. During November of wet and above normal water years, flow would be 21% lower under the PA than it would be under the NAA at Red Bluff, up to 24% lower at Wilkins Slough, and up to 17% lower at Verona, but in critical water years, flow would be greater at all the locations (up to 10% greater at Wilkins Slough). During January of critical water years, mean flow under the PA would be 7% greater than under the NAA at Red Bluff but would be similar to (less than 5% difference) flows under the NAA at the other two locations.

The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.1.3.4.3.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the April through January post-spawning adult emigration period for green sturgeon in the Sacramento River at Bend Bridge, Red Bluff, Hamilton City, and Knights Landing (Table 5.4-30) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-9, Table 5.C.7-10[59]. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the spawning reach of Keswick Dam to Red Bluff in all months of the period and water year types. The largest increase in mean monthly water temperatures under the PA relative

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[59] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

to NAA would be 1.0°F (1.4%) and would occur at Knights Landing in below normal years during August.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.9-7, Figure 5.C.7.10-7[60]). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of below normal years during August at Hamilton City, where the largest increase in mean monthly water temperature was seen, reveals that the curves were similar overall, although there were multiple difference of more than 1°F at the colder end of the range (Figure 5.4-249).

For the evaluation of threshold exceedances for post-spawn adult emigration, please see the combined non-spawning adult presence analysis in the Section 5.4.2.1.3.4.2, *Pre- and Post-Spawn Adult Holding*, which indicates that there would be no biologically meaningful water temperature-related effects on green sturgeon non-spawning adult presence.

5.4.2.1.3.4.4 Larval and Juvenile Rearing and Emigration

5.4.2.1.3.4.4.1 Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River at three locations (i.e., Red Bluff, Wilkins Slough, and Verona) along the downstream migration corridor of green sturgeon larvae and juveniles during the year-round emigration period (Table 5.4-30). Changes in flow can affect the instream area available for rearing, along with habitat quality, and downstream dispersal of larvae to rearing habitat in the bay and Delta. Changes in flow potentially affect emigration of green sturgeon larvae and juveniles, including the rate of downstream movement, as well as conditions for feeding, temperature, turbidity, and other habitat factors. Downstream dispersal of larvae to rearing habitat in the bay and Delta can also be affected. There is some evidence that green sturgeon year class strength is positively correlated with Delta outflow, perhaps as a result, in part, of improved downstream dispersal. This potential effect is evaluated as part of Delta outflow in Section 5.4.1.3.2.2.2.1, *Delta Outflow*. Quantitative relationships between flow and green sturgeon emigration are poorly understood. As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* on balance, except under very high flows, the benefits of increased flow generally outweigh the costs and, therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for emigration of green sturgeon larvae and juveniles.

Shasta Reservoir storage volume at the end of May and the end of September influence flow rates in the Sacramento River. Mean Shasta May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3). Mean Shasta September storage under the PA would also be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA.

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[60] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

In general, mean flow under the PA at the Red Bluff, Wilkins Slough, and Verona locations in the Sacramento River would be similar to (less than 5% difference) or lower than flow under the NAA during the summer and fall months and would be similar to (less than 5% difference) or greater than flows under the NAA during the winter and spring months, with exceptions (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). During January of critical water years, mean flow under the PA would be 7% greater than it would be under the NAA at Red Bluff and would be similar to (less than 5% difference) flows under the NAA at the other two locations. During February of critical water years, mean flow would be 7% and 6% lower under the PA compared with the NAA at Red Bluff and Wilkins Slough, respectively, and would be similar for the two scenarios (less than 5% difference) at Verona. During March, flow under the PA at Keswick would be 9% greater in above normal and below normal years and 8% greater in critical years, and there would be no differences greater than 5% at the other locations. During May, flow would be 5% and 8% greater in dry years at Red Bluff and Wilkins Slough, respectively, but would be similar (less than 5% difference) at Verona. The greatest increases in flow would occur during June, when flow under the PA would be greater at all the locations, including all water year types at Verona and all water year types, except wet years, at Red Bluff and Wilkins Slough. The increases for all water year types would be greater at Wilkins Slough and Verona (up to 25% greater in above normal years at Verona) compared with those at Red Bluff. During July, mean flow in critical water years under the PA would be 10% and 13% lower than under the NAA at Wilkins Slough and Verona, but the flows would be similar (less than 5% difference) at Red Bluff. During August, mean flow in below normal years would be lower at all three locations (up to 18% lower at Wilkins Slough). During August of dry and critical years, flow under the PA would be greater (up to 10% greater) at Wilkins Slough and Verona. Mean flow during September would be lower for most water year types at all the locations (up to 24% lower in below normal years at Verona). During October, flow under the PA would be lower at all the locations, ranging from 7% to 11% lower in wet years, but would be up to 17% higher in below normal and dry years. During November of wet and above normal water years, flow would be 21% lower under the PA than it would be under the NAA at Red Bluff, up to 24% lower at Wilkins Slough, and up to 17% lower at Verona, but in critical water years, flow would be greater at all the locations (up to 10% greater at Wilkins Slough).

As described in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods*, no WUA curves were located for green or white sturgeon in the Sacramento River, and therefore, effects of flow on rearing habitat for green sturgeon were evaluated qualitatively using the flow predictions described above for the year-round green sturgeon rearing period. Again, as described in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* it is assumed for the purposes of this effects analysis that increased flow would increase the availability and quality of rearing habitat and thereby benefit green sturgeon. As such, effects of the PA on green sturgeon rearing habitat are expected to be beneficial during June for all water year types, except wet years, when there would be no effect. Effects would be negative during September, except in wet years, and during November, except in dry and critical years. In the critical years, the effects would be positive. During August and October, both positive and negative effects are expected, depending on the water year type and location (Appendix 5.A, *CALSIM Methods and Results*). It should be noted that the assumed monotonically increasing relationship between flow and green sturgeon rearing habitat, on which the above conclusions are based, has low certainty.

The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.1.3.4.4.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the year-round larval and juvenile rearing period for green sturgeon in the Sacramento River between Bend Bridge and Knights Landing (Table 5.4-30) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-7, Table 5.C.7-8, Table 5.C.7-9, Table 5.C.7-10[61]. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the juvenile rearing reach in all months and water year types. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 1.0°F (1.4%) and would occur at Knights Landing in below normal years during August, which is outside of the June and July peak rearing period.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the larval and juvenile rearing period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.9-7, Figure 5.C.7.10-7[62]). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of below normal years during August at Hamilton City, where the largest increase in mean monthly water temperature was seen, reveals that the curves were similar overall, although there were multiple difference of more than 1°F at the colder end of the range (Figure 5.4-249).

The threshold water temperature of 66°F was used to evaluate water temperature threshold exceedances during the green sturgeon rearing life stage in the Sacramento River between Bend Bridge and Knights Landing (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-49). This threshold is the upper end of the range of optimal bioenergetics performance of Age 0 and 1 sturgeon with full or reduced food supply (Mayfield and Cech 2004).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-156 and Tables 5.D-158 through 5.D-160. At Bend Bridge and Red Bluff, there would be no months or water year types in which there would be either more than 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold or a more-than-0.5°F difference in the magnitude of average daily exceedance (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-158 and Table 5.D-159).

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[61] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

[62] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

At Hamilton City, there would be one instance in which temperatures would exceed the threshold on more than 5% more days under the PA compared to the NAA: September of below normal water years (14.2% higher) (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-160). However, there would be no concurrent increase under the PA relative to the NAA of more than 0.5°F in the magnitude of average daily exceedance. There would also be two instances in which there would be a reduction under the PA in the percent of days exceeding the 66°F threshold: August of dry and critical water years (9.2% and 9.1% reductions, respectively). In dry years, there would be no difference between the PA and NAA in the magnitude of average daily exceedance above the threshold. In critical water years, there would be a 0.5°F increase in the magnitude of average daily exceedance above the threshold. This indicates that the frequency of days above the threshold would decrease under the PA, but exceedances would be higher on average.

At Knights Landing, for the 66°F threshold, there would be two instances in which temperatures would exceed the threshold on more than 5% more days under the PA compared to the NAA: September (18.7% higher) and October (5.6% higher) of above normal water years (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-156). In September, there would be no difference of more than 5% in the magnitude of average daily exceedance above the threshold between the NAA and PA. However, for October, there would be a reduction of 1.1°F in the magnitude of average daily exceedance above the threshold. This indicates that, for October of above normal water years, the frequency of days above the threshold would increase under the PA, but exceedances would be lower on average.

Overall, the thresholds analysis indicates that there would be more exceedances (5% or greater) in certain months and water year types under the PA, which could cause lethal or sublethal effects to larval and juvenile green sturgeon, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further, this does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival. This process may result in refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. Although the process targets improving winter-run Chinook salmon egg to fry survival, there may be benefits gained by green sturgeon as a result of some of these refinements. The biological interpretation of these results, combined with all upstream results, in the context of real-time operational management is provided in Section 5.4.2.3, *Summary of Upstream Effects*, below.

5.4.2.1.3.4.5 Adult Immigration

5.4.2.1.3.4.5.1 Flow-Related Effects

Mean monthly flows were evaluated in the Sacramento River during the February through June adult green sturgeon immigration period at Red Bluff, Wilkins Slough, and Verona, which are located along the upstream migration corridor (Table 5.4-30). Changes in flow affect conditions for upstream migration of adults, potentially including bioenergetic cost, water quality, crowding, and passage conditions, but quantitative relationships between flow and such conditions are poorly understood. As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* on balance, except under very high flows, the benefits of increased flow generally outweigh the costs and, therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for upstream migration of adult green sturgeon.

Shasta Reservoir storage volume at the end of September may influence flow rates in the Sacramento River during the early part of the green sturgeon immigration period, and Shasta storage volume at the end of May influences flows in June. Mean Shasta September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 7% higher mean storage during critical water years under the PA. Mean Shasta May storage under the PA would also be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-3).

For most months and water year types of the adult immigration period, mean flow at Red Bluff, Wilkins Slough and Verona would be similar (less than 5% difference) between the PA and the NAA or would be greater under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-14, Table 5.A.6-35, Table 5.A.6-36). Only flow in February of critical water years at Red Bluff and Wilkins Slough would be lower under the PA than it would be under the NAA (up to 7% lower at Red Bluff). During May, flow under the PA would be greater (up to 8% greater at Wilkins Slough), except at Verona. During June, flow under the PA would be greater at all the locations, including all water year types at Verona and all water year types, except wet years, at the other locations. The increases for all water year types would be greater at Wilkins Slough and Verona (up to 25% greater in above normal years) than those at Red Bluff.

The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*.

As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* mean monthly flow below about 3,250 cfs is considered to have potentially adverse effects on Chinook salmon, CCV steelhead, and green sturgeon adult immigration conditions in the Sacramento River. The effect of the PA on the frequency of flows below this threshold was evaluated for green sturgeon by comparing CALSIM flows between the PA and the NAA at the Red Bluff and Wilkins Slough migration corridor locations in the river. The CALSIM results indicate no flows below 3,250 cfs for the Sacramento River at either of these locations for any month of the green sturgeon adult immigration period.

5.4.2.1.3.4.5.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the February through June green sturgeon adult immigration period in the Sacramento River between Bend Bridge and Knights Landing (Table 5.4-30) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-7, Table

5.C.7-8, Table 5.C.7-9, Table 5.C.7-10[63]. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) throughout the juvenile rearing reach in all months and water year types. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.3°F (0.5%) and would occur at Bend Bridge in below normal years during May.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the adult immigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.7-7, Figure 5.C.7.8-7, Figure 5.C.7.9-7, Figure 5.C.7.10-7[64]). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of below normal water years during May at Bend Bridge (Figure 5.4-247), where the largest increase in mean monthly water temperature was seen, reveals that there would be two years in which water temperatures would be higher under the PA relative to the NAA. However, upon closer examination of these years reveals that this appears to be due to CALSIM II attempting to balance storage levels among the CVP reservoirs and there are no operational requirements, such as cold-water pool storage, temperature, or outflow requirements, that would cause these years to differ so widely in water temperatures. Therefore, there is no practical reason why real operations under the PA would be different from those under the NAA in these months and years.

For the evaluation of threshold exceedances for adult immigration, please see the combined non-spawning adult presence analysis in Section 5.4.2.1.3.4.2, *Pre- and Post-Spawn Adult Holding*, which indicates that there would be no biologically meaningful water temperature-related effects on green sturgeon non-spawning adult presence.

5.4.2.1.4 Assess Risk to Individuals

5.4.2.1.4.1 Winter-Run Chinook Salmon

Based on the responses of winter-run Chinook salmon exposed to the PA described in Section 5.4.2.1.3, *Assess Species Response to the Proposed Action*, above, the risk to individuals in the Sacramento River would generally be insignificant, with occasional moderate risk related to early life stages, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects. Fitness of individuals, including reproductive success during spawning, survival during embryo incubation, survival and growth during fry and juvenile rearing, survival and growth during immigration and emigration, and expression of life history as a result of spawning, rearing, and migration habitat availability, would mostly differ insignificantly between the NAA and PA. Modeling results indicate occasional instances in which there would be small effects to individuals resulting from changes in reservoir operations under the PA. Results also indicate an increased risk under the PA of small reductions in survival of egg, alevin, fry, and juvenile life stages of winter-run Chinook salmon due to increased water temperatures during August and September and increased risk of redd dewatering for June and August cohorts, as well as reduced survival and growth during juvenile emigration in September and November due to reduced

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[63] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

[64] Water temperature results for Wilkins Slough were used to represent Knights Landing for this analysis

instream flows. Please see Section 5.4.2.3, *Summary of Upstream Effects*, for a description of how actual operations of the PA and the current RPA revision process may reduce the likelihood that these effects would occur.

5.4.2.1.4.2 Spring-Run Chinook Salmon

Based on the responses of spring-run Chinook salmon exposed to the PA described in Section 5.4.2.1.3, *Assess Species Response to the Proposed Action*, above, the risk to individuals in the Sacramento River would mostly be insignificant, with occasional moderate risk related to early life stages, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects. Fitness of individuals, including reproductive success during spawning, survival during embryo incubation, survival and growth during fry and juvenile rearing, survival and growth during immigration and emigration, and expression of life history as a result of spawning, rearing, and migration habitat availability, would mostly differ insignificantly between the NAA and PA. Modeling results indicate occasional instances in which there would be small effects to individuals resulting from changes in reservoir operations under the PA. Results also indicate an increased risk under the PA of small reductions in survival of egg, alevin, fry, and juvenile life stages of spring-run Chinook salmon due to increased water temperatures during August and September and increased risk of redd dewatering for August cohorts, reductions in rearing WUA in June[65], reduced survival and growth during juvenile emigration in November and adult immigration in September due to reduced instream flows. Please see Section 5.4.2.3, *Summary of Upstream Effects*, for a description of how real-time operational management of the PA and the current RPA revision process may reduce the likelihood that these effects would occur.

5.4.2.1.4.3 California Central Valley Steelhead

Based on the responses of CCV steelhead salmon exposed to the PA described in Section 5.4.2.1.3, *Assess Species Response to the Proposed Action*, the risk to individuals in the Sacramento River would mostly be insignificant. Fitness of individuals, including reproductive success during spawning, survival during embryo incubation, survival and growth during juvenile rearing, survival and growth during immigration and emigration, and expression of life history as a result of spawning, rearing, and migration habitat availability, would mostly differ insignificantly between the NAA and PA. Modeling results indicate occasional instances in which there would be small effects to individuals resulting from changes in reservoir operations under the PA. Results also indicate an increased risk under the PA of small reductions in in rearing WUA in June[66], and reduced survival and growth during juvenile emigration and adult immigration in November due to reduced instream flows. Please see Section 5.4.2.3, *Summary of Upstream Effects*, for a description of how real-time operational management of the PA and the current RPA revision process may reduce the likelihood that these effects would occur.

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[65] Reductions in WUA would be of immediate concern if habitat was a limiting factor. Habitat limitation has not been a concern in recent years due to low population size, but it could be in the future if population size was to increase or there was a strong year class. Awareness of the effects to be managed in the best interest of the species is necessary, regardless of variability in population size.

[66] Habitat limitation has not been a concern in recent years due to low population size, but it could be in the future if population size was to increase or there was a strong year class. Awareness of the effects to be managed in the best interest of the species is necessary, regardless of variability in population size

5.4.2.1.4.4 Green Sturgeon

Based on the responses of green sturgeon exposed to the PA described in Section 5.4.2.1.3, *Assess Species Response to the Proposed Action*, above, the risk to individuals in the Sacramento River would be insignificant. See Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* for descriptions of how real-time operational management would be used to avoid and minimize any modeled effects. In addition, see Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, for a description of the process for refining the RPA to improve upstream temperature conditions. Fitness of individuals, including reproductive success during spawning, survival during embryo incubation, survival and growth during larval and juvenile rearing, survival and growth during immigration and emigration, and expression of life history as a result of spawning, rearing, and migration habitat availability, would mostly differ insignificantly between the NAA and PA.

5.4.2.1.5 Effects of the Action on Designated and Proposed Critical Habitat

The critical habitat designation final rules (winter-run Chinook salmon: June 16, 1993, 58 FR 33212; spring-run Chinook salmon and CCV steelhead: September 2, 2005, 70 FR 52488; green sturgeon: October 9, 2009, 74 FR 52300), provide the physical and biological features (PBFs) that are essential for the conservation of the species. The Sacramento River provides several PBFs that support one or more life stages of winter-run Chinook salmon, spring-run Chinook salmon, CCV steelhead, and green sturgeon. Because the Sacramento River upstream of the Delta is exclusively a freshwater riverine system, only PBFs pertaining to freshwater riverine systems are discussed here.

For each species, please refer to Section 5.4.2.3, *Summary of Upstream Effects*, for a description of how real-time operational management of the PA and the current RPA revision process may reduce the likelihood that the effects described here would occur.

5.4.2.1.5.1 Winter-Run Chinook Salmon

5.4.2.1.5.1.1 Access to Spawning Areas in the Upper Sacramento River

Access to spawning areas in the Upper Sacramento River by adult winter-run Chinook salmon is affected by flow- and water temperature-related conditions throughout the Sacramento River upstream of the Delta. Winter-run Chinook salmon spawning occurs between Keswick Dam and Red Bluff Diversion Dam, although the vast majority of spawning currently occurs upstream of Airport Bridge (CDFW unpubl. data). Section 5.4.2.1.3.1.4, *Adult Immigration*, evaluated flow- and water temperature-related effects of the PA on adult immigration relative to the NAA in the Sacramento River upstream of the Delta and found that effects of the PA on winter-run Chinook salmon migration habitat would be insignificant.. Therefore, the results indicate that there would be insignificant adverse effects of the PA on this physical and biological feature. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects.

5.4.2.1.5.1.2 The Availability of Clean Gravel for Spawning Substrate

The availability of clean gravel is a function of upstream supply and flow regimes that allow for periodic cleaning of fine sediment but are not high enough to mobilize the gravel. The PA would not affect the amount of upstream gravel supply or natural pulse flows. Further, the insignificant flow differences due to the PA (Section 5.4.2.1.3.1.1, *Spawning, Egg Incubation, and Alevins*; Appendix 5.A, *CALSIM Methods and Results*) are not expected to cause substantial changes in availability of clean gravel because these non-pulse flows are not responsible for cleaning gravel. Therefore, there would be no effect of the PA on this physical and biological feature.

5.4.2.1.5.1.3 Adequate River Flows for Successful Spawning, Incubation of Eggs, Fry Development and Emergence, and Downstream Transport of Juveniles

As indicated in Section 5.4.2.1.3.1.1, *Spawning, Egg Incubation, and Alevins*; Section 5.4.2.1.3.1.2, *Fry and Juvenile Rearing*; Section 5.4.2.1.3.1.3, *Juvenile Emigration*, there would be insignificant differences in flows between the NAA and PA throughout the Sacramento River upstream of the Delta during the winter-run Chinook salmon spawning, rearing, and emigration periods. Therefore, the results indicate there would be insignificant effects of the PA on this physical and biological feature. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.1.4 Water Temperatures for Successful Spawning, Egg Incubation, and Fry Development

As indicated in Section 5.4.2.1.3.1.1, *Spawning, Egg Incubation, and Alevins* and Section 5.4.2.1.3.1.2, *Fry and Juvenile Rearing*, water temperatures would differ insignificantly between the NAA and PA in spawning and rearing reaches throughout the Sacramento River upstream of the Delta during the winter-run Chinook salmon spawning and rearing periods with few exceptions. Therefore, the results indicate that there would be insignificant effects of the PA on this physical and biological feature. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects. Further, this does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival.

5.4.2.1.5.1.5 Habitat Areas and Adequate Prey that Are not Contaminated

In the Sacramento River upstream of the Delta, the PA is not likely to adversely affect contaminant sources. As indicated throughout Section 5.4.2.1.3.1, *Winter-Run Chinook Salmon*, there would be insignificant differences in flows between the NAA and PA in winter-run Chinook salmon habitat areas throughout the Sacramento River upstream of the Delta. These flows could influence dilution of contaminants Therefore, the results indicate there would be insignificant effects of the PA on this physical and biological feature. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.1.6 Riparian Habitat that Provides for Successful Juvenile Development and Survival

In the Sacramento River upstream of the Delta, any change in riparian habitat is expected to be insignificant. The range of flows, which can influence riparian vegetation, would not change substantially under the PA. Therefore, the effect of the PA on this physical and biological feature would be insignificant.

5.4.2.1.5.1.7 Access Downstream so that Juveniles Can Migrate from Spawning Grounds to San Francisco Bay and the Pacific Ocean

Juvenile winter-run Chinook salmon emigration from spawning grounds would be limited by flow- and water temperature-related conditions throughout the Sacramento River upstream of the Delta. Section 5.4.2.1.3.1.3, *Juvenile Emigration*, evaluated flow- and water temperature-related effects of the PA relative to the NAA in the Sacramento River upstream of the Delta and found that there would predominantly be insignificant differences in flows and water temperatures between the PA and NAA in juvenile winter-run Chinook salmon migration habitat. Therefore, there would predominantly be insignificant effects of the PA on this physical and biological feature, However, there would be reductions in flow between the NAA and PA during November, which indicate that there would be a potential risk during November of negative effects of the PA on this PBF. This does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.2 Spring-Run Chinook Salmon

5.4.2.1.5.2.1 Spawning Habitat

As indicated in Section 5.4.2.1.3.2.1, *Spawning, Egg Incubation, and Alevins*, there would be insignificant differences in flow and water temperature between the PA and NAA in spring-run Chinook salmon spawning habitat in the Sacramento River. Therefore, the results indicate that there would be insignificant effects of the PA on this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects. Further, this does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival.

5.4.2.1.5.2.2 Freshwater Rearing Habitat

As indicated in Section 5.4.2.1.3.2.2, *Fry and Juvenile Rearing*, there would be insignificant differences in flow and water temperature between the PA and NAA in fry and juvenile spring-run Chinook salmon rearing habitat in the Sacramento River upstream of the Delta. Therefore, the results indicate that there would be insignificant effects of the PA on this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.2.3 Freshwater Migration Corridors

As indicated in Section 5.4.2.1.3.2.3, *Juvenile Emigration*, and Section 5.4.2.1.3.2.4 *Adult Immigration*, there would predominantly be insignificant differences in flow and water temperature between the PA and NAA in juvenile and adult spring-run Chinook migration habitat in the Sacramento River upstream of the Delta. Therefore, the results indicate that there would predominantly be insignificant effects of the PA on this PBF. However, there would be reductions in flow between the NAA and PA during November, which indicate that there would be a potential risk during November of negative effects of the PA on this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.3 California Central Valley Steelhead

5.4.2.1.5.3.1 Spawning Habitat

As indicated in Section 5.4.2.1.3.3.1, *Spawning, Egg Incubation, and Alevins*, there would be insignificant differences in flow and water temperature between the PA and NAA in CCV steelhead spawning habitat in the Sacramento River. Therefore, the results indicate that there would be insignificant effects of the PA on this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects. Further, this does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival.

5.4.2.1.5.3.2 Freshwater Rearing Habitat

As indicated in Section 5.4.2.1.3.3.3, *Juvenile Rearing*, there would be insignificant differences in flow and water temperature between the PA and NAA in juvenile CCV steelhead rearing habitat in the Sacramento River upstream of the Delta. Therefore, the results indicate that there would be insignificant effects of the PA on this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.3.3 Freshwater Migration Corridors

As indicated in Section 5.4.2.1.3.3.2, *Kelt Emigration*, Section 5.4.2.1.3.3.4, *Smolt Emigration,* and Section 5.4.2.1.3.3.5, *Adult Immigration*, there would predominantly be insignificant differences in flow and water temperature between the PA and NAA in kelt, smolt, and adult CCV steelhead migration habitat in the Sacramento River upstream of the Delta. Therefore, the results indicate that there would predominantly be insignificant effects of the PA on this PBF. However, there would be reductions in flow between the NAA and PA during November, which indicate that there would be a potential risk during November of negative effects of the PA on this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.4 Green Sturgeon

5.4.2.1.5.4.1 Food Resources

The PA would not directly affect food resources in the Sacramento River upstream of the Delta, although food availability could potentially be affected by changes in flows and water temperatures. As described throughout Section 5.4.2.1.3.4, *Green Sturgeon*, there would be insignificant reductions in flows and increases in water temperature in the Sacramento River. These results indicate there would be insignificant effects to this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.4.2 Substrate Type or Size

The PA would not directly affect substrate type of size, although substrate could potentially be affected by changes in flows in the Sacramento River. As described throughout Section 5.4.2.1.3.4, *Green Sturgeon*, there would be insignificant reductions in flows in the Sacramento River. These results indicate there would be insignificant effects to this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.4.3 Water Flow

As described throughout Section 5.4.2.1.3.4, *Green Sturgeon*, there would be insignificant reductions in flows in the Sacramento River. These results indicate there would be insignificant effects to this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.4.4 Water Quality

In the critical habitat designation final rule for green sturgeon (October 9, 2009, 74 FR 52300), the Water Quality PBF includes “temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages”. These factors could potentially be affected by changes in flows and increases in water temperatures in the Sacramento River. As described throughout Section 5.4.2.1.3.4, *Green Sturgeon*, there would be insignificant reductions in flows and increases in water temperatures in the Sacramento River. These results indicate there would be insignificant effects to this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects. Further, this does not consider the current revision process to OCAP RPA Action Suite 1.2 described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*, to improve winter-run Chinook salmon egg-to-fry survival.

5.4.2.1.5.4.5 Migratory Corridor

As described in Section 5.4.2.1.3.4.3, *Post-Spawn Adult Emigration*, Section 5.4.2.1.3.4.4, *Larval and Juvenile Rearing and Emigration*, and Section 5.4.2.1.3.4.5 *Adult Immigration*, there would mostly be insignificant reductions in flows in the Sacramento River. These results indicate there would mostly be insignificant effects to this PBF. However, there would be reductions in flow between the NAA and PA during November, which indicate that there would be a potential risk during November of negative effects of the PA on this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time*

Operations Upstream of the Delta, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.4.6 Water Depth

The PA would not directly affect the number of deep holding pools for green sturgeon in the Sacramento River, but could potentially affect the depth and water quality of these pools indirectly through changes in flows in the Sacramento River. As described throughout Section 5.4.2.1.3.4, *Green Sturgeon*, there would be insignificant reductions in flows in the Sacramento River. These results indicate there would be insignificant effects to this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.1.5.4.7 Sediment Quality

The PA would not directly affect sediment quality for green sturgeon in the Sacramento River, but could potentially affect it indirectly through changes in flows in the Sacramento River. As described throughout Section 5.4.2.1.3.4, *Green Sturgeon*, there would be insignificant reductions in flows in the Sacramento River. These results indicate there would be insignificant effects to this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.2 American River

5.4.2.2.1 Deconstruct the Action

The PA could cause changes in cold-water pool storage in American Reservoir and operations of Folsom Lake, which could cause changes to instream flows and water temperatures in the American River. Changes in the magnitude, duration, frequency, timing, and rate of change of flows in the American River can all affect habitat characteristics of the life stages of CCV steelhead that are present. For spawning and egg incubation, this analysis evaluates flow-related effects on weighted usable area of spawning habitat, redd dewatering, and redd scour. Changes in flow rates can affect the amount of weighted usable area of spawning habitat, which is characterized by velocity, depth, and substrate type (U.S. Fish and Wildlife Service 2003a, 2005a, 2006). Redd dewatering occurs when flows are reduced when eggs and alevins are still in the gravel after a spawning event (U.S. Fish and Wildlife Service 2006). Redd scour and entombment can occur when flood flows are of a high enough magnitude to mobilize the gravel, although attempts are made to spread flood control releases out when possible.

For fry and juveniles, this analysis evaluates flow-related effects on weighted usable area of rearing habitat and juvenile stranding. Changes in flow rates can affect the amount of weighted usable area of rearing habitat, which is characterized by velocity, depth, and substrate type (U.S. Fish and Wildlife Service 2005b). Juvenile stranding occurs when flows are reduced rapidly and individuals are unable to escape an area that is isolated from the main channel, often leading to mortality (U.S. Fish and Wildlife Service 2006). Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods*, provides detail on the methods used to evaluate flow effects of the PA.

As cold-water species, salmonids are sensitive to water temperatures. Changes to water temperatures may influence the suitability of habitat for each life stage present in the American River and can lead to sublethal impairments that include reduced growth, inhibited smoltification, altered migration, disease, and ultimately death. Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, provides detail on the methods used to evaluate water temperature effects of the PA.

5.4.2.2.2 Assess Species Exposure

5.4.2.2.2.1 California Central Valley Steelhead

The PA would expose CCV steelhead to changes in flows and water temperatures throughout their presence in the American River. Table 5.4-77 presents the timing of the upstream presence of each life stage for steelhead in the American River.

Table 5.4-77. Temporal Occurrence of California Central Valley Steelhead by Life Stage, American River

Life Stage	J	F	M	A	M	J	J	A	S	O	N	D
Spawning, egg incubation, and alevins[1]	■	■	■	▨	▨							▨
Kelt emigration[2]		▨	▨	▨								
Juvenile rearing[1]	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Smolt emigration[3]	▨	■	■	■	▨	▨						▨
Adult immigration[2]	■	■	▨	░						▨	▨	■
Adult holding[4]										▨	▨	
	■	High				▨	Med			░	Low	

Sources:; [1] Reclamation 2008; [2] Inferred from spawning period; [3] SWRI 2001; Does not include migrant parr; [4] Inferred from adjacent life stages

CCV steelhead spawn in the American River and eggs and alevins remain in the gravel primarily between December and May, with a peak during January through March. It was assumed that, because of constraints on water temperature and other habitat features, steelhead spawn throughout the reach from Hazel Avenue to Watt Avenue.

After spawning, steelhead adults either die or kelts emigrate back to the ocean between February and April.

Juvenile steelhead rear for 1 to 3 years; therefore, individuals are present in the river throughout the year. It was assumed that, because of constraints on water temperature and other habitat features, steelhead rear throughout the reach from Hazel Avenue to Watt Avenue.

Smolts, not including migrant parr, begin migrating downstream towards the ocean beginning in December and continue until June, with a peak migration period of February through April.

Adult CCV steelhead migrate upstream during October and April with a peak between December and February. Adults hold from October and November.

Changes in hydrologic conditions caused by the PA could affect migratory life stages of CCV steelhead throughout the American River because they are present throughout the river.

5.4.2.2.3 Assess Species Response to the Proposed Action

5.4.2.2.3.1 California Central Valley Steelhead

5.4.2.2.3.1.1 Spawning, Egg Incubation, and Alevins

5.4.2.2.3.1.1.1 Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA during the December through May spawning and incubation period for Central Valley Steelhead (Table 5.4-77). Changes in flow can affect the instream area available for spawning and egg incubation, along with the quality of the habitat, and can result in dewatering or scour of the redds. Folsom Reservoir storage volume at the end of September influences flow rates below the dam during some of the steelhead spawning and egg incubation period in some years. Mean Folsom September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 8% lower mean storage during dry water years under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-5). Mean flow of the American River at Nimbus Dam would generally be similar (less than 5% difference) between the PA and the NAA throughout the steelhead spawning period, with maximum changes including a reduction under the PA of about 10% during March of critical water years and an increase of about 7% in February of below normal years (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-16).

5.4.2.2.3.1.1.1.1 Spawning WUA

Spawning WUA for steelhead in the American River was determined by USFWS (2003b) for several river segments located within about 6 miles of Nimbus Dam, where most steelhead spawning occurs. To evaluate the effects of the PA on steelhead spawning habitat, steelhead spawning WUA was estimated for CALSIM II flows at Nimbus Dam under the NAA and the PA during the December through May spawning period for all of the river segments combined (see Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*).

Differences in steelhead spawning WUA under the PA and NAA were examined using exceedance plots of monthly mean WUA during the steelhead spawning period for each water year type and all water year types combined. The exceedance curves with all water years combined (Figure 5.4-252) and those broken out by water year type (Figure 5.4-253 through Figure 5.4-257 are similar between the PA and the NAA.

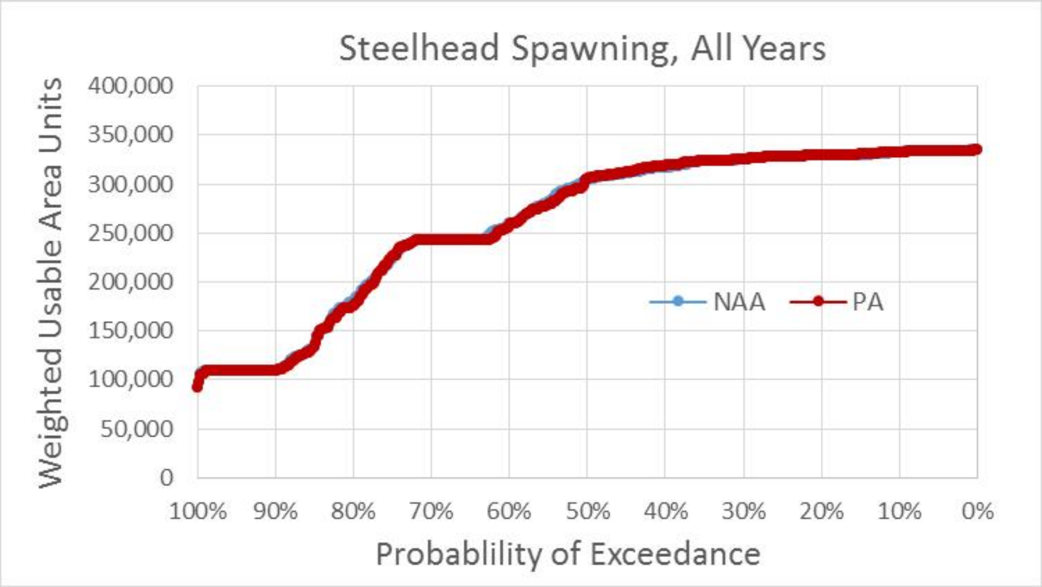

Figure 5.4-252. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios, All Water Years

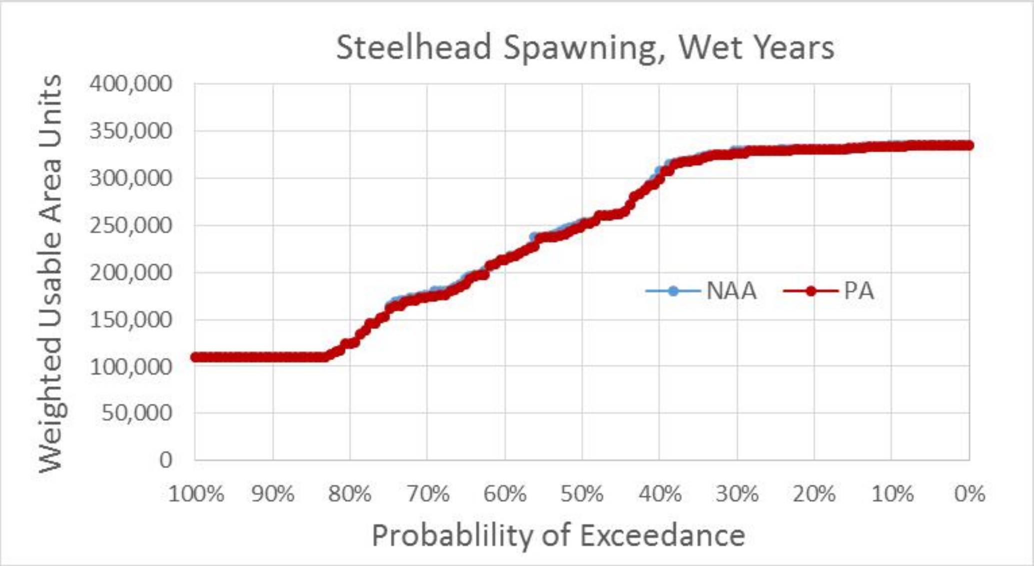

Figure 5.4-253. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios, Wet Water Years

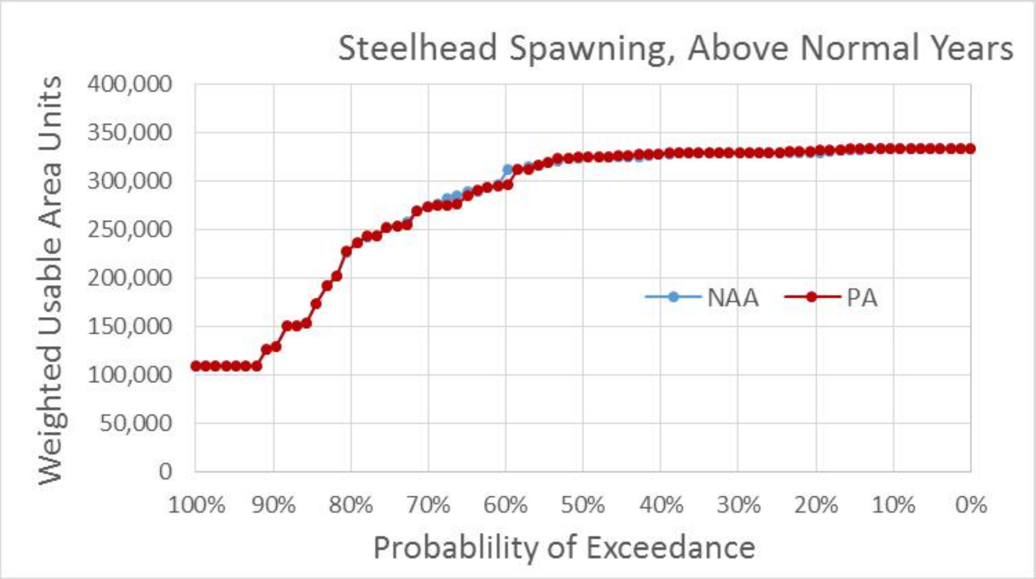

Figure 5.4-254. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios, Above Normal Water Years

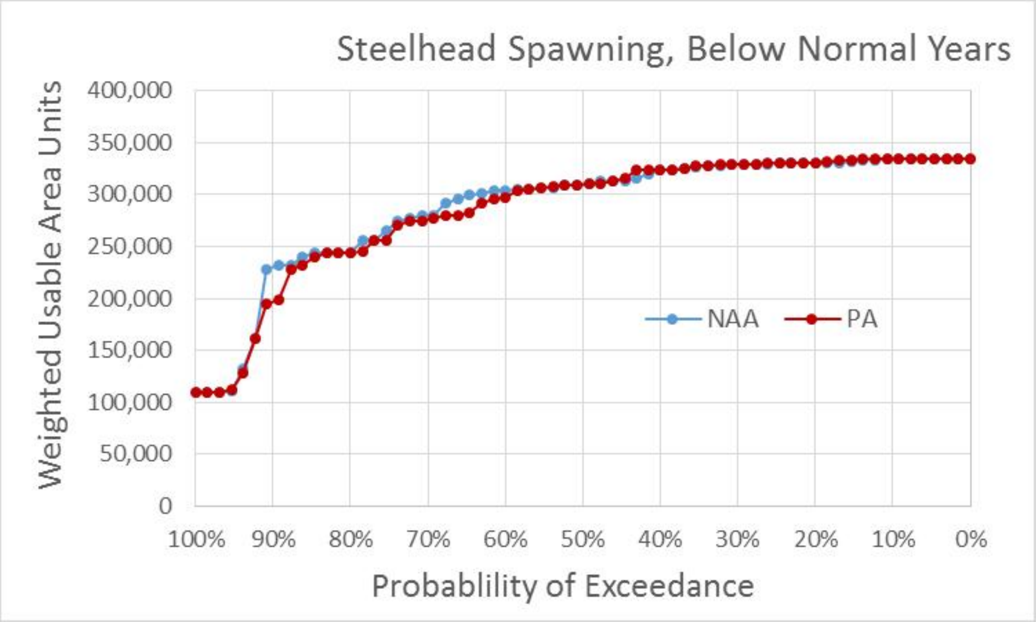

Figure 5.4-255. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios, Below Normal Water Years

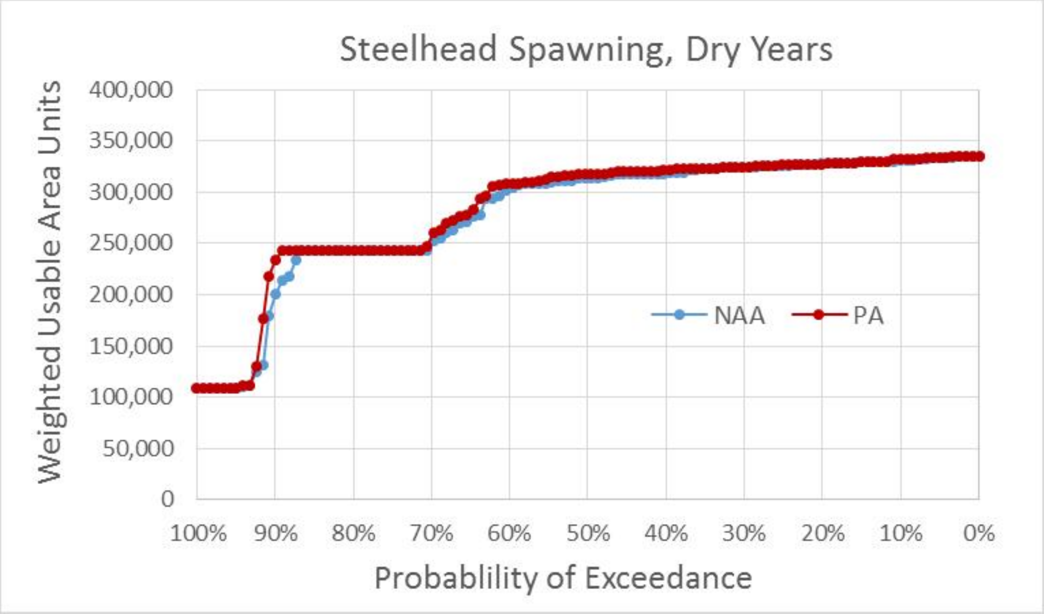

Figure 5.4-256. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios, Dry Water Years

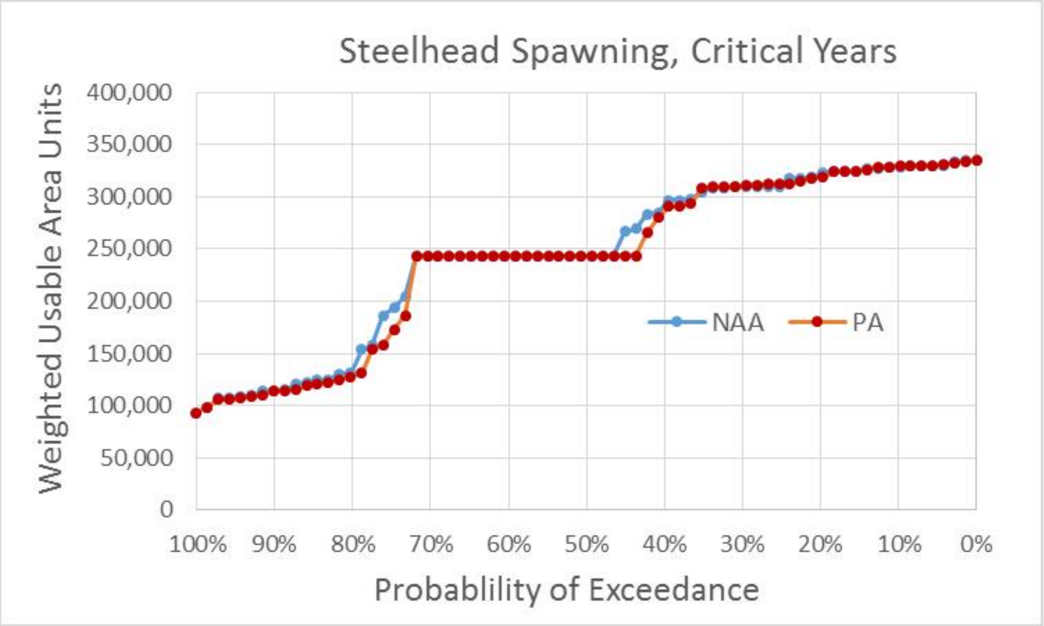

Figure 5.4-257. Exceedance Plot of Central Valley Steelhead Spawning Weighted Usable Area (WUA) for NAA and PA Model Scenarios, Critical Water Years

Differences in the mean spawning WUA for the months of the spawning period under each water year type and all water year types combined also indicate that spawning WUA would be little affected by the PA (less than 5% difference), except for a 5% increase in mean WUA during January of dry years and a 9% reduction in mean WUA during March of critical years (Table 5.4-78). As described above, March of critical years had the largest reduction in mean flow during the steelhead spawning period.

Table 5.4-78. Central Valley Steelhead Spawning Weighted Usable Area (WUA) and Differences (Percent Differences) between Model Scenarios (green indicates PA is at least 5% higher [raw difference] than NAA; red indicates PA is at least 5% lower)

Month	WYT	NAA	PA	PA vs. NAA
December	Wet	289,486	285,118	-4,368 (-2%)
	Above Normal	308,417	307,818	-599 (-0.2%)
	Below Normal	295,864	291,133	-4,731 (-1.6%)
	Dry	268,622	268,556	-66 (0%)
	Critical	243,160	240,549	-2,612 (-1.1%)
	All	281,475	278,962	-2,513 (-1%)
January	Wet	257,434	256,711	-723 (-0.3%)
	Above Normal	286,887	287,327	440 (0.2%)
	Below Normal	254,906	253,543	-1,363 (-0.5%)
	Dry	243,976	256,523	12,547 (5%)
	Critical	226,444	235,865	9,420 (4.2%)
	All	253,947	258,043	4,097 (1.6%)
February	Wet	173,420	172,412	-1,009 (-0.6%)
	Above Normal	215,102	216,238	1,137 (0.5%)
	Below Normal	274,961	268,561	-6,400 (-2%)
	Dry	298,601	299,131	530 (0.2%)
	Critical	248,422	248,480	58 (0%)
	All	235,157	234,297	-861 (-0.4%)
March	Wet	222,098	222,118	19 (0.01%)
	Above Normal	240,540	237,783	-2,758 (-1%)
	Below Normal	300,002	300,512	510 (0.2%)
	Dry	281,382	285,819	4,438 (2%)
	Critical	252,093	228,802	-23,291 (-9%)
	All	254,321	251,633	-2,689 (-1.1%)
April	Wet	251,017	251,001	-16 (-0.01%)
	Above Normal	301,209	301,342	133 (0.04%)
	Below Normal	298,534	295,493	-3,041 (-1%)
	Dry	288,950	290,083	1,133 (0.4%)
	Critical	245,781	246,103	322 (0.1%)
	All	273,834	273,766	-68 (0%)
May	Wet	240,778	240,939	162 (0.07%)
	Above Normal	320,030	320,089	59 (0.02%)
	Below Normal	300,813	300,835	22 (0%)
	Dry	304,879	305,996	1117 (0.4%)
	Critical	250,842	248,455	-2387 (-1%)
	All	278,503	278,490	-13 (0%)

5.4.2.2.3.1.1.1.2 Redd scour

The probability of flows in the American River occurring under the PA and the NAA that would be high enough to mobilize sediments and scour Central Valley steelhead redds was estimated from CALSIM II estimates of mean monthly flows, using a relationship determined from the historical record between actual mean monthly and maximum daily flow (Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*). The actual monthly and daily flow data used in the analysis are from gage records at Hazel Avenue, and the CALSIM II estimates used to compare probabilities of redd scour for the PA and the NAA are for the Nimbus Dam location. As discussed in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*, 40,000 cfs is treated as the minimum daily flow at which redd scour occurs in the American River. The analysis of the Hazel Avenue gage data shows that for months with a mean monthly flow of at least 19,350 cfs, the maximum daily flow in that month is always at least 40,000 cfs. Therefore, redd scour probabilities for the PA and the NAA were evaluated by comparing frequencies of CALSIM II flows greater than 19,350 cfs at Nimbus during the steelhead December through May spawning and incubation period. Further information on the redd scour analysis methods is provided in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*.

Of the months in the CALSIM II record during the spawning and incubation period of Central Valley steelhead in the American River (December through May), fewer than 2% would have flows of more than 19,350 cfs at Hazel Avenue under both the PA and the NAA (Table 5.4-79).

Table 5.4-79. Water Years and Months with Mean Flow > 19,350 cfs at Hazel Avenue during the Central Valley Steelhead Spawning and Incubation Period in the American River

Water Year	Month	WYT	Flow (cfs)	
			NAA	PA
1964	December	Dry	21,494	21,414
1968	January	Below Normal	23,260	23,929
1969	January	Wet	25,092	25,092
1983	March	Wet	19,927	19,927
1983	December	Wet	22,909	22,909
1986	February	Wet	37,305	37,305
1995	March	Wet	19,730	19,721
1996	January	Wet	38,218	38,218

5.4.2.2.3.1.1.1.3 Redd dewatering

The percentage of steelhead redds dewatered by reductions in American River flow was estimated from CALSIM II estimates of monthly mean flows during the 3 months following each of the months that steelhead spawn (Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods,* Table 5.D-54) because the period of egg incubation is assumed to last about three months after the eggs are spawned. No model for predicting percentages of redds dewatered, such as that developed for the Sacramento River (U.S. Fish and Wildlife Service 2006), has been developed for the American River. Therefore, the maximum reduction in American River flow for the 3 months following each of the months during which steelhead spawn was used as a proxy for percent of redds dewatered. CALSIM II flows at Nimbus were used for this analysis. Larger maximum reductions are assumed to increase the percent of redds dewatered and, therefore, to have a negative effect on steelhead. Further information on the redd dewatering analysis methods is provided in Appendix 5.D, Section 5.D.2.2, *Spawning Flows Methods*.

Differences in maximum flow reductions under the PA and NAA were examined using exceedance plots of mean monthly maximum flow reductions, expressed as a percentage of the spawning flows, for the months that American River steelhead spawn (December through February) (Figure 5.4-258 through Figure 5.4-263). The exceedance curves for all water year types combined (Figure 5.4-258) and those for wet, above normal, below normal, and dry water years (Figure 5.4-259 through Figure 5.4-262) indicate that the PA would generally have slightly greater flow reductions than the NAA. The exceedance curve for critical years appears to indicate a pronounced increase in flow reductions for the PA. However, further inspection reveals that the increased reductions result from differences in only three months out of the 36 critical water year months of the CCV steelhead spawning period in the American River. Moreover, all three of these months are in the same water year (1933), and the increased flow reductions under the PA for all of them result from a flow in March 1933 that is more than 1000 cfs lower under the PA than under the NAA (1,445 cfs under the NAA and 392 cfs under the PA). The March 1933 reduced flow under the PA appears to be due to CALSIM II attempting to balance storage levels among the CVP reservoirs, resulting in higher releases from Keswick Dam and lower releases from Folsom for this month.

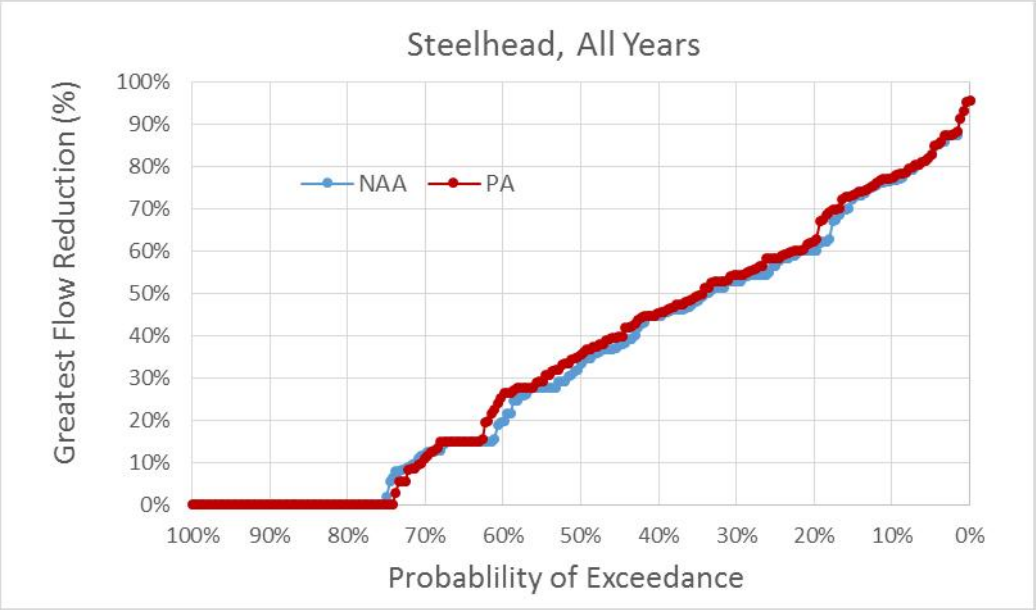

Figure 5.4-258. Exceedance Plot of Maximum Flow Reductions (%) for 3-Month Period after Central Valley Steelhead Spawning for NAA and PA Model Scenarios, All Water Years

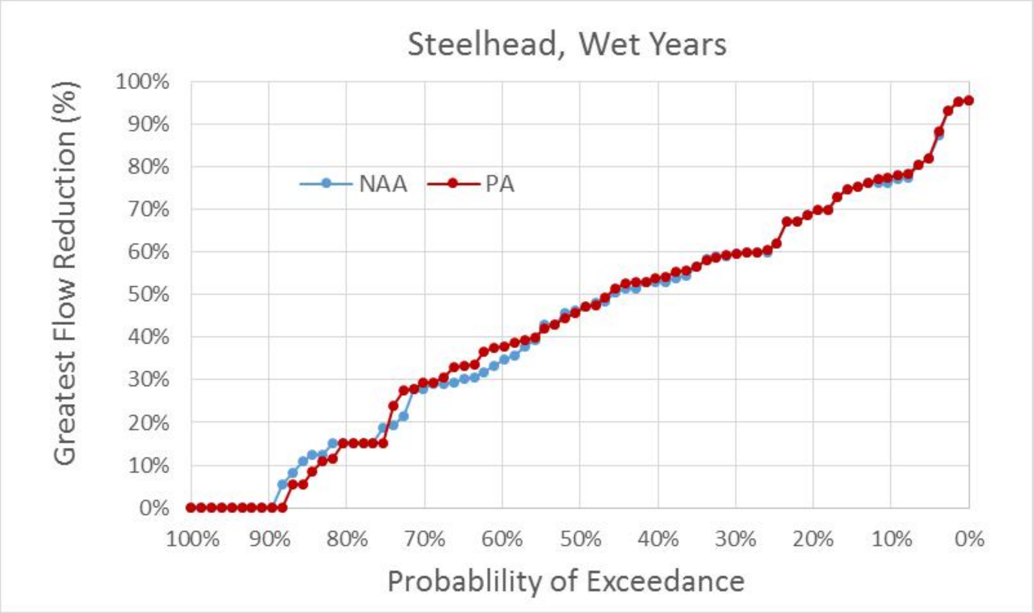

Figure 5.4-259. Exceedance Plot of Maximum Flow Reductions (%) for 3-Month Period after Central Valley Steelhead Spawning for NAA and PA Model Scenarios, Wet Water Years

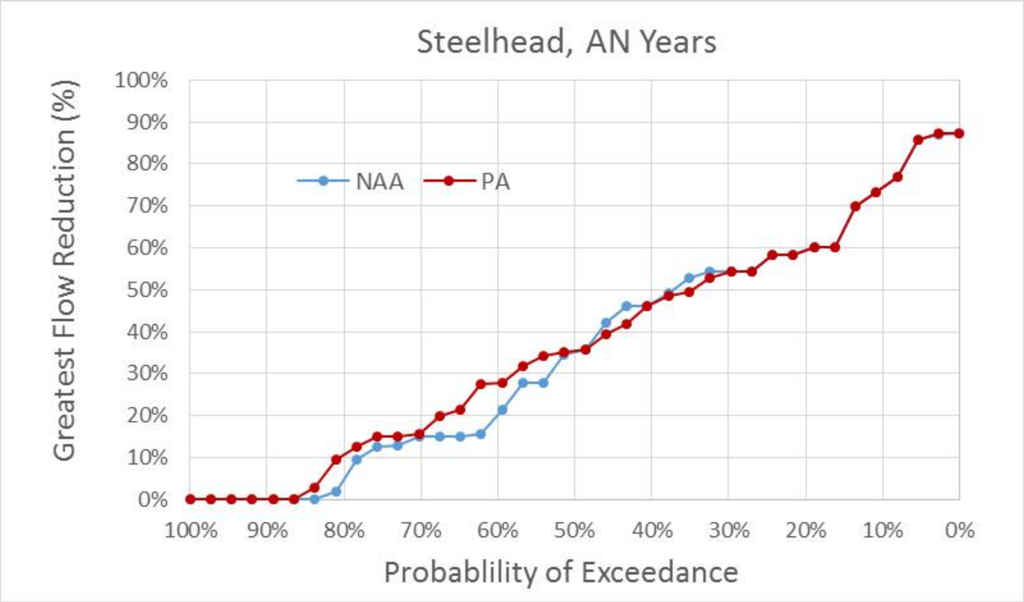

Figure 5.4-260. Exceedance Plot of Maximum Flow Reductions (%) for 3-Month Period after Central Valley Steelhead Spawning for NAA and PA Model Scenarios, Above Normal Water Years

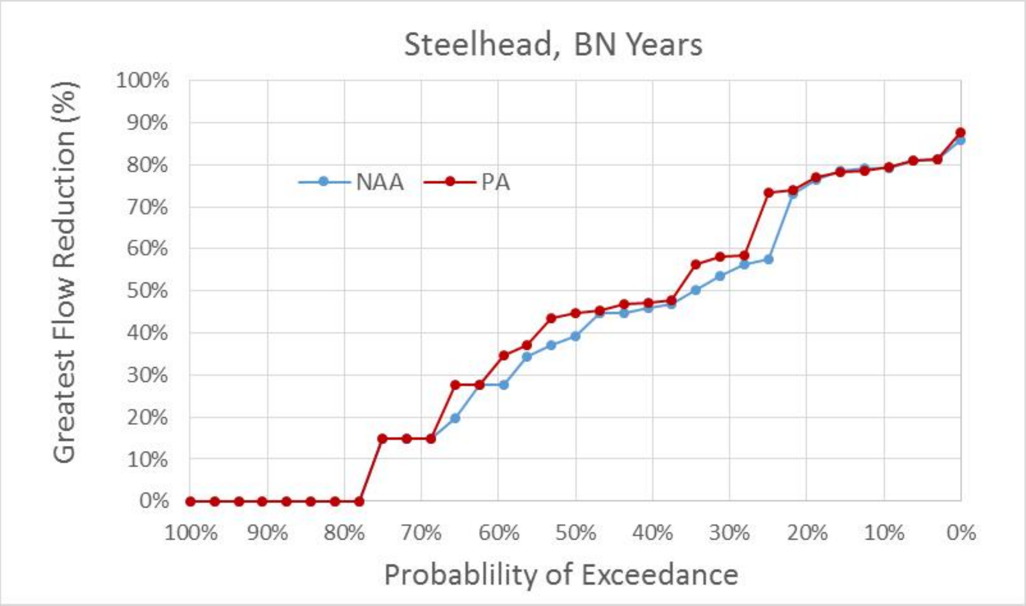

Figure 5.4-261. Exceedance Plot of Maximum Flow Reductions (%) for 3-Month Period after Central Valley Steelhead Spawning for NAA and PA Model Scenarios, Below Normal Water Years

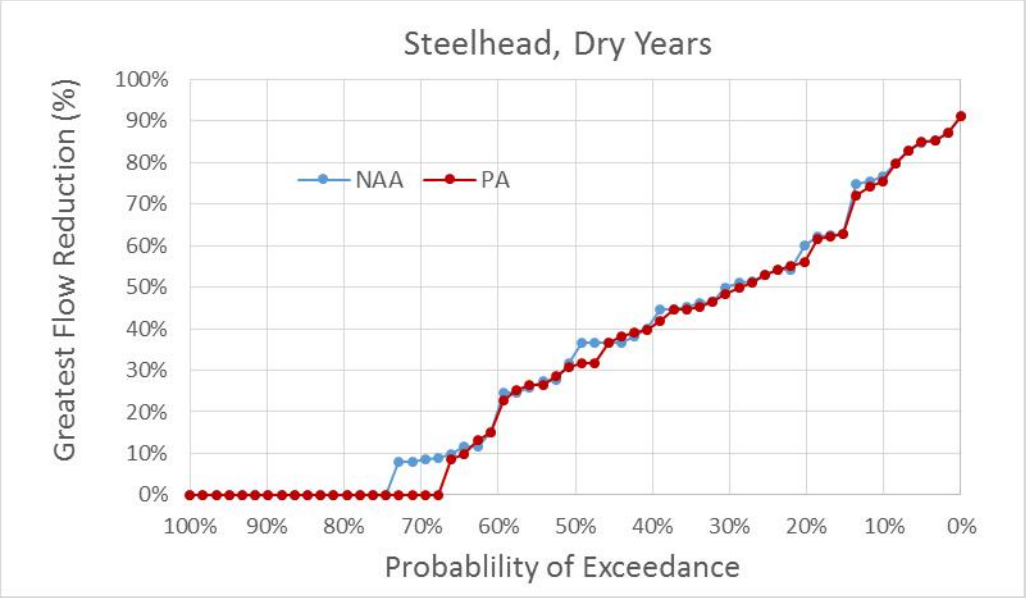

Figure 5.4-262. Exceedance Plot of Maximum Flow Reductions for 3-Month Period after Central Valley Steelhead Spawning for NAA and PA Model Scenarios, Dry Water Years

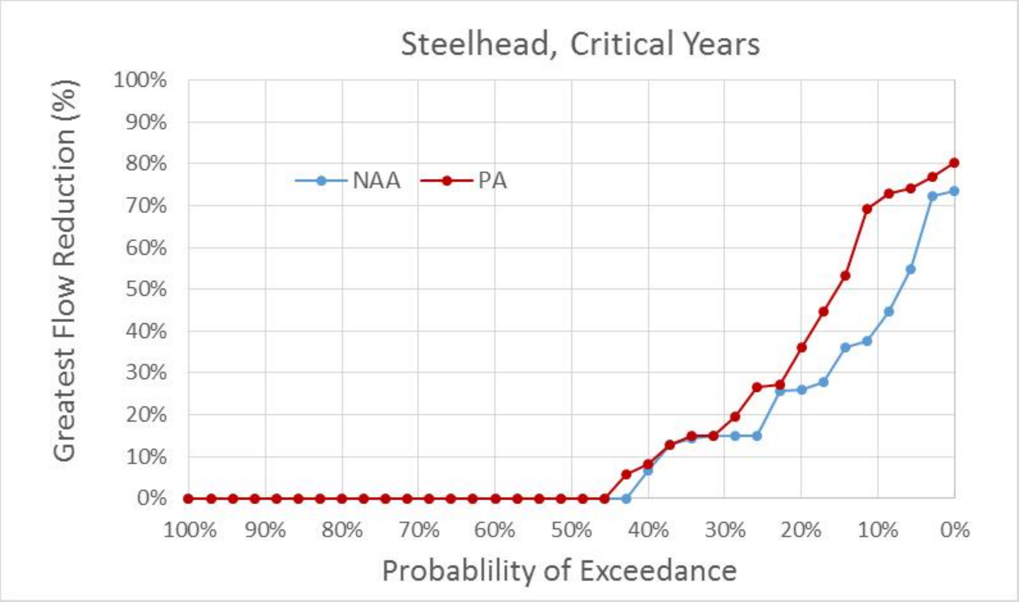

Figure 5.4-263. Exceedance Plot of Maximum Flow Reductions for 3-Month Period after Central Valley Steelhead Spawning for NAA and PA Model Scenarios, Critical Water Years

Differences in the mean maximum flow reduction, expressed as a percentage of the spawning flow, for each month of spawning under each water year type and all water year types combined indicate that steelhead redd dewatering would generally be little affected by the PA (less than 5% raw difference), except for a 5% increase in the maximum flow reduction for January of critical years and 6% and 7% increases for February of below normal and critical years, respectively (Table 5.4-80). As previously noted, increases in flow reduction are assumed to increase redd dewatering, negatively affecting steelhead, but the critical year flow reductions may largely be the result of the March 1933 flow difference discussed in the previous paragraph.

Table 5.4-80. Maximum Flow Reductions (cfs) for 3-Month Period after Central Valley Steelhead Spawning, and Differences in the Maximums (Percent Differences) between Model Scenarios (green indicates PA is at least 5% lower [raw difference] than NAA; red indicates PA is at least 5% higher)[1]

		Mean Greatest Flow Reduction, as Percent		Raw Difference	Relative (Percent) Difference
Month	WYT	NAA	PA	PA vs. NAA	PA vs. NAA
December	Wet	33.3%	33.5%	0.2%	0.7%
	Above Normal	29.1%	29.0%	-0.1%	-0.2%
	Below Normal	24.3%	24.3%	0.0%	-0.2%
	Dry	35.8%	32.9%	-2.9%	-8.2%
	Critical	15.8%	17.1%	1.3%	8.2%
	All	29.5%	29.0%	-0.5%	-1.6%
January	Wet	42.4%	42.3%	0.0%	-0.1%
	Above Normal	27.0%	26.9%	-0.2%	-0.6%
	Below Normal	40.2%	40.3%	0.1%	0.2%
	Dry	35.8%	36.1%	0.2%	0.6%

		Mean Greatest Flow Reduction, as Percent		Raw Difference	Relative (Percent) Difference
Month	**WYT**	**NAA**	**PA**	**PA vs. NAA**	**PA vs. NAA**
	Critical	8.1%	13.2%	5.0%	61.8%
	All	33.0%	33.8%	0.8%	2.3%
February	Wet	53.5%	54.3%	0.8%	1.4%
	Above Normal	50.7%	54.6%	3.9%	7.7%
	Below Normal	50.5%	56.5%	6.0%	11.9%
	Dry	28.1%	27.7%	-0.4%	-1.3%
	Critical	15.8%	22.8%	7.0%	44.5%
	All	41.0%	43.6%	2.6%	6.4%

[1] Increased flow reduction is assumed to increase redd dewatering, negatively affecting steelhead.

5.4.2.2.3.1.1.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the December through May spawning and egg incubation/alevins period for steelhead in the American River reach between Hazel Avenue and Watt Avenue (Table 5.4-77) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-14, Table 5.C.7-15. Overall, the PA would change mean water temperatures very little (less than 1°F, or less than 1%) throughout the reach in all months and water year types of the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.2°F, or 0.4%, and would occur at Watt Avenue during critical years in March. This greatest increase would occur during the peak spawning and egg incubation/alevins period (January through March).

Exceedance plots of monthly mean water temperatures were examined during each month throughout the spawning and incubation period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.14-7, Figure 5.C.7.15-7). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of critical water years during March at Watt Avenue, where the largest increase in mean monthly water temperature was seen, reveals that the curves were similar overall and that that the difference of 0.2°F in mean monthly temperatures between NAA and PA would cause no substantial differences between curves for the NAA and PA in the exceedance plot (Figure 5.4-264).

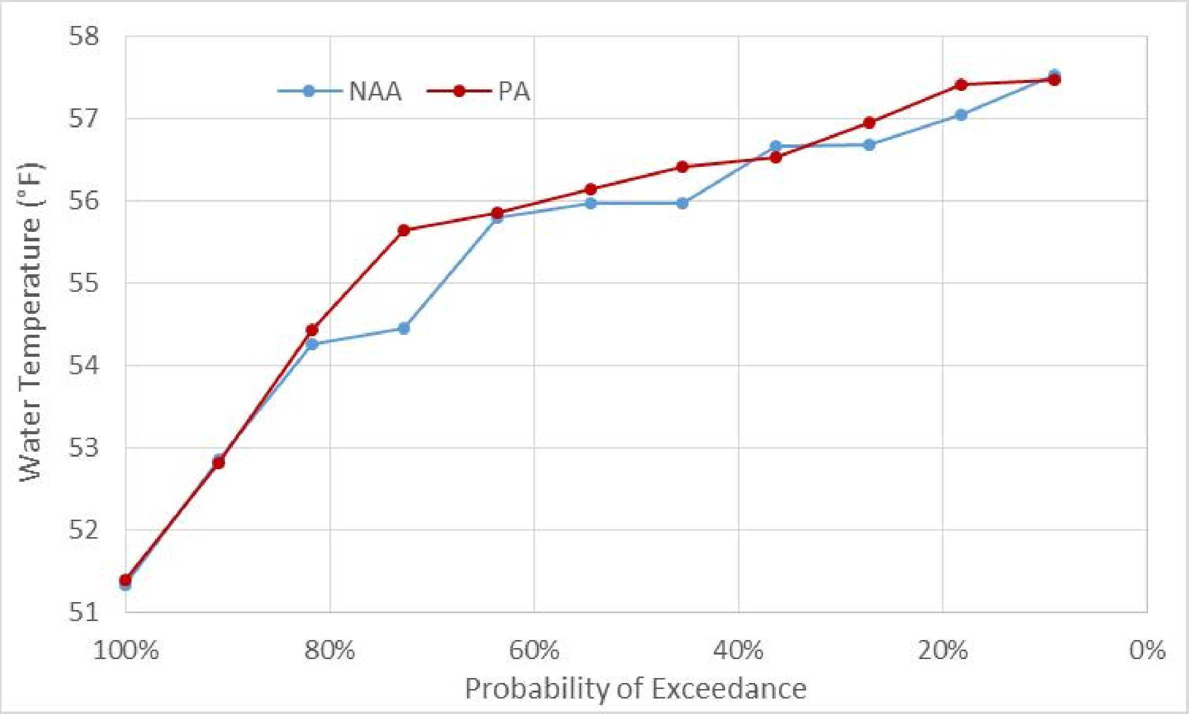

Figure 5.4-264. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the American River at Watt Avenue in March of Critical Water Years

The exceedance of temperature thresholds in the American River presented in Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-50 by modeled daily water temperatures were evaluated based on thresholds identified from the literature. For steelhead spawning and egg/alevin incubation, the threshold used was 53°F (McCullough et al. 2001).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-161 through Table 5.D-162. At both Hazel Avenue and Watt Avenue, there would be no months or water year types in which there would be either 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold or a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful water temperature-related effects on CCV steelhead spawning, egg incubation, and alevins.

5.4.2.2.3.1.2 Kelt Emigration

5.4.2.2.3.1.2.1 Flow-Related Effects

Mean monthly flows were evaluated in the American River at Nimbus Dam and the confluence with the Sacramento River during the February through May emigration period for CCV steelhead kelts (Table 5.4-77). Changes in flow potentially affect conditions for emigrating kelts, including bioenergetic cost, water quality, crowding, and passage conditions, but the quantitative relationship between flow and downstream migration is poorly understood. As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* on balance, except under very high flows, the benefits of increased flow generally outweigh the costs and, therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for emigration of CCV steelhead kelts. It is known that migration cues for anadromous fish species are often the result of natural pulse flows, which will not be affected by the PA (Milner et al. 2012; del Rosario et al. 2013). It should be noted, however, that natural pulse flows are less important for anadromous fish in the American River than in the Sacramento River because there are no significant tributaries in the lower American River, and except at very high flows, the flow is heavily controlled by Folsom Dam.

Folsom storage volume at the end of September may influence flows in the American River during kelt emigration period in some years. Mean Folsom September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 8% lower mean storage during dry water years under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-5).

Differences in mean flow between the PA and the NAA would be consistently similar at the Nimbus and confluence locations (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-16, Table 5.A.6-17). Mean flow under the PA would be similar to (less than 5% difference) flow under the NAA during most months and water year types of the CCV steelhead kelt emigration period. The only notable differences (greater than 5% difference) would occur in February of below normal water years and March and April of critical years. Mean flow under the PA would be 7% higher during February, 10% to 11% lower during March, and 7% to 8% lower during April.

The CALSIM modeling results given here indicate that the PA would have little effect on flow during the kelt migration period.

5.4.2.2.3.1.2.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the February through May kelt emigration period for steelhead in the American River from Hazel Avenue to Watt Avenue (Table 5.4-77) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-14, Table 5.C.7-15. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or less than 1%) throughout the reach in all months and water year types of the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.2°F, or 0.4%, and would occur at Watt Avenue during critical years in March.

Exceedance plots of mean monthly water temperatures were examined during each month and water year type throughout the kelt migration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.14-7, Figure 5.C.7.15-7). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of critical water years during March at Watt Avenue, where the largest increase in mean monthly water temperature was seen, reveals that the curves were similar overall and that that the difference of 0.2°F in mean monthly temperatures between NAA and PA would cause no substantial differences between curves for the NAA and PA in the exceedance plot (Figure 5.4-265).

There have been no known studies evaluating specific temperature effects on emigrating kelts. Therefore, adult immigration thresholds of 68°F 7DADM and 70°F were used for kelt migration, with an assumption that kelts migrating downstream would be affected by water temperatures similarly to adults migrating upstream (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-50). The 68°F 7DADM threshold was taken from USEPA (2003) and the 70°F threshold represents the average of the studies cited in Richter and Kolmes (2005) for the upper end of the suboptimal temperature range. The 7DADM threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-52).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-163 through Table 5.D-166. At both Hazel Avenue and Watt Avenue, there would be no months or water year types with either a more-than-5% increase in the percent of total days exceeding the 68°F 7DADM or 70°F threshold under the PA relative to the NAA, or a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful water temperature-related effects on CCV steelhead kelt immigration.

5.4.2.2.3.1.3 Juvenile Rearing

5.4.2.2.3.1.3.1 Flow-Related Effects

As discussed above in the winter-run fry and juvenile rearing section and in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* the stranding of juvenile salmonids is not evaluated in the effects analysis due to limitations of CALSIM modeling. However, as described in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* current operations of the American River include ramping rate restrictions, designed to minimize juvenile stranding, that limit the rate at which river flow can be changed. These restrictions would be kept in place for the PA.

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the American River at the Nimbus Dam and confluence with the Sacramento River locations during the CCV steelhead year-round juvenile rearing period (Table 5.4-77). Changes in flow can affect the instream area available for rearing, along with habitat quality, and stranding of juveniles, especially in side-channel habitats.

Folsom Reservoir storage volume at the end of May and the end of September influences flow rates in the Lower American River. Mean Folsom May storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A.6-5). Mean Folsom September storage under the PA would also be similar to (less than 5% difference) storage under NAA for all water year types, except for 8% lower mean storage during dry water years under the PA.

Mean flow due to the PA at the Nimbus Dam and confluence locations would generally be similar to (less than 5% difference) flow under the NAA during winter and spring months but would often be different than flow under the NAA during the summer and fall, with exceptions (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A-6-16, Table 5.A.6-17). Differences in flow between the scenarios would be predominantly similar between Nimbus Dam and the confluence with the Sacramento River so all results for Nimbus Dam are similar to results for the confluence presented here. Flows under the PA during December through February would be similar to (less than 5% difference) those under the NAA for all months and water year types, except for 5% higher flows in December of wet and below normal years and 7% higher flow in February of below normal years. Flows during March through May would be similar to (less than 5% difference) those under the NAA for all months and water year types, except for March and April of critical water years, when flows would be up to 11% lower under the PA. During June through November, flow under the PA would be as much 32% higher than flow under the NAA, and as much as 19% lower. The flows would differ by more than 5% for at least three of the five water year types, including all of the critical water years, in each of these months. The differences in the critical water years would range from 19% lower flow to 15% higher flow under the PA. In June, flow under the PA would range from 5% to 32% higher during wet, above normal, below normal and dry years, and would be 12% lower in critical years. Flow under the PA would be up to 11% higher and 19% lower than flow under the NAA during July, up to 23% higher and 10% lower during August, up to 19% lower during September, and up to 15% higher and 13% lower in October. In November, flow under the PA would be more than 5% lower than flow under the NAA in all water year types except below normal water years, ranging up to 14% lower in wet years.

As described in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods*, no rearing habitat WUA curves were available for CCV steelhead or any other salmonid in the American River and, therefore, effects of flow on rearing habitat for steelhead in the American River were evaluated qualitatively, using the flow predictions described above for the year-round steelhead rearing period. Although, as evidenced by the rearing habitat WUA curves for Sacramento River Chinook salmon provided in Appendix 5.D, Section 5.D.2.3, *Rearing Flows Methods,* effects of river flow on rearing habitat are generally complex, it is assumed for the purposes of this effects analysis that increased flow would increase the availability and quality of rearing habitat and thereby benefit steelhead. As such, effects of the PA on CCV steelhead rearing habitat are expected to be positive during June for all water year types except critical water years, when the effects are expected to be negative. Effects during the months of September and November would also be negative for most water year types. During July, August and October, both positive and negative effects are predicted, depending on the water year type (Appendix 5.A, *CALSIM Methods and Results*). It should be noted that the assumed monotonically increasing relationship between flow and CCV steelhead rearing habitat, on which the above conclusions are based, has low certainty. The CALSIM modeling results given here indicate that the PA would reduce flow in several months and water year types and thereby potentially negatively affect juvenile rearing habitat for CCV steelhead. Further discussion regarding flow-related effects during the June through November period is provided in Section 5.4.2.3, *Summary of Upstream Effects*.

5.4.2.2.3.1.3.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures during the year-round juvenile rearing period for steelhead in the American River between Hazel Avenue and Watt Avenue (Table 5.4-77) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-14, Table 5.C.7-15. Overall, the PA would change mean water temperatures very little (predominantly less than 1°F, or approximately 1%) throughout the juvenile rearing reach in all months and water year types. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 1.0°F, or up to 1.4%, and would occur at Watt Avenue in critical water years during August.

Exceedance plots of mean monthly water temperatures were examined during each month and water year type throughout the juvenile rearing period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.14-7, Figure 5.C.7.15-7). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of critical water years during August at Watt Avenue, where the largest increase in mean monthly water temperature was seen, reveals that the colder end of the curves overlap substantially, but the higher end of the PA curves up to approximately 4°F higher for individual months depending on the exceedance percentile (Figure 5.4-265). The potential biological impacts of these differences are described below under the temperature thresholds analysis.

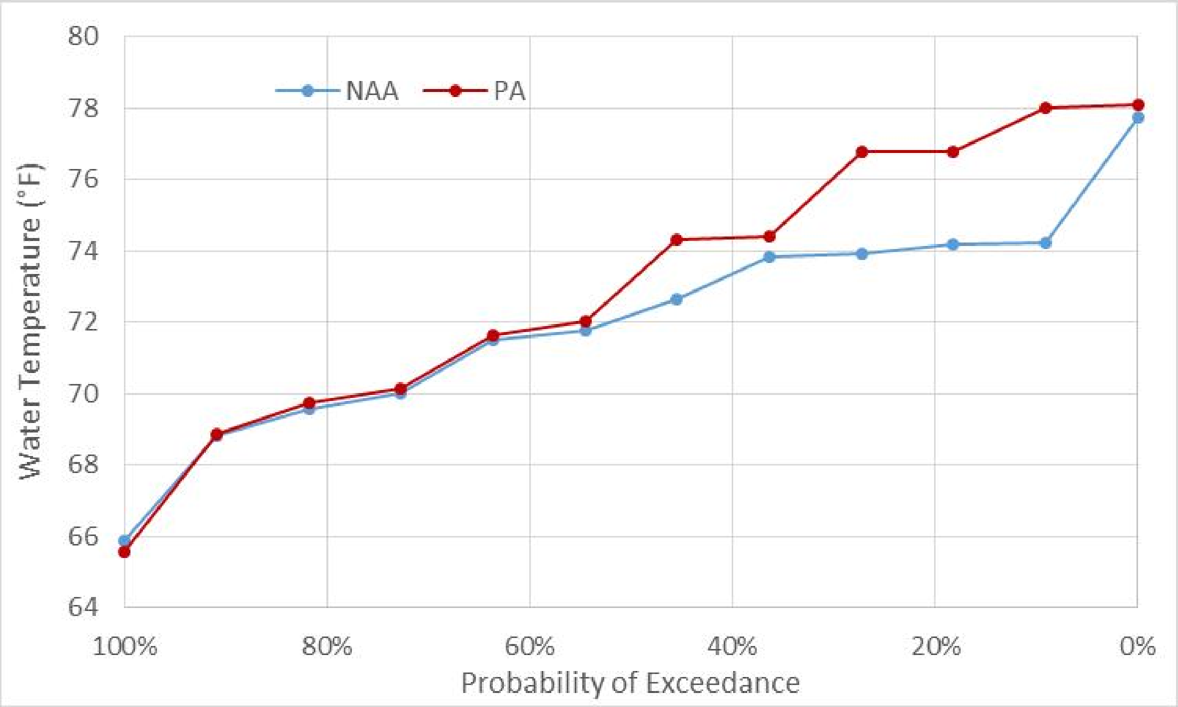

Figure 5.4-265. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the American River at Watt Avenue in August of Critical Water Years

Thresholds water temperatures of 63°F and 69°F (7DADM) were used to evaluate water temperature threshold exceedances during the steelhead juvenile rearing life stage in the American River between Hazel Avenue and Watt Avenue (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-50). The 63°F threshold was derived by taking the intermediate value of the ranges of optimal growth from several studies (Grabowski 1973; Wurtsbaugh and Davis 1977; Hokanson et al 1977; Myrick and Cech 2005; and Beakes et al. 2014). The 69°F 7DADM was used based on Sullivan (2000) and was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-52).

Results of the water temperature thresholds analysis are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-167 through 5.D-170. At Hazel Avenue, there would be two instances in which there would be more than 5% more days under the PA compared to the NAA on which temperatures would exceed the 63°F threshold: June (7.7% higher) and October (8.6% higher) of above normal water years. In neither instance would the magnitude of average daily exceedance under the PA be more than 0.5°F greater than that under the NAA. For the 69°F 7DADM threshold, there would be three instances in which there would be more than 5% more days under the PA compared to the NAA on which temperatures would exceed the threshold: July of below normal water years (5.6% higher), August of critical water years (21.0% higher), and September of dry years (5.3% higher). In July of below normal years, the average daily exceedance above the threshold under the PA would also be 1.0°F higher than that under the NAA. Furthermore, in August of critical water years, the average daily exceedance above the threshold under the PA would also be 0.7°F higher than that under the NAA. These two instances could represent biologically meaningful negative effects on rearing juvenile steelhead, although see Section 5.4.2.3, *Summary of Upstream Effects*, for a description of CALSIM limitations and real-time operations and decision making processes. In September of dry years, there would be no concurrent increase of more than 0.5°F in the magnitude of average daily exceedance under the PA relative to the NAA.

At Watt Avenue, there would be no instances in which there would be more than 5% more days under the PA compared to the NAA on which temperatures would exceed the 63°F threshold (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-169). There would be one water year type within 1 month in which the magnitude of average daily exceedance under the PA would be more than 0.5°F greater than that under the NAA: August of critical water years (1.0°F increase). There would be no instances in which there would be more than 5% more days under the PA compared to the NAA on which temperatures would exceed the 69°F threshold (Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-170), and the magnitude of average daily exceedance would be less than 0.5°F for this instance. These results indicate that there would be no biologically meaningful effect at Watt Avenue on juvenile rearing.

An additional threshold analysis was conducted to determine how the PA would affect smoltification. A 54°F threshold was used, based on an average of temperatures from Zaugg and Wagner (1973), Adams et al (1975), Zaugg (1981), and Hoar (1988), and above which smoltification can be impaired. This analysis was conducted for January through March in the reach from Hazel Avenue to Watt Avenue.

Results of the water temperature thresholds analysis for steelhead smoltification are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-173 and 5.D-174. At Hazel Avenue and Watt Avenue, there would be no months or water year types with either a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA, or a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful water temperature-related effects on CCV steelhead smoltification.

5.4.2.2.3.1.4 *Smolt Emigration*

5.4.2.2.3.1.4.1 Flow-Related Effects

Mean monthly flows were evaluated in the American River at Nimbus Dam and the confluence with the Sacramento River during the December through June emigration period, with peak migration from February through April (Table 5.4-77). Changes in flow potentially affect emigration of smolts, including the timing and rate of emigration, as well as conditions for feeding, protective cover, resting, temperature, turbidity, and other habitat factors. Crowding and stranding, especially in side-channel habitats, can also be affected (Moyle 2002; Quinn 2005; Williams 2006). While there is uncertainty in the mechanism that relates greater survival rate with greater flow, it is well-documented that juvenile salmonids migrate on flow pulses and benefit from higher flows (Milner et al. 2012; del Rosario et al. 2013). Therefore, as described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* it is assumed for the purposes of this effects analysis that increased flow would improve conditions for emigration of CCV steelhead smolts. It should be noted that natural pulse flows are less important for anadromous fish in the American River than in the Sacramento River because there are no significant tributaries in the lower American River, and except at very high flows, the flow is heavily controlled by Folsom Dam.

Folsom storage volume at the end of September potentially influences flows in the American River during the first part of the smolt emigration period, and Folsom storage at the end of May influences flows in June. Mean Folsom September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 8% lower mean storage during dry water years under the PA. Mean Folsom May storage under the PA would also be similar (less than 5% difference) to storage under NAA for all water year types (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A-6-5).

Differences in mean flow between the PA and the NAA would be consistently similar at the Nimbus and confluence locations (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A-6-16, Table 5.A.6-17). In general, mean flow under the PA would be similar to (less than 5% difference) or greater than flow under the NAA during most months and water year types of the CCV steelhead smolt emigration period. The largest changes in flow between the PA and the NAA would occur during June. Mean flow under the PA would be 5% greater during June of wet years and would range from 22% to 32% greater than flow under the NAA in above normal, below normal, and dry years. During June of critical years, flow would be 11% or 12% lower under the PA. During December, mean flows would be similar (less than 5% difference) between the PA and the NAA, except for 5% to 6% greater flow under the PA for wet and below normal years. During February of below normal years, flow under PA would be 7% higher. During March and April of critical water years, flow would be 7% to 11% lower under the PA than it would be under the NAA. The peak of the smolt emigration period occurs from February through April, so the March and April average flow reductions during critical water years would potentially have a negative effect on emigrating smolts.

5.4.2.2.3.1.4.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the American River in the reach from Hazel Avenue to Watt Avenue during the December through June smolt emigration period, with a peak during January through March (Table 5.4-77) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-14, Table 5.C.7-15. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) throughout the American River in the reach from Hazel Avenue to Watt Avenue in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.4°F (0.5 to 0.6%), and would occur at Hazel Avenue during June of above normal water years and at Watt Avenue in June of critical years. These largest increases would be outside the peak period of presence.

Exceedance plots of mean monthly water temperatures were examined during each month and water year type throughout the smolt emigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.14-7, Figure 5.C.7.15-7). The curves for PA generally match those of the NAA. Further examination of June of above normal water years at Hazel Avenue (Figure 5.4-266) and in June of critical years at Watt Avenue (Figure 5.4-267), where the largest increases in mean monthly water temperatures were seen, reveals that the curves were mostly similar overall with the exception of a few differences of more than 1°F in the middle of the range.

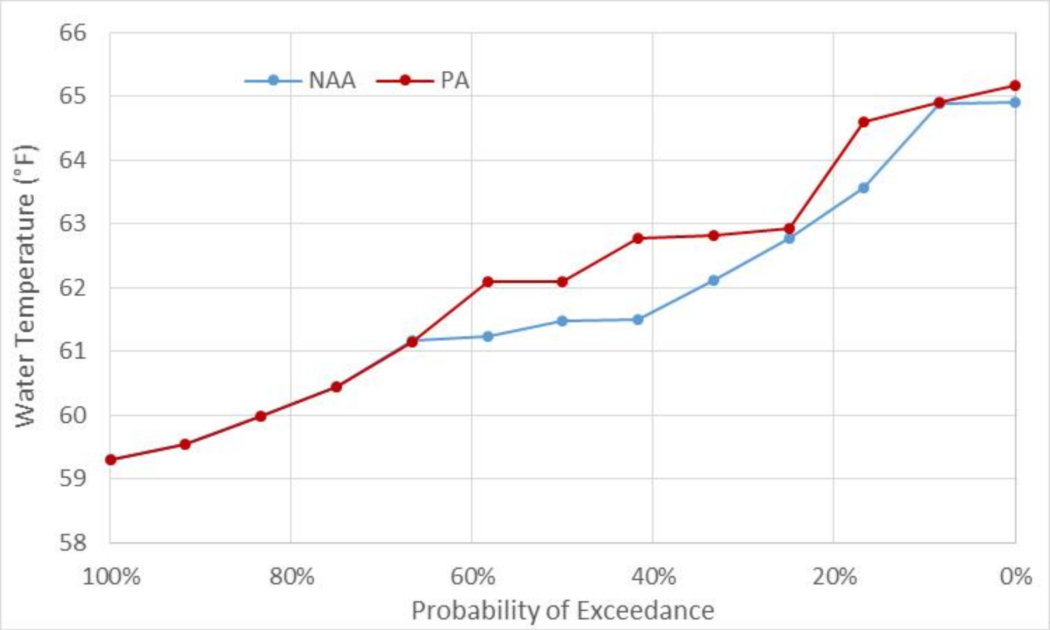

Figure 5.4-266. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the American River at Hazel Avenue in June of Above Normal Water Years

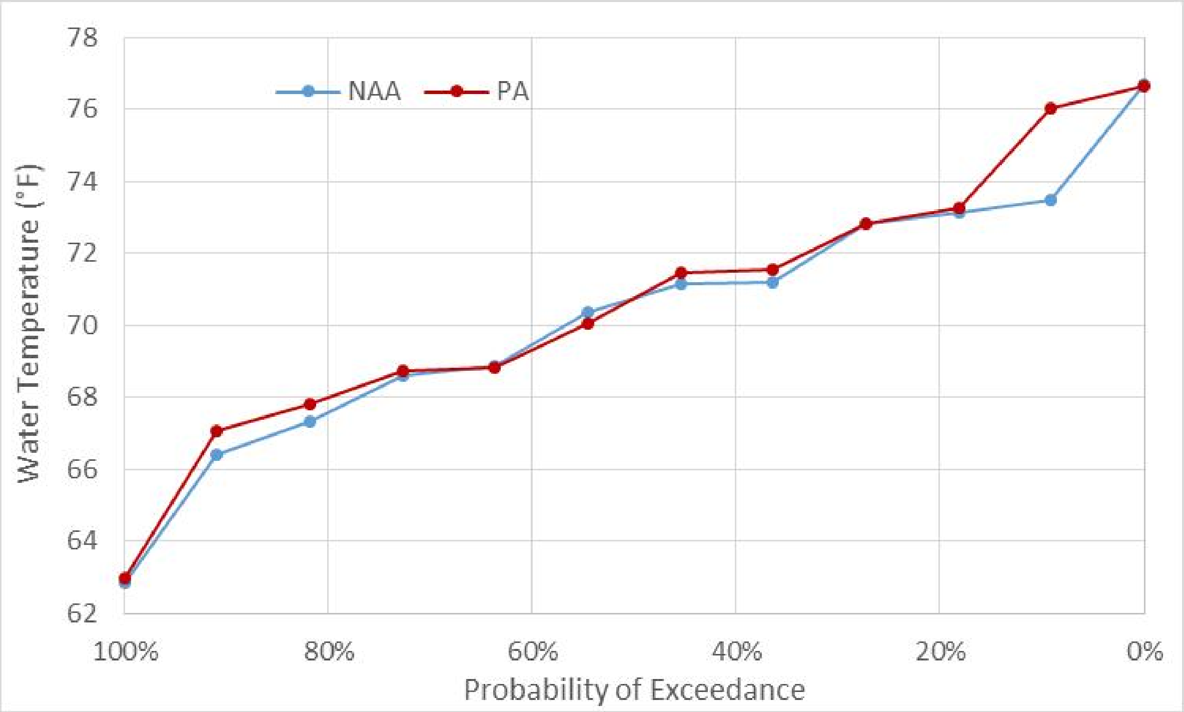

Figure 5.4-267. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the American River at Watt Avenue in June of Critical Water Years

The exceedance of temperature thresholds in the American River between Hazel Avenue and Watt Avenue presented in Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-50 by modeled daily water temperatures were evaluated based on thresholds identified in USEPA's temperature water quality guidance (U.S. Environmental Protection Agency 2003). Two thresholds, 61°F 7DADM and 64°F 7DADM, were evaluated. The 61°F value represents the core, defined by USEPA (2003) as "moderate to high density", location of Hazel Avenue and the 64°F value represents non-core, defined by USEPA (2003) as "low to moderate density", location of Watt Avenue. The 7DADM values were converted by month to function with daily model outputs (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-52).

Results of the water temperature thresholds analysis for steelhead smolt emigration are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5-D-171 and Table 5.D-172. At both Hazel Avenue and Watt Avenue, there would be no months or water year types with a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA, or with a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful water temperature-related effects on CCV steelhead smolt emigration.

5.4.2.2.3.1.5 Adult Immigration

5.4.2.2.3.1.5.1 Flow-Related Effects

Mean monthly flows were evaluated in the American River at Nimbus Dam and the confluence with the Sacramento River during the October through April immigration period, with peak migration from December through February (Table 5.4-77). Changes in flow potentially affect conditions for upstream migration of adults, including bioenergetic cost, water quality, crowding, cues for locating natal streams, and passage conditions, but the quantitative relationship between flow and upstream migration is poorly understood (Quinn 2005; Milner et al. 2012). As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* on balance, except under very high flows, the benefits of increased flow generally outweigh the costs and, therefore, it is assumed for the purposes of this effects analysis that increased flow would improve conditions for upstream migration of adult CCV steelhead. It is known that migration cues for anadromous fish species are often the result of natural pulse flows, which will not be affected by the PA (Milner et al. 2012; del Rosario et al. 2013). It should be noted, however, that natural pulse flows are less important for anadromous fish in the American River than in the Sacramento River because there are no significant tributaries in the lower American River, and except at very high flows, the flow is heavily controlled by Folsom Dam.

Folsom storage volume at the end of September influences flows in the American River during much of the immigration period. Mean Folsom September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 8% lower mean storage during dry water years under the PA (Appendix 5.A, *CALSIM Methods and Results* Table 5.A.6-5).

The differences in mean flow between the PA and the NAA at the Nimbus location would consistently be similar to the differences at the confluence location (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A-6-16, Table 5.A.6-17). During November, mean flow under the PA would be lower (up to 13% lower at Nimbus and 14% lower at the confluence) in all water year types, except below normal years, when there would be little difference in flow. Flow would also be 13% lower in October of wet years and up to 11% lower in March and April of critical years. The largest increases in flow would occur during October of critical years (14% greater at Nimbus and 15% greater at the confluence) and below normal years (8% greater flow at both locations). During the December through February peak of the adult immigration period, mean flows would be similar (less than 5% difference) between the PA and the NAA or would be slightly greater under the PA. The CALSIM modeling results given here indicate that the PA would reduce flow in some months and water year types, although this does not consider real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* that would be used to avoid and minimize any modeled effects. Further discussion regarding flow-related effects during the June through November period are provided in Section 5.4.2.3, *Summary of Upstream Effects*.

As described in Appendix 5.D, Section 5.D.2.4, *Migration Flows Methods,* mean monthly flow below about 1,000 cfs is considered to have potentially adverse effects on CCV steelhead adult immigration conditions in the American River. The effect of the PA on the frequency of flows below this threshold was evaluated by comparing CALSIM flows between the PA and the NAA at Nimbus Dam and the confluence with the Sacramento River. Mean flow at the Nimbus Dam was less than 1,000 cfs for 92 of the 574 months (16.0%) within the CCV steelhead migration period under the NAA and for 93 months (16.2%) of migration period under the PA. Mean flow at the confluence was less than 1,000 cfs in 112 months (19.5%) under the NAA and 106 months (18.5%) under the PA (Table 5.4-81). These results indicate that the PA would have an insignificant effect, with respect to the frequency of flow below the 1,000 cfs threshold, on adult CCV steelhead immigration conditions in the American River.

Table 5.4-81. Number and Percent of the 574 Months within the California Central Valley Steelhead Adult Immigration Period from the 82-year CALSIM Record with Flow < 1,000 cfs

	Months with Mean Flow < 1,000 cfs		Percent with Mean Flow < 1,000 cfs		Difference in Months and Percent Difference
Location	NAA	PA	NAA	PA	PA vs. NAA
Nimbus	92	93	16.0	16.2	1 (1%)
Confluence	112	106	19.5	18.5	-6 (-5%)

5.4.2.2.3.1.5.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the American River at Hazel Avenue and Watt Avenue during the October through April adult immigration period for steelhead (Table 5.4-77) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-14, Table 5.C.7-15. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.2°F (0.4%), and would occur at Hazel Avenue during October of above normal water years, and at Watt Avenue during March of critical water years and October of above normal water years.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the adult immigration period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.14-7, Figure 5.C.7.15-7). The values for the PA in these exceedance plots generally match those of the NAA period. Further examination of October of above normal water years at Hazel Avenue (Figure 5.4-268), March of critical water years at Watt Avenue (Figure 5.4-264), and October of above normal water years at Watt Avenue (Figure 5.4-269), where the largest increases in mean monthly water temperatures were seen, reveals that the curves were largely similar overall and that the difference of 0.2°F in mean monthly temperatures between NAA and PA would cause no substantial differences between curves for the NAA and PA in each exceedance plot. A difference of 0.2°F is likely within the uncertainty of the CALSIM and HEC5Q models, as described in Appendix 5.A, *CALSIM Methods and Results*, Section 5.A.4.5, *Limitations and Appropriate Use of Model Results*, and Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.2.5, *Model Limitations*. One exception would be at Hazel Avenue in October of above normal water years, in which there would be 2 years during which water temperatures under the PA would be approximately 1°F higher than those under the NAA (Figure 5.4-268). Further examination of these years reveals that this appears to be due to CALSIM II attempting to balance storage levels among the CVP reservoirs and there are no operational requirements, such as cold-water pool storage, temperature, or outflow requirements, that would cause these years to differ so widely in water temperatures. Mean Folsom September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 8% lower mean storage during dry water years under the PA (Appendix 5.A, *CALSIM*

Methods and Results).Therefore, there is no practical reason why actual operations under the PA would be different from those under the NAA in these months and years.

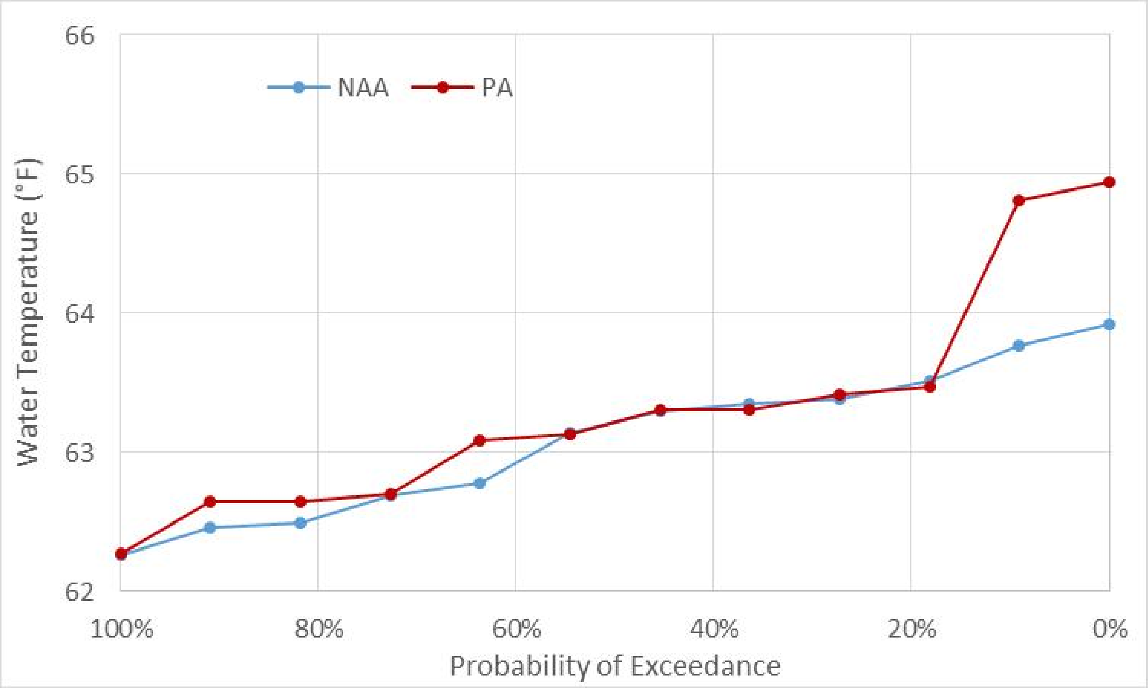

Figure 5.4-268. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the American River at Hazel Avenue in October of Above Normal Water Years

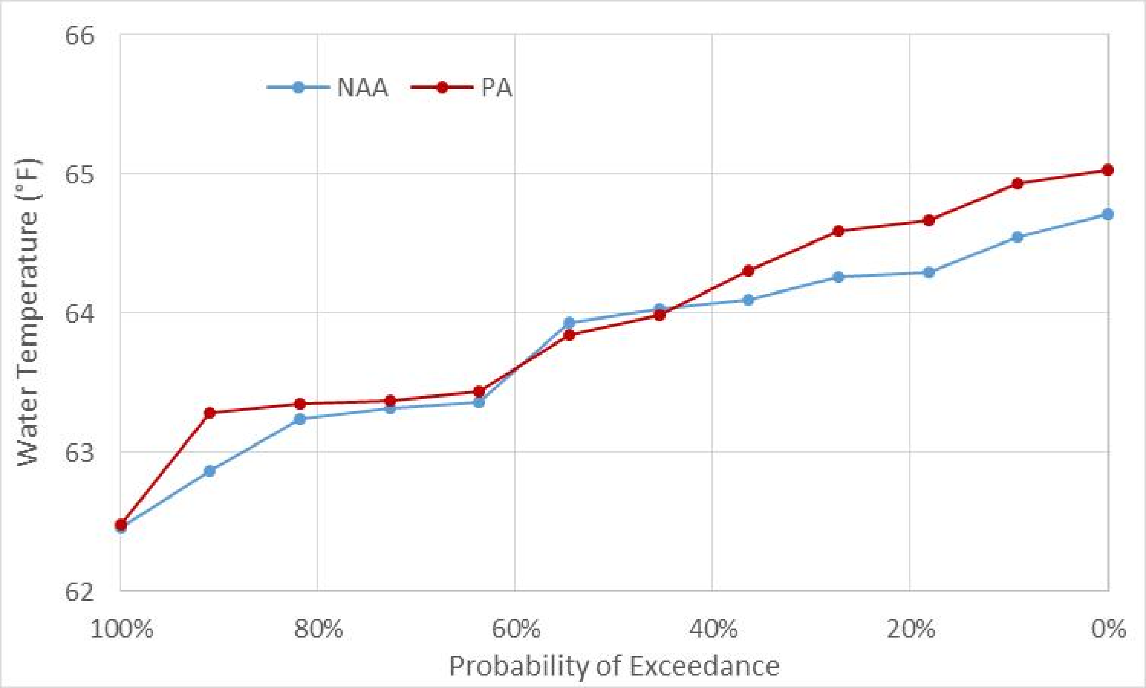

Figure 5.4-269. Exceedance Plot of Mean Monthly Water Temperatures (°F) in the American River at Watt Avenue in October of Above Normal Water Years

To evaluate water temperature threshold exceedance during the steelhead adult immigration life stage at Hazel Avenue and Watt Avenue, thresholds of 68°F 7DADM and 70°F were used (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-50). The 68°F 7DADM threshold was taken from USEPA (2003) and the 70°F threshold represents the average of the studies cited in Richter and Kolmes (2005) for the upper end of the suboptimal temperature range. The 7DADM threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-52).

Results of the water temperature thresholds analysis for adult steelhead immigration are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Table 5.D-175 through Table 5.D-178. At both Hazel Avenue and Watt Avenue, there would be no months or water year types with a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA, or with a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful water temperature-related effects on adult CCV steelhead immigration.

5.4.2.2.3.1.6 Adult Holding

5.4.2.2.3.1.6.1 Flow-Related Effects

Mean monthly flow rates and reservoir storage volumes were examined for the PA and NAA in the American River during the October and November holding period for Central Valley steelhead (Table 5.4-77). Changes in flow likely affect holding habitat for steelhead, with higher flows potentially providing greater depths and improved water quality in pools. Folsom Reservoir storage volume at the end of September influences flow rates below the dam during the steelhead holding period. Mean Folsom September storage under the PA would be similar (less than 5% difference) to storage under NAA for all water year types, except for 8% lower mean storage during dry years under the PA (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A-6-5). The mean flows at the Nimbus Dam location in the American River during October would be 8% and 14% higher under the PA than the NAA for below normal and critical water year types, respectively, and would be 13% lower for wet years (Appendix 5.A, *CALSIM Methods and Results*, Table 5.A-6-16). During November, mean flow under the PA would be 8% to 13% lower than flow under the NAA in all except below normal water years, for which there would be little difference (less than 5%). On balance, the changes in flow are expected to have an insignificant effect on Central Valley steelhead holding habitat.

5.4.2.2.3.1.6.2 Water Temperature-Related Effects

Modeled mean monthly water temperatures in the American River at Hazel Avenue and Watt Avenue during the October and November steelhead adult holding period (Table 5.4-77) are presented in Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Table 5.C.7-14, Table 5.C.7-15. Overall, the PA would change mean water temperatures very little (less than 1°F, or approximately 1%) at these locations in all months and water year types in the period. The largest increase in mean monthly water temperatures under the PA relative to NAA would be 0.2°F (0.4%), and would occur at both locations during October of above normal water years.

Exceedance plots of monthly mean water temperatures were examined during each month throughout the adult holding period (Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.7, *Upstream Water Temperature Modeling Results,* Figure 5.C.7.14-7, Figure 5.C.7.15-7). The values for the PA in these exceedance plots generally match those of the NAA. Further examination of October in above normal years at Watt Avenue (Figure 5.4-267), where the largest increase in mean monthly water temperatures were seen, reveals that the curves were largely similar overall and that the difference of 0.2°F in mean monthly temperatures between NAA and PA would cause no substantial differences between curves for the NAA and PA in the exceedance plot. A difference of 0.2°F is likely within the uncertainty of the CALSIM and HEC5Q models, as described in Appendix 5.A, *CALSIM Methods and Results*, Section 5.A.4.5, *Limitations and Appropriate Use of Model Results*, and Appendix 5.C, *Upstream Water Temperature Methods and Results*, Section 5.C.2.5, *Model Limitations*. Further examination of October of above normal water years at Hazel Avenue (Figure 5.4-266), also where the largest increase in mean monthly water temperatures were seen, reveals that there would be 2 years during which water temperatures under the PA would be approximately 1°F higher than those under the NAA. However, upon closer examination, this is appears to be due to CALSIM II attempting to balance storage levels among the CVP reservoirs and there are no operational requirements, such as cold-water pool storage, temperature, or outflow requirements, that would cause these years to differ so widely in water temperatures. Therefore, there is no practical reason why actual operations under the PA would be different from those under the NAA in these months and years.

To evaluate water temperature threshold exceedance during the steelhead adult holding life stage at Hazel Avenue and Watt Avenue, the USEPA's 7DADM threshold value of 61°F was used Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-50) (U.S. Environmental Protection Agency 2003). The threshold was converted to function with daily model outputs for each month separately (Appendix 5.D, Section 5.D.2.1, *Water Temperature Analysis Methods*, Table 5.D-52).

Results of the water temperature thresholds analysis for adult steelhead holding are presented in Appendix 5.D, Section 5.D.2.5, *Detailed Water Temperature Threshold Analysis Results*, Tables 5.D-179 and 5.D-180. At both Hazel Avenue and Watt Avenue, there would be no months or water year types with a more-than-5% increase in the percent of total days exceeding the threshold under the PA relative to the NAA, or with a more-than-0.5°F difference in the magnitude of average daily exceedance. Therefore, it was concluded that there would be no biologically meaningful water temperature-related effects on adult CCV steelhead holding.

5.4.2.2.4 Assess Risk to Individuals

5.4.2.2.4.1 California Central Valley Steelhead

Based on the responses of CCV steelhead salmon exposed to the PA described in Section 5.4.2.1.3, *Assess Species Response to the Proposed Action*, above, the risk to individuals would be small to insignificant in the American River. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects. Fitness of individuals, including reproductive success during spawning, survival during embryo incubation, survival and growth during juvenile rearing, survival and growth during immigration and emigration, and expression of life history as a result of spawning, rearing, and migration habitat availability, would mostly differ insignificantly between the NAA and PA. As described above, modeling results indicated one month (November at Nimbus and the Sacramento River confluences during most water year types) in which there would be reductions in flow under the PA. These reductions would potentially increase mortality risk during the adult migration period. Please see Section 5.4.2.3, *Summary of Upstream Effects*, for a description of how real-time operational management of the PA may reduce the likelihood that these effects would occur.

5.4.2.2.5 Effects of the Action on Designated and Proposed Critical Habitat

The Central Valley steelhead critical habitat designation final rule (September 2, 2005, 70 FR 52488) provides PBFs that are essential to the conservation of the species. The American River provides several PBFs that support one or more life stages of CCV steelhead. Because the American River is exclusively a freshwater riverine system, only PBFs pertaining to freshwater riverine systems are discussed here.

Please see Section 5.4.2.3, *Summary of Upstream Effects*, for a description of how real-time operational management of the PA may reduce the likelihood that the effects described here would occur.

5.4.2.2.5.1 California Central Valley Steelhead

5.4.2.2.5.1.1 Spawning Habitat

As indicated in Section 5.4.2.2.3.1.1, *Spawning, Egg Incubation, and Alevins*, effects of the PA on flows and water temperatures relative to the NAA in the CCV steelhead spawning reach in the American River during the spawning period would be insignificant. Therefore, the results indicate that there would be insignificant effects of the PA on this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which would be used to avoid and minimize any modeled effects.

5.4.2.2.5.1.2 Freshwater Rearing Habitat

As indicated in Section 5.4.2.2.3.1.3, *Juvenile Rearing*, effects of the PA on flows and water temperatures relative to the NAA in the juvenile rearing reach of CCV steelhead in the American River during the rearing period would insignificant. Therefore, the results indicate that there would be insignificant effects of the PA on this PBF.

5.4.2.2.5.1.3 Freshwater Migration Corridors

As indicated in Section 5.4.2.2.3.1.2, *Kelt Emigration* and Section 5.4.2.2.3.1.4, *Smolt Emigration*, effects of the PA on flows and water temperatures relative to the NAA in the CCV steelhead migration corridor in the American River during the kelt and smolt migration periods would insignificant. As indicated in Section 5.4.2.2.3.1.5, *Adult Immigration*, there would be reductions in flow between the NAA and PA, especially during November. These results indicate that there would be a potential risk during November of negative effects of the PA on this PBF. This conclusion does not include consideration of real-time operational management described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time*

Operational Decision-Making Process, which would be used to avoid and minimize any modeled effects.

5.4.2.3 Summary of Upstream Effects

The results presented in Section 5.4.2.1 *Sacramento River*, and Section 5.4.2.2, *American River*, indicate that, overall, upstream effects of the PA on winter- and spring-run Chinook salmon, CCV steelhead, and green sturgeon are expected to be predominantly small to insignificant. There are a few particular upstream changes described here that are noteworthy because physical conditions under the PA may potentially cause degraded conditions relative to the NAA for these species, although there is considerable uncertainty in the likelihood of a biological effect resulting from the changes in the physical conditions. Under each change stated below, differences in the physical conditions under the PA relative to the NAA that are the key drivers are identified. The noted upstream changes are primarily a result of reductions in the September and November flows under the PA relative to the NAA, as modeled using CalSim II. An explanation of whether the physical drivers that may cause degraded conditions for the species under PA as modeled can be avoided during actual PA operations is also provided.

1. **Increased frequency of exceedance of water temperature thresholds for rearing winter- and spring-run Chinook salmon during September from Keswick to Red Bluff, especially in below normal water years, under the PA relative to the NAA.** These increases in the modeled frequency of water temperature threshold exceedances likely result primarily from reduced Shasta releases associated with the PA's operational modeling. Modeling of the coldwater pool volume, which is more indicative of temperature management suggests PA end-of-September (EOS) storage similar to that of the NAA (Appendix 5.C, Table 5.C.7.21-1, *Shasta Cold Water Pool Volume*). If real-time cold water pool management efforts under the PA use similar decision making tools and criteria as currently utilized (i.e. NAA), then releases from Shasta Lake under the PA would actually be sustained at similar levels as the NAA during September. Thus, it is likely that the PA would not experience higher water temperatures relative to the NAA during September, as was modeled in this analysis. Further, Reclamation is committed to participating in the OCAP RPA revision process with NMFS and other federal and state agencies to improve egg-to-fry survival to Red Bluff, as described below.

2. **Increased frequency of exceedance of water temperature thresholds for spawning winter- and spring-run Chinook salmon during August and September (and into October) in the Sacramento River from Clear Creek to Bend Bridge, especially in above normal and below normal water years, under the PA relative to the NAA.** As noted above the increased temperatures in the reach of the Sacramento River downstream of Clear Creek are primarily a result of the lower Shasta releases under the PA relative to the NAA. Given that winter-run Chinook salmon spawning is limited to the Sacramento River upstream of Clear Creek (see Section 5.4.2.1.2, *Assess Species Exposure*), and the temperatures within this reach under the PA are similar to the NAA, it is likely that there would be insignificant, if any, effects on the spawning winter-run Chinook salmon under the PA relative to the NAA. The majority of spring-run Chinook salmon in the Sacramento River spawn upstream of Battle Creek, so there is some overlap with the reach in which the frequency of exceeding water temperature thresholds increase under

the PA relative to the NAA. In addition, for all water year types during these months in which there is an increase of 5% in the frequency of exceedance under the PA relative to the NAA, the actual difference in mean magnitude of exceedance would be insignificant (<0.5°F) (Section 5.4.2.1.3.1.1.2, *Water Temperature-Related Effects*, and Section 5.4.2.1.3.2.2.2, *Water Temperature-Related Effects*). Therefore, although there are more exceedances under the PA during these months, the magnitude would be insignificant. Moreover, as discussed above, in reviewing the modeled cold water pool conditions in the Shasta Reservoir leading to the releases in the late summer months and assuming similar real-time cold water pool management decisions under the PA and the NAA, the PA is likely to result in similar conditions as the NAA (Appendix 5C, Table 5.C.7.21-1, *Shasta Cold Water Pool Volume*). Thus, it is likely that the PA would not experience higher water temperatures relative to the NAA during August and September, as was modeled in this analysis. Further, Reclamation is committed to participating in the OCAP RPA revision process with NMFS and other federal and state agencies to improve egg-to-fry survival to Red Bluff, as described below.

3. **Increased risk of redd dewatering for June cohorts of winter-run Chinook salmon and August cohorts of winter-run and spring-run Chinook salmon in the Sacramento River from Keswick to Battle Creek under the PA relative to the NAA.** This increase risk is a result of the lower Shasta releases in September and November under the PA relative to the NAA. However, it is unlikely that the increased risk of redd dewatering seen in this analysis would occur during future operations because, as discussed above, Sacramento River flows in September would likely be sustained at similar levels as the NAA to meet cold water pool requirements.

4. **Decreased rearing weighted usable area for spring-run Chinook salmon and CCV steelhead juveniles under the PA relative to the NAA during June in the Sacramento River reaches from Keswick to A.C.I.D. Dam and from Cow Creek to Battle Creek[67].** These decreases are due to increased Sacramento River flow under the PA relative to the NAA during June. As described earlier, weighted usable area estimate is a potential indicator of suitable habitat for rearing juveniles. However, the direct biological effect of reduction in the weighted usable area in limited reaches of the Sacramento River on the rearing juveniles is uncertain. As described in the footnote below, this may only be a concern if population numbers in the Sacramento River were high enough that the habitat was limiting, which currently is not the case. Higher modeled Shasta Reservoir releases during June under the PA relative to the NAA are primarily the reason for the reduction in the weighted usable area estimates found in this analysis.

5. **Reduced flows during September, primarily in above normal, below normal, and dry water years, which may result in degraded migration conditions for juvenile winter-run and adult spring-run Chinook salmon, CCV steelhead, and green sturgeon in the Sacramento River under the PA relative to the NAA.** These reduced

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[67] Habitat limitation has not been a concern in recent years due to low population size, but it could be in the future if population size was to increase or there was a strong year class. Awareness of the effects to be managed in the best interest of the species is necessary, regardless of variability in population size

flows are primarily a result of reductions in modeled Shasta Reservoir releases. However, as described above, assuming similar real-time cold water pool management decisions under the PA and the NAA, actual differences in September Shasta Reservoir releases between the PA and the NAA would be small and reductions in migration flows, therefore, may not occur. Further, there is low certainty in the assumed positive linear relationship between flow and migration success (see Appendix 5.D, Section 5.D.2.4, *Migration Flow Methods*). Finally, migration cues for anadromous fish species are often the result of pulse flows (Milner et al. 2012; del Rosario et al. 2013), which will not be affected by the PA.

6. **Reduced flows during November, primarily in wet and above normal water years, which may result in degraded migration conditions for juvenile winter-run Chinook salmon, spring-run Chinook salmon, CCV steelhead, and green sturgeon in the Sacramento River, and CCV steelhead adults in the Sacramento and American Rivers.** These reduced flows are the result of lower releases from Shasta Reservoir and Folsom Reservoir, respectively. As noted above, there is a low certainty in the assumed positive linear relationship between flow and migration success (see Appendix 5.D, Section 5.D.2.4, *Migration Flow Methods*). Also, migration cues for anadromous fish species are often the result of pulse flows (Milner et al. 2012; del Rosario et al. 2013), which will not be affected by the PA. It should be noted, however, that natural pulse flows are less important for anadromous fish in the American River than in the Sacramento River because there are no significant tributaries in the lower American River, and except at very high flows, the flow is heavily controlled by Folsom Dam.

In summary, these CalSim II results show that the upstream storage conditions under the PA would generally be similar to the NAA. With the increased flexibility offered by the proposed north Delta diversion under the PA, additional natural excess runoff in the winter and spring months are expected to be available for the Delta exports, thereby reducing stored water releases in some fall months and improving carryover storage and cold water pool in the following year. In modeling of the NAA, given the winter and spring export restrictions under the BiOps, higher releases continue for Delta exports through the fall months unlike the PA. Thus typically model results show lower river flows in the fall months (primarily in September and November) under the PA compared to the NAA. The September flow reductions modeled under PA result in slightly higher water temperatures in the rivers compared to the NAA. These modeling outcomes do not reflect the totality of the annual, seasonal, and real-time considerations that would be used to determine how to make reservoir releases.

CalSim II, used to represent the operations of the NAA and PA, is a long-term planning model that allows for quantitative simulation of the CVP and SWP operations on a monthly time-step across a wide range of hydrologic, regulatory and operations instances. The CalSim II model uses a set of pre-defined generalized rules that represent the assumed regulations and to specify the operations of the CVP/SWP systems. These inputted rules are often specified as a function of year type or a prior month's simulated storage or flow condition. As described above, the model has no capability of adjusting these rules to respond to specific events that may have occurred historically, e.g., fish presence, levee failures, fluctuations in barometric pressure that may have affected delta tides and salinities, facility outages, etc. These generalized rules have been developed based on historical operational trends and on limited CVP/SWP operator input and only provide a coarse representation of the project operations over the inputted hydrologic conditions. Thus, results do not exactly match what operators might do in a specific month or year within the simulation period since the latter would be informed by numerous real-time considerations that cannot be inputted into the CalSim II model. Rather, results are intended to be a reasonable representation of long-term operational trends of CVP and SWP, providing the ability to compare and contrast the effect of current and assumed future operational conditions.

Day-to-day decision-making by the CVP-SWP operators considers the recommendations from many of the decision-making/advisory teams, such as the Sacramento River Temperature Technical Group (SRTTG), Water Operations Management Team (WOMT), b2 interagency team (B2IT) and American River Operations Group. CalSim II cannot consider all of these factors. Instead, CalSim II simulates a generalized representation of likely long-term operations under each scenario. Appendix 5A, *CALSIM Methods and Results*, provides a detailed description of the CalSim II model, assumptions used to model the NAA and the PA scenarios, and the many limitations of the tool, including limitations with respect to application of model outputs to analyses such as those used in this effects analysis. These analyses cannot consider the research and monitoring results that will be obtained during the Adaptive Management Program.

Most of the teams listed above include representatives from the three fishery agencies (NMFS, USFWS, and CDFW), operators, other regulatory agencies, and stakeholders. These teams provide forums for real-time information exchange between biologists and reservoir operators, leading to recommendations on the reservoir operations and compliance with existing water temperature requirements per SWRCB WRO 90-05, and to 2009 NMFS BiOp Action I.2. For example, the SRTTG provides recommendations on short-term operational aspects of reservoir management including coordinating real-time operations and reporting on the temperature requirements specified by SWRCB WRO 90-05 and the 2009 NMFS BiOp RPAs, based on the factors such as run timing, location of redds, air and surface water temperature modeling, and projected versus actual extent of the cold water pool. The current decision-making processes and the advisory groups will continue and will be improved under the PA (see Chapter 3, Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3, *Operations and Maintenance for the New and Existing Facilities*). A separate real time operations coordination team (RTOCT) will meet to assist DWR and Reclamation in fulfilling their responsibility to inform the SWP and CVP participants regarding available information and real-time decisions. This coordination effort may 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. This revised process and RTOCT will allow for minimization of modeled effects identified above to listed species under future operations of the PA.

In addition, Reclamation will work with NMFS and other state and Federal agencies to adjust the RPA Action Suite 1.2, as described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*. The adjustment will be made pursuant to the 2009 NMFS BiOp section 11.2.1.2. *Research and Adaptive Management*, where it states: “After completion of the annual review, NMFS may initiate a process to amend specific measures in this RPA to reflect new information, provided that the amendment is consistent with the Opinion’s underlying analysis and conclusions and does not limit the effectiveness of the RPA in avoiding jeopardy to listed species or adverse modification of critical habitat.” This process is anticipated to conclude in the fall of 2016, and may include refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. The adjusted RPA Action Suite I.2 will apply to Reclamation's Shasta operations. This RPA revision process is intended to improve egg-to-fry survival of winter-run Chinook salmon to Red Bluff, but would likely improve survival of other races of Chinook salmon, steelhead, and green sturgeon, depending on the timing of refinements that will be made.

5.5 Effects of Construction and Maintenance of Conservation Measures[68]

5.5.1 Tidal, Channel Margin, and Riparian Habitat Protection and Restoration

5.5.1.1 Deconstruct the Action

As summarized in Table 3.4-1 in Chapter 3, *Description of the Proposed Action*, tidal wetland restoration would be undertaken to mitigate permanent and temporary impacts from construction of the NDD, the HOR gate, and barge landings. Typical activities to be undertaken at tidal wetland restoration sites are discussed in Section 3.4.3.1, *Tidal Wetland Restoration*. The main activities include excavating channels; modifying ditches, cuts, and levees; removal/breaching and/or setting back of existing levees/embankments; and altering land surface elevations by scalping higher elevation land or importing dredge/fill. Channel margin habitat would also be restored (Table 3.4-1). As discussed in Section 3.4.3.2, *Channel Margin Siting and Design Considerations*, typical activities would include riprap removal; bench creation through grading; installation of large woody material; and planting of riparian/emergent wetland vegetation on created benches.

5.5.1.2 Assess Species Exposure

5.5.1.2.1.1 Salmonids

Construction at habitat restoration sites will be undertaken during approved in-water work windows (summer/fall) and therefore most winter-run and spring-run Chinook salmon and steelhead individuals are unlikely to be exposed; any exceptions are most likely to be adult steelhead moving upstream in fall. Once constructed, Chinook salmon and steelhead could be exposed to the restoration sites during their periods of occurrence within the Delta.

5.5.1.2.1.2 Green Sturgeon

Green sturgeon have the potential to be near restoration areas at any time of the year and therefore could be exposed to construction effects, in addition to the effects of the sites following restoration.

5.5.1.3 Assess Fish Species Response

5.5.1.3.1.1 Salmonids

As previously noted, restoration construction effects are expected to be limited given the proposed timing of in-water work. For any individuals that are present, the types of construction

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[68] Although not a conservation meaure, localized reduction of predatory fishes to minimize predator density at north and south Delta export facilities is considered in this section (see also Appendix 3.H).

effects at restoration sites are likely to be similar to those described in Section 5.2, *Effects of Water Facility Construction on Fish*, for construction of the NDD, although the magnitude of these effects will be substantially less given the minimal in-water work necessary and the area affected. These include temporary increased turbidity, effects on water quality, direct injury from equipment, and general disturbance. Construction of restoration sites will require very little in-water work and will be temporary and AMMs described in Chapter 3, *Description of the Proposed Action* (and in detail in Appendix 3.F, *General Avoidance and Minimization Measures*) will minimize construction-related effects to salmonids.

To the extent that individual migrating Chinook salmon and steelhead encounter restoration sites, the restoration may enhance habitat value in these areas, relative to the unrestored state of the habitat where the restoration is undertaken, e.g., by increasing production of prey, and providing new resting areas and cover. These newly restored areas will be designed in coordination with NMFS and DFW to maximize the potential for these new habitat areas to provide habitat values to salmon and sturgeon, while minimizing potential adverse effects. The restoration is intended to offset adverse effects from loss of habitat from water facility construction and operations, e.g., loss of physical habitat because of the NDD construction and less frequent inundation of riparian benches because of NDD operations. The extent to which this offsetting occurs is based on the acreage and linear extent of habitat that is affected, with typical restoration ratios applied (Table 3.4-1 in Chapter 3, *Description of the Proposed Action*). Potential adverse effects to Chinook salmon and steelhead from restored habitat include degraded water quality (e.g., liberation of contaminants such as mercury from soils, if such contaminants have not been removed by soil grading activities) and increased predation risk depending on site characteristics, although the latter can be avoided by careful design of restoration sites to limit potential for colonization by invasive aquatic vegetation. Such potential effects are expected to be limited in scale, given the limited size of the areas to be restored.

5.5.1.3.1.2 Green Sturgeon

As noted for salmonids, the types of construction effects from restoration are likely to be similar to those described in Section 5.2, *Effects of Water Facility Construction on Fish*, for construction of the NDD and include increased turbidity, effects on water quality, direct injury from equipment, and general disturbance, although the magnitude of these effects will be substantially less given the minimal in-water work necessary and the area affected. Construction of restoration sites will require very little in-water work and will be temporary. AMMs described in Chapter 3, *Description of the Proposed Action* (and in detail in Appendix 3.F, *General Avoidance and Minimization Measures*) will minimize construction-related effects on green sturgeon.

As described for salmonids, to the extent that individual green sturgeon encounter restoration sites, the restoration may enhance habitat value in these areas, e.g., by increasing suitable benthic habitat, which is intended to offset adverse effects from loss of habitat because of water facility construction. The extent to which this offsetting occurs is based on the acreage and linear extent of habitat that is affected, with typical restoration ratios applied (Table 3.4-1 in Chapter 3, *Description of the Proposed Action*). Potential adverse effects to green sturgeon from restored habitat include degraded water quality (e.g., liberation of contaminants from soils). Such potential effects are expected to be limited in scale, given the limited size of the areas to be restored

5.5.1.4 Assess the Effects of the Action on Designated Critical Habitat

Potential effects to designated critical habitat for listed salmonids and green sturgeon from habitat restoration would be expected to be minimal in terms of temporary construction effects because the footprint of in-water work would be contained within the breach or setback area and the immediate surroundings, AMMs would be implemented to avoid and minimize construction-related effects, and the overall time to complete in-water construction would be within a single year or less. Timing of construction would avoid species occurrence except adult steelhead and green sturgeon. All of the effects to critical habitat would be temporary, and very little construction activity would occur within critical habitat itself, as most would occur adjacent to the water. In general, however, the habitat restoration conservation measures would be expected to beneficially affect designated critical habitat of listed salmonids and green sturgeon.

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

5.5.2.1 Deconstruct the Action

As described in Appendix 3.H, localized reduction of predatory fishes will be undertaken at the NDD and Clifton Court Forebay, if approved by NMFS and DFW, using physical reduction methods, 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). Predator removal efforts will require additional feasibility evaluations prior to any actual activities in the water. Several considerations, including the most effective locations, methods, target species, and measures to avoid listed species need to be considered. As outlined in the description of this AMM, DWR and Reclamation will work with NMFS and DFW to design and implement these feasibility studies. 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 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 be focused on the winter/spring period (~December-June) when juvenile salmonids are migrating through the Delta and 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.

Given the uncertainties and constraints associated with this AMM, the predator reduction AMM will initially be implemented as an experimental feasibility assessment study and a series of connected research actions. The potential effects of the predator removal activities are described below.

5.5.2.2 Assess Species Exposure

5.5.2.2.1.1 Salmonids

The timing and locations of this AMM are intended to minimize predatory fish density at two locations where juvenile salmonids occur in appreciable numbers and therefore these juvenile salmonids will be exposed to the action. The seasonal timing of the action also indicates the potential for adult upstream migrants to be exposed to the action, in particular winter-run and spring-run Chinook salmon, but also steelhead. Most exposure will be expected to occur during the predatory fish reduction at the NDD, given its location on the main migratory route to and from the Sacramento River basin. In this regard, effects to San Joaquin River basin steelhead and spring-run Chinook salmon would not be expected to occur at the NDD, but could occur in Clifton Court Forebay.

5.5.2.2.1.2 Green Sturgeon

Year-round occurrence of green sturgeon juveniles in the Delta means that they will have the potential to be exposed to the predatory fish reduction AMM.

5.5.2.3 Assess Fish Species Response

5.5.2.3.1.1 Salmonids

The methods that could be used to implement predatory fish minimization at the NDD and Clifton Court Forebay will have some potential to adversely affect downstream-migrating juvenile salmonids, with the main effect perhaps being startling of individuals during gear deployment (which could increase predation susceptibility) or injury if contacting nets before escape through the mesh, for example. Capture of juvenile winter-run Chinook salmon, spring-run Chinook salmon, or steelhead by hook-and-line fishing will be unlikely to occur because hook sizes will target larger predatory fish. Passive or active capture methods involving traps or nets will involve mesh sizes targeting predatory fishes, through which juvenile salmonids will be able to escape. However, it is possible that juvenile salmonids could be gilled in the netting of fyke traps or enter the trap and be eaten by larger fish within the trap (National Marine Fisheries Service 2003). Electrofishing gear will be set to target fish of the size likely to be predators on juvenile salmonids, and as such will be unlikely to affect juvenile salmonids because at a given voltage gradient, total body voltage increases with length, resulting in greater potential to capture larger fish without effects to smaller fish (Reynolds and Kolz 2012). Any juvenile salmonids incidentally caught by electrofishing will be carefully handled, and if necessary held in a bucket of water until recovered, then released.

As described in the predation effects assessments for the north Delta (Section 5.4.1.3.1.1.1.3 *Predation*) and south Delta (Section 5.4.1.3.1.1.2.2 *Predation*), to the extent that predatory fish density reduction is successful, it could reduce predation on juvenile salmonids occurring near the NDD and in Clifton Court Forebay by decreasing predator densities in areas where juvenile salmon occur, and providing an increased potential for survival and successful through-Delta migration. There is uncertainty in the ability to effectively reduce predation, given that previous efforts in Clifton Court Forebay did not produce measurable decreases in predatory density (Brown et al. 1996). However, more recent evaluations in Delta channels have found that there is the potential for measurable reductions in predation (increases in survival) given sustained efforts (Cavallo et al. 2013; Sabal 2014, Sabal et al. 2016).

Adult salmonids will be more susceptible to the adverse effects of localized predatory fish reduction than juvenile salmonids, given their larger body sizes. Adult salmonids could be caught by hook and line, but any fish collected in this manner will be carefully handled and released, after being held under water to recover if necessary. Common hook and line injuries include damage to the skeletal structure of the mouth, injury to gills, and secondary infections (National Marine Fisheries Service 2003). If adult or juvenile Chinook salmon or steelhead are inadvertently shocked by the electrofishing equipment, measures will be in place to reduce mortality of these individuals. For example, field staff will be trained to quickly identify listed species and will release live, mobile fish quickly to minimize handling stress; immobilized adult steelhead or Chinook salmon will be held under the water until they recover and then they will be released. Striped bass capture with fyke nets and gill nets during the Adult Striped Bass Monitoring Project provides perspective on the rate of incidental capture of salmonids in relation to target predatory fish. The capture of striped bass was 2-3 orders of magnitude greater than the capture of Chinook salmon or steelhead (Table 5.5-1 and Table 5.5-2). Note that this program targets the time of year when adult striped bass are moving upstream to spawn, but this is coincident with the timing of upstream movement of listed salmonids, spring-run Chinook salmon, in particular. All incidentally captured listed fish were released in excellent or good condition. Additionally, if initial efforts show that this measure is ineffective and/or harmful to salmonids, it will be suspended.

Table 5.5-1. Collections of Striped Bass and Listed Fish by Fyke Trapping during April-May for the Adult Striped Bass Monitoring Project at Knights Landing, Sacramento River, 2008-2012.

Species	2008	2009	2010	2011	2012
Striped Bass	2,907	1,830	2,952	5,696	6,671
Chinook salmon	45	2	1	6	37
Steelhead	2	0	0	0	1
Green Sturgeon	4	0	0	0	1

Sources: California Department of Fish and Game (2008b), DuBois and Mayfield (2009), and DuBois et al. (2010, 2011, 2012).

Table 5.5-2. Collections of Striped Bass and Listed Fish by Gill-Netting during April-May for the Adult Striped Bass Monitoring Project in the Lower Sacramento River and San Joaquin River, 2008-2009

Species	2008	2009
Striped Bass	2,462	1,415
Chinook salmon	4	1
Steelhead	3	1
Green Sturgeon	1	0

Sources: California Department of Fish and Game (2008) and DuBois and Mayfield (2009).

5.5.2.3.1.2 Green Sturgeon

As with salmonids, there is the risk that green sturgeon could be inadvertently captured during predatory fish reduction. Given the species' demersal position in the water column, capture of green sturgeon by gillnetting is unlikely. Green sturgeon caught by other gears, e.g., trapping, seining, hook-and-line fishing, or electrofishing will be carefully released. As shown for adult salmonids, the rate of capture of green sturgeon may be low in relation to capture of targeted species such as striped bass (Table 5.5-1 and Table 5.5-2).

5.5.2.4 *Assess the Effects of the Action on Designated Critical Habitat*

As previously described, localized reduction of predatory fishes would have a very small potential to affect listed fishes, principally adults through bycatch. This would constitute an effect to the migratory corridor and access upstream PBFs of designated critical habitat.

5.5.3 Georgiana Slough Nonphysical Fish Barrier

5.5.3.1 *Deconstruct the Action*

As described in Section 3.4, *Conservation Measures*, the Georgiana Slough Nonphysical Fish Barrier (NPB) will consist of a permanent NPB to reduce the likelihood of Sacramento River-origin juvenile salmonids entering the interior Delta through Georgiana Slough. Several pilot studies have been implemented to test this concept, but no final design has been selected. Additional pilot studies will be implemented to further improve understanding and the efficacy of the future permanent barrier. The construction effects of a NPB have been outlined in previous consultations on the pilot projects that have been implemented to date (Chapter 2, *Consultation History*). The final design of the NPB may differ from those that have been tested to date, but the general types and magnitudes of construction and operational effects would not exceed those described in the previous BiOps. Based on a recent evaluation of different technology to achieve the goal of minimizing entrance of juvenile salmon into the interior Delta via Georgiana Slough, a bioacoustic fish fence (BAFF) appears to offer more potential than a floating fish guidance structure (FFGS) for this location (California Department of Water Resources 2015b), although these and other options are possibilities. The analysis presented herein focuses on the potential effects of these types of NPB, as there is precedent for their installation at this location: a BAFF was tested in 2011 and 2012, and a FFGS was tested in 2014. Both technologies block the upper portion of the water column because the focus for protection is surface-oriented juvenile salmonids. The BAFF consists of acoustic deterrence stimuli broadcast from loudspeakers and contained within a bubble curtain that is illuminated with strobe lights (to allow the fish to orient away from the sound stimulus better), whereas the FFGS is a floating series of metal plates that deters fish based on them seeing the barrier and sensing the change in flow. Whereas the pilot studies of these technologies and their construction occurred in winter/spring, for the PA, construction will occur prior to the main period of juvenile salmonid (November/December–June) occurrence, and removal will occur after this period (e.g., July).

5.5.3.2 *Assess Species Exposure*

5.5.3.2.1.1 Salmonids

Juvenile salmonids emigrating from the Sacramento River will be exposed to NPB operations, but will be unlikely to be exposed to construction/removal effects. Adult winter-run and spring-run Chinook salmon migrating upstream to natal tributaries in the Sacramento River basin will be exposed to NPB operations, but will be unlikely to overlap the construction or removal period. Adult steelhead returning to the Sacramento River basin will have the potential to overlap the construction period and the operations period.

5.5.3.2.1.2 Green Sturgeon

Green sturgeon occur year-round in the Delta and therefore could be subject to both construction and operations effects of the NPB.

5.5.3.3 Assess Fish Species Response

5.5.3.3.1.1 Salmonids

Any pile driving for NPB construction will be done with a vibratory hammer, which will minimize the potential for injury and likely limit adverse effects to avoidance by adult steelhead, the only listed salmonid likely to overlap construction. In-water work will be conducted using appropriate measures to minimize effects, as was done during the pilot implementations of the BAFF (National Marine Fisheries Service 2011) and FFGS (National Marine Fisheries Service 2014a).).

The potential effectiveness of the NPB for deterring juvenile salmonids from entry into Georgiana Slough was discussed in the context of operations in Section 5.4.1.3.1.2.1.2.2 *Nonphysical Fish Barrier at Georgiana Slough*. Operational effects also could include enhanced risk of predation near the NPB, as NPBs include in-water structures that predatory fish may use as ambush habitat, and there may be increased susceptibility to predation if migrating juvenile salmonids are startled by the NPB (particularly the BAFF, with its acoustic deterrence) and swim rapidly away. However, there was no evidence from acoustic tracking that juvenile salmonids were being preyed upon at higher rates near the BAFF compared to farther away in 2011 and 2012, and little evidence from acoustic tracking of predators that they occupied areas near the BAFF more frequently than other areas (DWR 2012, 2015). Indeed, the 2011 and 2012 BAFF pilot studies provided evidence that predatory fish were deterred by the BAFF being turned on,[69] with general evidence for increasing avoidance over time, although some species may have become conditioned to the BAFF over time and therefore will not have been deterred. Studies of the 2014 FFGS have not been completed to address these topics.

Migrating adult salmonids encountering the NPB could have upstream passage blocked or disrupted by the NPB, particularly if attempting to move upstream from Georgiana Slough to the Sacramento River, although based on the configurations used during the pilot studies[70], passage will be available under/around the FFGS, or under the BAFF. Installation of a nonphysical barrier at this location generally would not be anticipated to affect downstream-migrating juvenile San Joaquin River-origin steelhead and spring-run Chinook salmon, including fish from the Mokelumne/Cosumnes Rivers, assuming fish are generally going in a downstream direction (flow in Georgiana Slough generally being downstream). However, Del Real et al. (2012) found that a portion (20%) of acoustically tagged wild steelhead juveniles migrating from the Mokelumne River to Chipps Island migrated upstream through Georgiana Slough to the Sacramento River before moving towards Chipps Island. Upstream migration of juvenile steelhead in Georgiana Slough could lead to some individuals encountering the NPB. An FFGS

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[69] The BAFF was switched on and off every ~25 hours in order to test its effectiveness in deterring migrating juvenile salmonids.

[70] The BAFF pilot studies in 2011 and 2012 blocked the entire entrance to Georgiana Slough (allowing several feet of passage below the barrier), whereas the FFGS pilot study in 2014 had the FFGS slightly upstream of the entrance to Georgiana Slough to deter juvenile salmonids away from the left bank.

would be unlikely to pose much of a delay (assuming the whole channel mouth is not blocked), whereas a BAFF could result in passage delay or some risk of near-field predation, as discussed previously. The potential to swim under a BAFF would be good at Georgiana Slough, based on pilot studies wherein the sound stimulus and bubble-generating apparatus were in the middle of the water column in order to maintain the integrity of the bubble curtain. Alternatively, juvenile steelhead could migrate back downstream, which would lower the prospects for survival because this migration route generally results in greater mortality than the mainstem Sacramento River (Singer et al. 2013).

5.5.3.3.1.2 Green Sturgeon

As with adult steelhead, there may be limited construction effects to green sturgeon from disturbance, e.g., underwater noise from vibratory pile driving, but any construction effects will be limited with appropriate avoidance and minimization measures, as undertaken for the pilot studies and addressed in previous consultations (National Marine Fisheries Service 2011, 2014a). There will be limited potential for operational effects of the NPB on green sturgeon because the species' generally demersal position in the water column will allow passage under the NPB (with an above-bottom configuration, as employed for the BAFF in the 2011/2012 studies), and because green sturgeon that encounter the BAFF at close range would be expected to have a much more limited response to the acoustic stimuli of a BAFF compared to the response of the juvenile salmonids that the BAFF is targeting. The auditory thresholds of green sturgeon have not been determined, but the thresholds for a congeneric species (lake sturgeon, *Acipenser fulvescens*) are ~20-25 dB greater than the thresholds for juvenile Chinook salmon (Lovell et al. 2005; Oxman et al. 2007). For example, at 250 Hz, the threshold for lake sturgeon is ~130 dB re 1µPa (Lovell et al. 2005), whereas for juvenile Chinook salmon, it is just over 105 dB re 1µPa (Oxman et al. 2007). Avoidance of acoustic deterrents increases as the sound pressure level above the auditory threshold increases, with sound levels of 50-90 dB above threshold generally giving a stronger reaction than lower levels, by the majority of individuals (Nedwell et al. 2007). Given the BAFF's sound pressure levels (e.g., 146 to 159 dB re 1 µPa [mean = 152 dB re 1 µPa] for the 2011 study; Perry et al. 2014), the effects on green sturgeon would be expected to be much more limited than those for juvenile Chinook salmon, if the sturgeon encountered the BAFF and did not swim beneath it. .

5.5.3.4 Assess the Effects of the Action on Designated Critical Habitat

Designated critical habitat for listed salmonids (principally for adult steelhead) and green sturgeon could be affected by NPB construction, although the effects would be expected to be minimal and would be avoided or minimized by standard AMMs. The permanent footprint of the NPB is unknown, but given it is meant to be 'non-physical' to minimally affect flow, the footprint of the structure will be minimal and within the range described in previous consultations. Operations of the NPB would be expected to generally be beneficial to juvenile listed salmonids by keeping them in the mainstem Sacramento River; this would increase the proportion of winter-run Chinook salmon juveniles remaining within designated critical habitat, as only the mainstem Sacramento River is designated as critical habitat within this portion of the action area. As previously described, delay of adult salmonids (or juvenile steelhead from the Mokelumne River) migrating upstream through Georgiana Slough could occur, which would be an effect to migratory corridor or upstream access PBFs; however, passage around or under the NPB would be available. Green sturgeon tend to be demersal and have limited hearing ability in the range of the acoustic deterrent compared to the juvenile salmonids targeted by a BAFF (see discussion in Section 5.5.3.3.1.2 above), so effects from the NPB on critical habitat would be minimal and limited to temporary occupation of benthic habitat by supporting piles, for example.

5.6 Effects on Southern Resident Killer Whale

The Southern Resident killer whale DPS had 83 members as of April 13, 2016, excluding "Lolita", the confined individual at the Miami Seaquarium (Orca Network 2016). The DPS has a variable productivity rate (National Marine Fisheries Service 2009).

Two factors that could change under the PA and could affect Southern Resident killer whale are prey availability and exposure to contaminants.

5.6.1 Effects on Prey Availability

The PA will be implemented in freshwater and estuarine systems, but its effect may reach the marine system occupied by Southern Resident killer whales because Chinook salmon, the predominant prey of Southern Resident killer whales (Hanson et al. 2010, National Marine Fisheries Service 2014b), reside in the ocean for three to five years until returning to freshwater to spawn. A change in Southern Resident killer whale prey abundance could affect foraging efficiency, including the amount of energy expended per prey capture, ultimately affecting overall nutrition, reproductive capacity, immunity, and, if severe enough, survival. Changes in the average size and caloric density of prey fish can also influence the number of captures necessary to meet energetic requirements (O'Neill et al. 2014). Photographs of thin whales and observations of the "peanut-head syndrome" (loss of the nuchal fat pad behind the skull) in Southern Resident killer whales suggest that a few individuals in some seasons are significantly emaciated, although the ultimate cause of such malnutrition could be disease and other factors rather than a food shortage (NMFS 2010).

Changes to prey availability can act synergistically with other threats to produce a beneficial or adverse effect. For example, insufficient prey abundance could force whales to rely upon their fat stores, which may contain high contaminant levels (Ross et al. 2000). An increase in contaminant levels in the blood stream could induce immune suppression, impair reproduction, and produce other adverse physiological effects.

The PA has a potential to affect overall Chinook salmon abundance in the ocean. Fall-run Chinook salmon compose the large majority of Chinook salmon produced in the Central Valley, averaging an estimated 89% of total Chinook salmon escapement from 2006 to 2015 (CDFW 2016), and are the most common Central Valley Chinook salmon race eaten by Southern Resident killer whales (Hanson et al. 2010, National Marine Fisheries Service 2014b). Wild individuals make up 10 ± 6% of the overall fall-run Chinook salmon ocean fishery (Barnett-Johnson et al. 2007). Combined, these two values suggest that hatchery fall-run constitute a substantial proportion of all Chinook salmon entering the ocean from the Central Valley. This analysis of prey availability focuses on the fall-run Chinook, with special emphasis on hatchery produced fall-run, since this race, of all Central Valley salmon races, is currently the predominant prey of Southern Resident killer whales.

5.6.1.1 Effects of the Proposed Action on Central Valley Chinook Salmon Populations

The PA has the potential to result in incidental take of fall-run Chinook salmon associated with construction and operations. Construction effects include underwater noise from pile driving, in-water use of construction equipment, fish rescue efforts, and accidental discharge of contaminants (Section 5.2, *Effects of Water Facility Construction on Fish*). The effects of construction activities will be minimized through avoidance and minimization measures, and temporary and permanent habitat losses will be offset by channel margin enhancement and tidal wetland restoration.

As described in Appendix 5E, *Essential Fish Habitat Assessment*, the following changes have a potential to affect fall-run Chinook salmon in the Sacramento and American Rivers, upstream of the Delta. These changes are expected to result from operational effects of the PA: (1) increased frequency of water temperature threshold exceedances in the Sacramento River during September and October, coinciding with a portion of the spawning and juvenile rearing period; (2) decreased rearing habitat Weighted Usable Area (WUA) during June in some portions of the Sacramento River; (3) reduced flows in the Sacramento and American Rivers during some water year types in September and November that coincide with portions of the adult migration period; and (4) increased risk of redd dewatering for egg cohorts spawned in October in the Sacramento and American Rivers.

As discussed in Section 5.4.2.3, *Summary of Upstream Effects*, all upstream quantitative analyses are based on CalSim II modeling, and the uncertainties associated with using CalSim II outputs must be considered in interpreting biological analyses, as noted in Appendix 5.A, *CALSIM Methods and Results*. Results of CalSim II modeling do not exactly match what operators might do in a specific month or year within the simulation period because the latter would be informed by numerous real-time considerations that cannot be input to CalSim II. Rather, results are intended to be a reasonable representation of long-term operational trends of CVP and SWP, providing the ability to compare and contrast the effect of current and assumed future operational conditions.

The current real-time operations decision-making processes and the advisory groups will continue and will be improved under the PA (see Chapter 3, Section 3.1.5 *Real-Time Operations Upstream of the Delta*, and Section 3.3, *Operations and Maintenance for the New and Existing Facilities*). A separate real time operations coordination team (RTOCT) will meet to assist DWR and Reclamation in fulfilling their responsibility to inform the SWP and CVP participants regarding available information and real-time decisions. This coordination effort may 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. This revised process and RTOCT will allow for minimization of modeled effects identified above to listed species under future operations of the PA.

In the Delta, the PA has the potential to affect fall-run Chinook salmon through entrainment (Appendix 5E, Section 5.E.5.3.1.2.1.1.1 *North Delta Exports* and Section 5.E.5.3.1.2.1.1.2, *Entrainment*), impingement (Appendix 5E, Section 5.E.5.3.1.2.1.1.1 *North Delta Exports*), predation at the NDD and south Delta facilities (Appendix 5E, Section 5.E.5.3.1.2.1.1.3 *Head of Old River Gate* and Section 5.E.5.3.1.2.1.1.1 *Predation*), and changes in flows that may affect migratory success, including both near-field and far-field effects (Appendix 5E, Section 5.E.5.3.1.2.1.2.1, *Indirect Mortality Within the Delta*) or availability of inundated riparian bench habitat (Appendix 5E, Section 5.E.5.3.1.2.1.2.2 *Habitat Suitability*). The principal near-field effect is predation at the NDD. The far-field effects primarily include NDD water diversions leading to lower flow velocity and therefore greater potential for predation; potential for greater entry into the interior Delta via Georgiana Slough (a lower survival route compared to the main stem Sacramento River); and less inundation of restored riparian bench habitats along the Sacramento River. For the south Delta, the PA is expected to reduce operational effects on fall-run Chinook salmon compared to the NAA based on improved south Delta channel flows, lower entrainment, and lower entry into the south Delta because of the HOR gate. Actions taken in compliance with NMFS (2009) and the proposed operational criteria for south Delta, NDD, and DCC provide protection during the winter and spring, thereby reducing the impact of CVP/SWP Delta operations on migrating fall-run Chinook salmon. In general, potential effects of the PA on fall-run Chinook salmon are expected to be less than those for winter-run and spring-run Chinook salmon because the timing of fall-run migration coincides more with the spring period, during which Sacramento River flows under the PA would be more similar to those under the NAA compared to other times of year.

The RTOCT and the Adaptive Management Program included in the PA provide additional opportunities to better define the operating criteria and make adjustments to CVP/SWP Delta operations to minimize the risk of incidental take while maximizing water supply. Identified operational effects of the PA on Sacramento winter-run and Central Valley spring-run Chinook salmon would be mitigated, and this mitigation is expected to reduce effects on fall-run Chinook salmon. The mitigation includes restoring channel margin habitat (Section 5.4.1.3.1.2.2.1.2 *Operational Effects*) and installing a nonphysical barrier at the Sacramento River-Georgiana Slough divergence (Section 5.4.1.3.1.2.1.2.2 *Nonphysical Fish Barrier to Georgiana Slough*). Projected operation of other Delta facilities (for example, the North Bay Aqueduct, Rock Slough Diversion, and the Suisun Marsh Salinity Control Gates [SMSCG]) is expected to result in discountable take of Chinook salmon (Sections 5.4.1.3.1.1.5 through 5.4.1.3.1.1.7, *Suisun Marsh Facilities, North Bay Aqueduct, Other Facilities*, respectively). With the implementation of real-time operations and these mitigation measures, effects from water facility operations on fall-run Chinook salmon would not be expected to produce measurable changes in population status, compared to existing conditions.

The potential effects of the PA on fall-run Chinook salmon described above apply to wild fall-run fish, but only apply for a subset of hatchery fish. Since the mid-1980s, the proportion of hatchery fall-run Chinook salmon juveniles released downstream of the Delta has varied from around 20% to 60% (Huber and Carlson 2015). These fish would not be susceptible or minimally susceptible to effects of the PA. However, hatchery fish released upstream would be subject to changes affecting juvenile migration habitat as well as all changes in the Delta, which could affect their abundance in the ocean.

Effects of the PA to late fall-, spring-, and winter-run Chinook salmon are similar to those described above for fall-run Chinook salmon, with small differences primarily resulting from differences in the timing of occurrence of the life stages. As previously indicated, these runs currently constitute about 11% of the total Central Valley Chinook salmon production, and are not known to constitute a substantial portion of the prey base for Southern Resident killer whale (relative to Central Valley fall-run Chinook salmon). However, the survival of the late fall-, spring-, and winter-run Chinook salmon increases the diversity of the prey available to Southern Resident killer whales, potentially contributing to the long-term sustainability of their prey base (NMFS 2009). The following three summaries list the changes upstream of the Delta with the most potential to affect the three runs.

The changes in the Delta as summarized above are the same for all the runs, except that effects occurring in the south Delta would be somewhat more important for fall-run Chinook salmon because they spawn and rear in the San Joaquin River Basin in addition to the Sacramento River Basin, whereas late fall- and winter-run Chinook salmon spawn and rear only in the Sacramento River Basin. Spring-run Chinook salmon spawn and rear primarily in the Sacramento River Basin, but, as previously described in Section 4.5.2 *Chinook Salmon, Central Valley Spring-Run ESU*, they are currently being reintroduced to the San Joaquin River Basin and have been observed in the San Joaquin River tributaries in recent years (NMFS 2016). The discussions above concerning effects of CalSim II modeling uncertainties and real-time operations apply to late fall-, spring-, and winter-run Chinook salmon, as well. In fact, spring- and winter-run may benefit more from real-time operations because the operations target these ESUs due to their protected status.

As described in Appendix 5E *Essential Fish Habitat Assessment*, the following changes, which have a potential to affect late fall-run Chinook salmon in the Sacramento River upstream of the Delta, are expected to result from the PA: (1) increased frequency of water temperature threshold exceedances in the Sacramento River during September and October, coinciding with portions of the spawning and juvenile rearing periods; (2) decreased rearing habitat Weighted Usable Area (WUA) during June in some portions of the Sacramento River; and (3) reduced flows in the Sacramento River during September, coinciding with a portion of the juvenile migration period, and during November, coinciding with portions of the juvenile and adult migration periods; and (4) increased risk of redd dewatering for egg cohorts spawned in October in the Sacramento River.

As provided in Chapter 7 *Effects Determination*, the following changes, which have a potential to affect spring-run Chinook salmon in the Sacramento River upstream of the Delta, are expected to result from the PA: (1) increased frequency of water temperature threshold exceedances during August through October, coinciding with portions of the spawning and rearing periods; (2) increased risk of redd dewatering for egg cohorts spawned in August; (3) decreased rearing WUA during June in some portions of the Sacramento River, and (4) reduced flows during September, which could affect adult migration, and during November, which could affect juvenile migration.

As provided in Chapter 7 *Effects Determination*, the following changes, which have a potential to affect winter-run Chinook salmon in the Sacramento River upstream of the Delta, are expected to result from the PA: (1) increased frequency of water temperature threshold exceedances during August through October, coinciding with portions of the spawning and rearing periods; (2) increased risk of redd dewatering for egg cohorts spawned in June and August; and (3) reduced flows during September and November that could affect juvenile migration.

The PA has the potential to affect the abundance and/or size distribution of Central Valley late fall-, spring-, and winter-run Chinook salmon adults in the ocean. Mitigation measures and real-time operations (described above) under the PA would minimize potential impacts. These runs currently constitute about 10% of the total Central Valley Chinook salmon production (CDFW 2016), and are not known to constitute a significant portion of the prey base for Southern Resident killer whale (relative to the fall-run Chinook salmon). The survival of the late fall-, spring-, and winter-run Chinook salmon increases the diversity of the prey available to Southern Resident killer whales, potentially contributing to the long-term sustainability of their prey base (NMFS 2009).

5.6.1.2 Effects of the Proposed Action on Southern Resident Killer Whales

Overall ocean abundance estimates for Chinook salmon are provided by the Pacific Fisheries Management Council (2016). Estimates for 2016 indicate an ocean abundance for Central Valley Chinook salmon stocks of 299,600 fish. The only other tracked stock south of the Columbia River, the Klamath River, is estimated to have a 2016 ocean abundance of 142,200 fish. The Columbia River stocks account for a further 1,317,700 fish, with other stocks south of the Strait of Juan de Fuca providing another 65,500 fish. Puget Sound, Hood Canal, and the Strait of Juan de Fuca provide another 150,600 fish. Thus, total Chinook salmon abundance from sources in the action area amounts to 1,975,600 fish, of which 299,600/1,975,600=15% originate from the Central Valley.

If the PA is to affect prey availability of Southern Resident killer whales, there must be overlap in the spatial and temporal distributions of the whales and Central Valley salmon. Some overlap must exist under current conditions because Central Valley fall-run Chinook salmon have been documented in the diet of Southern Resident killer whale (Hanson 2010), but the frequency of occurrence of such overlap is poorly known.

During summer, most Southern Resident killer whales reside in the protected inland waters of Washington State and southern British Columbia, where they feed primarily on Fraser River Chinook salmon (Hanson et al. 2013, 2010). Their distribution during winter and spring is less well known, but less than a third of the whales remain in their summer habitat, with many moving into coastal waters primarily south of their summer range (NMFS 2010, Hanson 2013). They have been sighted as far south as Monterey Bay in central California (NMFS 2014b). Passive acoustic monitors sited from Cape Flattery, Washington, to Point Reyes, north of San Francisco Bay, during January through June, have detected Southern Resident killer whales at all locations, but predominantly near and north of the Columbia River (Hanson et al. 2013). During 2011, the one year when results were available from all the monitors, seven detections, or about 5% of the total, were obtained from locations south of the Columbia River. These results and others (NMFS 2010) indicate that Southern Resident killer whales occur in California coastal waters, but infrequently.

Weitkamp's (2010) study of recoveries of coded wire tagged (CWT) hatchery Chinook salmon in ocean fisheries provides strong evidence that marine distributions vary greatly according to the origin of the stocks. The Central Valley stocks were recovered as far north as Vancouver Island, but 94% were recovered south of the Columbia River. Bellinger et al. (2015) conducted a more fine-grained study of the ocean distributions of Chinook salmon south of the Columbia

River using genetic stock identification data rather than CWT recoveries. Central Valley Chinook salmon (primarily fall-run) made up about 22% of the Chinook salmon sampled off the Oregon coast and about 50% of those sampled off the California coast (south to Big Sur) (data from Appendix 3, Bellinger et al. 2015). Note that for both studies, the results were from late-spring to early-autumn, when Southern Resident killer whales are believed not to inhabit the coast south of the Columbia River. However, except when salmon are migrating to spawn, the winter and spring distributions are assumed to be similar.

Given that Southern Resident killer whales occur during winter months as far south as Monterey Bay (NMFS 2014b) and that Central Valley chinook salmon compose a large percentage of the Chinook salmon available south of the Columbia River (Bellinger et al. 2015), it is reasonable to expect that the whales could be affected by a change in the availability of Central Valley Chinook salmon. Because the population of Southern Resident killer whales is low, loss of a single individual or reduction in its reproductive capacity could adversely affect recovery of the population (NMFS 2009). As indicated in the previous section, the PA is expected to have some effects on Chinook salmon, but given the complexity of the effects, including that there are both positive and negative effects, it is not feasible to identify either the magnitude or even the sign of changes in population abundance of the Central Valley Chinook salmon resulting from project implementation. In addition, with regard to an evaluation of the potential effects of reduced ocean harvest of Chinook salmon on Southern Resident killer whale, Ward et al. (2013) found that, although there would likely be short-term benefits to Southern Resident killer whale, they had low confidence in their ability to detect differences resulting from the increase in prey abundance. A similar finding was noted by Strange (2016), which implicated wide confidence intervals resulting from uncertainties and assumptions of multiple model parameters as the cause for a lack of differences in Southern Resident killer whale population response to various hatchery production and ocean harvest rate scenarios. Similarly, there may be effects of the PA, but there is low confidence in the ability to detect these differences. Regardless of the uncertainties related to the effect on Southern Resident killer whale due to changes in their prey base, with implementation of real-time operations, the Cooperative Science and Adaptive Management Program, and proposed mitigation measures, effects of the PA on Central Valley Chinook salmon ocean abundances, and thus on use of that prey base by the Southern Resident killer whale, are expected to be insignificant.

5.6.2 Effects on Exposure to Contaminants

Southern resident killer whales are susceptible to accumulating high contaminant loads from their prey because of their position atop the food web and long life expectancy (Ylitalo et al. 2001; Grant and Ross 2002; National Marine Fisheries Service 2014). Killer whales are exposed to many anthropogenic contaminants, but persistent organic pollutants such as PCBs, DDT, dioxins, and furans are of particular concern because they bioaccumulate in aquatic food chains and are toxic to biota (O'Shea 1999; Reijnders and Aguilar 2002).

The PA would cause negligible differences in the contaminant load of Chinook salmon during their residence in fresh water. Selenium would not increase in salmon because species in which selenium accumulates are long lived and epibenthic, such as sturgeon. Chinook salmon are in the Delta for short periods (less than one year) and are not epibenthic. As described in Section 5.4.1.3.1.2.2.3, *Selenium*, this was confirmed by quantitative analyses of potential effects on trophic level 3 species, which include Chinook salmon, showing essentially no difference between PA and NAA scenarios in particulate, invertebrate, or whole-body estimates of selenium concentration (see Appendix 5.F, *Selenium Analysis*).

Minor or negligible increases in methylmercury may occur as a result of tidal marsh restoration that would be undertaken to offset losses caused by water facility construction. With AMMs to address the potential for methylmercury production at the tidal restoration site(s) and the relatively small area proposed for restoration, no measurable effects on Chinook salmon are expected. Microcystis does not generally overlap with salmonids and, therefore Chinook salmon would not be affected by Microcystis. As such the PA does not result in changes in any contaminants and salmonids acquire most of their contaminant loads while in marine waters (O'Neill et al. 1998; Grant and Ross 2002). Therefore, any changes in contaminants under the PA are not expected to result in adverse bioaccumulation effects on southern resident killer whales because the PA would not result in changes in contaminant loads in the whale's prey base.

5.6.3 Effects on Critical Habitat

Critical habitat for the Southern Resident killer whale was designated in November 2006 (71 CFR 229). Three specific areas are designated, (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca, which comprise approximately 2,560 square miles (6,630 sq km) of marine habitat. The designation includes the following PBFs essential for conservation of the Southern Resident killer whale:

1. Water quality to support growth and development; and
2. Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and
3. Passage conditions to allow for migration, resting, and foraging.

NMFS is currently conducting a 12-month review of critical habitat and will consider including an additional PBF related to in-water sound levels (80 CFR 36).

Southern Resident killer whales rely on 23 different species as prey, with salmon being the preferred prey (71 CFR 229). Given that critical habitat occurs within Puget Sound and the Strait of Juan de Fuca, the majority of prey consumed within critical habitat consists of populations native to rivers tributary to that habitat. The precise proportion of Central Valley-origin Chinook salmon consumed in the Southern Resident killer whale diet when they are feeding within critical habitat has not been determined, but fewer than 10% of Central Valley-origin Chinook salmon are collected from as far north as Tillamook Head on the northern Oregon coast (Satterthwaite et al. 2013), and Southern Resident killer whale critical habitat is several hundred kilometers north of that area. The principal source of prey for Southern Resident killer whale within critical habitat is Fraser River-origin Chinook salmon, with chum salmon also important for fall foraging in Puget Sound (National Marine Fisheries Service 2014b).

In summary, the PA has no potential to affect water quality within Southern Resident killer whale critical habitat; the PA has low potential to affect the production of Central Valley–origin

Chinook salmon; and the proportion of Central Valley-origin Chinook salmon occurring within designated critical habitat is very low and thus has negligible potential to affect the Southern Resident killer whale prey base within critical habitat.

5.6.4 Conclusion

The PA would not be expected to result in change in the abundance of Southern Resident killer whales' Chinook salmon prey in the ocean, and no other mechanism has been identified through which the PA could affect the Southern Resident killer whale.

5.7 Cumulative Effects on Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale

Cumulative effects are those effects of future state or private activities that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the PA are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA. A list of specific projects considered for the cumulative effects analysis is included as Appendix 5.G, *Projects to Be Included in Cumulative Effects Analysis for the Conveyance Section 7 Biological Assessment*. The EIR/EIS includes a cumulative analysis consistent with NEPA and CEQA and can further inform the potential for cumulative effects.

5.7.1 Water Diversions

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Thousands of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, their tributaries, and the Delta, and many of them remain unscreened. For example, as of 1997, 98.5% of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). Most of the 370 water diversions operating in Suisun Marsh are unscreened (Herren and Kawasaki 2001).

Depending on the size, location, and season of operation, these unscreened diversions may entrain and kill many life stages of aquatic species, including juvenile listed anadromous species.

5.7.2 Agricultural Practices

Agricultural practices occur throughout the Central Valley adjacent to waterways used by Chinook, steelhead, and green sturgeon. These activities, including burning or removal of vegetation on levees and livestock grazing, may negatively affect riparian and wetland habitats through upland modifications that lead to increased siltation or reductions in water flow in stream channels flowing into the action area, including the Sacramento River and Delta. Agricultural practices may also introduce nitrogen, ammonia, and other nutrients into the basin, which then flow into receiving waters. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect salmonid and sturgeon reproductive success and survival rates (Dubrovsky et al. 1998; Kuivila and Moon 2004; Scholz et al.2012). Discharges occurring outside the action area but that flow downstream into the action area also contribute to cumulative effects.

5.7.3 Increased Urbanization

The Delta Protection Commission's Economic Sustainability Plan for the Delta reported a growth rate of about 54% within the statutory Delta between 1990 and 2010, as compared with a 25% growth rate statewide during the same period (Delta Protection Commission 2012). The report also indicated that population growth had occurred in the Secondary Zone of the Delta but not in the Primary Zone and that population in the central and south Delta areas had decreased since 2000. Growth projections through 2050 indicate that all counties overlapping the Delta are projected to grow at a faster rate than the state as a whole. Total population in the Delta counties is projected to grow at an average annual rate of 1.2% through 2030 (California Department of Finance 2012). Table 5.7-1 illustrates past, current, and projected population trends for the five counties in the Delta. As of 2010, the combined population of the Delta counties was approximately 3.8 million. Sacramento County contributed 37.7% of the population of the Delta counties, and Contra Costa County contributed 27.8%. Yolo County had the smallest population (200,849 or 5.3%) of all the Delta counties.

Table 5.7-1. Delta Counties and California Population, 2000–2050

Area	2000 Population (millions)	2010 Population (millions)	2020 Projected Population (millions)	2025 Projected Population (millions)	2050 Projected Population (millions)
Contra Costa County	0.95	1.05	1.16	1.21	1.50
Sacramento County	1.23	1.42	1.56	1.64	2.09
San Joaquin County	0.57	0.69	0.80	0.86	1.29
Solano County	0.40	0.41	0.45	0.47	0.57
Yolo County	0.17	0.20	0.22	0.24	0.30
Delta Counties	3.32	3.77	4.18	4.42	5.75
California	34.00	37.31	40.82	42.72	51.01

Source: California Department of Finance 2012.

Table 5.7-2 presents more detailed information on populations of individual communities in the Delta. Growth rates from 2000 to 2010 were generally higher in the smaller communities than in larger cities such as Antioch and Sacramento. This is likely a result of these communities having lower property and housing prices, and their growth being less constrained by geography and adjacent communities.

Table 5.7-2. Delta Communities Population, 2000 and 2010

Community	2000	2010	Average Annual Growth Rate 2000–2010
Contra Costa County			
Incorporated Cities and Towns			
Antioch	90,532	102,372	1.3%
Brentwood	23,302	51,481	12.1%
Oakley	25,619	35,432	3.8%
Pittsburg	56,769	63,264	1.1%
Small or Unincorporated Communities			
Bay Point	21,415	21,349	-0.0%
Bethel Island	2,252	2,137	-0.5%
Byron	884	1,277	4.5%
Discovery Bay	8,847	13,352	5.1%
Knightsen	861	1,568	8.2%
Sacramento County			
Incorporated Cities and Towns			
Isleton	828	804	-0.3%
Sacramento	407,018	466,488	1.5%
Small or Unincorporated Communities			
Courtland	632	355	-4.4%
Freeport and Hood	467	309[a]	-3.4%
Locke	1,003	Not available	—
Walnut Grove	646	1,542	13.9%
San Joaquin County			
Incorporated Cities and Towns			
Lathrop	10,445	18,023	7.3%
Stockton	243,771	291,707	2.0%
Tracy	56,929	82,922	4.6%
Small or Unincorporated Communities			
Terminous	1,576	381	-7.6%
Solano County			
Incorporated Cities and Towns			
Rio Vista	4,571	7,360	6.1%
Yolo County			
Incorporated Cities and Towns			
West Sacramento	31,615	48,744	5.4%
Small or Unincorporated Communities			
Clarksburg	681	418	-3.9%

Sources: U.S. Census Bureau 2000; U.S. Census Bureau 2011.

[a] Freeport had a population of 38; Hood had a population of 271.

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions will not require Federal permits and thus will not undergo review through the Section 7 consultation process.

Adverse effects on Chinook, steelhead, and green sturgeon and their critical habitat may result from urbanization-induced point and non-point source chemical contaminant discharges within the action area. These contaminants include, but are not limited to ammonia and free ammonium ion, numerous pesticides and herbicides, and oil and gasoline product discharges. Increased urbanization also is expected to result in increased recreational activities in the region. Among the activities expected to increase in volume and frequency is recreational boating and fishing. Boating activities typically result in increased wave action and propeller wash in waterways. This potentially will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This, in turn, would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids and green sturgeon moving through the system. Increased recreational boat operation in the Delta is anticipated to result in more contamination from the operation of gasoline and diesel powered engines on watercraft entering the water bodies of the Delta.

5.7.4 Wastewater Treatment Plants

Two wastewater treatment plants (one located on the Sacramento River near Freeport and the other on the San Joaquin River near Stockton) have received special attention because of their discharge of ammonia. The Sacramento Regional Wastewater Treatment Plan (SRWTP), in order to comply with Order no. R5-2013-0124, has begun implementing compliance measures to reduce ammonia discharges. Construction of treatment facilities for three of the major projects required for ammonia and nitrate reduction was initiated in March 2015 (Sacramento Regional County Sanitation District 2015) Order no. R5-2013-0124, which was modified on October 4, 2013, by the Central Valley Regional Water Quality Control Board–imposed new interim and final effluent limitations, which must be met by May 11, 2021 (Central Valley Regional Water Quality Control Board 2013). By May 11, 2021, the SRWTP must reach a final effluent limit of 2.0 milligrams per liter (mg/L) per day from April to October, and 3.3 mg/L per day from November to March (Central Valley Regional Water Quality Control Board 2013). However, the treatment plant is currently releasing several tons of ammonia in the Sacramento River each day.

EPA published revised national recommended ambient water quality criteria for the protection of aquatic life from the toxic effects of ammonia in 2013.

Few studies have been conducted to assess the effects of ammonia on Chinook salmon, steelhead, or sturgeon. However, studies of ammonia effects on various fish species have shown numerous effects including membrane transport deficiencies, increases in energy consumption, immune system impairments, gill lamellae fusions deformities, liver hydropic degenerations, glomerular nephritis, and nervous and muscular system effects leading to mortality (Connon et al. 2011). Additionally, a study of Coho salmon and rainbow trout exposed to ammonia showed a decrease in swimming performance due to metabolic challenges and depolarization of white muscle (Wicks et al. 2002).

5.7.5 Activities within the Nearshore Pacific Ocean

Future tribal, state and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. Activities are primarily those conducted under state, tribal or Federal government management. These actions may include changes in ocean policy and increases and decreases in the types of activities that currently occur, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. These realities, added to the geographic scope, which encompasses several government entities exercising various authorities, and the changing economies of the region, make analysis of cumulative effects speculative.

A Final Recovery Plan for Southern Resident killer whales was published in 2008 (National Marine Fisheries Service 2008). Although state, tribal and local governments have developed plans and initiatives to benefit marine fish species, ESA-listed salmonids, green sturgeon, and Southern Residents, they must be applied and sustained in a comprehensive way before NMFS can consider them “reasonably certain to occur” in its analysis of cumulative effects. Private activities are primarily associated with commercial and sport fisheries, construction, and marine pollution. These potential factors are ongoing and expected to continue in the future, and the level of their impact is uncertain. For these reasons, it is not possible to predict beyond what is included in the subsections pertaining to cumulative effects, above whether future non-Federal actions will lead to an increase or decrease in prey available to Southern Resident, or have other effects on their survival and recovery.

5.7.6 Other Activities

Other future, non-Federal actions within the action area that are likely to occur and may adversely affect Chinook, steelhead, and green sturgeon and their critical habitat include: the dumping of domestic and industrial garbage that decreases water quality; oil and gas development and production that may affect aquatic habitat and may introduce pollutants into the water; and state or local levee maintenance that may also destroy or adversely affect habitat and interfere with natural, long term habitat-maintaining processes.

Power plant cooling system operations can also affect aquatic habitat. Contra Costa Power Plant, which was owned and operated by NRG Delta, LLC, was retired in 2013 and replaced with the new natural gas power plant, Marsh Landing Generating Station. The Pittsburg Generating Station (PGS) remains in operation and consisted of seven once-through cooling systems, four of which have been retired, one of which is in the process of being retired, and two of which remain in operation. The once-through cooling system intake process can cause the impingement and entrainment of marine animals, kill organisms from all levels of the food chain, and disrupt the normal processes of the ecosystem. Additionally, the plant can discharge heated water that can reach temperatures as high as 100°F into the action area. This sudden influx of hot water can adversely affect the ecosystem and the animals living in it (San Francisco Baykeeper 2010).

On May 4, 2010, the SWRCB adopted a Statewide Policy on the Use of Coastal and Estuarine Water for Power Plant Cooling under Resolution No. 2010–0020, which required existing cooling water intake structures to reflect the best technology available for minimizing adverse environmental impacts (State Water Resources Control Board 2010). The PGS was required to submit an implementation plan to comply with this policy by December 31, 2017. The PGS chose to comply by retrofitting two of the existing units and retiring one unit. The retrofit and retirement of these units is underway (GenOn 2011).

5.8 Effects of Monitoring Activities

As described in Section 3.4.8, *Monitoring and Research Program*, effectiveness monitoring for fish would consist of a combination of continuation of existing monitoring authorized under the 2008/2009 BiOps (i.e., principally salvage and larval smelt monitoring at the south Delta export facilities), as well as additional monitoring of the NDD (principally entrainment and impingement monitoring). Entrainment monitoring at the NDD would consist of sampling entrained fish behind the fish screens with a fyke net (see Table 3.4-5 in Chapter 3); impingement monitoring methods are not specified at this time, but on the basis of existing monitoring (e.g., Freeport Regional Water Authority intake's fish screen), would be likely to consist of visual observation by diver survey or acoustic imaging camera. Other monitoring activities that are part of the PA would be unlikely to affect listed salmonids or green sturgeon and are not discussed here. Existing monitoring activities that would inform operations of the PA (e.g., trawl and seines surveys by DFW and USFWS) are not part of the PA. Although monitoring activities at restoration sites have not been determined, they are not expected to include in-water work with any potential to harm salmonids or green sturgeon.

5.8.1 Salmonids

As discussed in Section 5.4.1.3.1.1.1.1, *Entrainment*, for the NDD, the NDD fish screens would exclude juvenile salmonids from entrainment, so there would be no effect from entrainment monitoring at the NDD. If impingement monitoring were to consist of visual observation by diver survey, there would be minor potential for migrating salmonids occurring immediately adjacent to the fish screens to be startled and leave the immediate area if encountering the divers; there would be no effect if conducting observations with an acoustic imaging camera. At the south Delta export facilities, salvage of juvenile salmonids would be done in the same way under NAA and PA. Some juvenile salmonids collected during sampling of salvaged fish would die; however, as shown in Section 5.4.1.3.1.1.2, *Impingement, Screen Contact, and Screen Passage Time*, entrainment at the south Delta export facilities is expected to be lower under the PA than NAA, therefore any effects to juvenile salmonids from salvage monitoring would be lower under the PA than NAA. Given that monitoring informs adjustments to operations to protect migrating juvenile salmonids, the ultimate net effect of monitoring would be expected to be positive from a population-level perspective. Monitoring would have no effects on designated critical habitat for listed salmonids.

5.8.2 Green Sturgeon

Much of the prior discussion for salmonids also applies to green sturgeon with respect to the potential for effects from monitoring activities. As discussed in Section 5.4.1.3.2.1.1.1, *Entrainment*, for the NDD, the NDD fish screens would exclude juvenile salmonids from entrainment, so there would be no effect from entrainment monitoring at the NDD. As noted for salmonids, diver observation during impingement monitoring could startle any sturgeon near the NDD, whereas such effects would be absent with video monitoring. Less green sturgeon would be expected to be sampled under the PA compared to NAA during monitoring of south Delta salvage, because of lower south Delta exports under the PA (see Section 5.4.1.3.2.1.2.1, *Entrainment*). Monitoring would have no effects on designated critical habitat for green sturgeon.

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5.9.1 Personal Communications

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6 Effects Analysis for Delta Smelt and Terrestrial Species

The following analyses describe effects of the PA on species under the jurisdiction of the USFWS. Additionally, Appendix 6.C *Suisun Marsh Species* provides analyses of effects on federally listed species limited to Suisun Marsh.

6.1 Effects on Delta Smelt

The potential effects of the proposed action (PA) on Delta Smelt are evaluated in this section for Water Facility Construction; Water Facility Maintenance; Water Facility Operations; Conservation Measures; Monitoring Activities; and Cumulative Effects.

Within each of the subsections, effects are evaluated for five life stages: migrating adults (December–March), spawning adults (February–June), eggs/embryos (spring: ~March–June), larvae/young juveniles (spring: ~March–June), and juveniles (~July–December). As previously described, for each life stage, individual-level effects are considered (*i.e.*, the effects to individual fish), as well as population-level effects (*i.e.*, the proportion of the population that could be affected by the individual-level effects).

The ability to estimate population-level effects has uncertainty, and by necessity is qualitative. In recent years, there have been several modeling efforts to determine factors driving long-term species abundance trends, but the results have been disparate, suggesting multiple factors. The population-level analysis in this document does not quantitatively evaluate the magnitude of change in Delta Smelt abundance that a predicted change in the analyzed factors could cause, which would require the use of a population/life cycle model (e.g., Maunder and Deriso 2011; Rose *et al.* 2013a,b; Newman *et al.* in preparation) incorporating the factors of importance for which predictions of values for NAA and PA could be made.

Scientific uncertainty exists with respect to the potential effects of the PA on Delta Smelt. As described in Section 3.4.7 *Collaborative Science and Adaptive Management Program*, the Collaborative Science and Adaptive Management Program will help to address scientific uncertainty by guiding the development and implementation of scientific investigations and monitoring for both permit compliance and adaptive management, and applying new information and insights to management decisions and actions.

Each subsection also includes analysis of effects to critical habitat, with specific reference to the primary constituent elements, which USFWS has defined as follows[1]:

- Primary Constituent Element 1: "Physical habitat" is defined as the structural components of habitat. Because Delta Smelt is a pelagic fish, spawning substrate is the only known important structural component of habitat. It is possible that depth variation is an important structural characteristic of pelagic habitat that helps fish maintain position within the estuary's low-salinity zone (LSZ) (Bennett *et al.* 2002; Hobbs *et al.* 2006).

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[1] This text is adapted from the USFWS Biological Opinion on the 2014 Georgiana Slough Floating Fish Guidance Structure Project.

- Primary Constituent Element 2: “Water” is defined as water of suitable quality to support various Delta Smelt life stages with the abiotic elements that allow for survival and reproduction. Delta Smelt inhabit open waters of the Delta and Suisun Bay. Certain conditions of temperature, turbidity, and food availability characterize suitable pelagic habitat for Delta Smelt. Factors such as high entrainment risk and contaminant exposure can degrade this PCE even when the basic water quality is consistent with suitable habitat.

- Primary Constituent Element 3: “River flow” is defined as transport flow to facilitate spawning migrations and transport of offspring to LSZ rearing habitats. River flow includes both inflow to and outflow from the Delta, both of which influence the movement of migrating adult, larval, and juvenile Delta Smelt. Inflow, outflow, and Old and Middle Rivers flow influence the vulnerability of Delta Smelt larvae, juveniles, and adults to entrainment at Banks and Jones Pumping Plants. River flow interacts with the fourth primary constituent element, salinity, by influencing the extent and location of the highly productive LSZ where Delta Smelt rear.

- Primary Constituent Element 4: “Salinity” is defined as the LSZ nursery habitat. The LSZ is where freshwater transitions into brackish water; the LSZ is defined as 0.5–6.0 psu (Kimmerer 2004). The 2 psu isohaline is a specific point within the LSZ where the average daily salinity at the bottom of the water is 2 psu (Jassby *et al.* 1995). By local convention the location of the LSZ is described in terms of the distance from the 2 psu isohaline to the Golden Gate Bridge (X2); X2 is an indicator of habitat suitability for many San Francisco Estuary organisms and is associated with variance in abundance of diverse components of the ecosystem (Jassby *et al.* 1995; Kimmerer 2002). The LSZ expands and moves downstream when river flows into the estuary are high. Similarly, it contracts and moves upstream when river flows are low. During the past 40 years, monthly average X2 has varied from as far downstream as San Pablo Bay (45 km) to as far upstream as Rio Vista on the Sacramento River (95 km). At all times of year, the location of X2 influences both the area and quality of habitat available for Delta Smelt to successfully complete their life cycle. In general, Delta Smelt habitat quality and surface area are greater when X2 is located in Suisun Bay. Both habitat quality and quantity diminish the more frequently and further the LSZ moves upstream, toward the confluence.

Although the analysis focuses on these definitions of critical habitat, it is acknowledged that important aspects of habitat occur outside these definitions. For example, as noted by the IEP MAST Team (2015: 106), although some researchers describe the low salinity zone as the center of distribution for juvenile Delta Smelt, Delta Smelt occur in relatively high abundance in the Cache Slough complex, which can also be considered as nursery habitat. In addition, recent laboratory studies suggest that Delta Smelt acclimate easily to LSZ salinity and above (up to 10 ppt), which points to other factors such as food, turbidity, or temperature playing a greater role in survival (Kammerer *et al.* 2015). As another example, factors in addition to inflow, outflow, and Old and Middle River flows that affect entrainment potential by the south Delta export facilities include turbidity (Grimaldo et al. 2009).

6.1.1 Effects of Water Facility Construction on Delta Smelt

6.1.1.1 Preconstruction Studies (Geotechnical Exploration)

Geotechnical investigations in open water at the proposed locations for the water conveyance facilities and alignments have the potential to affect Delta Smelt and its designated critical habitat. Approximately 100 over-water borings are currently proposed to collect geotechnical data at the proposed locations of the north Delta intakes, barge landings, tunnel alignment crossings, HOR gate, and CCF facilities (Table 3-4). Site-specific studies will investigate several geotechnical properties of these sites, including the stability of canal embankments and levees, liquefaction of soils, seepage through coarse-grained soils, settlement of embankments and structures, subsidence, and soil-bearing capacity. Specific field activities will include drilling of sample soil borings, cone penetration, and other *in situ* tests (slug tests, aquifer/pumping tests, and test pits) to evaluate subsurface conditions. In-water borings will be conducted using a mud rotary method in which a conductor casing will be pushed into the sediment to isolate the drilling area, drilling fluids (bentonite), and cuttings from the surrounding water. Drilling fluids and cuttings will be contained within the conductor casing and returned to a recirculation tank on the drill ship or barge where they will be transferred to drums for storage and disposal.

DWR plans to restrict in-water drilling to the approved in-water work window (August 1 to October 31) between the hours of sunrise and sunset. The 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. A number of AMMs are proposed to avoid or minimize potential turbidity, suspended sediment, and other water quality impacts (e.g., bentonite or contaminant spills) on listed species and aquatic habitat during geotechnical activities: AMM1 *Worker Awareness Training;* 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 Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

Restricting in-water drilling to August 1 to October 31 will effectively avoid the periods when Delta Smelt may be present in the action areas of the proposed geotechnical activities. Therefore, no direct effects on Delta Smelt are anticipated. Geotechnical activities in open water may affect the designated critical habitat of Delta Smelt through suspension and deposition of sediment (resulting in burial of potential spawning substrate) or direct disturbance of spawning substrate or shallow water habitat. However, these effects are expected to be negligible based on the small areas and nature of disturbance resulting from installation and removal of the casings, and the general lack of physical features at the propose sites that are thought to be preferred by Delta Smelt for spawning (see Section 6.1.1.2 *North Delta Intakes*, Section 6.1.1.3 *Barge Landings*, Section 6.1.1.4 *Head of Old River Gate*, and Section 6.1.1.5 *Clifton Court Forebay*). Consequently, with implementation of the proposed in-water work window and AMMs, geotechnical exploration is not likely to adversely affect Delta Smelt or its designated critical habitat.

6.1.1.2 North Delta Intakes

Three intakes will be constructed on the east bank of the Sacramento River between Clarksburg and Courtland at river miles (RMs) 41.1, 39.4, and 36.8 (Intakes 2, 3, and 5) (Appendix 3.A *Map Book for the Proposed Action*). Each intake can divert a maximum of 3,000 cfs from the Sacramento River. 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 the Intermediate Forebay (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). Additional details on the intake design, construction methods, and proposed construction schedule are described in Chapter 3 *Description of the Proposed Action*.

Construction activities that could potentially affect Delta Smelt include the following in-water activities: cofferdam installation and removal, levee clearing and grubbing, riprap placement, dredging, and barge operations. In-water construction or work activities are defined here as activities occurring within the active channel of the river, which would be part of, or immediately adjacent to, the river (e.g., at waterline, in water column, on riverbed, or along river shoreline). All other sediment-disturbing activities associated with construction of the north Delta intakes and associated facilities, including construction of the sedimentation basins, will be isolated from the Sacramento River and will use appropriate BMPs and AMMs to prevent the discharge of sediment to the river.

Construction of each intake is projected to take approximately 4 to 5 years. In the first year of construction, cofferdams will be installed in the Sacramento River to isolate the majority of work area from the river during the remaining years of construction. The cofferdams will become permanent components of the intake structure. Some clearing and grubbing at the construction site may be required prior to cofferdam installation depending on site conditions (e.g., presence of vegetation). Once the cofferdam is installed, the area within the perimeter of the cofferdam will be dewatered to the extent possible. Dewatering of the cofferdam will be performed using a screened intake to prevent entrainment of fish. Before dewatering is complete, fish rescue and salvage activities will be performed to collect any stranded fish and return them to the river. Water pumped from within the cofferdams will be discharged to settling basins or Baker tanks to remove the sediment before being returned to the river via pumping or gravity flow. After the cofferdams have been dewatered, dredging, foundation pile driving, and other construction activities will proceed within the perimeter of the cofferdams.

It is assumed that once the intakes are completed, the area in front of each intake will be dredged to provide appropriate water depths and hydraulic conditions at each intake. If dredging is required, it will occur within the in-water construction window (June 1 through October 31) when listed fish species are least likely to occur in the action area. It is also assumed that periodic maintenance dredging will be needed to maintain appropriate flow conditions and would occur only during the approved in-water work window.

During the in-water construction period, a total of approximately 5.6 acres of shallow water habitat will be permanently[2] affected by construction activities. These impacts include 0.4 acres that will be altered by dredging and barge operations through changes in channel depths, benthic habitat, cover, and temporary in-water and overwater structure (barges, spud piles) within active work areas adjacent to the proposed intake structure and levee slope. The footprints of proposed intake structures, transition walls, and bank protection will result in the permanent loss of approximately 3.2 acres of shallow water habitat. In addition, the 5.6-acre estimate includes potential suspended sediment effects 1,000 feet downstream of each intake (a total of 1.9 acres of shallow water habitat; see Section 6.1.1.2.1.2.1 *Individual-Level Effects*). The impacts to shallow water habitat will be mitigated at a 5:1 ratio, for a total of 28 acres (Table 3.4-1). Permanent modifications of nearshore habitat due to the presence of these structures will encompass a total of 5,367 feet of shoreline. At each intake, between 1.6 and 3.1 acres of river area will be located within the cofferdams during construction.

6.1.1.2.1 Turbidity and Suspended Sediment

Construction activities that disturb the riverbed and banks within the footprints of the north Delta intake facilities may temporarily increase turbidity and suspended sediment levels in the Sacramento River. These activities include cofferdam installation and removal, levee clearing and grading, riprap placement, dredging, and barge operations. These activities will be restricted to the in-water construction window (June 1 through October 31) when listed fish species are least likely to occur in the action area. In addition to limiting activities to the in-water work window, AMMs are proposed to avoid or minimize impacts due to increases in turbidity and suspended sediment levels on water quality and direct and indirect affects to listed fish species resulting from sediment-disturbing activities. AMMs include the following: AMM1 *Worker Awareness Training;* 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 Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

All other sediment-disturbing activities associated with construction of the north Delta intake facilities, including construction of the sedimentation basins, will be isolated from the Sacramento River and will not result in the discharge of sediment to the river with implementation of the proposed avoidance and minimization measures and best management practices related to off-bank (land-based) construction activities.

Construction-related turbidity and suspended sediment may occur during winter and spring due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with the timing restrictions on in-water activities and implementation of the proposed erosion and sediment control measures (AMM4) and other BMPs to ensure the effectiveness of these measures (AMM2 *Construction Best Management Practices and Monitoring*), no adverse water quality effects are anticipated during this period.

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[2] All impacts to Delta Smelt habitat are assumed to be permanent because they would occur over multiple years, which could affect multiple generations of Delta Smelt, given that the species generally lives for ~1 year.

6.1.1.2.1.1 Migrating Adults (December-March)

6.1.1.2.1.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults from temporary increases in turbidity and suspended sediment.

6.1.1.2.1.1.2 Population-Level Effects

No population-level effect would occur.

6.1.1.2.1.2 Spawning Adults (February-June)

6.1.1.2.1.2.1 Individual-Level Effects

During cofferdam installation, levee clearing and grubbing, riprap placement, and barge operations, turbidity and suspended sediment levels in the river are anticipated to exceed ambient river levels in the immediate vicinity of these activities. Increases in turbidity and suspended sediment levels associated with these activities will be temporary and localized, and unlikely to reach levels causing direct injury or mortality to Delta Smelt.

Little is known about the spawning requirements of Delta Smelt or the sensitivity of spawning adults to turbidity and suspended sediment. In general, Delta Smelt are adapted to turbid waters where they presumably benefit from increased feeding efficiency and avoidance of sight-feeding predators. In laboratory experiments, the feeding rates of Delta Smelt generally were found to be highest at turbidities less than or equal to 12 NTU, relatively persistent over a broad range of turbidities (12-120 NTU), and showed a strong decline at 250 NTU (Hasenbein *et al.* 2013). This finding is consistent with monitoring data which shows that Delta Smelt are often captured in turbidities between 10 and 50 NTU (Feyrer *et al.* 2007).

During in-water construction activities at the proposed intake sites, turbidity and suspended sediment levels in the river are anticipated to exceed ambient river levels in the immediate vicinity of these activities, creating turbidity plumes that may extend several hundred feet downstream of construction activities. NMFS (2008) reviewed observations of turbidity plumes during installation of riprap for bank protection projects along the Sacramento River and concluded that visible plumes are expected to be limited to only a portion of the channel width, extend no more than 1,000 feet downstream, and dissipate within hours of cessation of in-water activities. Based on these observations, NMFS concluded that such activities could result in turbidity levels exceeding 25–75 NTUs. These levels would not be expected to adversely affect Delta Smelt based on the general association and feeding responses of Delta Smelt to turbidity (Hasenbein *et al.* 2013). However, under the assumption that there could be some effect up to 1,000 feet downstream from each intake, this would result in 1.9 acres of impact to shallow water habitat (which is included in the overall 5.6 acres of shallow water habitat impact from the NDD; see Section 6.1.1.2 *North Delta Intakes*). This would be mitigated at a 5:1 ratio (Table 3.4-1).

Increases in suspended sediment during in-water construction activities may result in localized sediment deposition in the vicinity of the proposed intakes, degrading potential spawning habitat of Delta Smelt through burial of suitable substrates. However, the Sacramento River in the vicinity of the proposed intake sites do not likely support significant spawning of Delta Smelt because of the low quality of spawning habitat in the action area. There appears to be little or no habitat thought to be preferred by Delta Smelt for spawning in this reach, which is dominated by steep levee slopes, existing riprap, and low quantities of riparian and aquatic vegetation.

6.1.1.2.1.2.2 Population-Level Effects

Spawning adults may be present in the vicinity of the intakes during February through June. Thus, the timing of in-water construction activities (June 1–October 31) will avoid most of the spawning season (January through June, with peak numbers during February through May). In addition, historical survey data indicate that most of the Delta Smelt population is distributed downstream of the proposed intake sites. Adults and larvae have been reported to occur in the north Delta and farther upstream (Vincik and Julienne 2012) but the results from various surveys and general life history information suggest that the proportion of the population occupying the action area is low and most likely to occur during the primary winter and spring migration and spawning periods. For example, the mean densities of Delta Smelt larvae collected in the vicinity of the proposed intakes during the 1991-1994 egg and larval surveys was 4-6% of the mean densities collected downstream of these locations during April and May (Section 6.1.3 *Effects of Water Facility Operations on Delta Smelt*). The low proportion of migrating adults that would be expected to occur near the proposed intake sites during construction and operation of these facilities is also supported by the results of the DSM2-PTM analysis described in Section 6.A.2.1 *Migrating Adult Movement Upstream (DSM2-PTM)*, of Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*. Thus, the potential effects of increased turbidity and suspended sediment would be limited to a small proportion of the population that may be present in the action area in June. The low quality of spawning habitat and expected low utilization of the intake sites by spawning adults further reduces the likelihood of population-level effects.

6.1.1.2.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.1.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although the potential for exposure is low, individual eggs would be subject to burial by the deposition of suspended sediment generated by in-water construction activities.

6.1.1.2.1.3.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, the low proportion of the population utilizing the action area, and the low quality of spawning habitat in the affected reaches.

6.1.1.2.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.1.4.1 Individual-Level Effects

Based on the general discussion of effects above (see *Spawning Adults*), Delta Smelt larvae and early juveniles are not likely to adversely affected by the levels of turbidity and suspended sediment generated by in-water construction activities at the north Delta intake sites.

6.1.1.2.1.4.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, the low proportion of the population utilizing the action area, and general association and feeding responses of Delta Smelt to turbidity within the range generated by in-water activities.

6.1.1.2.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.1.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake locations in the summer and fall and therefore would be unaffected by increased turbidity and suspended sediment during in-water construction activities.

6.1.1.2.1.5.2 Population-Level Effects

No population-level effect would occur.

6.1.1.2.2 Contaminants

Construction of the north Delta intakes poses an exposure risk to Delta Smelt from potential spills of hazardous materials from construction equipment, barges and towing vessels, and other machinery, and from potential mobilization of contaminated sediment. The risk of accidental spills of contaminants and other hazardous materials will exist throughout the construction period but will be highest during in-water construction activities due to the proximity of construction activities to the Sacramento River.

6.1.1.2.3 Accidental Spills

Construction of the north Delta intakes could result in accidental spills of contaminants, including oil, fuel, hydraulic fluids, concrete, paint, and other construction-related materials, resulting in localized water quality degradation and potential adverse effects on Delta Smelt. Potential effects of contaminants on fish include direct injury and mortality (e.g., damage to gill tissue causing asphyxiation) or delayed effects on growth and survival (e.g., increased stress or reduced feeding), depending on the type of contaminant, extent of the spill, and exposure concentrations. The risk of such effects is highest during in-water construction activities, including cofferdam installation, levee grading and armoring, and barge operations, because of the proximity of construction equipment to the Sacramento River.

Implementation of Appendix 3.F *General Avoidance and Minimization Measures,* AMM5 *Spill Prevention, Containment, and Countermeasure Plan* and AMM14 *Hazardous Materials Management* is expected to minimize the potential for contaminant spills and guide rapid and effective response in the case of inadvertent spills of hazardous materials. With implementation of these and other required construction BMPs (e.g., AMM3 *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to the Sacramento River from in-water or upland sources would be effectively minimized.

6.1.1.2.4 Disturbance of Contaminated Sediments

Contaminants may also enter the aquatic environment through disturbance, resuspension, or discharge of contaminated soil and sediments from construction sites. Sediments act as a sink or source of contaminant exposure depending on local hydrologic conditions, habitat type, and frequency of disturbance. Sediment is a major sink for more persistent chemicals that have been introduced into the aquatic environment, with most organic and inorganic anthropogenic chemicals and waste materials accumulating in sediment (Ingersoll 1995). Thus, resuspension of contaminated sediments may have adverse effects on fish that encounter sediment plumes or come into contact with deposited or newly exposed sediment. Suspended sediment can also adversely affect fish by causing localized increases in chemical oxygen demand in waters in or near plumes.

The proposed intake sites are downstream of the City of Sacramento where sediments have been affected by historical and current urban discharges from the city. No information on sediment contaminants at these sites is currently available. Metals, PCBs, and hydrocarbons (typically oil and grease) are common urban contaminants that are introduced to aquatic systems via nonpoint-source stormwater drainage, industrial discharges, and municipal wastewater discharges. Many of these contaminants readily adhere to sediment particles and tend to settle out of solution relatively close to the primary source of contaminants. PCBs are persistent, adsorb to soil and organic matter, and accumulate in the food web. Lead and other metals also will adhere to particulates and can bioaccumulate to levels sufficient to cause adverse biological effects. Mercury is also present in the Sacramento River system and could be sequestered in riverbed sediments. Hydrocarbons biodegrade over time in an aqueous environment and do not tend to bioaccumulate or persist in aquatic systems.

Dredging has the potential to release contaminants from disturbed sediments into the water column during construction and maintenance dredging at the proposed intakes. Current estimates indicate the total dredging and channel disturbance would affect 12.1 acres of the riverbed adjacent to the cofferdams at the north Delta intakes. Measured sediment plumes from hydraulic dredging operations (Hayes et al. 2000) suggest that less than 0.1% of disturbed sediments and associated contaminants would likely be re-suspended during cutterhead dredging operations. In sediments, only a small fraction of the total amount of heavy metals and organic contaminants is dissolved. In the case of heavy metals, releases during dredging may be largely due to the resuspension of fine particles from which the contaminants may be desorbed, and in the case of organic contaminants, most of the chemicals released into the dissolved phase would be expected to be bound to dissolved organic matter. Therefore, the potential release of contaminants from suspended sediment is expected to be limited because many of the chemical constituents preferentially adsorb or attach to organically enriched or fine particles of sediment.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material* in Appendix 3.F *General Avoidance and Minimization Measures*. These measures include the preparation and implementation of a pre-construction sampling and analysis plan (SAP) to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (e.g., silt curtains) to achieve compliance with existing Basin Plan objectives will be an important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

6.1.1.2.4.1 Migrating Adults (December-March)

6.1.1.2.4.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Some risk would also exist outside the in-water construction period.

However, with the implementation of proposed pollution prevention and erosion and sediment control AMMs, there is little or no risk of exposure of migrating adults to contaminants.

6.1.1.2.4.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.4.2 Spawning Adults (February-June)

6.1.1.2.4.2.1 Individual-Level Effects

Exposure of fish to contaminants as a result of spills or sediment disturbance can cause effects that range from physiological stress, potentially resulting in delayed effects on growth, survival, and reproductive success, to direct mortality (acute toxicity) depending on the on the concentration, toxicity, solubility, bioavailability, and duration of exposure, as well as the sensitivity of the exposed organisms. For example, Delta Smelt are highly sensitive to sublethal levels of pyrethrin which causes neurological damage and results in impaired swimming ability and potential effects on chemosensory abilities (Connon *et al.* 2009). Such impairments may affect the ability of Delta Smelt to swim against tides or water currents, increasing their susceptibility to predation and lowering their ability to find food (Connon *et al.* 2009). Chemosensory impairment may also affect the ability of Delta Smelt to detect pheromones and find mates (Connon *et al.* 2009). In addition, contaminants can enter the aquatic food web and accumulate in fish through their diet, leading to adverse effects on behavior, tissues and organs, reproduction, growth, and immune system (Connon *et al.* 2009).

Based on the timing of in-water construction activities (June 1–October 31), spawning adults in the vicinity of the intake sites would be subject to direct exposure to contaminant spills or sediment-borne contaminants (i.e., through exposure to turbidity plumes) in June. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk.

6.1.1.2.4.2.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, distribution of spawning adults, low quality of spawning habitat in the vicinity of the intake sites, and implementation of the proposed pollution control and erosion and sediment control AMMs.

6.1.1.2.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.4.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although exposure of eggs or embryos is expected to be minimal, individual eggs could suffer adverse effects if directly exposed to contaminant spills or sediment-borne contaminants during construction. Implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.2.4.3.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, low proportion of spawning adults in the action area, low quality of spawning habitat, and implementation of the proposed pollution control and erosion and sediment control AMMs.

6.1.1.2.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.4.4.1 Individual-Level Effects

Based on the general discussion of effects above (see *Spawning Adults*), individual larvae and early juveniles, if present, may be adversely affected by direct exposure to contaminant spills or sediment-borne contaminants during construction of the intakes. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.2.4.4.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, low proportion of the population utilizing the action area, and implementation of the proposed pollution control and erosion and sediment control AMMs.

6.1.1.2.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.4.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake locations in the summer and fall and therefore are unlikely to be affected by contaminant spills or sediment-borne contaminants during construction of the intakes.

6.1.1.2.4.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.5 Underwater Noise

During construction of the north Delta intakes, activities that are likely to generate underwater noise include pile driving, riprap placement, dredging, and barge operations. Pile driving poses the greatest risk to fish because the levels of underwater noise produced by impulsive types of sounds often reach levels of sufficient intensity to injure or kill fish within a certain radius of the source piles (Popper and Hastings 2009). Other activities such as riprap placement, dredging, and barge operations generally produce more continuous, lower energy sounds below the thresholds associated with direct injury but may cause avoidance behavior or temporary hearing loss or physiological stress if avoidance is not possible or exposure is prolonged (Popper and Hastings 2009).

During construction of the north Delta intakes, underwater noise levels of sufficient intensity to cause direct injury or mortality of fish could occur over a period of 12-42 days during the proposed in-water work period (June 1-October 31) for up to 2 years at each intake location. Restriction of pile driving activities in or near open water in the Sacramento River to June 1 through October 31 will minimize the exposure of Delta Smelt to potentially harmful underwater noise. In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory methods or other non-impact driving methods (e.g., drill-shaft methods) to install the cofferdam sheet piles and foundation piles. The degree to which vibratory and non-impact driving methods can be performed is uncertain at this time (due to uncertain geologic conditions at the proposed intake sites) although reasonable assumptions are applied to sheet pile installation in the following analysis. If impact pile driving is required, DWR, in coordination with the USFWS, NMFS, and CDFW, will evaluate the feasibility of other protective measures including dewatering, physical devices (e.g., bubble curtains), and operational measures (e.g., restricting pile driving to specific times of the day) to limit the intensity and duration of underwater noise levels when listed fish species may be present. Coordination, implementation, and monitoring of these measures will be performed in accordance with the underwater sound control and abatement plan, which includes hydroacoustic monitoring to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and corrective actions to be taken should the thresholds be exceeded. These measures may include additional physical or operational measures to further limit the magnitude and/or duration of underwater noise levels.

6.1.1.2.5.1 Migrating Adults (December-March)

6.1.1.2.5.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. There would be no risk of exposure of migrating adults to impact pile driving noise.

6.1.1.2.5.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.5.2 Spawning Adults (February-June)

6.1.1.2.5.2.1 Individual-Level Effects

Restricting pile driving to June 1–October 31 would avoid most of the Delta Smelt spawning season, although some potential for exposure of spawning adults would occur in June. In general, the effects of pile driving noise on fish may include behavioral responses, physiological stress, temporary and permanent hearing loss, tissue damage (auditory and non-auditory), and mortality. Factors that influence the magnitude of effects include species, life stage, and size of fish; type and size of pile and hammer; frequency and duration of pile driving; site characteristics (e.g., depth); and distance of fish from the source. In Delta Smelt and most other teleost fish, the presence of a swim bladder to maintain buoyancy increases their vulnerability to underwater noise (Hastings and Popper 2005). Sublethal effects of elevated noise include damage to hearing organs that may temporarily affect swimming ability and hearing sensitivity, which may reduce the ability of fish to detect predators or prey. Non-injurious levels of underwater noise may also cause behavioral effects (e.g., startle or avoidance responses) that can disrupt or alter normal activities (e.g., migration, holding, or feeding), potentially increasing an individual's vulnerability to predation or reducing growth or spawning success.

Dual interim criteria representing the acoustic thresholds associated with the onset of physiological effects in fish have been established to provide guidance for assessing the potential for injury resulting from pile driving noise (Fisheries Hydroacoustic Working Group 2008) (Table 6.1-1). The dual criteria for impact pile driving are (1) 206 decibels (dB) for peak sound pressure level (SPL); and (2) 187 dB for cumulative sound exposure level (SEL) for fish larger than 2 grams, and 183 dB SEL for fish smaller than 2 grams. The peak SPL threshold is considered the maximum sound pressure level a fish can receive from a single strike without injury. The cumulative SEL threshold is considered the total amount of acoustic energy that a fish can receive from single or multiple strikes without injury. The cumulative SEL threshold is based on the total daily exposure of a fish to noise from sources that are discontinuous (in this case, noise that occurs up to 12 hours a day, with 12 hours between exposures). This assumes that the fish is able to recover from any effects during this 12-hour period. These criteria relate to impact pile driving only. Vibratory pile driving is generally accepted as an effective measure for minimizing or eliminating the potential for injury of fish from pile driving operations.

Table 6.1-1. Interim Criteria for Injury to Fish from Pile Driving Activities.

Interim Criteria	Agreement in Principle
Peak Sound Pressure Level (SPL)	206 dB re: 1μPa (for all sizes of fish)
Cumulative Sound Exposure Level (SEL)	187 dB re: 1μPa^2-sec—for fish size ≥ 2 grams 183 dB re: 1μPa^2-sec—for fish size < 2 grams

Fish smaller than 2 grams are more sensitive to underwater noise than larger individuals, and may experience injury at 183 dB (Fisheries Hydroacoustic Working Group 2008). Larval and juvenile delta smelt are generally smaller than 2 grams while adults average 2 to 3 grams (Foott and Bigelow 2010]). Because some adult delta smelt are less than the 2 grams, the lower injury threshold (183 dB) applies to this life stage as well. The interim criteria were set to be conservatively protective of fish.

In the following effects analysis, the potential for injury of fish from exposure to pile driving sounds was evaluated using a spreadsheet model developed by NMFS to calculate the distances from a pile that sound attenuates to the peak or cumulative criteria. These distances define the area in which the criteria are expected to be exceeded as a result of impact pile driving. The NMFS spreadsheet calculates these distances based on estimates of the single-strike sound levels for each pile type (measured at 10 meters from the pile) and the rate at which sound attenuates with distance. In the following analysis, the standard sound attenuation rate of 4.5 dB per doubling of distance was used in the absence of other data. To account for the exposure of fish to multiple pile driving strikes, the model computes a cumulative SEL for multiple strikes based on the single-strike SEL and the number of strikes per day or pile driving event. The NMFS spreadsheet also employs the concept of “effective quiet”. This assumes that cumulative exposure of fish to pile driving sounds of less than 150 dB SEL does not result in injury.

Other sources of in-water noise include generator and engine vibration transmitted through the hulls of work barges and associated vessels, and dredge equipment. Noise levels produced by these sources typically are less than those associated with vibratory pile driving and are likely to be comparable to ambient noise conditions in the vicinity of the intakes caused by traffic, boats, water skiers, etc. For routine vessel traffic, these noise levels typically range from peak levels of 160 to 190 dB at a range of 10 meters, depending on vessel size (Thomsen et al. 2009). Dredge equipment noise will vary depending on equipment type. For example, a hydraulic cutterhead dredge working in the Stockton Deepwater Ship Channel produced noise levels of around 152 to 157 dB at 1 meter from the source (Reine and Dickerson 2014). Removal of pilings or other underwater structures could involve use of vibratory methods. This could generate sounds that could cause avoidance behavior of any fish present. However, the noise levels generated by vibratory driving do not approach the peak or cumulative sound criteria outlined above.

Insufficient data are currently available to support the establishment of a noise threshold for behavioral effects (Popper *et al.* 2006). NMFS generally assumes that a noise level of 150 dB root mean square (RMS) is an appropriate threshold for behavioral effects. NMFS acknowledges this uncertainty in other BiOps but believes this noise level is appropriate for identifying the potential for behavioral effects of pile driving sound on fish until new information indicates otherwise.

Table 6.1-2 presents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds based on application of the NMFS spreadsheet model and the assumptions presented in Appendix 3.E *Pile Driving Assumptions for the Proposed Action*. This analysis considers only those pile driving activities that could generate noise levels sufficient to exceed the interim injury thresholds in the Sacramento River or other waters potentially supporting listed fish species. These activities include impact pile driving in open water, in cofferdams adjacent to open water, or on land within 200 feet of open water. For cofferdam sheet piles, it is assumed that approximately 70% of the length of each pile can be driven using vibratory pile driving, with impact driving used to finalize pile placement. For the intake structure foundation piles, the current design assumes the use of impact pile driving only. However, some degree of attenuation is expected assuming that the cofferdams can be fully dewatered. Therefore, predictions are shown for two scenarios, one in which dewatering results in a 5 dB reduction in reference noise levels, and one in which no attenuation is possible (no dewatering or other forms of attenuation). All computed distances over which pile driving sounds are expected to exceed the injury and behavioral thresholds assume an unimpeded sound propagation path. However, site conditions such as major channel bends and other in-water structures can reduce these distances by impeding the propagation of underwater sound waves.

Table 6.1-2. Extent, Timing, and Duration of Pile Driving Noise Levels Predicted to Exceed the Interim Injury and Behavioral Thresholds at the North Delta Intake Sites

Facility or Structure	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 187 dB SEL Injury Threshold[1, 2] (feet)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Construction Season	Timing of Pile Driving	Duration of Pile Driving (days)
Intake 2						
Cofferdam	30	2,814	13,058	Year 8	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 9	Jun–Oct	19
Foundation (with attenuation)	20	1,522	15,226	Year 9	June-Oct	19
Intake 3						
Cofferdam	30	2,814	13,058	Year 7	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 8	Jun–Oct	14
Foundation (with attenuation)	20	1,522	15,226	Year 8	June-Oct	14
Intake 5						
Cofferdam	30	2,814	13,058	Year 5	Jun–Oct	42
Foundation (no attenuation)	46	3,280	32,800	Year 6	Jun–Oct	19
Foundation (with attenuation)	20	1,522	15,226	Year 6	June-Oct	19

[1] Computed distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL). Calculation assumes that single strike SELs <150 dB do not accumulate to cause injury. Accordingly, once the distance to the cumulative injury threshold exceeds the distance to effective quiet, increasing the number of strikes does not increase the presumed injury distance.

[2] Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

Sound monitoring data collected during similar types of pile driving operations indicate that single-strike peak SPLs exceeding the interim injury thresholds are expected to be limited to areas within 30 feet of the cofferdam sheet piles and 20-46 feet of the intake foundation piles, depending on whether cofferdams can be dewatered (Table 6.1-2).

Based on a cumulative (daily) threshold of 187 dB SEL, the risk of injury is calculated to extend up to 5,628 feet (2,814 x 2) during installation of the cofferdams and 6,560 feet (3,280 x 2) during installation of the foundation piles (3,044 feet if the cofferdams can be dewatered) assuming an unimpeded propagation path.[3] The predictions in Table 6.1-2 apply to one intake location; the current construction schedule indicates that pile driving in a given year would occur at one intake only with the exception of Year 8 in which cofferdam installation at Intake 2 may coincide with foundation pile installation at intake 3 (Appendix 3.D *Construction Schedule for the Proposed Action*). In this case, there would be no overlap in the potential noise impact areas

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[3] Based on the estimated number of pile strikes per day, the computed distances to the injury thresholds are governed by the distance to "effective quiet" (150 dB SEL).

although fish migrating through the action area could be potentially exposed to pile driving noise over two reaches totaling 12,188 feet. Based on the duration of pile driving activities, such conditions could occur for up to 14 days based on the duration of foundation pile installation.

The potential for behavioral effects would exist beyond the distances associated with potential injury. Based on a threshold of 150 dB RMS, the potential for behavioral effects is calculated to extend up to 13,058 feet away during cofferdam sheet pile installation, and 32,800 feet away during intake foundation pile installation (15,226 feet away if the cofferdams can be dewatered) assuming an unimpeded propagation path. However, the extent of noise levels exceeding the injury and behavioral thresholds would be constrained to varying degrees by major channel bends that range from approximately 1,500 to 12,000 feet away from each intake facility.

For each intake facility, the current construction schedule indicates that cofferdam sheet piles would be installed over a period of 42 days at each intake location within the in-water construction season (June 1-October 31; August 1-September 30 if feasible) followed by installation of the intake foundation piles over a period of 14-19 days during the following season.

6.1.1.2.5.2.2 Population-Level Effects

Pile driving noise may have adverse effects on spawning delta smelt that are present or passing through the NDD construction sites during June while pile driving is occurring. Adults occur in the north Delta and farther upstream but the results from various surveys and general life history information suggest that the proportion of the population seasonally occupying the action area is low and most likely to occur during the winter and spring (December through May), when no in-water work would occur. Some potential exists for adults to occur in the action area in June when pile driving and other in-water construction activities for the north Delta intakes are scheduled to begin. However, because of the low abundance of delta smelt in this part of their range in June and the low quality of potential spawning habitat in the action area, the potential for exposure of delta smelt to pile driving noise is considered low. Potential exposure of the population to pile driving noise will be further minimized by implementation of an underwater sound control and abatement plan (Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*) that includes the use of vibratory and other non-impact pile driving methods, attenuation devices, and other potential physical and operational measures to avoid or minimize impacts on Delta Smelt. This plan will also include hydroacoustic monitoring and compliance requirements that will be developed in coordination with USFWS, NMFS, and CDFW to avoid and minimize potential impacts on listed fish species.

6.1.1.2.5.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.5.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although the potential for exposure is low, any individual eggs in the vicinity of the intake sites would be unable to avoid prolonged exposure to pile driving noise and potential adverse effects on survival, development, or viability.

6.1.1.2.5.3.2 Population-Level Effects

Based on the small proportion of spawning adults in the action area at the time of pile driving operations and expected low utilization of the affected reaches by spawning adults, any mortality of eggs or embryos due to pile driving noise would not be expected to have a significant effect on population abundance. Any potential losses will be further reduced by the use of vibratory and other non-impact pile driving methods, attenuation devices, and other physical and operational measures that may be implemented as part of the underwater sound control and abatement plan.

6.1.1.2.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.5.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles originating from upstream spawning areas may encounter pile driving noise during their downstream movement to estuarine rearing areas. Although the potential for exposure is low, any larval Delta Smelt passing the intakes during impact pile driving would be unable to avoid exposure to pile driving noise and therefore could be injured or killed depending on their proximity to the source piles and the duration of exposure.

6.1.1.2.5.4.2 Population-Level Effects

Based on the proportion of the adult population occurring in or upstream of the north Delta in June, any losses of larvae or early juveniles that encounter pile driving noise would represent a small proportion of total larval production in each year of pile driving operations. Potential losses will be further reduced by the use of vibratory and other non-impact pile driving methods, attenuation devices, and other physical and operational measures that may be implemented as part of the underwater sound control and abatement plan.

6.1.1.2.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.5.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be affected by pile driving noise.

6.1.1.2.5.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.6 Fish Stranding

Installation of cofferdams to isolate the construction areas for the proposed intake sites has the potential to strand fish, resulting in direct mortality of fish from dewatering, dredging, and pile driving within the enclosed areas of the channel. To minimize entrapment risk and the number of fish subject to capture and handling during fish rescue and salvage operations, cofferdam construction will be limited to the proposed in-water construction period (June 1–October 31) to avoid the peak abundance of adults and larvae in the north Delta. DWR will prepare and submit a fish rescue and salvage plan (Appendix 3.F *General Avoidance and Minimization Measures*, AMM8 *Fish Rescue and Salvage Plan*) to the fish and wildlife agencies (NMFS, USFWS, CDFW) for review and approval prior to implementation. The plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that would apply to all in-water activities with the potential to entrap fish. All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist. The biologist, in consultation with a designated agency biologist, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. Collection methods may include seines, dip nets, and electrofishing if permitted.

6.1.1.2.6.1 Migrating Adults (December-March)

6.1.1.2.6.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31), including cofferdam construction, will avoid the Delta Smelt adult migration season. Therefore, migrating adults are not at risk of being stranded.

6.1.1.2.6.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.6.2 Spawning Adults (February-June)

6.1.1.2.6.2.1 Individual-Level Effects

Although present in low numbers, spawning adults may be present in the action area in June and subject to stranding in cofferdams. Adults would be expected to move away from active construction areas, but some risk of stranding would exist as long as the affected areas are accessible to fish. Fish rescue and salvage activities using accepted fish collection methods can result in injury or mortality, but these effects are typically minor, and can often be avoided with appropriate training. However, adverse effects may still occur because of varying degrees of effectiveness of the collection methods and potential stress and injury associated with various capture and handling methods.

6.1.1.2.6.2.2 Population-Level Effects

Population-level effects are expected to be negligible because of the low densities of adults that may be present in the action area during cofferdam installation, the low utilization and expected avoidance of the intake sites by spawning adults, and implementation of fish rescue and salvage activities.

6.1.1.2.6.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.6.3.1 Individual-Level Effects

Based on the low utilization and expected avoidance of the intake sites by spawning adults, there is little or no risk of stranding of Delta Smelt eggs or embryos.

6.1.1.2.6.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.6.4.1 Individual-Level Effects

Although the potential for exposure is low, Delta Smelt larvae and early juveniles may be particularly vulnerable to stranding because of their limited swimming abilities and potential entrainment in open cofferdams. In addition, conventional fish collection methods are less effective and more likely to cause injury or death of these life stages compared to larger juveniles or adults.

6.1.1.2.6.4.2 Population-Level Effects

Population-level effects would be expected to be negligible based on the small proportion of adults that spawn in or upstream of the north Delta in June, the resulting low densities of larvae and juveniles passing the intake sites, and the limited influence of cofferdams on passage conditions in the river.

6.1.1.2.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.6.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be stranded in cofferdams.

6.1.1.2.6.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.7 Direct Physical Injury

During construction of the north Delta intakes, fish could be injured or killed by direct contact with equipment or materials that enter open waters of the Sacramento River. Potential mechanisms include fish being crushed by falling rock (riprap), impinged by sheetpiles, entrained by dredges, or struck by propellers. In addition to the proposed work window (June 1-October 31), the potential for injury of listed fish species would be minimized by limiting the duration of in-water construction activities to the extent practicable and implementing the following AMMs: AMM1 *Worker Awareness Training;* AMM4 *Erosion and Sediment Control Plan; Disposal of Spoils, Reusable Tunnel Material, and Dredged Material;* AMM7 *Barge Operations Plan;* and AMM8 *Fish Rescue and Salvage Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

6.1.1.2.7.1 Migrating Adults (December-March)

6.1.1.2.7.1.1 Individual-Level Effects

The timing of in-water construction activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, migrating adults are not at risk of being injured.

6.1.1.2.7.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.7.2 Spawning Adults (February-June)

6.1.1.2.7.2.1 Individual-Level Effects

Spawning adults may be present in very small numbers in June and therefore subject to injury. Although adults would be expected to move away from active construction areas, it is assumed that some potential for injury exists whenever heavy equipment or materials are operated or placed in open water.

6.1.1.2.7.2.2 Population-Level Effects

Population-level effects are expected to be negligible because of the low densities of adults that may be present in the action area during in-water construction activities, and the low utilization and expected avoidance of the intake sites by spawning adults.

6.1.1.2.7.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.7.3.1 Individual-Level Effects

Based on the low utilization and expected avoidance of the intake sites by spawning adults, there is little or no risk of injury of Delta Smelt eggs or embryos.

6.1.1.2.7.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.7.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.7.4.1 Individual-Level Effects

Although the potential for exposure is low, Delta Smelt larvae and early juveniles may be particularly vulnerable to injury because of their limited swimming abilities.

6.1.1.2.7.4.2 Population-Level Effects

Population-level effects would be expected to be negligible based on the small proportion of adults that spawn in or upstream of the north Delta in June, the resulting low densities of larvae and juveniles passing the intake sites, and the limited influence of construction equipment and materials on passage conditions in the river.

6.1.1.2.7.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.7.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be injured by construction activities.

6.1.1.2.7.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.2.8 Loss or Alteration of Habitat

Construction of the north Delta intakes will result in permanent loss or alteration of aquatic habitat that includes the designated critical habitat of Delta Smelt. The effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed. A total of approximately 13.1 acres of shallow water habitat will be permanently[4] affected by intake construction. This consists of 9.9 acres that will be altered by dredging and barge operations through changes in channel depths, benthic habitat, cover, and temporary in-water and overwater structure (barges, spud piles) within active work areas adjacent to the proposed intake structure and levee slope. The footprints of proposed intake structures, transition walls, and bank protection will result in the permanent loss of approximately 3.2 acres of shallow water habitat. Permanent losses of nearshore habitat due to the presence of the three NDD intake structures will encompass a total of 5,367 feet of shoreline.

During construction activities, DWR will implement AMM2 *Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. DWR proposes to offset unavoidable habitat impacts at the

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[4] All impacts to Delta Smelt habitat are assumed to be permanent because they would occur over multiple years, which could affect multiple generations of Delta Smelt, given that the species generally lives for ~1 year.

proposed intake sites through on-site and/or off-site mitigation, including the purchase of conservation credits at an approved conservation bank.

6.1.1.2.8.1 Migrating Adults (December-March)

6.1.1.2.8.1.1 Individual-Level Effects

Construction of the three intake structures will result in a permanent loss or alteration of 13.1 acres of shallow water habitat and 5,367 feet of channel margin habitat near the northern limit of the geographic area used by Delta Smelt for migration, potential spawning, and larval dispersal to the estuary. Cofferdams will isolate the work areas, temporarily reducing the width of the river channel and eliminating the shallow, low-velocity nearshore zones currently available to migrating Delta Smelt along the east bank of the river. The creation of deeper, higher-velocity zones adjacent to the cofferdams and riprap could also increase predator habitat. Although affecting a small proportion of the population that may migrate past these sites, these changes may impair adult passage and subject adults to an elevated risk of predation as they attempt to pass the construction sites.

6.1.1.2.8.1.2 Population-Level Effects

The loss of low-velocity shoreline areas and increased predation risk at the intake construction sites could potentially reduce the number of migrating adults that successfully pass the sites and survive to reach upstream spawning areas. The effect on passage success depends on the number attempting to pass the site on the east side of river and the ability of adults to use alternative routes (e.g., the west side of the river would remain unaffected) or spawning areas (e.g., returning downstream to spawn). Overall, however, the small proportion of the population that migrates and spawns in the reaches upstream of the intake site indicates that any population-level effects would be small.

6.1.1.2.8.2 Spawning Adults (February-June)

6.1.1.2.8.2.1 Individual-Level Effects

There appears to be little or no habitat thought to be preferred by Delta Smelt for spawning at the proposed intake sites, which are dominated by steep levee slopes, existing riprap, and low quantities of riparian and aquatic vegetation. Consequently, permanent losses of nearshore habitat resulting from construction of the intakes would have little or no effect on spawning site selection or spawning success of adults.

6.1.1.2.8.2.2 Population-Level Effects

The existing value and function of the habitat for Delta Smelt within the footprint of the proposed intakes and work areas is low compared to core areas of the species' habitat which occurs farther downstream in the estuary. Loss or alteration of this habitat would likely have a negligible population-level effect because of the small proportion of the population spawning in the action area, expected low utilization of the intake sites by spawning adults, and negligible contribution of this habitat to the overall spawning capacity of the upper estuary.

6.1.1.2.8.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.2.8.3.1 Individual-Level Effects

Based on the small proportion of the population spawning in the action area, expected low utilization of the intake sites by spawning adults, and negligible contribution of this habitat to the overall spawning capacity, there is little risk of direct or indirect effects on egg/embryo production or survival.

6.1.1.2.8.3.2 Population-Level Effects

Population-level effects are expected to be negligible.

6.1.1.2.8.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.2.8.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles migrating from upstream spawning areas to estuarine rearing areas may be subject to an elevated risk of predation as they pass the intake construction sites because of the presence of in-water and overwater structures and the loss of shallow, low-velocity nearshore areas. To the extent that these conditions provide beneficial habitat or increased predation opportunities for predators of larvae and early juveniles (e.g., silversides; Baerwald et al. 2012), there could be an elevated risk of predation for these young life stages. However, it is not clear that these structures provide beneficial habitat as these small predators may be susceptible to the same larger predators that consume adult Delta Smelt. Therefore, elevated predation on Delta Smelt larvae is unlikely.

6.1.1.2.8.4.2 Population-Level Effects

Even if larvae and juveniles are subject to elevated predation rates as they pass the construction sites for the NDD intakes, the population-level effect would be small based on the small proportion of the population occurring in or upstream of the action area.

6.1.1.2.8.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.2.8.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be affected by losses or alteration of habitat during construction.

6.1.1.2.8.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3 Barge Landings

Temporary barge landings will be constructed at each of the TBM launch shaft sites for the loading and unloading of construction equipment, materials, fill, and tunnel spoils. A total of seven barge landings are currently proposed (Appendix 3.A *Map Book for the Proposed Action*) at the following locations:

- Snodgrass Slough north of Twin Cities Road (adjacent to proposed intermediate forebay)
- Little Potato Slough (Bouldin Island south)
- San Joaquin River (Venice Island south)
- San Joaquin River (Mandeville Island east at junction with Middle River)
- Middle River (Bacon Island north)

- Middle River (Victoria Island northwest)
- Old River (junction with West Canal at Clifton Court Forebay)

These locations are approximate but represent the general areas for these facilities based on their proximity to the launch shaft sites. 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. Additional details on the design, construction methods, and proposed construction schedule for the barge landings are described in Chapter 3.

Major construction elements of this action include barge landing construction, levee clearing and armoring (as necessary), and barge operations. The barge landings will be constructed over a period of 2 years. The specific design of the barge landings is unknown at this time. Docks supported by steel piles are currently proposed although floating barges will be used where possible to minimize in-water construction activities. Docks would each occupy an overwater area of approximately 300 by 50 feet (0.34 acre) spanning 5-9% of the total channel widths at the proposed locations. Some clearing and armoring of the levee may be required to provide access and protect the levee from wave erosion; such effects are included within the footprint estimate (30 acres total) for barge landings.

Following construction, these facilities will operate for 5-6 years serving the TBM launch and retrieval sites as well as other construction sites as needed. During construction of the tunnels and other water conveyance facilities, it is projected that up to 15,000 barge trips may be added to the daily vessel traffic in the action area. If these trips are divided evenly among the 7 proposed barge landings and spread over the number of days for 5.5 years, this corresponds conservatively to an average of 7.5 barge trips per day (1.1 per landing). To protect aquatic habitat and listed fish species, the barge operations plan (AMM7) will require barges and towing vessels to comply with standard navigation and operating rules to avoid or minimize physical disturbances and water quality impacts in the navigable waterways of the Delta. Where avoidance is not possible, the plan will include provisions to minimize effects as described in Appendix 3.F *General Avoidance and Minimization Measures*, Section 3.F.2.7.4 *Environmental Training* and Section 3.F.2.7.5 *Dock Approach and Departure Protocol*.

Construction of the barge landings will result in permanent impacts to approximately 22.4 acres of tidal perennial habitat that includes the footprint of the docks, mooring structures, and adjacent channel area that will be affected by propeller wash and scour from barges and tidal action. Estimates of the amount of shallow water habitat or suitable spawning substrate potentially affected by construction are not currently available.

6.1.1.3.1 Turbidity and Suspended Sediment

Pile driving, barge operations, and levee armoring will be the principal sources of turbidity and suspended sediment during construction of the barge landings. These activities will result in disturbance of the channel bed and banks, resulting in periodic increases in turbidity and suspended sediment in the adjacent waterways. In-water vibratory and impact driving of the sheet piles are expected to generate turbidity plumes that could extend beyond the immediate vicinity of the source piles depending on the direction and velocity of tidal flows. Pile driving will be restricted to the in-water construction window (August 1 through October 31) to avoid the primary periods of occurrence of Delta smelt in the action area.

Potential turbidity and sediment impacts on listed fish species and aquatic habitat will be minimized by restricting in-water construction activities to August 1 through October 31 at most locations[5]. In addition, DWR proposes to develop and implement AMM7, *Barge Operations Plan*, which includes specific measures to minimize bed scour, bank erosion, loss of submerged and emergent vegetation, and disturbance of benthic communities (Appendix 3.F *General Avoidance and Minimization Measures*). Other AMMs that are proposed to avoid or minimize potential turbidity, suspended sediment, and other water quality impacts include AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan; Erosion and Sediment Control Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan;* and AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F).

Some potential exists for construction-related turbidity and suspended sediment to occur outside the in-water construction period due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with implementation of the proposed erosion and sediment control measures (AMM4) and other BMPs to ensure the effectiveness of these measures (AMM2 *Construction Best Management Practices and Monitoring*), no adverse water quality effects are anticipated at the barge landings outside of the in-water construction season.

6.1.1.3.1.1 Migrating Adults (December-March)

6.1.1.3.1.1.1 Individual-Level Effects

The timing of in-water construction activities at the barge landing (August 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults from temporary increases in turbidity and suspended sediment during in-water construction activities. Some risk would exist outside the in-water construction period. However, implementation of the proposed pollution prevention, erosion and sediment control, and barge operations AMMs would minimize this risk throughout the construction period.

6.1.1.3.1.1.2 Population-Level Effects

No population-level effect would occur.

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[5] In-water construction activities at the north Delta intakes (Intake 3 and 5) and CCF, which may include barge landings, will be conducted June 1-October 31 and July 1-November 30, respectively.

6.1.1.3.1.2 Spawning Adults (February-June)

6.1.1.3.1.2.1 Individual-Level Effects

The timing of in-water construction activities at the barge landings (August 1–October 31) will avoid the Delta Smelt spawning adult season. Therefore, there would be no effect on spawning adults from temporary increases in turbidity and suspended sediment during in-water construction activities. Some risk would exist outside the in-water construction period. However, implementation of the proposed pollution prevention, erosion and sediment control, and barge operations AMMs would minimize this risk throughout the construction period.

6.1.1.3.1.2.2 Population-Level Effects

Based on the general timing and abundance of Delta Smelt in the east and south Delta, the August 1 – October 31 in water work window should be protective of Delta Smelt. Because Delta Smelt are generally found in the west Delta and Cache Slough/Liberty Island area during spring and summer, the majority of the population will not be exposed to construction activities at the proposed barge landing sites. In addition, the timing of in-water construction activities (August 1–October 31) will avoid the spawning season (January through June, with peak numbers during February through May). With the timing restrictions on in-water activities and implementation of the proposed pollution prevention, erosion and sediment control, and barge operations AMMs, no population-level effects attributable to increased turbidity and suspended sediment are anticipated.

6.1.1.3.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.1.3.1 Individual-Level Effects

Based on the timing of in-water construction activities (August 1–October 31), eggs/embryos would not be exposed to increases in turbidity and suspended sediment during construction of the barge landings. Some risk would exist outside the in-water construction period. However, implementation of the proposed pollution prevention, erosion and sediment control, and barge operations AMMs would minimize this risk throughout the construction period.

6.1.1.3.1.3.2 Population-Level Effects

No population-level effect would occur.

6.1.1.3.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.1.4.1 Individual-Level Effects

Based on the timing of in-water construction activities (August 1–October 31), larvae/young juveniles would not be exposed to increases in turbidity and suspended sediment during construction of the barge landings. Some risk would exist outside the in-water construction period. However, implementation of the proposed pollution prevention, erosion and sediment control, and barge operations AMMs would minimize this risk throughout the construction period.

6.1.1.3.1.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.1.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the barge landing locations in the summer and fall and therefore would be unaffected by increased turbidity and suspended sediment during in-water construction activities.

6.1.1.3.1.5.2 Population-Level Effects

No population-level effect would occur.

6.1.1.3.2 Contaminants

Construction of the barge landings poses an exposure risk to Delta smelt from potential spills of hazardous materials from construction equipment, barges and towing vessels, and other machinery, and from potential mobilization of contaminated sediment. The risk of accidental spills of contaminants and other hazardous materials during construction of the barge landings would be similar to that described for the north Delta intakes (section 6.1.1.2.2) due to the proximity of construction activities to the waters of the Delta. Implementation of Appendix 3.F *General Avoidance and Minimization Measures,* AMM5 *Spill Prevention, Containment, and Countermeasure Plan* and AMM14 *Hazardous Materials Management* is expected to minimize the potential for introduction of contaminants into surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials. These AMMs include the use of watertight forms and other containment structures to prevent spills or discharge of raw concrete, wash water, and other contaminants from entering surface waters and other sensitive habitats during casting of the barge decks and other overwater activities. With implementation of these and other required construction BMPs (e.g., AMM3 *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to Delta waters from in-water and overwater sources would be effectively minimized.

Contaminants may also enter the aquatic environment through disturbance, resuspension, or discharge of contaminated soil and sediments from construction sites. Because the barge landings would be constructed on Delta waterways adjacent to major agricultural islands, these sites are more likely to contain agricultural-related toxins such as copper and organochlorine pesticides. As described in Section 5.2.2.3 *Contaminants*, sediments act as a sink or source of contaminant exposure and resuspension of contaminated sediments may have adverse effects on fish that encounter sediment plumes or come into contact with deposited or newly exposed sediment.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under Appendix 3.F *General Avoidance and Minimization Measures,* AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material*. These measures include the preparation and implementation of a pre-construction sampling and analysis plan (SAP) to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (e.g., silt curtains) to achieve compliance with existing Basin Plan objectives will be an important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

6.1.1.3.2.1 Migrating Adults (December-March)

6.1.1.3.2.1.1 Individual-Level Effects

The potential effects of contaminants on Delta Smelt were discussed previously (see 6.1.1.3 *North Delta Intakes*). The timing of in-water construction activities (August 1–October 31) will avoid the Delta Smelt adult migration season. Some risk of contaminant spills and runoff of contaminated soil would exist outside the in-water construction period but implementation of proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk.

6.1.1.3.2.1.2 Population-Level Effects

With implementation of proposed pollution prevention and erosion and sediment control AMMs, there is little or no risk of exposure of migrating adults to contaminants. No population-level effects would occur.

6.1.1.3.2.2 Spawning Adults (February-June)

6.1.1.3.2.2.1 Individual-Level Effects

The potential effects of contaminants on Delta Smelt were discussed previously (see 6.1.1.3 *North Delta Intakes*). Based on the timing of in-water construction activities (August 1–October 31), spawning adults would not be subject to direct exposure to contaminant spills or sediment-borne contaminants. Some risk would also exist outside the in-water construction period. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.3.2.2.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.3.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.2.3.1 Individual-Level Effects

Based on the timing of in-water construction activities (August 1–October 31), eggs/embryos would not be subject to direct exposure to contaminant spills or sediment-borne contaminants. Some risk would also exist outside the in-water construction period. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.3.2.3.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities. Implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize the risk of contaminant exposure throughout the construction period.

6.1.1.3.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.2.4.1 Individual-Level Effects

The timing of in-water construction activities (August 1-October 31) will avoid the downstream migration period of Delta Smelt larvae/young juveniles. Therefore, larvae/young juveniles would not be subject to direct exposure to contaminant spills or sediment-borne contaminants. Some risk would also exist outside the in-water construction period. However, implementation of the proposed pollution prevention and erosion and sediment control AMMs would effectively minimize this risk throughout the construction period.

6.1.1.3.2.4.2 Population-Level Effects

No population-level effects are anticipated because of the timing of in-water construction activities, low proportion of the population utilizing the action area, and implementation of the proposed pollution control and erosion and sediment control AMMs.

6.1.1.3.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.2.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake locations in the summer and fall and therefore are unlikely to be affected by contaminant spills or sediment-borne contaminants during construction of the barge landings.

6.1.1.3.2.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.3 Underwater Noise

Impact pile driving at the barge landing sites would potentially produce underwater noise levels of sufficient intensity and duration to cause injury to fish. Currently, it is estimated that each barge landing would require vibratory and/or impact driving of 107 steel pipe piles (24-inch diameter) to construct the dock and mooring facilities. Based on the concurrent operation of 4 impact pile drivers at each site and an estimated installation rate of 60 piles per day, pile driving noise would be expected to occur over a period of 2 days at each barge landing.

Based on the general timing and abundance of Delta Smelt in the east and south Delta, restriction of pile driving activities to August 1 through October 31 will essentially eliminate the potential for exposure of Delta Smelt to pile driving noise during barge landing construction. In addition, as described in Section 6.1.1.3 *North Delta Intakes*, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when Delta Smelt and other listed fish species may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and corrective actions that will be taken should the thresholds be exceeded.

6.1.1.3.3.1 Migrating Adults (December-March)

6.1.1.3.3.1.1 Individual-Level Effects

The timing of in-water construction activities (August 1–October 31) will avoid the Delta Smelt adult migration season. There would be no risk of exposure of migrating adults to impact pile driving noise.

6.1.1.3.3.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.3.2 Spawning Adults (February-June)

6.1.1.3.3.2.1 Individual-Level Effects

Based on the timing of pile driving operations at the barge landings (August 1–October 31) and the general timing and abundance of Delta Smelt in the east and south delta, spawning adults would not be exposed to pile driving noise.

6.1.1.3.3.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.3.3.1 Individual-Level Effects

Pile driving at the barge landings would occur between August 1 and October 31, and therefore would not affect eggs/embryos.

6.1.1.3.3.3.2 Population-Level Effects

There would be no population-level effects on eggs/embryos from pile driving in association with barge landings.

6.1.1.3.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.3.4.1 Individual-Level Effects

Pile driving at the barge landings would occur between August 1 and October 31, and therefore would not affect larvae/young juveniles.

6.1.1.3.3.4.2 Population-Level Effects

There would be no population-level effects on larvae/young juveniles from pile driving in association with barge landings.

6.1.1.3.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.3.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed barge landing sites in summer and fall and therefore would not be affected by pile driving noise.

6.1.1.3.3.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.4 Fish Stranding

No actions are proposed at the barge landings that could result in stranding of Delta Smelt or require fish rescue and salvage activities.

6.1.1.3.5 Direct Physical Injury

During construction of barge landings, fish could be injured or killed by direct contact with equipment or materials that are operated or placed in open waters of the adjacent Delta channels. Potential mechanisms include fish being crushed by falling rock (riprap), impinged by sheetpiles or mooring piles, or struck by propellers. In addition to the proposed work window (August 1-October 31), the potential for injury of listed fish species would be minimized by limiting the duration of in-water construction activities to the extent practicable and implementing the following AMMs: AMM1 *Worker Awareness Training;* AMM4 *Erosion and Sediment Control Plan;* AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material;* AMM7 *Barge Operations Plan; and Fish Rescue and Salvage Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

6.1.1.3.5.1 Migrating Adults (December-March)

6.1.1.3.5.1.1 Individual-Level Effects

The timing of in-water construction activities (August 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, migrating adults are not at risk of being injured.

6.1.1.3.5.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.5.2 Spawning Adults (February-June)

6.1.1.3.5.2.1 Individual-Level Effects

The timing of in-water construction activities (August 1–October 31) will avoid the Delta Smelt spawning season. Therefore, spawning adults are not at risk of being injured.

6.1.1.3.5.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.5.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.5.3.1 Individual-Level Effects

The timing of in-water construction activities (August 1–October 31) will avoid the Delta Smelt incubation season. Therefore, eggs/embryos are not at risk of being injured.

6.1.1.3.5.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.5.4.1 Individual-Level Effects

During in-water construction activities at the barge landings (August 1 and October 31), larvae/young juveniles would not be present at the barge landings and therefore would not be at risk of being injured.

6.1.1.3.5.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.5.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake sites in the summer and fall and therefore are unlikely to be injured by construction activities.

6.1.1.3.5.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.3.6 Loss or Alteration of Habitat

Construction of the barge landings will result in temporary to permanent losses or alteration of aquatic habitat in several channels of the east and south Delta that are within the designated critical habitat of Delta Smelt. Temporary effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed. With implementation of the proposed water quality and sound abatement and control AMMs, in-water construction activities will result in temporary, localized increases in turbidity, suspended sediment, and noise in the vicinity of construction sites but these parameters are expected to return to baseline levels following cessation of construction activities and will not result in long-term impacts on aquatic habitat.

Construction of the barge landing would result in permanent impacts to approximately 22.4 acres of tidal perennial habitat (approximately 3.2 acres per landing). Approximately 0.34 acres of tidal perennial habitat will be replaced by the permanent dock and mooring structures or alternatively, floating docks supported by temporary piles. During construction, and continuing during operation of the barge landings, the channel banks, bed, and waters adjacent to the dock will be periodically disturbed by propeller wash and scour from barges and tidal action, resulting in changes in water depths, benthic substrates, and loss of submerged and emergent vegetation that may be present. Estimates of the amount of shallow water habitat that could be affected by construction are not currently available.

During construction activities, DWR will implement AMM2 *Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. To further minimize adverse effects to aquatic habitat associated with barge operations, DWR also proposes to implement a *Barge Operations Plan*, which includes specific measures to minimize bed scour, bank erosion, loss of submerged and emergent vegetation, and disturbance of benthic communities (Appendix 3.F *General Avoidance and Minimization Measures*). Unavoidable impacts to critical habitat of listed fish species will be offset through on-site and/or off-site mitigation, including the purchase of conservation credits at an approved conservation bank.

6.1.1.3.6.1 Migrating Adults (December-March)

6.1.1.3.6.1.1 Individual-Level Effects

Although affecting a small proportion of the population, migrating adults may be subject to an elevated risk of predation as they pass the construction sites because of potential increases in predator habitat. The presence of in-water and overwater structures (sheet pile wall, floating docks, piles, and vessels) provides shade and cover that may attract certain predatory fish species (e.g., striped bass, largemouth bass, Sacramento pikeminnow) and increase their ability to ambush prey. These structures may also improve predation opportunities for piscivorous birds (e.g., gulls, terns, cormorants) by providing perch sites immediately adjacent to open water.

6.1.1.3.6.1.2 Population-Level Effects

Increased predation risk at the barge landing sites would potentially result in increased mortality of migrating adults. The small proportion of the population spawning in the east and south Delta indicates that the population-level effect would be small.

6.1.1.3.6.2 Spawning Adults (February-June)

6.1.1.3.6.2.1 Individual-Level Effects

Loss or alteration of aquatic habitat within the footprints of the docks, mooring structures, and operational areas of the barges may result in reductions in the amount of shallow water habitat potentially available to spawning adults. Because the barge landings will likely be sited in areas with steep, riprapped levees and deep nearshore areas, the potential for utilization of these sites by Delta Smelt for spawning is low. Consequently, permanent losses or alteration of nearshore habitat resulting from construction of the barge landings would not likely have a significant effect on spawning habitat use or spawning success of adults.

6.1.1.3.6.2.2 Population-Level Effects

Population-level effects are expected to be negligible because of the small proportion of the population spawning in the action area and expected low utilization of the barge landing sites by spawning adults.

6.1.1.3.6.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.3.6.3.1 Individual-Level Effects

Based on the small proportion of the population spawning in the action area and expected low utilization of the barge landing sites by spawning adults, there is little risk of adverse effects on eggs or embryos.

6.1.1.3.6.3.2 Population-Level Effects

Population-level effects are expected to be negligible.

6.1.1.3.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.3.6.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles migrating from upstream spawning areas to estuarine rearing areas may be subject to an elevated risk of predation as they pass the barge landings because of the presence of in-water and overwater structures and the loss of shallow, low-velocity nearshore areas. To the extent that these conditions provide beneficial habitat or increased predation opportunities for predators of larvae and early juveniles (e.g., silversides; Baerwald et al. 2012), there could be an elevated risk of predation for these young life stages. However, it is not clear that these structures provide beneficial habitat as these small predators may be susceptible to the same larger predators that consume adult Delta Smelt. Therefore, elevated predation on Delta Smelt larvae is unlikely.

6.1.1.3.6.4.2 Population-Level Effects

Even if larvae and juveniles are subject to elevated predation rates as they pass the construction sites, the population-level effect would be small based on the small proportion of the population occurring in or upstream of the action area.

6.1.1.3.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.3.6.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed barge landing sites in the summer and fall and therefore are unlikely to be affected by losses or alteration of habitat during construction.

6.1.1.3.6.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4 Head of Old River Gate

An operable gate (Head of Old River [HOR] gate) will be constructed at the HOR to prevent migrating juvenile salmonids from entering Old River from the San Joaquin River, and thereby minimize their exposure to the CVP/SWP pumping facilities. The gate will be located at the divergence of the HOR and the San Joaquin River (Appendix 3.A *Map Book for the Proposed Action*), and will be 210 feet long and 30 feet wide, with top elevation of +15 feet (Appendix 3.C *Conceptual Engineering Report*, Volume 2, Sheets 11, 12, and 13). The gate will include seven bottom-hinged gates, fishway, boat lock, control building, boat lock operator's building, and communications antenna. Additional details on the intake design, construction methods, and proposed construction schedule are described in Chapter 3.

Construction of the HOR gate is expected to take 3 years. The HOR gate will be constructed in two phases using cofferdams to isolate and dewater half the channel during the first phase and the other half during the second phase. All in-water construction work, including cofferdam installation, riprap placement, dredging, and barge operations, would be restricted to August 1-November 30 to minimize or avoid potential effects on Delta Smelt and juvenile salmonids. In addition, all pile driving requiring the use of an impact pile driver in or near open water (cofferdams and foundation piles) will be restricted to this period to avoid or minimize exposure of listed species to potentially harmful underwater noise levels. Construction of the HOR gate will require dredging of approximately 500 feet of channel (150 feet upstream to 350 feet downstream from the proposed gate) and removal of up to 1,500 cubic yards of material with a barge-mounted hydraulic or a sealed clamshell dredge. The need for additional clearing and grading of the site for construction, staging, and other support facilities is expected to be minimal because of the presence of existing access roads and staging areas that have been used in the past for installation of a temporary rock barrier.

Construction of the HOR gate will result in temporary impacts on water quality and permanent impacts on physical habitat within the footprint of the gate and channel reaches that would be affected by dredging. These impacts encompass a total of approximately 2.9 acres of tidal perennial habitat that includes the permanent footprint of the gate, fish passage structure, and boat lock.

6.1.1.4.1 Turbidity and Suspended Sediment

In-water construction activities would result in disturbance of the channel bed and banks, resulting in temporary increases in turbidity and suspended sediment levels in Old River and potentially the San Joaquin River. These activities include cofferdam construction (sheet pile installation), dredging, riprap placement, and barge operations. All other sediment-disturbing activities will be outside or isolated from the active channel and would not result in the discharge of sediment to the river. Water pumped from the cofferdams will be treated (removing all sediment) using settling basins or Baker tanks, and returned to the river. Dredging, foundation pile driving, and other construction activities will proceed within the confines of the cofferdams.

In addition to the in-water work window, a number of AMMs are proposed to avoid or minimize potential impacts on water quality and listed fish species during construction of the HOR gate. These AMMs include AMM1 *Worker Awareness Training;*AMM2 *Construction Best Management Practices and Monitoring; Stormwater Pollution Prevention Plan;* AMM4 *Erosion and Sediment Control Plan; Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan;* and AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F *General Avoidance and Minimization Measures*).

Some potential exists for construction-related turbidity and suspended sediment to occur during winter and spring due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with the timing restrictions on in-water activities and implementation of the proposed erosion and sediment control AMMs, no adverse water effects are anticipated during this period.

6.1.1.4.1.1 Migrating Adults (December-March)

6.1.1.4.1.1.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults from temporary increases in turbidity and suspended sediment.

6.1.1.4.1.1.2 Population-Level Effects

No population-level effect would occur.

6.1.1.4.1.2 Spawning Adults (February-June)

6.1.1.4.1.2.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt spawning season. However, increases in suspended sediment during in-water construction activities may result in localized sediment deposition, degrading potential spawning habitat of Delta Smelt through burial of suitable substrates. However, Old River in the vicinity of the proposed HOR gate does not likely support significant spawning of Delta Smelt, serving mainly as a migration corridor for adults during their migration to upstream spawning areas and larvae during their downstream dispersal to estuarine habitat. There appears to be little or no habitat thought to be preferred by Delta Smelt for spawning in this reach, which is dominated by steep levee slopes, existing riprap, and low quantities of riparian and aquatic vegetation.

6.1.1.4.1.2.2 Population-Level Effects

Most of the Delta Smelt population is distributed downstream of the proposed HOR gate (Moyle 2002) but Delta Smelt have been found as far upstream as Moss Landing (Vincik and Julienne 2012). Available monitoring data suggest that adult Delta Smelt occur in very low numbers near the HOR gate. Over 2,300 beach seine samples[6] in the San Joaquin River between Dos Reis (river mile 51) and Weatherbee (river mile 58) between 1994 and 2015 yielded four Delta Smelt (all in February–April) (U.S. Fish and Wildlife Service 2015a). Nearly 30,000 trawl samples at Mossdale[7] from 1994 to 2015 resulted in the capture of 44 Delta Smelt, principally in March-June (U.S. Fish and Wildlife Service 2015a). The low abundance of Delta Smelt and low quality of potential spawning habitat in the vicinity of the HOR gate indicates that any impacts on potential spawning habitat resulting from sedimentation of suitable substrates would have negligible population-level effects.

6.1.1.4.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.1.3.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt incubation season. Therefore, there would be no effect on eggs/embryos from temporary increases in turbidity and suspended sediment.

6.1.1.4.1.3.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.4.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.1.4.1 Individual-Level Effects

The timing of in-water construction activities (August 1-November 30) will avoid the downstream migration period of Delta Smelt larvae/young juveniles. Therefore, there would be no effect on Delta smelt larvae/young juveniles from temporary increases in turbidity and suspended sediment.

6.1.1.4.1.4.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.4.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.1.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed HOR gate in the summer and fall and therefore would be unaffected by increased turbidity and suspended sediment during in-water construction activities.

6.1.1.4.1.5.2 Population-Level Effects

No population-level effect would occur.

6.1.1.4.2 Contaminants

Construction of the HOR gate poses an exposure risk to listed fish species from potential spills of hazardous materials from construction equipment, barges and towing vessels, and other

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[6] Data were obtained from http://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm, files <Beach Seines CHN _ POD Species 1976-2011.xlsx> and <Beach Seines CHN _ POD Species 2012-2015.xlsx> accessed September 14, 2015.

[7] Data were obtained from http://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm, files < Mossdale Trawls CHN _ POD Species 1994-2011.xlsx> and < Mossdale Trawls CHN & POD Species 2012-2015.xlsx> accessed September 14, 2015.

machinery, and from potential mobilization of contaminated sediment. The risk of accidental spills of contaminants and other potentially hazardous materials would be similar to that described for the north Delta intakes (section 5.2.2.3) due to the proximity of construction activities to the waters of the Delta. Implementation of AMM5, *Spill Prevention, Containment, and Countermeasure Plan*, and AMM14 *Hazardous Materials Management* (see Appendix 3.F *General Avoidance and Minimization Measures*) is expected to minimize the potential for introduction of contaminants into surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials. With implementation of these and other required construction BMPs (e.g., AMM3, *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to Delta waters from in-water or upland sources would be effectively minimized.

Contaminants may also enter the aquatic environment through disturbance, resuspension, or discharge of contaminated soil and sediments from construction sites. As described in section 5.2.2.3, sediments act as a sink or source of contaminant exposure, and resuspension of contaminated sediments may have adverse effects on fish that encounter sediment plumes or come into contact with deposited or newly exposed sediment. Contaminated sediments may be present in Old River and within the footprint of the proposed HOR gate because of the proximity of the site to major municipal, industrial, and agricultural areas. The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material* in Appendix 3.F *General Avoidance and Minimization Measures*. These measures include the preparation and implementation of a pre-construction sampling and analysis plan (SAP) to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (e.g., silt curtains) to achieve compliance with existing Basin Plan objectives will be important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

6.1.1.4.2.1 Migrating Adults (December-March)

6.1.1.4.2.1.1 Individual-Level Effects

The potential effects of contaminants on Delta Smelt were discussed previously (see 6.1.1.3 *North Delta Intakes*). The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt adult migration season. With implementation of proposed pollution prevention and erosion and sediment control AMMs, little or no risk of contaminant exposure would exist throughout the construction period.

6.1.1.4.2.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.2.2 Spawning Adults (February-June)

6.1.1.4.2.2.1 Individual-Level Effects

The timing of in-water construction activities (August 1-November 30) will avoid the Delta Smelt adult migration season. With implementation of proposed pollution prevention and erosion and sediment control AMMs, little or no risk of contaminant exposure would exist throughout the construction period.

6.1.1.4.2.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.2.3.1 Individual-Level Effects

The timing of in-water construction activities (August 1-November 30) will avoid the Delta Smelt incubation season. With implementation of proposed pollution prevention and erosion and sediment control AMMs, little or no risk of contaminant exposure would exist throughout the construction period.

6.1.1.4.2.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.2.4.1 Individual-Level Effects

The timing of in-water construction activities (August 1-November 30) will avoid the downstream migration period of Delta Smelt larvae and early juveniles. With implementation of proposed pollution prevention and erosion and sediment control AMMs, little or no risk of contaminant exposure would exist throughout the construction period.

6.1.1.4.2.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.2.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intake locations in the summer and fall and therefore are unlikely to be affected by contaminant spills or sediment-borne contaminants during construction of the intakes.

6.1.1.4.2.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.3 Underwater Noise

Impact pile driving at the HOR gate would potentially produce underwater noise levels of sufficient intensity and duration to injure or kill fish. Currently, it is estimated that the HOR gate would require the installation of 550 temporary sheet piles (275 piles per season) to construct the cofferdams and 100 14-inch steel pipe or H-piles (50 piles per season) to construct the foundation. Based on an assumed installation rate of 15 piles per day, pile driving would be expected to occur up to 19 days per season during installation of the sheet piles, and up to 4 days per season during installation of the foundation piles. DWR proposes to avoid exposure of Delta Smelt to pile driving noise and other water quality impacts by conducting all in-water construction activities between August 1 and November 30. This will effectively avoid the periods when Delta Smelt may be present.

6.1.1.4.3.1 Migrating Adults (December-March)

6.1.1.4.3.1.1 Individual-Level Effects

The timing of impact pile driving activities (August 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of exposure of migrating adults to impact pile driving noise.

6.1.1.4.3.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.3.2 Spawning Adults (February-June)

6.1.1.4.3.2.1 Individual-Level Effects

The timing of impact pile driving activities (August 1–November 30) will avoid the Delta Smelt spawning season. There would be no risk of exposure of spawning adults to impact pile driving noise.

6.1.1.4.3.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.3.3.1 Individual-Level Effects

The timing of impact pile driving activities (August 1–November 30) will avoid the Delta Smelt incubation season. There would be no risk of exposure of eggs or embryos to impact pile driving noise.

6.1.1.4.3.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.3.4.1 Individual-Level Effects

The timing of impact pile driving activities (August 1–November 30) will avoid the downstream migration period of Delta Smelt larvae and early juveniles. There would be no risk of exposure of larvae or early juveniles to impact pile driving noise.

6.1.1.4.3.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.3.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the HOR gate in summer and fall and therefore are unlikely to be affected by pile driving noise.

6.1.1.4.3.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.4 Fish Stranding

The use of cofferdams to construct the HOR gate will exclude fish from active construction areas but could also strand fish that are not able to avoid these areas, resulting in direct injury and mortality from dewatering, dredging, and pile driving activities within the enclosed cofferdams.

To minimize fish stranding losses, DWR will implement a fish rescue and salvage plan (Appendix 3.F *General Avoidance and Minimization Measures*, AMM8 *Fish Rescue and Salvage Plan*). The plan will be submitted to the fish and wildlife agencies (NMFS, USFWS, CDFW) for review and approval prior to implementation. The plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that would apply to all in-water activities with the potential to entrap fish. All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist. The biologist, in consultation with a designated agency biologist, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. Collection methods may include seines, dip nets, and electrofishing if permitted. DWR proposes to minimize the potential for stranding of Delta Smelt and juvenile salmonids by conducting all in-water construction activities between August 1 and November 30. This will effectively avoid the periods when Delta Smelt adults, larvae, and early juvenile may be present.

6.1.1.4.4.1 Migrating Adults (December-March)

6.1.1.4.4.1.1 Individual-Level Effects

The timing of cofferdam construction (August 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of stranding of migrating adults.

6.1.1.4.4.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.4.2 Spawning Adults (February-June)

6.1.1.4.4.2.1 Individual-Level Effects

The timing of cofferdam construction (August 1–November 30) will avoid the Delta Smelt spawning season. There would be no risk of stranding of spawning adults.

6.1.1.4.4.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.4.3.1 Individual-Level Effects

The timing of cofferdam construction (August 1–November 30) will avoid the Delta Smelt incubation season. There would be no risk of stranding of eggs or embryos.

6.1.1.4.4.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.4.4.1 Individual-Level Effects

The timing of cofferdam construction (August 1–November 30) will avoid the downstream migration period of Delta Smelt larvae and early juveniles. There would be no risk of stranding of larvae or early juveniles.

6.1.1.4.4.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.4.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the HOR gate in summer and fall and therefore are unlikely to be stranded in the cofferdams.

6.1.1.4.4.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.5 Direct Physical Injury

During construction of the HOR gate, fish could be injured or killed by direct contact with equipment or materials that are operated or placed in open waters of Old River. Potential mechanisms include fish being impinged by sheetpiles, entrained by dredges, or struck by propellers during barge operations. DWR proposes to minimize the potential for injury of Delta Smelt and juvenile salmonids by conducting all in-water construction activities between August 1 and November 30. This will effectively avoid the periods when Delta Smelt adults, larvae, and early juvenile may be present. In addition to the proposed work window, the potential for injury of listed fish species would be minimized to the extent practicable by limiting the duration of in-water construction activities and implementing the AMMs described in Appendix 3.F *General Avoidance and Minimization Measures*. Applicable AMMs include AMM1 *Worker Awareness Training;* AMM4 *Erosion and Sediment Control Plan;* AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material;* AMM7 *Barge Operations Plan;* and AMM8 *Fish Rescue and Salvage Plan*.

6.1.1.4.5.1 Migrating Adults (December-March)

6.1.1.4.5.1.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of injury of migrating adults.

6.1.1.4.5.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.5.2 Spawning Adults (February-June)

6.1.1.4.5.2.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt spawning season. There would be no risk of injury of spawning adults.

6.1.1.4.5.2.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.5.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.5.3.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the Delta Smelt incubation season. There would be no risk of injury of eggs or embryos.

6.1.1.4.5.3.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.5.4.1 Individual-Level Effects

The timing of in-water construction activities (August 1–November 30) will avoid the downstream migration period of Delta Smelt larvae and early juveniles. There would be no risk of injury of larvae or early juveniles.

6.1.1.4.5.4.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.5.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the HOR gate in summer and fall and therefore are unlikely to be injured by in-water construction activities.

6.1.1.4.5.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.4.6 Loss or Alteration of Habitat

Construction of the HOR gate would result in temporary to permanent losses or alteration of aquatic habitat in Old River. Temporary effects of construction activities on water quality were previously discussed. With implementation of the proposed water quality and sound abatement and control AMMs, in-water construction activities will result in temporary, localized increases in turbidity, suspended sediment, and noise in the vicinity of construction sites but these parameters are expected to return to baseline levels following cessation of construction activities and will not result in long-term impacts on aquatic habitat.

Construction of the HOR gate will result in permanent impacts to approximately 2.9 acres of tidal perennial habitat, including the footprint of the gate and the channel segments upstream and downstream of the structure that will be affected by dredging. Estimates of the amount of shallow water habitat potentially affected by construction are not currently available.

During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. DWR proposes to offset unavoidable impacts to critical habitat through on-site and/or off-site mitigation, including the purchase of conservation credits at an approved conservation bank.

6.1.1.4.6.1 Migrating Adults (December-March)

6.1.1.4.6.1.1 Individual-Level Effects

Although affecting a small proportion of the population, migrating Delta Smelt adults may be subject to potential delays in migration and increased predation as they attempt to pass the cofferdams during the 3-year construction period. Cofferdams that constrict the flow to half the channel's width would increase water velocities and potentially impede the migration of adults attempting to pass the site. The presence of in-channel cofferdams and/or the partially competed HOR gate may also increase the amount of predatory fish habitat and create hydraulic conditions that improve their ability to prey on Delta Smelt as they migrate past the site.

6.1.1.4.6.1.2 Population-Level Effects

Based on the apparent low abundance of Delta Smelt in the San Joaquin River in the vicinity of HOR, potential adverse effects on migration and survival of migrating adults would likely be limited to a very small proportion of the population, resulting in negligible effects on the total spawning stock of Delta Smelt.

6.1.1.4.6.2 Spawning Adults (February-June)

6.1.1.4.6.2.1 Individual-Level Effects

Loss or alteration of aquatic habitat within the footprints of the cofferdams, riprapped banks, and dredged channel areas would reduce the amount of shallow water habitat potentially available to spawning adults. However, this portion of the Old River channel is frequently disturbed by the annual installation of a temporary rock barrier and is dominated by steep levee slopes, riprap, and low quantities of riparian and aquatic vegetation. There is little or no potential spawning habitat that would be affected by construction of HOR gate and thus little likelihood of adverse effects on spawning adults.

6.1.1.4.6.2.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.4.6.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.4.6.3.1 Individual-Level Effects

Based on the lack of preferred spawning habitat for delta, the potential for adverse effects on eggs and embryos is negligible.

6.1.1.4.6.3.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.4.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.4.6.4.1 Individual-Level Effects

Similar to migrating adults, Delta Smelt larvae and early juveniles may be subject to an elevated risk of predation as they pass the cofferdams and/or partially completed HOR gate.

6.1.1.4.6.4.2 Population-Level Effects

Based on the apparent low abundance of Delta Smelt in the San Joaquin River in the vicinity of HOR, potential adverse effects on survival of larvae and juveniles would likely be limited to a very small proportion of the population, resulting in negligible effects on juvenile and adult recruitment.

6.1.1.4.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.4.6.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the HOR gate in summer and fall and therefore are unlikely to be affected by losses or alteration of habitat during construction.

6.1.1.4.6.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5 Clifton Court Forebay

Construction activities at Clifton Court Forebay (CCF) that may potentially affect Delta Smelt include expansion and dredging of SCCF, construction of divider wall and east/west embankments, dewatering and excavation of NCCF, construction of NCCF outlet canals and siphons, and construction of a SSCF intake structure and NCCF emergency spillway. The estimated 7-year construction period will be phased, beginning with expansion of SCCF (Phases 1, 2, and 3); construction of the divider wall between NCCF and SCCF (Phase 4); construction of the west and east embankments (Phase 5); and construction of the NCCF east, west, and north side embankments (Phases 6, 7, and 8). Details on the design, construction methods, and proposed construction schedule for CCF are described in Chapter 3.

Permanent impacts on aquatic habitat include the loss of an estimated 258 acres of tidal perennial habitat in CCF that would be replaced by permanent fill and structures associated with the new CCPP, perimeter and divider embankments, outlet canals and siphons, and intake structure and spillway (Mapbook M3.A). Estimates of the amount of shallow water habitat potentially affected by construction are not currently available.

6.1.1.5.1 Turbidity and Suspended Sediment

In-water construction activities at CCF would result in elevated turbidity and suspended sediment levels in CCF and Old River. The principal sources of increased turbidity and suspended sediment are dredging and cofferdam construction (sheet pile installation and removal). Minor increases in turbidity and suspended sediment in CCF and Old River are also expected during construction of the CCPP, outlet canals and siphons, SSCF intake structure, and North CCF (NCCF) emergency spillway. All other sediment-disturbing activities within cofferdams, upland areas, or non-fish-bearing waters pose little or no risk to listed fish species or aquatic habitat.

The potential for adverse effects of elevated turbidity and suspended sediment on listed fish species would be minimized by restricting all in-water construction activities to July 1-November 30, limiting the duration of these activities to the extent practicable, and implementing the AMMs described in Appendix 3.F *General Avoidance and Minimization Measures* to protect listed fish species from water quality impairment. These measures include AMM1 *Worker Awareness Training;* AMM2 *Construction Best Management Practices and Monitoring;* AMM3 *Stormwater Pollution Prevention Plan; Erosion and Sediment Control Plan;* AMM5 *Spill Prevention, Containment, and Countermeasure Plan;* AMM14 *Hazardous Material Management Plan,* and AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material Plan*.

Dredging could cause extensive, long-term effects on turbidity and suspended sediment within CCF. Potential secondary effects include potential increases in chemical and biological oxygen demand associated with the decomposition of vegetation and organic material in disturbed sediments. In addition to implementing the AMMs listed above, DWR proposes to limit the potential exposure of listed species to water quality impacts by restricting the timing, extent, and frequency of major sediment-disturbing events. For example, DWR proposes to limit the extent of dredging impacts in CCF by restricting daily operations to two dredges operating for 10-hour periods (daylight hours) within 200-acre cells enclosed by silt curtains (representing approximately 10% of total surface area of CCF). In addition, dredging will be monitored and regulated through the implementation of the *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material Plan*, which includes preparation of a sampling and analysis plan, compliance with NPDES and SWRCB water quality requirements during dredging activities, and compliance with applicable in-water work windows established by CDFW, NMFS, and USFWS.

Some potential exists for construction-related turbidity and suspended sediment to occur during winter and spring due to increased erosion and mobilization of sediment in runoff from disturbed levee surfaces. However, with implementation of the proposed erosion and sediment control measures (AMM4) and other BMPs to ensure the effectiveness of these measures (*AMM2, Construction Best Management Practices and Monitoring*), no adverse water quality effects are anticipated outside of the in-water construction season.

6.1.1.5.1.1 Migrating Adults (December-March)

6.1.1.5.1.1.1 Individual-Level Effects

The timing of in-water construction activities at CCF (July 1–November 30) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults from temporary increases in turbidity and suspended sediment.

6.1.1.5.1.1.2 Population-Level Effects

No population-level effect would occur.

6.1.1.5.1.2 Spawning Adults (February-June)

6.1.1.5.1.2.1 Individual-Level Effects

The timing of in-water construction activities (July 1–November 30) will minimize the potential for exposure of spawning adults to increases in turbidity and suspended sediment. Adults may be present in CCF and Old River in July although the numbers of adults are expected to be very low based on salvage records (see below).

6.1.1.5.1.2.2 Population-Level Effects

Based on the general timing and abundance of Delta Smelt inferred from salvage and fish monitoring data, restriction of dredging and other in-water construction activities in CCF to July 1-November 30 will minimize potential exposure of spawning adults, eggs, and larvae to increased turbidity and suspended sediment. Salvage records indicate that adults and larvae may be present in June and July but abundance is low and declining in these months, especially in July as water temperatures typically exceed the upper tolerance levels for successful reproduction. In addition, Old River in the vicinity of CCF is highly channelized and lacks the general attributes of preferred spawning habitat (complex channels, shoals, and tidal marsh), and CCF is not considered suitable habitat because of the low likelihood of survival of larvae, juveniles, and adults that are entrained into the forebay (Castillo *et al.* 2012). No population-level effects are anticipated.

6.1.1.5.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.1.3.1 Individual-Level Effects

Based on the timing of in-water construction activities (July 1–November 30) and low probability of successful spawning of Delta Smelt, eggs/embryos are not likely to be affected by increases in turbidity and suspended sediment from in-water construction activities.

6.1.1.5.1.3.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.5.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.1.4.1 Individual-Level Effects

Based on the timing of in-water construction activities (July 1–November 30) and low probability of successful spawning of Delta Smelt, larvae/young juveniles are not likely to be adversely affected by increases in turbidity and suspended sediment from in-water construction activities.

6.1.1.5.1.4.2 Population-Level Effects

No population-level effects are anticipated.

6.1.1.5.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.1.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF and the adjacent south Delta channels in the summer and fall and therefore would be unaffected by increases in turbidity and suspended sediment during construction.

6.1.1.5.1.5.2 Population-Level Effects

No population-level effect would occur.

6.1.1.5.2 Contaminants

Dredging, excavation, and expansion of the CCF and construction of new water conveyance facilities presents an exposure risk to fish from potential spills of hazardous materials from construction equipment and from potential exposure and re-suspension of contaminated sediment. The risk of accidental spills of contaminants and other potentially hazardous materials would be similar to that described for the north Delta intakes (section 6.1.1.2) due to the proximity of construction activities to the waters of CCF and adjacent waterways. Implementation of AMM5, *Spill Prevention, Containment, and Countermeasure Plan*, and AMM14 *Hazardous Materials Management* (see Appendix 3.F *General Avoidance and Minimization Measures*) is expected to minimize the potential for introduction of contaminants into surface waters and guide rapid and effective response in the case of inadvertent spills of hazardous materials. With implementation of these and other required construction BMPs (e.g., AMM3, *Stormwater Pollution Prevention Plan*), the risk of contaminant spills or discharges to Delta waters from in-water or upland sources would be effectively minimized.

As described in Section 5.2.2.3 *Contaminants*, contaminated sediments can adversely affect fish through direct exposure from mobilized sediment or indirect exposure through accumulation of contaminants in the food web. Consequently, dredging, excavation, and expansion of CCF poses a substantial short-term and long-term risk of exposure of fish and other aquatic organisms to elevated concentrations of contaminants. Current estimates indicate the dredging will affect up to 1,932 acres of CCF while expansion of the SCCF will create an additional 590 acres of newly exposed sediment. The proximity of the south Delta to agricultural, industrial, and municipal sources indicates that a broad range of contaminants that are toxic to fish and other aquatic biota, including metals (e.g., copper, mercury), hydrocarbons, pesticides, and ammonia, could be present. Mud and silt in south Delta waterways have been shown to contain elevated concentrations of contaminants, including mercury, pesticides (chlorpyrifos, diazinon, DDT), and other toxic substances (California State Water Resources Control Board 2010). Impairments in Delta waterways also include heavy metals such as selenium, cadmium, and nickel (G. Fred Lee & Associates 2004). Thus, exposure and resuspension of sediments during in-water construction could lead to degradation of water quality and adverse effects on fish or their food resources in the action area.

The potential for introduction of contaminants from disturbed sediments will be addressed through the implementation of specific measures addressing containment, handling, storage, and disposal of contaminated sediments, as described under AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material* in Appendix 3.F *General Avoidance and Minimization Measures*. These measures include the preparation and implementation of a pre-construction sampling and analysis plan (SAP) to characterize contaminants and determine appropriate BMPs to minimize or avoid mobilization of contaminated sediments during in-water construction activities. Because potential mobilization of contaminants is closely linked to sediment disturbance and associated increases in turbidity and suspended sediment, turbidity monitoring and control measures (e.g., silt curtains) to achieve compliance with existing Basin Plan objectives will be important measures for limiting dispersal of contaminated sediments during dredging and other in-water construction activities.

6.1.1.5.2.1 Migrating Adults (December-March)

6.1.1.5.2.1.1 Individual-Level Effects

The timing of in-water construction activities (July 1-November 30) will avoid the Delta Smelt adult migration season and potential direct exposure of migrating adults to potential spills and resuspension of contaminated sediments. However, the presence of newly exposed sediment and resuspension of sediments by currents and wind-driven mixing could increase exposure of spawning adults at other times of the year. This risk will be minimized by implementing the proposed pollution prevention and erosion and sediment control AMMs.

6.1.1.5.2.1.2 Population-Level Effects

Because of the low likelihood of survival of migrating adults that are entrained into CCF, construction-related increases in contaminant exposure are not likely to have measurable population-level effects.

6.1.1.5.2.2 Spawning Adults (February-June)

6.1.1.5.2.2.1 Individual-Level Effects

The timing of in-water construction activities (July 1–November 30) will minimize the potential for direct exposure of spawning adults to contaminants resulting from potential spills and resuspension of contaminated sediments. Adults may be present in CCF in July although the numbers of adults are expected to be very low based on salvage records (see 6.1.1.5.1.2.2). However, the presence of newly exposed sediment and resuspension of sediments by currents and wind-driven mixing could increase exposure of spawning adults at other times of the year. This risk will be minimized by implementing the proposed pollution prevention and erosion and sediment control AMMs.

6.1.1.5.2.2.2 Population-Level Effects

Because of the low probability of successful spawning of Delta Smelt in CCF, construction-related increases in contaminant exposure are not likely to have measurable population-level effects.

6.1.1.5.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.2.3.1 Individual-Level Effects

The timing of in-water construction activities (July 1–November 30) will minimize the potential for direct exposure of eggs/embryos to contaminants resulting from potential spills and resuspension of contaminated sediments, although the presence of newly exposed sediment and resuspension of sediments by currents and wind-driven mixing could increase exposure of eggs/embryos at other times of the year. This risk will be minimized by implementing the proposed pollution prevention and erosion and sediment control AMMs.

6.1.1.5.2.3.2 Population-Level Effects

Because of the low probability of successful spawning of Delta Smelt in CCF, construction-related increases in contaminant exposure are not likely to have measurable population-level effects.

6.1.1.5.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.2.4.1 Individual-Level Effects

The timing of in-water construction activities (July 1-November 30) will minimize the potential for direct exposure of larvae/young juvenile to contaminants resulting from potential spills and resuspension of contaminated sediments during construction activities, although the presence of newly exposed sediment and resuspension of sediments by currents and wind-driven mixing could increase exposure of larvae/young juveniles at other times of the year. This risk will be minimized by implementing the proposed pollution prevention and erosion and sediment control AMMs.

6.1.1.5.2.4.2 Population-Level Effects

Because of the low probability of survival of larvae/young juveniles in CCF, construction-related increases in contaminant exposure are not likely to have measurable population-level effects.

6.1.1.5.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.2.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF and the adjacent south Delta channels in the summer and fall and therefore are unlikely to be affected by contaminant spills or sediment-borne contaminants during construction.

6.1.1.5.2.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.3 Underwater Noise

During construction of the CCF water conveyance facilities, activities that are likely to generate underwater noise include in-water pile driving, riprap placement, dredging, and barge operations. Pile driving conducted in or near open water poses the greatest risk to fish because the levels of underwater noise produced by impulsive types of sounds often reach levels of sufficient intensity to injure or kill fish within a certain radius of the source piles (Popper and Hastings 2009). Other activities such as riprap placement, dredging, and barge operations generally produce more continuous, lower energy sounds below the thresholds associated with direct injury but may cause avoidance behavior or temporary hearing loss or physiological stress if avoidance is not possible or exposure is prolonged (Popper and Hastings 2009).

Pile driving conducted in or near open water can produce underwater noise of sufficient intensity to injure or kill fish within a certain radius of the source piles. Pile driving information for CCF is available for the embankments, divider wall, siphon at NCCF outlet, and siphon at Byron Highway (Appendix 3.E *Pile Driving Assumptions for the Proposed Action*). Pile driving operations include the installation of an estimated 19,294 temporary sheet piles to construct the cofferdams for the embankments and divider wall, and 2,160 14-inch diameter concrete or steel pipe piles to construct the siphon at the NCCF outlet. Pile driving for the siphon under Byron Highway is not addressed in the following analysis because all pile driving would be conducted on land and more than 200 feet from water potentially containing listed fish species. A total of 4 construction seasons will likely be required to complete pile driving operations based on the estimated duration of pile installation (Appendix 3.D *Construction Schedule for the Proposed Action*).

DWR proposes to minimize the potential exposure of Delta Smelt to pile driving noise by conducting all in-water construction activities between July 1 and November 30. In addition, DWR will develop and implement an underwater sound control and abatement plan outlining specific measures that will be implemented to avoid and minimize the effects of underwater construction noise on listed fish species (Appendix 3.F *General Avoidance and Minimization Measures*, AMM9 *Underwater Sound Control and Abatement Plan*). These measures include the use of vibratory and other non-impact driving methods as well as other physical and operational measures to limit the intensity and duration of underwater noise levels when listed fish species may be present. Where impact pile driving is required, hydroacoustic monitoring will be performed to determine compliance with established objectives (e.g., distances to cumulative noise thresholds) and identify corrective actions to be taken should the thresholds be exceeded.

Table 6.1-3 presents the extent, timing, and duration of pile driving noise levels predicted to exceed the interim injury and behavioral thresholds during installation of cofferdam sheet piles for the embankments and divider wall, and the structural piles for the NCCF siphon based on application of the NMFS spreadsheet model and the assumptions presented in Appendix 3.E *Pile Driving Assumptions for the Proposed Action*. For cofferdam sheet piles, it is assumed that approximately 70% of the length of each pile can be driven using vibratory pile driving, with impact driving used to finalize pile placement. For the NFFC siphon piles, the current design assumes the use of impact pile driving only. However, some degree of attenuation is expected assuming that the cofferdams can be fully dewatered. Therefore, predictions are shown for two scenarios, one in which dewatering results in a 5 dB reduction in reference noise levels, and one in which no attenuation is possible.

Table 6.1-3. Extent, Timing, and Duration of Pile Driving Noise Levels Predicted to Exceed the Interim Injury and Behavioral Thresholds at CCF.

Facility	Distance to 206 dB SPL Injury Threshold (feet)	Distance to Cumulative 187 dB SEL Injury Threshold[1, 2] (feet)	Distance to 150 dB RMS Behavioral Threshold[2] (feet)	Number and Timing of Construction Seasons	Timing of Pile Driving	Duration of Pile Driving (days)
Clifton Court Forebay						
Embankment Cofferdams	30	2,814	13,058	1 (Year 5)	Jul–Nov	85
Divider Wall	30	2,814	13,058	1 (Year 4)	Jul–Nov	86
NCCF Siphon (no attenuation)	46	1,774	9,607	2 (Years 2-3)	Jul–Nov	72
NCCF Siphon (with attenuation)	20	823	4,458	2 (Years 2-3)	Jul–Nov	72

[1] Computed distances to injury thresholds are governed by the distance to "effective quiet" (150 dB SEL). Calculation assumes that single strike SELs <150 dB do not accumulate to cause injury. Accordingly, once the distance to the cumulative injury threshold exceeds the distance to effective quiet, increasing the number of strikes does not increase the presumed injury distance.

[2] Distance to injury and behavioral thresholds assume an attenuation rate of 4.5 dB per doubling of distance and an unimpeded propagation path; on-land pile driving, vibratory driving or other non-impact driving methods, dewatering of cofferdams, and the presence of major river bends or other channel features can impede sound propagation and limit the extent of underwater sounds exceeding the injury and behavioral thresholds.

Sound monitoring data collected during similar types of pile driving operations indicate that single-strike peak SPLs exceeding the interim injury thresholds are expected to be limited to areas within 30 feet of the cofferdam sheet piles and 20-46 feet of the NCCF siphon piles (Table 5.2-5). Based on a cumulative (daily) threshold of 187 dB, the risk of injury is calculated to extend 2,814 feet away from the source piles during installation of cofferdam sheet piles and 1,774 feet during installation of the NCCF siphon piles (823 feet if the cofferdams can be dewatered).[8] Based on a threshold of 150 dB RMS, the potential for behavioral effects is calculated to extend 13,058 and 9,607 feet (4,458 if the cofferdams can be dewatered), respectively. Such exposures would occur over a period of up to 72 days (36 days per season) during installation of the NCCF siphon piles (second and third years of construction activities at CCF), 86 days during cofferdam construction for the divider wall (year 4), and 85 days during cofferdam construction for the embankments (year 5).

6.1.1.5.3.1 Migrating Adults (December-March)

6.1.1.5.3.1.1 Individual-Level Effects

The timing of impact pile driving activities (July 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of exposure of migrating adults to impact pile driving noise.

6.1.1.5.3.1.2 Population-Level Effects

No population-level effects would occur.

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[8] In this case, the distance to the injury thresholds are governed by the distance to "effective quiet" (150 cB SEL).

6.1.1.5.3.2 Spawning Adults (February-June)

6.1.1.5.3.2.1 Individual-Level Effects

Based on the general timing and abundance of Delta Smelt inferred from salvage and fish monitoring data, restriction of impact pile driving in CCF to July 1-November 30 will minimize potential exposure of spawning adults to potentially harmful underwater noise levels (see 6.1.1.5.1.2.2).

6.1.1.5.3.2.2 Population-Level Effects

The extent to which adult smelt spawn in CCF is unknown but the ultimate survival of larvae or juveniles in CCF has been shown to be very low due to high levels of pre-screening mortality and entrainment (Castillo *et al.* 2012). Consequently, potential injury or mortality of spawning adults from pile driving noise is unlikely to have measurable population-level effects.

6.1.1.5.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.3.3.1 Individual-Level Effects

Based on the general timing and abundance of Delta Smelt inferred from salvage and fish monitoring data, restriction of impact pile driving in CCF to July 1-November 30 will minimize potential exposure of eggs/embryos to potentially harmful underwater noise levels.

6.1.1.5.3.3.2 Population-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). Although exposure would be low, individual eggs or embryos would be unable to avoid prolonged exposure to pile driving noise. However, any adverse effects on individual eggs or embryos would have negligible effects on overall survival because of the low probability of survival of larvae that successfully hatch in CCF or in the adjacent channels. Therefore, potential injury or mortality of eggs/embryos from pile driving noise is unlikely to have measurable population-level effects.

6.1.1.5.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.3.4.1 Individual-Level Effects

Based on the general timing and abundance of Delta Smelt inferred from salvage and fish monitoring data, restriction of impact pile driving in CCF to July 1-November 30 will minimize potential exposure of larvae/young juveniles to potentially harmful underwater noise levels.

6.1.1.5.3.4.2 Population-Level Effects

No measurable population-level effects would occur because of the low likelihood of survival of larvae and juveniles in CCF.

6.1.1.5.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.3.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF in the summer and fall and therefore are unlikely to be affected by pile driving noise.

6.1.1.5.3.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.4 Fish Stranding

Installation of cofferdams to isolate construction areas in CCF and the adjacent Old River channel has the potential to strand fish, resulting in direct injury and mortality of fish that become trapped inside the cofferdams. To minimize potential stranding losses, DWR will implement a fish rescue and salvage plan (Appendix 3.F *General Avoidance and Minimization* Measures, AMM8 *Fish Rescue and Salvage Plan*). This plan will be submitted to the fish and wildlife agencies (NMFS, USFWS, CDFW) for review and approval prior to implementation. The plan will include detailed procedures for fish rescue and salvage, including collection, holding, handling, and release, that would apply to all in-water activities with the potential to entrap fish. All fish rescue and salvage operations will be conducted under the guidance of a qualified fish biologist. The biologist, in consultation with a designated agency biologist, will determine the appropriate fish collection and relocation methods based on site-specific conditions and construction methods. Collection methods may include seines, dip nets, and electrofishing if permitted.

6.1.1.5.4.1 Migrating Adults (December-March)

6.1.1.5.4.1.1 Individual-Level Effects

The timing of cofferdam installation (July 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of stranding of migrating adults.

6.1.1.5.4.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.4.2 Spawning Adults (February-June)

6.1.1.5.4.2.1 Individual-Level Effects

Small numbers of spawning adults may be present in CCF and Old River in July and subject to stranding during cofferdam construction. Fish rescue and salvage activities using accepted fish collection methods will minimize these losses but some injury or mortality will still occur because of varying degrees of effectiveness of the collection methods and potential stress and injury associated with various capture and handling methods.

6.1.1.5.4.2.2 Population-Level Effects

Based on the small numbers of spawning adults that may be present during cofferdam installation and the low likelihood of survival of Delta Smelt in CCF, potential injury or mortality of spawning adults from stranding would not be expected to have a measurable population-level effect. Similarly, rescue of stranded adults is unlikely to contribute to overall survival because of the levels of pre-screening mortality and entrainment in CCF.

6.1.1.5.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.4.3.1 Individual-Level Effects

Because eggs and embryos are immobile and attached to substrate or other structures during incubation, they are particularly susceptible to stranding and subsequent injury or mortality in cofferdams.

6.1.1.5.4.3.2 Population-Level Effects

No measurable population-level effects would occur because of the small numbers of eggs/embryos that may be subject to stranding and the low likelihood of survival of Delta Smelt in CCF.

6.1.1.5.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.4.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may be particularly vulnerable to stranding because of their limited swimming abilities. In addition, conventional fish collection methods are less effective and more likely to injure or kill these life stages compared to larger juveniles or adults.

6.1.1.5.4.4.2 Population-Level Effects

No measurable population-level effects would occur because of the small numbers of larvae/young juvenile that may be subject to stranding and the low likelihood of survival of Delta Smelt in CCF.

6.1.1.5.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.4.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF in summer and fall and therefore are unlikely to be present during cofferdam construction and other in-water activities.

6.1.1.5.4.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.5 Direct Physical Injury

Fish could be injured or killed by direct contact with equipment or materials during in-water construction activities in CCF and the adjacent Old River channel. Potential mechanisms include fish being crushed by rock (riprap), impinged by sheetpiles, entrained by dredges, or struck by propellers. In addition to the proposed in-water work period, DWR proposes to implement a number of AMMs to minimize the potential for impacts on listed fish species, including AMM1 *Worker Awareness Training;* AMM4 *Erosion and Sediment Control Plan;* AMM6 *Disposal of Spoils, Reusable Tunnel Material, and Dredged Material;* AMM7 *Barge Operations Plan;* AMM9 *Underwater Sound Control and Abatement Plan,* and AMM8 *Fish Rescue and Salvage Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

6.1.1.5.5.1 Migrating Adults (December-March)

6.1.1.5.5.1.1 Individual-Level Effects

The timing of in-water construction activities (July 1–November 30) will avoid the Delta Smelt adult migration season. There would be no risk of injury of migrating adults.

6.1.1.5.5.1.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.5.2 Spawning Adults (February-June)

6.1.1.5.5.2.1 Individual-Level Effects

Spawning adults may be present in low numbers in CCF and Old River in July and therefore subject to injury during in-water construction activities.

6.1.1.5.5.2.2 Population-Level Effects

Based on the small numbers of spawning adults that may be present during in-water construction activities and the low likelihood of survival of Delta Smelt in CCF, potential losses of spawning adults due to direct injury or mortality from in-water construction activities would not be expected to have a measurable population-level effect.

6.1.1.5.5.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.5.3.1 Individual-Level Effects

Because eggs and embryos are immobile and attached to substrate or other structures during incubation, they are particularly vulnerable to direct injury and mortality from in-water construction activities such as dredging, pile driving, and riprap placement.

6.1.1.5.5.3.2 Population-Level Effects

Based on the small numbers of eggs/embryos that may be present during in-water construction activities and the low likelihood of survival of Delta Smelt in CCF, potential losses of eggs/embryos due to direct injury or mortality from in-water construction activities would not be expected to have a measurable population-level effect.

6.1.1.5.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.5.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may be particularly vulnerable to direct injury and mortality from in-water construction activities because of their limited swimming abilities.

6.1.1.5.5.4.2 Population-Level Effects

Based on the small numbers of larvae/young juvenile that may be present during in-water construction activities and the low likelihood of survival of Delta Smelt in CCF, potential losses of larvae/young juveniles due to direct injury or mortality from in-water construction activities would not be expected to have a significant effect on population abundance.

6.1.1.5.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.5.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF in summer and fall and therefore are unlikely to be exposed to in-water construction activities.

6.1.1.5.5.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.5.6 Loss or Alteration of Habitat

Construction of the new water conveyance facilities at CCF would result in temporary to permanent losses or alteration of aquatic habitat in CCF and, near the new SCCF intake and the NCCF emergency spillway, in the Old River. Temporary effects of construction activities on water quality, including turbidity and suspended sediment, underwater noise, and contaminants, were previously discussed. The following analysis focuses on permanent impacts on physical habitat associated with construction activities. Cofferdam installation, dredging, embankment construction, and construction of CCPP, NCCF emergency spillway, and SCCF intake, and NCCF canal and siphons would affect an estimated 1,932 acres of tidal perennial habitat (Mapbook M3.A) through changes in water depths, vegetation, and substrate. Permanent impacts on aquatic habitat encompass an estimated 258 acres of tidal perennial habitat in CCF that would be replaced by permanent fill and structures associated with the new CCPP, embankments, canals and siphons, and intake structure and spillway.

During construction activities, DWR will implement AMM2, *Construction Best Management Practices and Monitoring*, to protect listed fish, wildlife, and plant species, their designated critical habitat, and other sensitive natural communities (Appendix 3.F *General Avoidance and Minimization Measures*). These BMPs include a number of measures to limit the extent of disturbance of aquatic and riparian habitat during construction, and, following construction, to restore temporarily disturbed areas to pre-construction conditions. All construction and site restoration BMPs will be subject to an approved construction and post-construction monitoring plan to ensure their effectiveness. Compensation for unavoidable impacts on aquatic habitat in CCF is not proposed because CCF is not considered suitable habitat for Delta Smelt.

6.1.1.5.6.1 Migrating Adults (December-March)

6.1.1.5.6.1.1 Individual-Level Effects

The potential effects of turbidity and suspended sediment, underwater noise, and other construction-related hazards on Delta Smelt were previously discussed. Potential changes in physical habitat resulting from dredging, installation of cofferdams, and construction of new water conveyance facilities include the loss of shallow water habitat, removal of vegetation, placement of riprap, and changes in hydraulic conditions. These changes could adversely affect migrating adults by increasing predator habitat but would likely have little effect on individual spawning success because of the low quality of spawning habitat and low likelihood of survival of larvae that may be produced in this region of the Delta.

6.1.1.5.6.1.2 Population-Level Effects

CCF and Old River in the vicinity of CCF have been highly altered for the purpose of water conveyance and lack many of the structural and functional attributes (PCEs) of the designated critical habitat of Delta Smelt due to channelization, levee clearing and armoring, maintenance dredging, unfavorable hydrodynamic conditions, high predator densities, and entrainment. Although the expected changes in physical habitat resulting from construction activities could affect the survival of migrating adults, the degraded status of spawning and larval/juvenile transport habitat in this portion of the Delta suggests that there would be no measurable effect on spawning success or recruitment of larvae and juveniles to the adult population.

6.1.1.5.6.2 Spawning Adults (February-June)

6.1.1.5.6.2.1 Individual-Level Effects

The expected changes in physical habitat in CCF and Old River, including deepening of CCF, disturbance of benthic substrates, and removal of vegetation, may affect potential spawning habitat for Delta Smelt but the effects on individual spawning success would be negligible because of the low quality of spawning habitat and low likelihood of survival of larvae that may be produced in this region of the Delta.

6.1.1.5.6.2.2 Population-Level Effects

As described above, CCF and Old River in the vicinity of CCF generally lack the physical attributes of preferred spawning habitat for Delta Smelt or the habitat conditions supporting larval and juvenile transport to suitable estuarine rearing habitat. Consequently, no population-level effect would occur.

6.1.1.5.6.3 Eggs/Embryos (Spring: ~March-June)

6.1.1.5.6.3.1 Individual-Level Effects

The modification of physical habitat in CCF and Old River would have little if any effect on individual spawning success or the viability of eggs or embryos because of the low quality of spawning habitat and low likelihood of survival of larvae that may be produced in this region of the Delta.

6.1.1.5.6.3.2 Population-Level Effects

Based on the degraded status of habitat for Delta Smelt spawning and larval and juvenile transport in CCF and Old River, no substantial population-level effects are expected.

6.1.1.5.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.1.5.6.4.1 Individual-Level Effects

Similar to migrating adults, Delta Smelt larvae and early juveniles may experience reduced survival in CCF and Old River because of the loss of shallow water habitat, removal of vegetation, placement of riprap, and changes in hydraulic conditions, but the effects of these changes on survival would be negligible because of the low likelihood of survival of larvae that may be produced in this region of the Delta.

6.1.1.5.6.4.2 Population-Level Effects

Based on the degraded status of habitat for larval and juvenile transport in CCF and Old River, no substantial population-level effects are expected.

6.1.1.5.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.1.5.6.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of CCF in summer and fall and therefore are unlikely to be affected by losses or alteration of habitat associated with construction activities.

6.1.1.5.6.5.2 Population-Level Effects

No population-level effects would occur.

6.1.1.6 Effects of Construction Activities on Delta Smelt Critical Habitat

Construction activities would not affect the Delta Smelt critical habitat PCEs 3 and 4 because there would be no effect on river flows or salinity as a result of these activities. The effects to PCEs 1 and 2 are described below.

6.1.1.6.1 PCE 1: Physical Habitat (Spawning Substrate)

Construction of the north Delta intakes would result in the temporary or permanent loss of approximately 13.1 acres of shallow water habitat for Delta Smelt, and construction of the HOR gate would permanently affect 2.9 acres. Estimates of the amount of shallow water habitat or suitable spawning substrate potentially affected by barge landing construction are not currently available. Based on existing site conditions, none of this habitat is considered preferred spawning habitat for Delta Smelt.

Increases in suspended sediment generated by in-water construction activities may result in localized sediment deposition in the vicinity of the proposed intakes, barge landings, and HOR gate, degrading potential spawning habitat of Delta Smelt through burial of suitable substrate. However, potential adverse effects of sedimentation on physical habitat (spawning substrate) from construction would be minimized by siting the barge landings on levees with steep, riprapped banks and deep nearshore areas that lack shallow water areas where spawning could occur. Additionally, the Sacramento River and Old River in the vicinity of the proposed NDD and HOR gate, respectively, do not likely support significant spawning of Delta Smelt. Similar to the barge landings area, there appears to be little or no habitat thought to be preferred by Delta Smelt for spawning in the vicinity of the NDD or HOR gate, which is dominated by steep levee slopes, existing riprap, and low quantities of riparian and aquatic vegetation.

6.1.1.6.2 PCE 2: Water (Quality)

Construction activities could affect Delta Smelt critical habitat PCE 2, water quality in the vicinity of the NDD, HOR gate, and barge landings through elevated noise, increased turbidity and suspended sediments, and potential increases in contaminants, predation risks, and other construction-related hazards. Elevated noise levels from pile driving and other sources will result in a temporary reduction in water of suitable quality for Delta Smelt, adversely affecting its designated critical habitat. Adverse effects on critical habitat will occur within areas subjected to sound levels associated with potential injury and behavioral effects. Underwater noise levels will return to baseline levels following cessation of pile driving and other construction activities.

Increases in turbidity and suspended sediment levels during sheet pile and cofferdam installation, riprap placement, and barge operations will cause temporary, localized reductions in water quality. Water quality is expected to return to baseline levels following cessation of construction activities. The potential release of contaminants through spills or sediment disturbance could result in temporary impacts on water quality. With implementation of the proposed pollution prevention and erosion and sediment control AMMs, potential adverse effects on the critical habitat of Delta Smelt will likely be avoided.

Other effects include the risk of stranding and direct injury that would adversely affect the suitability of water for Delta Smelt during the in-water construction periods for the NDD (June 1-October 31), barge landings (August 1-October 31), and HOR gate (August 1-November 30). The overall effect on the designated critical habitat of Delta Smelt would be minimal because of the timing of in-water construction activities and construction AMMs.

6.1.2 Effects of Water Facility Maintenance on Delta Smelt

6.1.2.1 North Delta Intakes

Maintenance of the proposed intake facilities (including intakes, pumping plants, sedimentation basins, and solids lagoons) includes regular visual inspections and adjustments of the facilities to maintain compliance with engineering and performance standards, and periodic repairs to prevent mechanical, structural, and electrical failures. Emergency maintenance is also anticipated. It is anticipated that major equipment repairs and overhauls would be conducted at a centralized maintenance shop at one of the intake facilities or at the intermediate pumping plant site.

Maintenance activities that could affect listed fish species and aquatic habitat include suction dredging or mechanical excavation of accumulated sediment around the intake structures; periodic removal of debris and biofouling organisms (e.g., algae, clams, mussels) from the log boom, fish screen panels, cleaning system, and other structural and mechanical elements exposed to the river; and levee maintenance activities, including repairs (e.g., RSP replacement) and vegetation control on the waterside levee slope. It is anticipated that in-river dredging will be required every 2-3 years on average. A formal dredging plan describing specific maintenance dredging activities will be developed prior to dredging activities. Guidelines related to dredging activities and disposal and reuse of spoils, including compliance with in-water work windows and turbidity standards, are described in AMM6, *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F *General Avoidance and Minimization Measures*). The replacement of RSP may necessitate access and work either from the levee crest (e.g., using an excavator) or from the water (e.g., using a barge and crane).

It is assumed that all in-water maintenance activities would be conducted within the same work window proposed for in-water construction activities (June 1-October 31), and subject to the same AMMs, including AMM1 *Worker Awareness Training;* 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 Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

6.1.2.1.1 Migrating Adults (December-March)

6.1.2.1.1.1 Individual-Level Effects

The timing of in-water maintenance activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults.

6.1.2.1.1.2 Population-Level Effects

No population-level effect would occur.

6.1.2.1.2 Spawning Adults (February-June)

6.1.2.1.2.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt,* increases in turbidity and suspended sediment, noise, and other hazards associated with dredging, riprap replacement, and barge operations (e.g., direct physical injury) could adversely affect Delta Smelt through harassment, injury, or mortality of spawning adults, depending on the location, timing, and nature of the activities. Spawning adults may also be affected by loss or degradation of spawning habitat from changes in water depths, substrate, and hydraulic conditions from sedimentation and direct disturbance of channel areas adjacent to the intakes that are periodically disturbed by dredging or levee repair activities.

6.1.2.1.2.2 Population-Level Effects

Spawning adults may be present in the Delta during February through June, with peak spawning typically occurring from March to May. Thus, the timing of in-water maintenance activities (June 1–October 31) will avoid most of the spawning season and the months when adults are most likely to occur in the north Delta. In addition, as described in 6.1.1, *Effects of Water*

Facility Construction on Delta Smelt, exposure of the population to maintenance activities would be further limited by the low proportion of the population utilizing the north Delta, the low quality of spawning habitat in the affected reaches, and implementation of the AMMs described in Appendix 3.F *General Avoidance and Minimization Measures*. Population-level effects are expected to be negligible.

6.1.2.1.3 Eggs/Embryos (Spring: ~March–June)

6.1.2.1.3.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt,* Delta Smelt eggs and embryos are demersal and adhesive and therefore unable to avoid exposure to suspended sediment (*i.e.*, potential burial by deposited sediment), contaminants, or direct physical contact with machinery or materials (e.g., riprap) during in-water maintenance activities.

6.1.2.1.3.2 Population-Level Effects

Population-level effects are expected to be negligible based on the potential for exposure of spawning adults described above.

6.1.2.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.2.1.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may encounter active dredges and levee repair activities at the intake sites during their downstream movement from upstream spawning areas to estuarine rearing areas. Although the proposed work windows and BMPs would avoid or minimize exposure of larvae and early juveniles to potential water quality impacts or other hazards, this life stage, if present, would be unable to avoid active work areas and would therefore be particularly susceptible to the hazards of in-water maintenance activities.

6.1.2.1.4.2 Population-Level Effects

Population-level effects are expected to be negligible based on the small proportion of adults that spawn in or upstream of the north Delta in June, the resulting low densities of larvae and early juveniles in this region of the Delta, and implementation of the AMMs described in Appendix 3.F *General Avoidance and Minimization Measures*.

6.1.2.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.2.1.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed intakes in the summer and fall and therefore would be unaffected by maintenance activities.

6.1.2.1.5.2 Population-Level Effects

No population-level effects would occur.

6.1.2.2 Barge Landings

Maintenance activities at the barge landings include regular visual inspections, routine maintenance, and periodic repairs of the docking, loading, and unloading facilities. Maintenance dredging from barges may be required to maintain sufficient water depths for access, maneuvering, and mooring of barges over the course of barge landing operations. Maintenance activities also include levee repairs (e.g., riprap replacement) and vegetation control measures on the waterside slope of the levee. The replacement of RSP may necessitate access and work either from the levee crest (e.g., using an excavator) or from the water (e.g., using a barge and crane). It is assumed that all in-water maintenance activities would be conducted within the same work window proposed for in-water construction activities (June 1-October 31), and subject to the same AMMs, including AMM1 *Worker Awareness Training;* 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 Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

6.1.2.2.1 Migrating Adults (December-March)

6.1.2.2.1.1 Individual-Level Effects

The timing of in-water maintenance activities (June 1–October 31) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults.

6.1.2.2.1.2 Population-Level Effects

No population-level effect would occur.

6.1.2.2.2 Spawning Adults (February-June)

6.1.2.2.2.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt,* increases in turbidity and suspended sediment, noise, and other hazards associated with dredging, riprap replacement, and barge operations (e.g., direct physical injury) could adversely affect Delta Smelt through harassment, injury, or mortality of spawning adults. Spawning adults may be affected by loss or degradation of spawning habitat from changes in water depths, substrate, and hydraulic conditions from sedimentation and direct disturbance of channel areas adjacent to the landings that are periodically disturbed by dredging or levee repair activities.

6.1.2.2.2.2 Population-Level Effects

Because Delta Smelt are generally found in the west Delta and Cache Slough/Liberty Island area during spring and summer, the majority of the population will not be exposed to maintenance activities at the proposed barge landing sites. In addition, the timing of in-water maintenance activities (June 1-October 31) will avoid most of the spawning season and the months when adults are most likely to occur in the east and south Delta. In addition, as described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, exposure of the population to temporary and long-term effects of maintenance activities on aquatic habitat would be limited by the low quality of spawning habitat at preferred sites for barge access and loading and unloading operations.

6.1.2.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.2.2.3.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt,* Delta Smelt eggs and embryos are demersal and adhesive and therefore unable to avoid exposure to suspended sediment (*i.e.*, potential burial by deposited sediment), contaminants, or direct physical contact with machinery or materials (e.g., riprap) during in-water maintenance activities.

6.1.2.2.3.2 Population-Level Effects

Population-level effects are expected to be negligible based on the potential for exposure of spawning adults described above.

6.1.2.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.2.2.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may encounter active dredges and levee repair activities at the barge landings during their downstream movement from upstream spawning areas to estuarine rearing areas. This life stage would be unable to avoid active work areas and would therefore be particularly susceptible to the hazards of in-water maintenance activities.

6.1.2.2.4.2 Population-Level Effects

Population-level effects are expected to be negligible based on the small proportion of adults that spawn in the east and south Delta in June, the resulting low densities of larvae and early juveniles in this region of the Delta, and implementation of the AMMs described in Appendix 3.F *General Avoidance and Minimization Measures*.

6.1.2.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.2.2.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed barge landings in the summer and fall and therefore would be unaffected by maintenance activities.

6.1.2.2.5.2 Population-Level Effects

No population-level effects would occur.

6.1.2.3 Head of Old River Gate

Maintenance of the Head of Old River (HOR) gate, including fishway, boat lock, and navigation structures, includes require regular visual inspections and adjustments of the facilities to maintain compliance with engineering and performance standards, and periodic repairs to prevent mechanical, structural, and electrical failures. Emergency maintenance is also anticipated. Routine maintenance includes regular servicing and repair of motors, compressors, and control systems, and periodic repairs to the mechanical and structural elements of the gate, fishway, and boat lock. Maintenance activities include periodic dredging to remove accumulated sediment from around the gate structure, dewatering of the gate facilities for inspection and maintenance, and replacement of riprap to repair eroded or damaged portions of the waterside levee slope. Vegetation control measures would be performed as part of levee maintenance. It is assumed that all in-water maintenance activities would be conducted within the same work window proposed for in-water construction activities (August 1-November 30), and subject to the same AMMs, including AMM1 *Worker Awareness Training;* 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 Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material;* and AMM7 *Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*).

Maintenance dredging may be required every 3 to 5 years to remove sediment that may potentially interfere with gate operations, navigation, and fish passage. Dredging would be conducted with a sealed clamshell dredge operated from a barge or from the top of the levee. A floating turbidity control curtain will be used to limit the dispersion of suspended sediment during dredging operations. A formal dredging plan describing specific maintenance dredging activities will be developed prior to dredging activities. Guidelines related to dredging activities and disposal and reuse of spoils, including compliance with in-water work windows and turbidity standards, are described in AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material* (Appendix 3.F *General Avoidance and Minimization Measures*).

Each gate bay would be inspected annually at the end of the wet season for sediment accumulation. Each miter or radial gate bay would include stop log guides and pockets for stop log posts to facilitate the dewatering of individual bays for inspection and maintenance. Major maintenance could require a temporary cofferdam upstream and downstream for dewatering. When listed fish species may be present during dewatering operations, DWR proposes to minimize potential stranding losses by implementing a fish rescue and salvage plan (Appendix 3.F *General Avoidance and Minimization Measures,* AMM8 *Fish Rescue and Salvage Plan*).

6.1.2.3.1 Migrating Adults (December-March)

6.1.2.3.1.1 Individual-Level Effects

The timing of in-water maintenance activities (August 1–November 30) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults.

6.1.2.3.1.2 Population-Level Effects

No population-level effect would occur.

6.1.2.3.2 Spawning Adults (February-June)

6.1.2.3.2.1 Individual-Level Effects

The timing of in-water maintenance activities (August 1–October 31) will avoid the Delta Smelt spawning season. Therefore, there would be no direct effects of maintenance activities on spawning adults. However, spawning adults may be affected by loss or degradation of spawning habitat from changes in water depths, substrate, and hydraulic conditions from sedimentation and direct disturbance of channel areas adjacent to the HOR gate that are periodically disturbed by dredging or levee repair activities.

6.1.2.3.2.2 Population-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, most of the Delta Smelt population is distributed downstream of the proposed HOR gate (Moyle 2002) although adults have been detected in the lower San Joaquin River near the HOR junction. Based on the general lack of habitat thought to be preferred by Delta Smelt for spawning, Old River in the action area of the proposed gate does not likely support significant spawning of Delta Smelt, serving mainly as a migration corridor for adults during their migration to upstream spawning areas and larvae during their downstream dispersal to estuarine habitat. Thus, any impacts on potential spawning habitat resulting from sedimentation or direct disturbance of the channel bed would have negligible population-level effects.

6.1.2.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.2.3.3.1 Individual-Level Effects

The timing of in-water maintenance activities (August 1–November 30) will avoid the Delta Smelt incubation season. Therefore, there would be no direct effects of maintenance activities on eggs and embryos.

6.1.2.3.3.2 Population-Level Effects

Population-level effects are expected to be negligible based on the potential for exposure of spawning adults and habitat described above.

6.1.2.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.2.3.4.1 Individual-Level Effects

The timing of in-water maintenance activities (August 1–November 30) will avoid the potential occurrence of Delta Smelt larvae and early juveniles within the action area of the HOR gate.

6.1.2.3.4.2 Population-Level Effects

No population-level effect would occur.

6.1.2.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.2.3.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the HOR gate in summer and fall and therefore would be unaffected by maintenance activities.

6.1.2.3.5.2 Population-Level Effects

No population-level effects would occur.

6.1.2.4 Clifton Court Forebay

Maintenance of the water conveyance facilities and other infrastructure at CCF (including Clifton Court Pumping Plant [CCPP], divider and perimeter embankments, outlet canals and siphons, South CCF [SCCF] intake structure, and North CCF [NCCF] emergency spillway) will include regular visual inspections and adjustments of the facilities to maintain compliance with engineering and performance standards, and periodic repairs to prevent mechanical, structural, and electrical failures. Emergency maintenance is also anticipated. Maintenance requirements potentially affecting listed fish species and aquatic habitat in CCF and Old River include dredging or mechanical excavation of accumulated sediment around the pumping, intake, and outlet facilities, and embankment maintenance activities, including repairs (e.g., RSP replacement) and vegetation control on the divider and perimeter embankments. With upstream sediment removal at the north Delta sedimentation facilities and expansion of storage capacity at CCF, the need for additional dredging of NCCF and SCCF over the first 50 years following construction is expected to be minimal. It is assumed that all in-water maintenance activities would be conducted within the same work window proposed for in-water construction activities (June 1-November 30), and subject to the same AMMs, including AMM1 *Worker Awareness Training;* 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 Plan;* AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and*

Dredged Material; and AMM7 *Barge Operations Plan* (Appendix 3.F *General Avoidance and Minimization Measures*) (Appendix 3.F *General Avoidance and Minimization Measures*).

6.1.2.4.1 Migrating Adults (December-March)

6.1.2.4.1.1 Individual-Level Effects

The timing of in-water maintenance activities (June 1–November) will avoid the Delta Smelt adult migration season. Therefore, there would be no effect on migrating adults.

6.1.2.4.1.2 Population-Level Effects

No population-level effect would occur.

6.1.2.4.2 Spawning Adults (February-June)

6.1.2.4.2.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt,* increases in turbidity and suspended sediment, noise, and other hazards associated with dredging, riprap replacement, and barge operations (e.g., direct physical injury) could adversely affect Delta Smelt through harassment, injury, or mortality of spawning adults. Spawning adults may be affected by loss or degradation of spawning habitat from changes in water depths, substrate, and hydraulic conditions from sedimentation and direct disturbance of sediments adjacent to the water conveyance facilities that are periodically disturbed by dredging or levee repair activities.

6.1.2.4.2.2 Population-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, restriction of in-water maintenance activities in CCF to June 1-November 30 will avoid most of the spawning season (January through June) and peak abundance of adults, eggs, and larvae in the south Delta (February through May). In addition, Old River in the vicinity of CCF is highly channelized and lacks the general attributes of preferred spawning habitat, and CCF is not considered suitable habitat because of the low likelihood of survival of larvae, juveniles, and adults that are entrained into the forebay (Castillo *et al.* 2012). No population-level effects are anticipated.

6.1.2.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.2.4.3.1 Individual-Level Effects

As described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt,* Delta Smelt eggs and embryos are demersal and adhesive and therefore unable to avoid exposure to suspended sediment (*i.e.*, potential burial by deposited sediment), contaminants, or direct physical contact with machinery or materials (e.g., riprap) during in-water maintenance activities.

6.1.2.4.3.2 Population-Level Effects

Population-level effects are expected to be negligible based on the potential for exposure of spawning adults described above.

6.1.2.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.2.4.4.1 Individual-Level Effects

Delta Smelt larvae and early juveniles may encounter active dredges and levee repair activities in CCF or Old River during June and possibly into early July. This life stage would be unable to avoid active work areas and would therefore be particularly susceptible to the hazards of in-water maintenance activities.

6.1.2.4.4.2 Population-Level Effects

Population-level effects are expected to be negligible based on the small proportion of adults that spawn in the south Delta in June, the resulting low densities of larvae and early juveniles in this region of the Delta, and the low likelihood of survival of larvae or early juveniles due to high pre-screen mortality and entrainment losses in CCF and the Skinner Fish Facility.

6.1.2.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.2.4.5.1 Individual-Level Effects

Juvenile Delta Smelt rear downstream of the proposed barge landings in the summer and fall and therefore would be unaffected by maintenance activities.

6.1.2.4.5.2 Population-Level Effects

No population-level effects would occur.

6.1.2.5 Effects for Maintenance Activities on Delta Smelt Critical Habitat

Maintenance activities would not affect the Delta Smelt critical habitat PCEs 3 and 4 because there would be no effect on river flows or salinity as a result of these activities. The effects to PCEs 1 and 2 are described below.

6.1.2.5.1 PCE 1: Physical Habitat (Spawning Substrate)

Potential effects of maintenance activities on physical habitat include loss or degradation of spawning substrate from the deposition of sediment generated by dredging and levee repair activities. Spawning adults may also be affected by changes in water depths, substrate, and hydraulic conditions in areas adjacent to the water conveyance facilities that are periodically disturbed by dredging or levee repair activities, potentially affecting areas defined as shallow water habitat; however, as described in 6.1.1, *Effects of Water Facility Construction on Delta Smelt*, these areas re not considered preferred spawning habitat, and CCF is not part of the designated critical habitat.

6.1.2.5.2 PCE 2: Water (Quality)

Increases in turbidity, suspended sediment, and noise during dredging, levee repair activities, and other in-water maintenance activities are expected to cause temporary, localized reductions in water quality at times when few Delta Smelt are likely to be present (August 1–November 30) at the intake sites, and in Old River and CCF. Water quality is expected to return to baseline levels following cessation of maintenance activities.

6.1.3 Effects of Water Facility Operations on Delta Smelt

6.1.3.1 Introduction

This section analyzes the effects of water facility operations on Delta Smelt. There are eight main subsections:

- North Delta Exports: Analyzes the potential for entrainment, impingement, and elevated predation rates.
- South Delta Exports: Analyzes the potential for entrainment and elevated predation rates.

- Head of Old River (HOR) Gate: Analyzes potential effects on Delta hydraulics and near-field impacts (elevated predation rates and fish passage).

- Habitat Effects: Analyzes the combined effects of PA operations on Delta flows, abiotic habitat, water temperature, sediment removal (water clarity), entrainment of phytoplankton, conditions contributing to growth of *Microcystis*, and loading and bioaccumulation of contaminants (selenium).

- Delta Cross Channel: Analyzes the effects of Delta Cross Channel operations on Delta hydraulics.

- Suisun Marsh Facilities: Analyzes potential effects of the Suisun Marsh Salinity Control Gates, Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall.

- North Bay Aqueduct: Analyzes potential for entrainment, impingement, and predation.

- Other Facilities: Analyzes the effects of Contra Costa Water District Facilities and the Clifton Court Forebay Aquatic Weed Control Program.

6.1.3.2 North Delta Exports

The reach of the Sacramento River where the NDDs are proposed to be built is considered to be near the northern extent of where Delta Smelt occur. Surveys conducted within the Sacramento River reach of the proposed NDD locations indicate few Delta Smelt are found in the vicinity. On one occasion, the species has been found as far upstream as Knights Landing (Vincik and Julienne 2012). Thus, it is expected that there will be some entrainment and impingement of Delta Smelt at the proposed NDD. For the effects analysis below, population-level effects were considered in light of survey data in the general vicinity of the proposed intakes that were examined to inform the extent of exposure of the species. The survey data used included USFWS beach seine data (1976–2011, January–December), Interagency Ecological Program (IEP) fall midwater trawl data (1991–2010, September–December), and CDFW striped bass egg and larval survey data (1991–1994, February–July). For each of these surveys, data from stations on the Sacramento River between Georgiana Slough and approximately the northern limit of the statutory Delta (City of Sacramento at the I Street Bridge) were summarized to represent the potential occurrence of Delta Smelt that could be entrained or impinged (Figure 6.1-1). Summed catch data for these locations were then compared to other survey locations, which were designated as downstream sites. In addition, for migrating adult Delta Smelt, a DSM2-PTM-based analysis was used to infer potential spatial overlap with the NDD.

The analyses of the potential effects of north Delta exports on Delta Smelt that are presented in this section are limited to the near-field effects of the NDD (entrainment, impingement/screen contact, and predation). Potential far-field effects on Delta Smelt habitat are considered in Section 6.1.3.5, *Habitat Effects*, because both north and south Delta exports contribute to such effects together and it would be impractical to attempt to parse out these effects for the facilities separately.

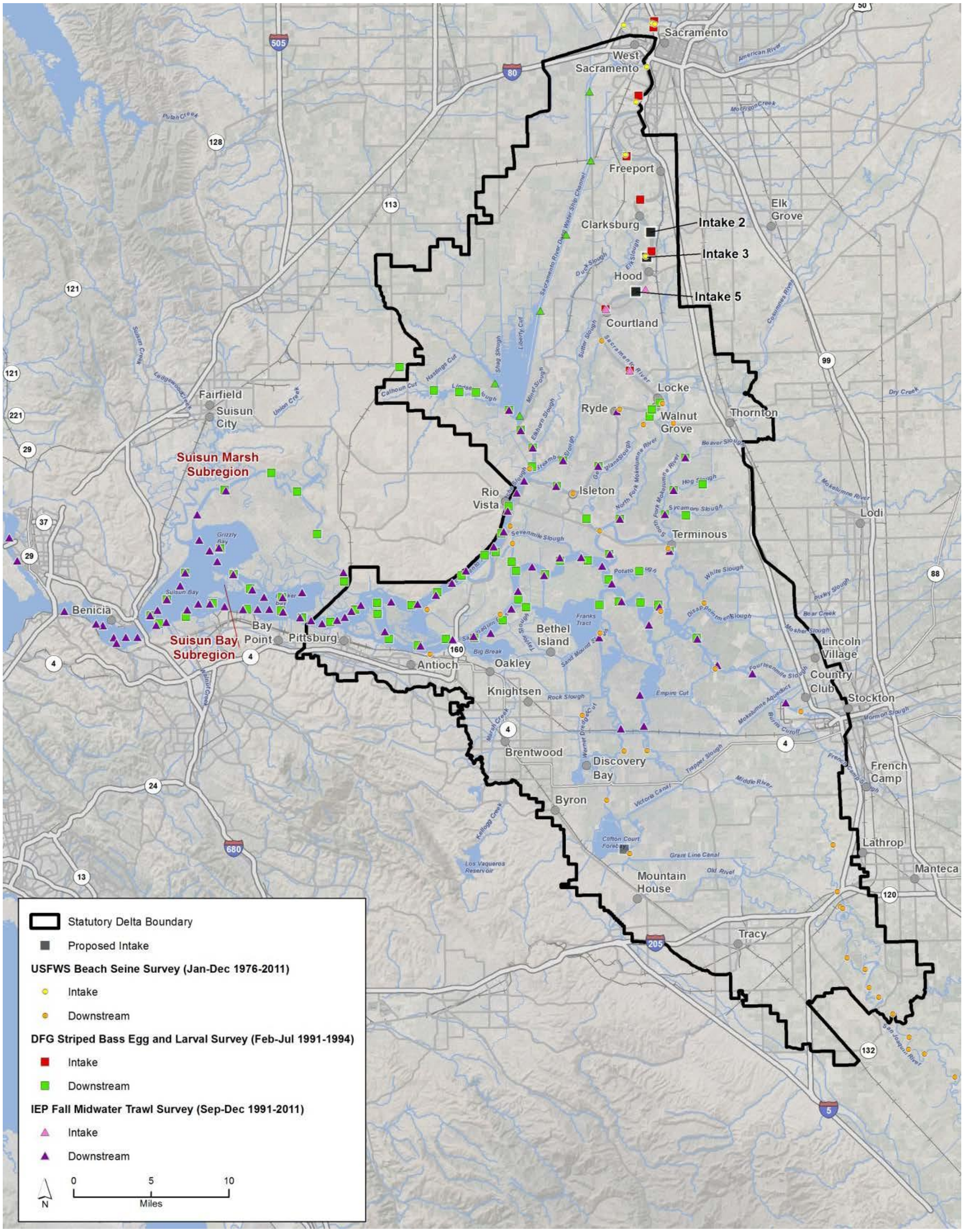


Figure 6.1-1. Survey Station Locations Used to Assess the Potential Presence of Delta Smelt Near the Proposed CVP/SWP North Delta Intakes

6.1.3.2.1 Entrainment

6.1.3.2.1.1 Migrating Adults (December-March)

6.1.3.2.1.1.1 Individual-Level Effects

Based on Delta Smelt body depth to body length ratios and using the screening effectiveness analysis described in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.2.2, the proposed NDD screen mesh of 1.75 mm would prevent Delta Smelt greater than standard length of around 20-21 mm from being entrained through the fish screens. Therefore, Delta Smelt older than approximately 90 days (Hobbs *et al.* 2007) could not be entrained through the NDD fish screens. All adult Delta Smelt exceed 90 days of age and 20-21 mm in length. Therefore, there would be no adverse effect to individual adult Delta Smelt.

6.1.3.2.1.1.2 Population-Level Effects

As there would be no individual-level adverse effect, there would be no population-level adverse effect to migrating adult Delta Smelt from entrainment at the NDD.

6.1.3.2.1.2 Spawning Adults (February-June)

6.1.3.2.1.2.1 Individual-Level Effects

As described for migrating adult Delta Smelt, the proposed NDD screen mesh of 1.75 mm would prevent Delta Smelt greater than standard length of around 22 mm from being entrained. Therefore, there would be no adverse effect to individual spawning adult Delta Smelt.

6.1.3.2.1.2.2 Population-Level Effects

Following from no individual-level adverse effect, there therefore would be no population-level adverse effect to spawning adult Delta Smelt from entrainment at the NDD.

6.1.3.2.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.2.1.3.1 Individual-Level Effects

Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). As such, individual eggs would not be subject to entrainment and there would be no individual-level adverse effect.

6.1.3.2.1.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs means that there would be no adverse population-level effects from the NDD with respect to entrainment.

6.1.3.2.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.2.1.4.1 Individual-Level Effects

As noted for adult Delta Smelt, based on Delta Smelt body depth to body length ratios (Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt, S*ection 6.A.2.2), the proposed screen mesh of 1.75 mm would exclude Delta Smelt greater than standard length of around 20-21 mm (generally, fish less than 90 days old). Therefore, Delta Smelt smaller than 20-21 mm could be entrained; however, fish that are over 20-21 mm may also be injured or killed by impingement whether they pass all the way through the screen or not because they may not be able free themselves from the fish screen if water is being drawn through it; impingement is discussed further in Section 6.1.3.2.2.

The Freeport Regional Water Authority's water intake is the most analogous to the proposed NDD. The intake is located at Freeport Bend (river mile 47 on the Sacramento River) and therefore is ~6 river miles upstream of the PA's Intake 2, the most upstream of the three proposed intakes. The Freeport intake is also considerably smaller than the proposed NDD: the intake has a capacity up to 286 cfs (*i.e.*, about 10% of the 3,000 cfs for each NDD intake), and the fish screen panels are 9.92 feet wide by 10.71 feet tall (compared to 15.6 feet wide by 12.5 to 17.0 feet for the NDD screens), with a total of 16 fish screens (compared to 66–90 screens for the NDD intakes 2, 3, and 5). Both facilities are designed to meet a 0.2 ft/s approach velocity criterion. Entrainment monitoring was undertaken in winter/spring of water years 2012–2014, although pumping rate was low in 2012 and 2013 (generally 23 cfs or less), whereas in 2014 pumping rate was greater (132–163 cfs) (ICF International 2015a). Hoop net and larval light trap monitoring behind the fish screens did not detect delta smelt in any of the years sampled, although in 2014 three unidentifiable smelt larvae were detected, in addition to two wakasagi larvae (*Hypomesus nipponensis*). USFWS trawls and beach seining upstream of the Freeport intake (Sherwood Harbor and Garcia Bend) have sometimes detected Delta Smelt during the period of entrainment monitoring, so adults and therefore possibly larvae are present in the general area, albeit in low abundance. The analysis of the Freeport intake suggests that when Delta Smelt larvae do occur in front of the NDD screens, some entrainment will occur.

For this effects analysis, it is assumed that entrainment risk of early life stage Delta Smelt is related to the percentage of river flow diverted by the intakes, with the risk increasing as higher percentages of flow are diverted (as shown for other species by ICF Jones & Stokes 2008). Given this assumption, the CalSim monthly mean modeling outputs can be used to provide estimates of the percentage of flow diverted, by dividing the NDD flow by the Sacramento River flow at Freeport. The percentage of flow diverted by the NDD increases as bypass flow constraints decrease: in wet years, the median percentage of flow diverted ranged from 7% in April (range 0% to 15%) to 32% in June (range 7–38%); in contrast, in critical years, the median percentage of flow diverted ranged from 3% in April (range 0% to 6%) to 6% in June (range 6% to 8%) (Table 6.1-4). Thus, the risk to individual fish is expected to be lower in drier years and the risk would be lower in April and May than in March or June.

Table 6.1-4. Summary Statistics of CalSim-Modeled Average Monthly North Delta Diversion as a Percentage of Sacramento River at Freeport Flows for the Proposed Action

Water Year Type		March	April	May	June
Wet	Maximum	35%	15%	21%	38%
	75th percentile	26%	9%	12%	35%
	Mean	20%	7%	9%	29%
	Median	17%	7%	8%	32%
	25th percentile	13%	5%	5%	25%
	Minimum	6%	0%	3%	7%
Above Normal	Maximum	34%	14%	15%	38%
	75th percentile	24%	9%	11%	36%
	Mean	21%	6%	8%	30%
	Median	19%	5%	10%	32%
	25th percentile	15%	4%	5%	28%
	Minimum	13%	1%	2%	16%
Below Normal	Maximum	31%	8%	12%	36%
	75th percentile	24%	7%	6%	28%
	Mean	16%	4%	4%	19%
	Median	13%	4%	2%	21%
	25th percentile	9%	0%	1%	6%
	Min	6%	0%	0%	6%
Dry	Max	32%	15%	16%	37%
	75th percentile	22%	6%	6%	26%
	Mean	18%	4%	4%	17%
	Median	20%	1%	3%	13%
	25th percentile	13%	0%	2%	6%
	Minimum	6%	0%	0%	6%
Critical	Maximum	17%	6%	6%	8%
	75th percentile	6%	4%	6%	6%
	Mean	7%	3%	4%	6%
	Median	6%	3%	4%	6%
	25th percentile	6%	1%	2%	6%
	Minimum	6%	0%	0%	6%

6.1.3.2.1.4.2 Population-Level Effects

Catch of Delta Smelt per cubic meter in the egg and larval survey in 1991–1994 was an order of magnitude lower in the vicinity of the proposed north Delta intakes than in downstream areas Table 6.1-5), and total catch in the vicinity of the intakes was considerably less than total catch downstream. Catch density tended to be greatest in April and May which, as shown previously, are expected to be the months when the lowest percentage of Sacramento River water would be diverted by the NDD (Table 6.1-4). These pieces of evidence suggest that any adverse population-level effect from entrainment by the NDD would be small.

It is not possible to provide a precise estimate of the proportion of the larval population that might be entrained by the NDD. However, to provide a coarse perspective, the ratio (intake/downstream) of the mean densities in April and May were 0.04–0.06 (*i.e.*, the density in the intake area was 4–6% that of the downstream area). Volumetric estimates of Delta channels used in DSM2 (Jones & Stokes 2005, Section 5.2, Table 5.2-1) suggest the downstream portion of the Delta included in the egg and larval survey (see Figure 6.1-1; note that much of the south Delta is excluded) is over 20 times greater than the volume of the Sacramento River upstream of Georgiana Slough and Delta Cross Channel, from which the intake density estimates were taken. Therefore, perhaps 0.25% of larvae could occur in the NDD reach. If 10% of water was diverted, this suggests that the order of magnitude of population-level larval entrainment from the NDD would be considerably less than 0.1% (and closer to 0.01%). Mean estimates of potential March–June larval population-level entrainment by the NDD using a DSM2-PTM analysis described in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.3.2, ranged from <0.1% in critical years to nearly 0.2% in other water year types (see further discussion in the Entrainment section for South Delta Exports). However, that analysis assumed density in the Sacramento River was the same as at all locations in the north Delta, including Cache Slough and surrounding areas, where density would be expected to be higher than in the Sacramento River, which may have biased these estimates somewhat high.

Further perspective on the proportion of the Delta Smelt population that could occur near the NDD was provided by a DSM2-PTM analysis incorporating movement into the upper 10% of the water column during flood tides, to simulate the upstream migration of adult Delta Smelt; as described in more detail in Section 6.1.3.2.2.1.2, this analysis also provided evidence that a very low proportion of the Delta Smelt population (migrating adults, and therefore their progeny) would be expected to occur near the NDD, as no particles originating downstream were entrained at the NDD (or moved upstream of Isleton; Table 6.1-7), indicating that there is no hydraulic reason to expect significant fractions of the Delta Smelt population to reach the NDDs.

Table 6.1-5. Number of Delta Smelt Larvae Collected and Catch per Cubic Meter during the CDFW Striped Bass Egg and Larval Survey in the Action Area

Year	Month	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Cubic Meter (Intake Area)	Catch Per Cubic Meter (Downstream)
		Intake Area	Downstream					
1991	2	14	74	2	0	1.00	0.01	0.00
	3	7	82	0	25	0.00	0.00	0.10
	4	21	362	2	33	0.06	0.01	0.13
	5	105	442	31	101	0.23	0.15	0.51
	6	70	279	2	24	0.08	0.01	0.12
1992	2	34	205	0	7	0.00	0.00	0.03
	3	55	348	4	38	0.10	0.02	0.17
	4	77	482	43	202	0.18	0.19	0.93
	5	101	509	6	228	0.03	0.03	1.10
	6	76	353	0	36	0.00	0.00	0.16
	7	12	167	0	1	0.00	0.00	0.00
1993	2	27	273	0	185	0.00	0.00	0.82
	3	59	405	16	284	0.05	0.07	1.32
	4	55	415	38	318	0.11	0.19	1.44
	5	64	419	44	487	0.08	0.19	3.03
	6	48	411	0	102	0.00	0.00	1.23
	7	8	237	0	55	0.00	0.00	0.37
1994	2	40	306	0	25	0.00	0.00	0.11
	3	64	453	20	565	0.03	0.09	2.46
	4	56	431	8	1723	0.00	0.04	7.39
	5	64	491	4	338	0.01	0.02	1.82
	6	56	432	0	258	0.00	0.00	1.31
	7	32	235	0	46	0.00	0.00	0.18
mean	2	28.8	214.5	0.5	54.3	0.25	0.00	0.24
	3	46.3	322.0	10.0	228.0	0.05	0.04	1.01
	4	52.3	422.5	22.8	569.0	0.09	0.10	2.47
	5	83.5	465.3	21.3	288.5	0.09	0.10	1.62
	6	62.5	368.8	0.5	105.0	0.02	0.00	0.71
	7	17.3	213.0	0.0	34.0	0.00	0.00	0.19

Source: California Department of Fish and Game unpublished data.

6.1.3.2.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.2.1.5.1 Individual-Level Effects

As described for adult Delta Smelt, the proposed NDD screen mesh of 1.75 mm would prevent Delta Smelt greater than standard length of around 22 mm from being entrained, and therefore would be expected to allow juvenile Delta Smelt to avoid entrainment but not necessarily impingement. There would be no adverse effect to individual juvenile Delta Smelt from entrainment.

6.1.3.2.1.5.2 Population-Level Effects

Based on the lack of effect to individual juvenile Delta Smelt, there would not be an adverse population-level effect from entrainment at the NDD to Delta Smelt juveniles.

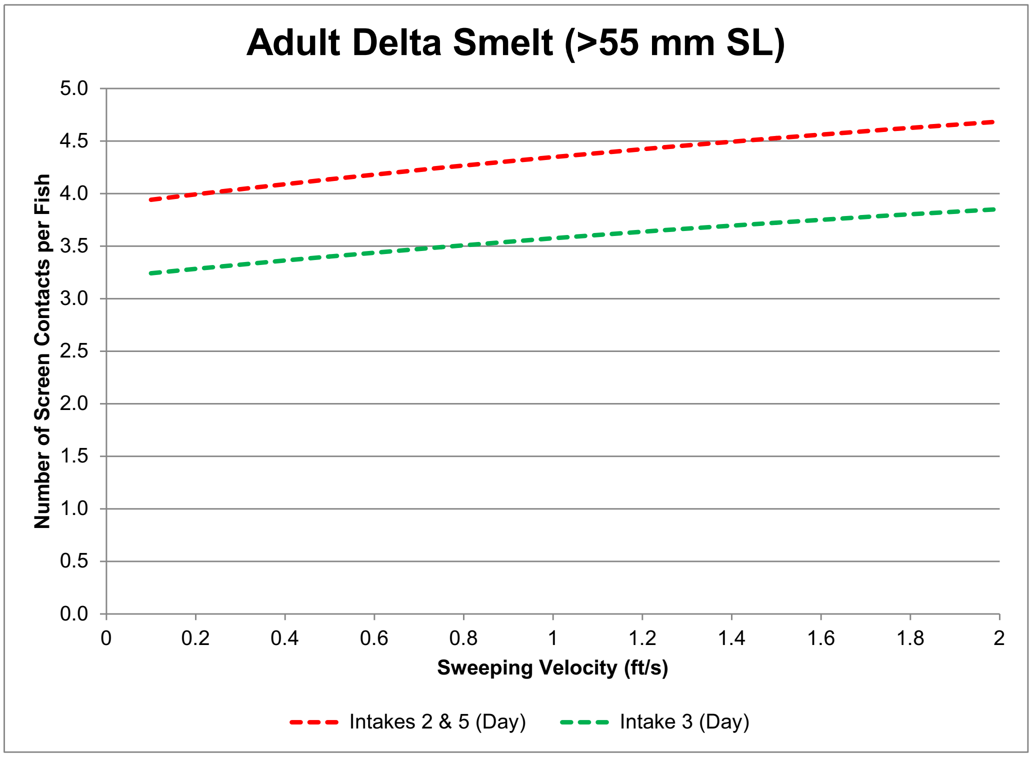
6.1.3.2.2 Impingement and Screen Contact

6.1.3.2.2.1 Migrating Adults (December-March)

6.1.3.2.2.1.1 Individual-Level Effects

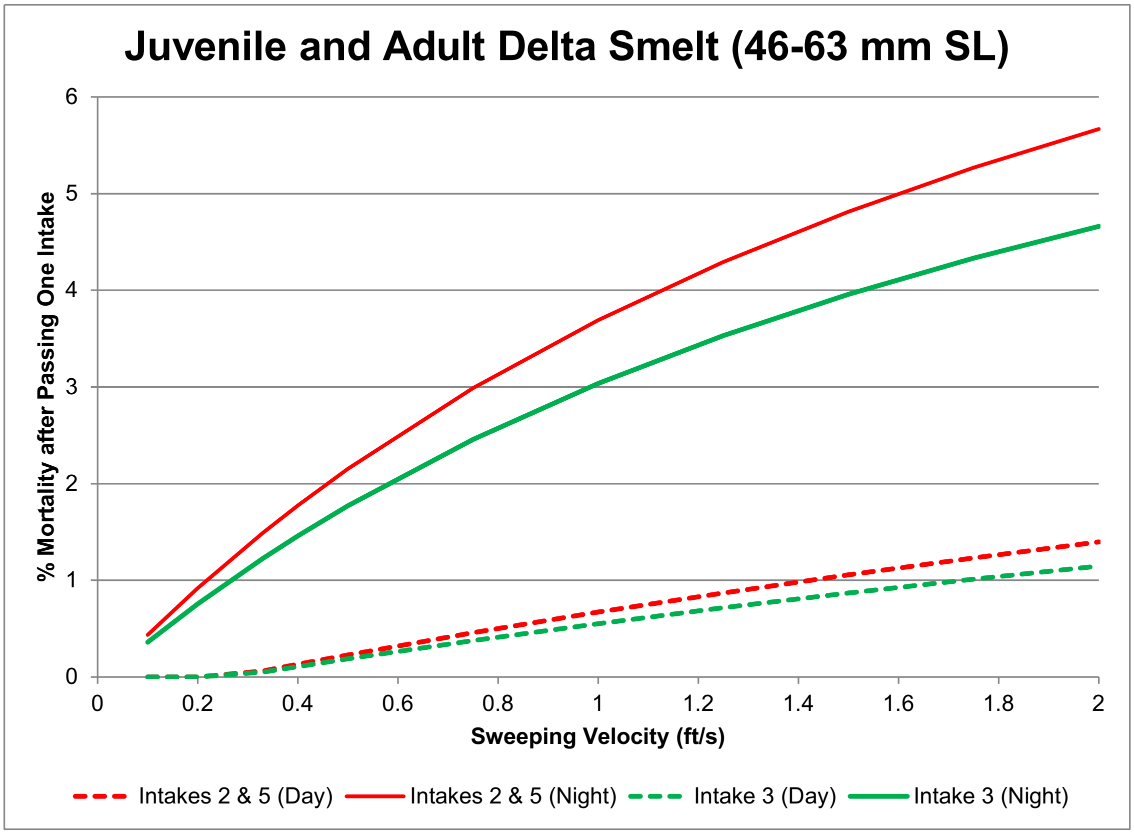
As noted in Chapter 3, *Description of the Proposed Action*, the NDD would be operated such that approach velocity is consistent with recommendations for Delta Smelt (0.2 ft/s). However, there remains the potential that Delta Smelt larger than the minimum screenable size of ~20-21 mm could contact the NDD screens and be injured or die. This potential exists for several reasons: (1) even at 0.2-ft/s approach velocity, Delta Smelt had some injurious screen contact in an experimental flume (White *et al.* 2007), (2) the sweeping flow velocity at which it was assumed that NDD diversions could commence (0.4 ft/s; see Section 5.A.5.2.4.9, *North Delta Diversion Bypass Flows*, in Appendix 5.A *CALSIM Methods and Results*, and Section 5.B.2.3.5, *North Delta Diversion Operations*, in Appendix 5.B *DSM2 Modeling and Results*) is within the velocity range at which captive Delta Smelt switched swimming modes from a noncontinuous stroke and glide behavior to continuous swimming, resulting in swimming failure because of inability (or unwillingness) to swim steadily (Swanson *et al.* 1998), and (3) the proposed fish screens are very long requiring that Delta Smelt will need to swim continuously against what they consider strong current for lengthy periods of time and it has not been determined that they can or will do so. The behavior-based PTM analysis (see Section 6.1.3.2.2.1.2, *Population-Level Effects*) supports the hypothesis that adult Delta Smelt migrating upstream in the vicinity of the NDD need to use the lower velocity periphery of the channel to swim upstream against unidirectional flow during periods when the NDD would be operating (*i.e.*, the typical tidal surfing behavioral conceptual model [Bennett and Burau 2015] would not move fish this far upstream). As a result, individuals that do migrate this far upstream may face a higher risk of contact with the screens if they migrated along the left bank of the river where the NDD would be located. Juvenile/adult injury and mortality has been found to occur following screen contact in laboratory experiments conducted at the UC Davis Fish Treadmill Facility (Swanson *et al.* 2005; White *et al.* 2007), and stress (measured as plasma cortisol) is positively correlated with screen contact in adult Delta Smelt (Young *et al.* 2010).

The published studies on Delta Smelt from the UC Davis Fish Treadmill Facility were used to assess the potential for screen contact, screen passage, and mortality. As described in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.2.3, two of the methods (Section 6.A.2.3.1.1 *Adult Delta Smelt (Number of Screen Contacts)*; Section 6.A.2.3.1.2 *Juvenile and Adult Delta Smelt (Percentage Mortality)*) were based on an assessment methodology undertaken as part of the BDCP Fish Facilities Technical Team planning effort. From these analyses, it is estimated the adult Delta Smelt passing one of the NDD screens—moving against the flow, *i.e.*, in an upstream direction, based on the laboratory studies—would contact the screen 3 to 5 times, and that there would be little variation in this estimate across a wide range of sweeping velocity (Figure 6.1-2). In addition, application of the relationships from the laboratory studies show that mortality is estimated to be 1% or less for fish encountering one of the intakes when sweeping velocity is low (0.2–0.3 ft/s), possibly increasing to 4–6% at sweeping velocity above 1.5 ft/s if encountered at night (Figure 6.1-3). A third analysis (Section 6.A.2.3.1.3 *Adult Delta Smelt (Screen Passage and Survival)*) was adapted from an analysis provided by USFWS. This analysis focused on the ability of Delta Smelt moving upstream near the left bank of the river to pass the lowermost NDD fish screen, given historic Sacramento River at Freeport water velocity, and also examined potential survival of those successfully passing the screen. Using December-June Freeport velocity information, the probability that an individual adult Delta Smelt would successfully pass the lowermost NDD fish screen was estimated to range from 0.073 to 0.075. When the data were restricted to the more likely December-March period, the estimate was 0.040 (0.0398 to 0.0405). The survival estimates for fish that actually pass the screen were relatively high and had low variability: mean ± standard deviation = 0.916 ± 0.0079, but the survival estimates had little influence on passage (*P*) because river velocity is almost always too high for Delta Smelt to swim the required distance upstream. As described in Section 3.2.2.2, *Fish Screen Design*, 22-foot-wide refugia could be provided between each of the six screen bay groups at the three intakes, which, if effective, could provide resting areas and predator refuge for Delta Smelt occurring near the intakes. However, given that the refugia are still in the conceptual design phase and there is uncertainty as to their effectiveness for Delta Smelt, the analyses presented above only accounted for the refugia by excluding the refugia length from the estimates of overall screen length at each intake.



Note: This plot is only relevant to the Delta Smelt occurring in the reach of the Sacramento River where the proposed NDD would be situated, and of those, only the ones encountering the intake screens at the river margins where the on-bank intakes would be sited. Plot only includes mean responses and does not consider model uncertainty.

Figure 6.1-2. Estimated Number of Screen Contacts of Adult Delta Smelt Encountering Fish Screens the Length of Intakes 2 and 5 (1,350 feet) and Intake 3 (1,110 feet) at an Approach Velocity of 0.2 feet per second during the Day



Note: This plot is only relevant to the Delta Smelt occurring in the reach of the Sacramento River where the proposed NDD would be situated, and of those, only the ones encountering the intake screens at the river margins where the on-bank intakes would be sited. Plot only includes mean responses and does not consider model uncertainty.

Figure 6.1-3. Estimated 48-hour Mortality of Juvenile and Adult Delta Smelt Encountering Fish Screens The Length of Intakes 2 and 5 (1,350 feet) and Intake 3 (1,110 feet) at an Approach Velocity of 0.2 feet per second during the Day and Night

Overall, the UC Davis Fish Treadmill studies indicate that there is potential for lethal and nonlethal take of juvenile and adult Delta Smelt from screen contact and impingement, for the subset of the population occurring in the reach of the river where the NDD would be located. However, monitoring by sonar cameras and diver surveys at the Freeport intake to evaluate impingement impacts did not reveal any impinged fish (eggs, larvae, or later life stages) in 2014 (or in 2011–2013), and there was no significant debris accumulation on screen panels (which can affect screen performance). A hydraulic evaluation of the Freeport intake in 2014 showed that approach velocity ranged from 0.09 ft/s to 0.27 ft/s and that 70% of approach velocity measurements did not exceed the target design approach velocity of 0.2 ft/s, although the facility was operating at 85% of capacity (ICF International 2015b). The analysis of the ability of migrating adult Delta Smelt to pass the most downstream intake if occurring near the left bank suggested that only a very small percentage (4%) of fish would be expected to do so. If successfully passing one intake and remaining near the left bank, the remaining Delta Smelt would have to pass the two other intakes, again with a similarly low probability of success. The extent to which these factors could constitute a barrier to migration to upstream habitat would depend on the ability of Delta Smelt to use lower velocity habitat on the right (west) bank of the river, near the channel bottom, or within the refugia along the intakes.

6.1.3.2.2.1.2 Population-Level Effects

For an assessment of distribution in relation to the NDD based on seine data, Delta Smelt adults for this analysis were assumed to be represented by fish ≥60 mm fork length (FL), based on Moyle's (2002) designation of adults as ~55-mm standard length. The proportion of Delta Smelt ≥60 mm FL collected in the reach of the Sacramento River where the proposed intakes would be situated averaged slightly below 20% of the total catch from seining and was highly variable between years, with mean catch per seine in some years comparable to downstream areas, and in other years substantially lower. It should be noted that seining is not extensive in some of the more important areas of Delta Smelt's current distribution (e.g., the Cache Slough and Sacramento Deep Water Ship Channel area, Suisun Bay and the Sacramento-San Joaquin river confluence) but seine sampling in the Sacramento River is quite common in order to target the Chinook salmon fry the survey was designed to monitor (Table 6.1-6). Seine data do indicate that adult Delta Smelt occur in low numbers in the reach of the river where the proposed north Delta intakes would be sited; however, as the proposed intake location is outside the main range of Delta Smelt, the potential for any adverse effect at the population level from impingement is minimal to nil. Further perspective on the proportion of the Delta Smelt population that could occur near the NDD was provided by a DSM2-PTM analysis incorporating movement into the upper 10% of the water column during flood tides (*i.e.* modeled tidal surfing behavior), to simulate the upstream migration of adult Delta Smelt, as described in Section 6.A.2.1 of Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*. This analysis also provided evidence that a very low proportion of the migrating adult Delta Smelt population would be expected to occur near the NDD if relying on tidal migration upstream (Bennett and Burau 2015), as no particles originating downstream were entrained at the NDD (or moved upstream of Isleton on the Sacramento River[9]; Table 6.1-7). Therefore tidal migration upstream toward the NDD would not be enhanced by the PA.

Conceptually, the population-level effect of the NDD on migrating adult Delta Smelt passage is the individual take of fish caused by impingement-related injury or mortality (including incidental loss to predators) multiplied by the fraction of the adult population that is anticipated to reach the NDD *and* attempt to pass them, but is unable to do so. Based on application of the equation predicting mortality as a function of contact rate, temperature, and approach velocity to February 1991 conditions (Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt,* Section 6.A.2.3.1.3 *Adult Delta Smelt (Screen Passage and Survival)*), the predicted mortality rate of fish swimming past the fish screen is about 8%. If for the sake of argument, 1% of all adult Delta Smelt attempt to pass one or more of the NDDs, the population loss would be 8% of 1%, which is 0.08% or about 8 of every 10,000 fish. As described in Section 6.A.2.3.1.3 *Adult Delta Smelt (Screen Passage and Survival)* of Appendix 6.A, February 1991 was a low flow period in a drought in which river velocity was less and therefore more likely to have allowed upstream migration by Delta smelt at a sufficient rate to pass the first NDD intake. As such, it would be expected that a smaller fraction of the population would attempt or even be able to successfully pass the intake during higher flow periods. It is not known what fraction of the adult Delta Smelt population ascends the Sacramento River and how that fraction varies from year to year. The catches and CPUEs of Delta Smelt using beach seines were summarized in

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[9] A breakdown of the fates of particles by geographic subregion is also provided in Section 6.A.2.1.2 of Appendix 6.A.

Table 6.1-6, but these are challenging to compare quantitatively because, as described in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt,* Section 6.A.2.3.1.3 *Adult Delta Smelt (Screen Passage and Survival)*, fish ascending the Sacramento River very likely have to use nearshore habitat sampled by the beach seines much more extensively than they do further downstream in the estuary. In addition, there is no known reason that Delta Smelt *have to* ascend the Sacramento River past the proposed NDD locations in order to spawn; most spawning seems to occur in Suisun Marsh, the river channels around Sherman Island, and in the Cache Slough/Deepwater Shipping Channel area. Thus, it is also possible that there will be no measurable population-level impact caused by migrating adult Delta Smelt either prevented from continuing past the NDD or being injured/impinged trying to pass them, because few or no individuals may attempt to keep moving upstream along the left bank once they encounter elevated velocities associated with the first diversion. However, Delta Smelt can currently ascend the river along its east bank if they choose to do so. Thus, the loss of low-velocity shoreline and increase in shoreline water velocity along the river's east (left) bank that will occur as a result of the NDD fish screens will have an impact to critical habitat because it will alter the capacity of the fish to ascend the river along its east bank. As previously discussed in the Individual-Level Effects section, the overall magnitude of this potential effect on individual Delta Smelt would depend on the ability of Delta Smelt to use lower velocity habitat on the right bank of the river, near the channel bottom, or within the refugia along the intakes. However, given the spatial distribution of most of the Delta Smelt population, *i.e.*, well downstream of the NDD, any effects from not being able to access habitat upstream of the NDD are not expected to affect Delta Smelt at a population level.

Table 6.1-6. Number of Delta Smelt (≥60 mm Fork Length) Collected and Catch per Seine during USFWS Beach Seine Sampling in the Action Area (December–March)

Year	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Seine (Intake Area)	Catch Per Seine (Downstream)
	Intake Area	Down-stream					
1977	15	15	0	0	.	0.00	0.00
1978	4	4	0	0	.	0.00	0.00
1979	4	7	0	0	.	0.00	0.00
1980	4	27	0	0	.	0.00	0.00
1981	10	35	0	13	0.00	0.00	0.37
1982	16	48	2	3	0.40	0.13	0.06
1983	13	54	4	5	0.44	0.31	0.09
1984	17	71	4	2	0.67	0.24	0.03
1985	12	39	0	0	.	0.00	0.00
1986	15	60	0	0	.	0.00	0.00
1987	12	48	0	0	.	0.00	0.00
1988	12	48	0	1	0.00	0.00	0.02
1989	12	48	0	0	.	0.00	0.00
1990	4	13	0	0	.	0.00	0.00
1991	16	58	0	0	.	0.00	0.00
1992	20	68	0	0	.	0.00	0.00
1993	13	41	0	2	0.00	0.00	0.05

Year	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Seine (Intake Area)	Catch Per Seine (Downstream)
	Intake Area	Down-stream					
1994	16	70	0	0	.	0.00	0.00
1995	44	41	1	2	0.33	0.02	0.05
1996	94	100	0	13	0.00	0.00	0.13
1997	29	34	0	2	0.00	0.00	0.06
1998	48	66	1	0	1.00	0.02	0.00
1999	38	83	0	0	.	0.00	0.00
2000	83	82	0	2	0.00	0.00	0.02
2001	61	75	0	1	0.00	0.00	0.01
2002	52	81	0	2	0.00	0.00	0.02
2003	41	72	0	3	0.00	0.00	0.04
2004	51	82	0	1	0.00	0.00	0.01
2005	67	74	0	0	.	0.00	0.00
2006	21	48	0	0	.	0.00	0.00
2007	36	86	0	0	.	0.00	0.00
2008	33	78	0	0	.	0.00	0.00
2009	28	81	0	0	.	0.00	0.00
2010	32	63	0	1	0.00	0.00	0.02
2011	29	66	0	0	.	0.00	0.00
Mean	29	56	0	2	0.18	0.02	0.03
5th percentile	4	11	0	0	0.00	0.00	0.00
25th percentile	13	41	0	0	0.00	0.00	0.00
Median	20	60	0	0	0.00	0.00	0.00
75th percentile	40	75	0	2	0.35	0.00	0.03
95th percentile	72	84	3	7	0.75	0.16	0.10

Source: U.S. Fish and Wildlife Service Delta Juvenile Fish Monitoring Program (Speegle pers. comm.).

Table 6.1-7. Adult Delta Smelt Upstream Movement Analysis Based on DSM2-PTM: Fate (Mean Percentage) of Particles By Release Location, Water Year Type, and Flux or Entrainment Location After 30 Days.

Release Location	Water Year Type	Downstream Flux Past Martinez			Downstream Flux Past Chipps Island			Entrainment into Clifton Court Forebay (State Water Project)			Entrainment into Jones Pumping Plant (Central Valley Project)			Entrainment into North Bay Aqueduct Barker Slough Pumping Plant			Upstream Flux Past Isleton			North Delta Diversion		
		NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
Cache Sl. at Liberty Island (Node 323)	W	63.0	61.2	-1.8 (-3%)	70.1	67.9	-2.1 (-3%)	1.5	1.0	-0.5 (-36%)	0.9	0.7	-0.2 (-24%)	0.5	0.7	0.1 (19%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	AN	61.6	60.0	-1.6 (-3%)	68.5	68.3	-0.2 (0%)	0.9	0.7	-0.2 (-22%)	0.6	0.2	-0.4 (-68%)	0.1	0.1	0.0 (-3%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	BN	19.3	13.8	-5.5 (-29%)	27.2	21.4	-5.8 (-21%)	0.7	0.7	0.0 (-6%)	0.5	0.3	-0.2 (-31%)	0.1	0.1	0.0 (8%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	D	11.6	9.5	-2.0 (-17%)	15.8	13.6	-2.2 (-14%)	0.7	0.7	0.0 (-4%)	0.6	0.5	-0.2 (-24%)	0.0	0.0	0.0 (13%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	C	1.3	0.9	-0.4 (-30%)	3.6	2.7	-0.9 (-24%)	0.1	0.1	0.0 (-25%)	0.1	0.1	0.0 (-14%)	0.0	0.0	0.0 (-28%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
Decker Island (Node 353)	W	77.1	73.9	-3.3 (-4%)	87.3	84.4	-2.9 (-3%)	0.9	0.5	-0.4 (-48%)	0.5	0.5	0.0 (-2%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	AN	73.7	74.7	1.0 (1%)	79.3	79.9	0.6 (1%)	2.3	2.4	0.1 (7%)	1.5	1.0	-0.5 (-34%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	BN	38.0	30.9	-7.1 (-19%)	49.2	46.9	-2.3 (-5%)	4.4	3.1	-1.3 (-29%)	3.1	2.6	-0.5 (-15%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	D	20.2	18.3	-1.9 (-9%)	32.2	28.6	-3.6 (-11%)	5.9	4.5	-1.4 (-24%)	4.0	4.0	0.1 (2%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	C	5.3	4.4	-0.9 (-18%)	10.3	8.8	-1.5 (-15%)	7.2	6.5	-0.7 (-9%)	4.2	3.6	-0.5 (-13%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
Montezuma Slough (Node 420)	W	18.9	18.5	-0.4 (-2%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	AN	0.6	0.6	0.0 (2%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	BN	0.2	0.0	-0.2 (-86%)	0.0	0.0	0.0 (-80%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	D	0.3	0.2	-0.1 (-45%)	-0.1	-0.1	0.1 (-50%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	C	0.9	0.6	-0.3 (-31%)	-0.5	-0.3	0.2 (-36%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
Chipps Island (Node 465)	W	83.6	80.6	-3.0 (-4%)	94.1	92.3	-1.9 (-2%)	0.2	0.1	-0.1 (-52%)	0.1	0.1	0.0 (-25%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	AN	78.5	78.9	0.4 (1%)	84.8	85.2	0.4 (0%)	1.3	1.4	0.1 (9%)	1.0	0.7	-0.3 (-29%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	BN	43.6	39.5	-4.1 (-9%)	57.6	58.1	0.5 (1%)	2.1	1.1	-1.0 (-48%)	1.4	0.9	-0.5 (-33%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	D	27.6	24.9	-2.8 (-10%)	44.2	40.4	-3.8 (-9%)	2.6	1.7	-0.9 (-35%)	1.8	1.6	-0.2 (-10%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)
	C	7.3	6.6	-0.7 (-10%)	13.2	12.2	-1.0 (-7%)	3.1	2.4	-0.7 (-23%)	2.0	1.3	-0.6 (-31%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)	0.0	0.0	0.0 (0%)

Note: Grey shading indicates that no particles had this fate for either the NAA or PA.

6.1.3.2.2.2 Spawning Adults (February-June)

6.1.3.2.2.2.1 Individual-Level Effects

Presumably the risk to adult Delta Smelt from impingement at the NDD would be greater for actively migrating adults, if spawning adults hold in a similar location prior to, during, and after spawning (possibly to spawn more than once). However, for those spawning adults moving past the NDD, the risk of impingement-related injury and mortality would be as described for migrating adults.

6.1.3.2.2.2.2 Population-Level Effects

As with migrating adults during December-March, in some years, the catch per unit effort of adult (≥60 mm) Delta Smelt in the vicinity of the NDD is comparable to that in downstream areas, although the bulk of the catch still occurs downstream and, as noted previously, the seine survey was designed to collect Chinook salmon fry (as opposed to Delta Smelt) (Table 6.1-8). The reported catch from the early years, particularly before the 1990s, is uncertain as it is widely recognized that Delta Smelt were frequently misidentified by survey staff. As with migrating adults, given the spatial distribution of most of the Delta Smelt population, *i.e.*, well downstream of the NDD, any effects from not being able to access habitat upstream of the NDD are not expected to affect spawning adult Delta Smelt at a population level.

Table 6.1-8. Number of Delta Smelt (≥60 mm Fork Length) Collected and Catch per Seine during USFWS Beach Seine Sampling in the Action Area (February-June)

Year	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Seine (Intake Area)	Catch Per Seine (Downstream)
	Intake Area	Down-stream					
1976	29	126	10	187	0.05	0.34	1.48
1977	87	169	9	115	0.07	0.10	0.68
1978	68	147	36	124	0.22	0.53	0.84
1979	71	282	28	411	0.06	0.39	1.46
1980	74	308	1	36	0.03	0.01	0.12
1981	83	273	78	195	0.29	0.94	0.72
1982	69	233	9	112	0.07	0.13	0.48
1983	52	213	13	56	0.19	0.25	0.26
1984	49	185	10	8	0.56	0.20	0.04
1985	47	191	0	29	0.00	0.00	0.15
1986	18	108	1	19	0.05	0.06	0.18
1987	32	124	0	19	0.00	0.00	0.15
1988	31	116	0	2	0.00	0.00	0.02
1989	37	154	0	5	0.00	0.00	0.03
1990	11	39	0	0	.	0.00	0.00
1991	28	94	4	0	1.00	0.14	0.00
1992	62	227	4	15	0.21	0.06	0.07
1993	81	255	18	7	0.72	0.22	0.03
1994	80	415	0	72	0.00	0.00	0.17
1995	134	355	5	10	0.33	0.04	0.03

Year	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Seine (Intake Area)	Catch Per Seine (Downstream)
	Intake Area	Down-stream					
1996	158	348	4	40	0.09	0.03	0.11
1997	132	342	6	20	0.23	0.05	0.06
1998	78	331	7	65	0.10	0.09	0.20
1999	70	434	28	34	0.45	0.40	0.08
2000	102	419	16	38	0.30	0.16	0.09
2001	82	395	2	21	0.09	0.02	0.05
2002	73	439	7	4	0.64	0.10	0.01
2003	76	404	17	23	0.43	0.22	0.06
2004	78	403	26	19	0.58	0.33	0.05
2005	81	420	25	2	0.93	0.31	0.00
2006	82	368	5	52	0.09	0.06	0.14
2007	62	387	1	8	0.11	0.02	0.02
2008	68	373	1	0	1.00	0.01	0.00
2009	85	397	6	4	0.60	0.07	0.01
2010	85	361	26	5	0.84	0.31	0.01
2011	80	348	35	5	0.88	0.44	0.01
Mean	72	287	12	45	0.33	0.16	0.18
5th percentile	25	104	0	0	0.00	0.00	0.00
25th percentile	57	188	1	5	0.07	0.02	0.02
Median	74	331	6	19	0.22	0.09	0.06
75th percentile	82	391	18	46	0.57	0.24	0.16
95th percentile	133	424	35	145	0.95	0.46	0.75

Source: U.S. Fish and Wildlife Service Delta Juvenile Fish Monitoring Program (Speegle pers. comm.).

6.1.3.2.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.2.2.3.1 Individual-Level Effects

As noted for entrainment, Delta Smelt eggs and embryos are demersal and adhesive, and so would not be subject to impingement.

6.1.3.2.2.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs means that there would be no adverse population-level effects from the NDD with respect to impingement.

6.1.3.2.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.2.2.4.1 Individual-Level Effects

Delta Smelt larvae and young juveniles that are large enough (>20-21 mm) to be excluded from entrainment by the NDD screens would be susceptible to impingement and screen contact. There are no quantitative laboratory studies to inform the potential risk to these sizes of fish, in contrast to larger juveniles and adults (> 45 mm; see previous discussion for migrating adults). However, it seems reasonable to assume that the potential injury and mortality effects on these early, more fragile life stages would be greater than for larger Delta Smelt, for which mortality was estimated to be up to ~6% of the small number of fish passing each of the longer intakes (2 and 5) during the night at the highest sweeping velocity.

6.1.3.2.2.4.2 Population-Level Effects

As described in the discussion for NDD entrainment risk, the available egg and larval survey data suggest that a very low percentage of the early life stages would be in the Sacramento River near the NDD (possibly < 0.1%). Therefore, adverse effects from impingement and screen contact would only affect a small proportion of the population, and be unlikely to have population-level effects.

6.1.3.2.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.2.2.5.1 Individual-Level Effects

The analysis presented previously for migrating adult Delta Smelt also included consideration of juvenile sizes of Delta Smelt (> 45 mm) and suggested that mortality could occur for up to ~6% of the fish passing each of the longer intakes (2 and 5) during the night at the highest sweeping velocity.

6.1.3.2.2.5.2 Population-Level Effects

Survey data and the opinions of numerous experts that have sampled the Delta extensively[10] suggest that juvenile Delta Smelt are mostly distributed downstream of the proposed north Delta intakes. During fall (September–December), very few Delta Smelt have been collected at the midwater trawl stations near the proposed intakes, with catches occurring in only 3 years from 1991 to 2010 (Table 6.1-9); these years were critically dry, wet, and below normal water year types. Relatively few Delta Smelt <60 mm FL (fork length) were collected during seining in July–December, and those were mostly collected downstream (Table 6.1-10). Therefore, it is concluded that the population-level effects of impingement at the NDD would usually be near zero (Table 6.1-8).

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[10] These opinions are reflected in the distribution of surveys targeting Delta Smelt, e.g., the Spring Kodiak Trawl survey (CDFW 2015, see map at http://www.dfg.ca.gov/delta/data/skt/skt_stations.asp).

Table 6.1-9. Number of Delta Smelt Collected and Catch per Trawl during the Fall Midwater Trawl Survey (September–December)

Year	Number of Samples		Total Caught		Proportion (Intake Area/Total)	Mean Catch Per Trawl	
	Intake Area	Downstream Area	Intake Area	Downstream Area		Intake Area	Downstream Area
1991	9	590	0	855	0.00	0.00	1.45
1992	21	685	0	223	0.00	0.00	0.33
1993	18	875	0	1040	0.00	0.00	1.19
1994	24	805	4	438	0.01	0.17	0.54
1995	21	713	0	924	0.00	0.00	1.30
1996	22	719	0	460	0.00	0.00	0.64
1997	18	626	1	345	0.00	0.06	0.55
1998	6	509	0	427	0.00	0.00	0.84
1999	12	532	0	997	0.00	0.00	1.87
2000	13	581	0	1126	0.00	0.00	1.94
2001	21	628	0	702	0.00	0.00	1.12
2002	9	356	0	143	0.00	0.00	0.40
2003	12	359	0	222	0.00	0.00	0.62
2004	12	357	0	170	0.00	0.00	0.48
2005	12	359	0	28	0.00	0.00	0.08
2006	8	351	0	39	0.00	0.00	0.11
2007	12	360	0	27	0.00	0.00	0.08
2008	12	356	0	22	0.00	0.00	0.06
2009	12	382	0	23	0.00	0.00	0.06
2010	12	384	1	49	0.02	0.08	0.13

Source: California Department of Fish and Game unpublished data.

Table 6.1-10. Number of Juvenile Delta Smelt (<60 mm Fork Length) Collected and Catch per Seine during USFWS Beach Seine Sampling in the Action Area (July–December)

Year	Number of Samples		Total Caught (Intake Area)	Total Caught (Downstream Area)	Proportion Caught (Intake Area/Total)	Catch Per Seine (Intake Area)	Catch Per Seine (Downstream)
	Intake Area	Down-stream					
1977	16	21	0	29	0.00	0.00	1.38
1979	20	74	0	19	0.00	0.00	0.26
1980	26	105	0	2	0.00	0.00	0.02
1982	16	40	0	0	.	0.00	0.00
1983	1	1	0	0	.	0.00	0.00
1990	4	4	0	0	.	0.00	0.00
1992	21	43	0	0	.	0.00	0.00
1993	55	117	0	0	.	0.00	0.00
1994	119	246	1	1	0.50	0.01	0.00
1995	319	249	6	0	1.00	0.02	0.00
1996	394	334	0	0	.	0.00	0.00
1997	283	317	0	10	0.00	0.00	0.03
1998	234	385	0	6	0.00	0.00	0.02
1999	215	337	0	3	0.00	0.00	0.01
2000	187	325	0	12	0.00	0.00	0.04
2001	221	454	0	32	0.00	0.00	0.07
2002	206	550	0	2	0.00	0.00	0.00
2003	215	538	0	8	0.00	0.00	0.01
2004	230	530	0	5	0.00	0.00	0.01
2005	238	512	0	2	0.00	0.00	0.00
2006	221	512	0	2	0.00	0.00	0.00
2007	262	521	0	4	0.00	0.00	0.01
2008	240	499	0	0	-	0.00	0.00
2009	245	492	0	0	-	0.00	0.00
2010	242	426	0	0	-	0.00	0.00
2011	238	438	0	0	-	0.00	0.00
2012	95	95	0	0	-	0.00	0.00
Mean	175	313	0	4	0.10	0.00	0.02
5th percentile	7	13	0	0	0.00	0.00	0.00
25th percentile	65	108	0	0	0.00	0.00	0.00
Median	218	336	0	2	0.00	0.00	0.00
75th percentile	240	497	0	5	0.00	0.00	0.01
95th percentile	310	536	1	17	0.65	0.01	0.06

Source: U.S. Fish and Wildlife Service Delta Juvenile Fish Monitoring Program (Speegle pers. comm.).

6.1.3.2.3 Predation at the North Delta Diversions

6.1.3.2.3.1 Migrating Adults (December-March)

6.1.3.2.3.1.1 Individual-Level Effects

Delta Smelt occurring in front of the NDD screens may be susceptible to an elevated risk of predation as they approach and attempt to pass the fish screens because the structures would result in a vertical wall with little cover, other than (possibly) the proposed in-screen refugia and the hydraulic effects of the water diversion described above. It is uncertain to what extent the predation rate in front of the screens will differ from the predation rate that would otherwise occur in this reach without the NDD present because there are no data available to estimate predation rates on Delta Smelt in this reach. A hydroacoustic survey as part of Freeport intake monitoring in 2014 (when diversions were over 130 cfs) found that predator-sized fish (*i.e.*, 12 inches long [305 mm long] and larger) density at the intake was similar or less than the density in upstream and downstream control reaches (ICF International 2015a), although only four surveys were undertaken, so there are few data from which to draw conclusions[11]. As discussed in Section 6.1.1.3, *Water Facilities Construction*, riprap used in association with the intakes could result in increased predator habitat and predation risk. The implementation of localized predatory fish reduction under the PA may limit predation risk (Section 6.1.4.2, *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities*), but there is uncertainty in the effectiveness of this measure given that the area is open to immigration and emigration of predators and turnover may be appreciable in a relatively short period of time (Cavallo *et al.* 2013). Because there is uncertainty in the potential effectiveness of localized reduction of predatory fishes, it is assumed in this effects analysis that it would not be effective.

6.1.3.2.3.1.2 Population-Level Effects

The potential adverse effect to individual migrating adult Delta Smelt from predation at the NDD would be a minimal adverse effect at the population level because, as discussed previously for impingement and screen contact, there generally would be expected to be a very small proportion of the Delta Smelt population near the NDD.

6.1.3.2.3.2 Spawning Adults (February-June)

6.1.3.2.3.2.1 Individual-Level Effects

To the extent that spawning adult Delta Smelt occur near the NDD, similar effects as described above for migrating adults would be expected, *i.e.*, potentially elevated predation. However, individual spawning adults would not be expected to undergo major movements, and therefore would be likely to have limited risk of predation at the NDD.

6.1.3.2.3.2.2 Population-Level Effects

As with migrating adult Delta Smelt, there generally would be expected to be a small proportion of the spawning Delta Smelt population near the NDD, so there would be a minimal adverse effect from predation at the NDD on this life stage.

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[11] NMFS also has been conducting hydroacoustic surveys of predator-sized fish near the Freeport intake; these data were not yet available for inclusion in this effects analysis.

6.1.3.2.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.2.3.3.1 Individual-Level Effects

Following Bennett (2005), it is generally thought that egg/embryo habitat for Delta Smelt consists of shallow sandy areas, which is not the type of habitat that would be found at the NDD. There therefore would be no effects on individual eggs or embryos.

6.1.3.2.3.3.2 Population-Level Effects

Following from the lack of individual-level effects of the NDD in terms of predation, there would therefore be no adverse population-level effect on eggs/embryos.

6.1.3.2.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.2.3.4.1 Individual-Level Effects

To the extent that the NDD provide beneficial habitat for predators of larval and early juvenile Delta Smelt (e.g., silversides; Baerwald *et al.* 2012), there could be an elevated risk of predation for these young life stages. However, it is not clear that the NDD would provide beneficial habitat, as presumably these small predators would be susceptible to the same larger predators that could consume adult Delta Smelt. Therefore, elevated predation on Delta Smelt larvae is unlikely.

6.1.3.2.3.4.2 Population-Level Effects

Even if all of the larvae passing the screens were eaten, the population-level effect would be small, based on the low (potentially < 0.1%) percentage of the population occurring near the NDD; see more detailed discussion in the analysis of the effects of entrainment.

6.1.3.2.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.2.3.5.1 Individual-Level Effects

As with adult Delta Smelt, elevated levels of predation risk could occur to individual juvenile Delta Smelt occurring near the NDD.

6.1.3.2.3.5.2 Population-Level Effects

Even if all of the juvenile Delta Smelt near the NDDs were eaten, the potential for population-level effects of predation on juvenile Delta Smelt near the NDD would be minimal because, as discussed for impingement and screen contact, monitoring data indicate a very small proportion of the population occurs near the NDD.

6.1.3.3 South Delta Exports

6.1.3.3.1 Entrainment

The entrainment of Delta Smelt into the Banks and Jones pumping plants is a direct effect of SWP and CVP operations. See Brown *et al.* (1996) for a description of fish salvage operations from which Delta Smelt entrainment estimates have historically been derived (e.g., Kimmerer 2008). However, the salvage estimates are indices - most entrained fish are not observed (Table 6.1-11), so most of the fish are not salvaged and therefore do not survive. Bennett (2005) suggested that many, if not most, of the Delta Smelt that do reach the fish facilities likely die due to handling stress and predation, however recent studies suggest there may be relatively high survival of adult Delta Smelt during collection, handling, transport, and release when they are salvaged during cool temperature conditions (Morinaka 2013). Pre-screen loss due to predation near and within the CVP and SWP fish facilities, is an additional cause of mortality for Delta Smelt. Pre-screen loss of captive-reared Delta Smelt released into Clifton Court Forebay ranged from about 90% to 100% for adults and nearly 100% for juveniles during a recent study (Castillo *et al.* 2012)[12].

Table 6.1-11. Factors Affecting Delta Smelt Entrainment and Salvage

Factor	Adults	Larvae < 20 mm	Larvae >20 mm and Juveniles	Source
Pre-screen loss (predation prior to encountering fish salvage facilities)	CVP: unquantified; SWP: 89.9–100%	Unquantified	CVP: unquantified; SWP: 99.9%	SWP: Castillo *et al.* (2012)
Fish facility efficiency	CVP: 13%; SWP: 43–89%	~0%	CVP: likely < 13% at all sizes, << 13% below 30 mm (based on adult data); SWP: 24–30%	CVP (Kimmerer 2008; adults only); SWP: Castillo *et al.* (2012)
Collection screens efficiency	~100%	~0%	<100% until at least 30 mm	USFWS (2011a)
Identification protocols	Identified from subsamples, then expanded in salvage estimates	Not identified	Identified from subsamples, then expanded in salvage estimates	USFWS (2011a)
Collection and handling	48-hour experimental mean survival of 93.5% (not statistically different from control) in 2005; 88.3% in 2006 (significantly less than 99.8% of control)	Unquantified	48-hour experimental mean survival of 61.3% in 2005 and 50.9% in 2006 (both significantly less than mean control survival of 82.0–85.9%)	Morinaka (2013)
Trucking and release (excluding post-release predation)	No significant additional mortality beyond collection and handling (above)	Unquantified	No significant additional mortality than collection and handling (above), although mean survival was 37.4% in 2005	Morinaka (2013)

The population-level effects of Delta Smelt entrainment vary; Delta Smelt entrainment can be characterized as a sporadically significant influence on population dynamics. Kimmerer (2008) estimated that annual entrainment of the Delta Smelt population (adults and their progeny

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[12] Although relatively high temperatures (for juveniles) and relatively low pumping (for juveniles and adults) could have affected the magnitude of pre-screen loss estimated by Castillo et al. (2012), high pre-screen loss has been estimated for other species such as Chinook salmon (Gingras 1997) and steelhead (Clark et al. 2009).

combined) ranged from approximately 10 to 60% per year from 2002–2006. Major population declines during the early 1980s (Moyle *et al.* 1992) and during the recent POD years (Sommer *et al.* 2007) were both associated with hydrodynamic conditions that greatly increased Delta Smelt entrainment losses as indexed by numbers of fish salvaged. However, currently published analyses of long-term associations between Delta Smelt salvage and subsequent abundance do not support the hypothesis that entrainment is driving population dynamics year in and year out (Bennett 2005; Manly and Chotkowski 2006; Kimmerer 2008; Mac Nally *et al.* 2010; Maunder and Deriso 2011[13]; Miller *et al.* 2012). However, this is an area of scientific debate with some researchers finding that entrainment (or water diversions during the time period when entrainment would be of concern) may affect population dynamics (Rose *et al.* 2013; Thomson *et al.* 2010). The USFWS (2008) and NMFS (2009) BiOps and their RPA actions related to south Delta entrainment have reduced the potential for entrainment loss since 2008–2009.

6.1.3.3.1.1 Migrating Adults (December–March)

6.1.3.3.1.1.1 Individual-Level Effects

Adult Delta Smelt are entrained into the south Delta export facilities during spawning migrations (Grimaldo *et al.* 2009; Sommer *et al.* 2011). Their spawning migrations occur during the winter when precipitation increases the freshwater flow and turbidity in the Delta. Salvage of adult Delta Smelt at the south Delta export facilities is an index of entrainment, albeit a very rough index (IEP MAST Team 2015: 59). Salvage of adults has mainly occurred from late December through March (Kimmerer 2008; Grimaldo *et al.* 2009). For migrating adults, the risk of entrainment is influenced by flow cues and turbidity in the south Delta (Grimaldo *et al.* 2009). Old and Middle Rivers are distributary channels of the San Joaquin River. Project pumping (*i.e.*, the export of water from the Delta) can cause the tidally filtered or "net" flows in these channels to move "upstream". This occurs because water removed by Banks and Jones, along with other diversions in the area, is back-filled by tidal and river flows. This phenomenon is mathematically depicted as negative flow. Negative Old and Middle River (OMR) flows and greater turbidity are often associated with adult Delta Smelt entrainment, but no particular OMR flow assures entrainment will or will not occur. The net OMR flows indicate how strongly the tidally averaged flows in these channels are moving toward Banks and Jones pumping plants. Thus, it is possible the net flows themselves are the mechanism that increases entrainment risk for Delta Smelt. However, high exports can also lead to strong tidal asymmetry in Old and Middle Rivers where flood tides toward the pumps become much stronger than the ebb tides away from the pumps (U.S. Fish and Wildlife Service 2011a), so altered tidal flows are a second, covarying mechanism that could increase Delta Smelt's risk of entrainment.

The empirical shape of the associations between estuarine salinity distribution (X2), OMR, turbidity and adult Delta Smelt salvage normalized by the FMWT is shown in Figure 6.1-4. Normalized Delta Smelt salvage is correlated in a nonlinear way with X2. An interpretation of this is that the intermediate river flow or X2 conditions are associated with the highest salvage

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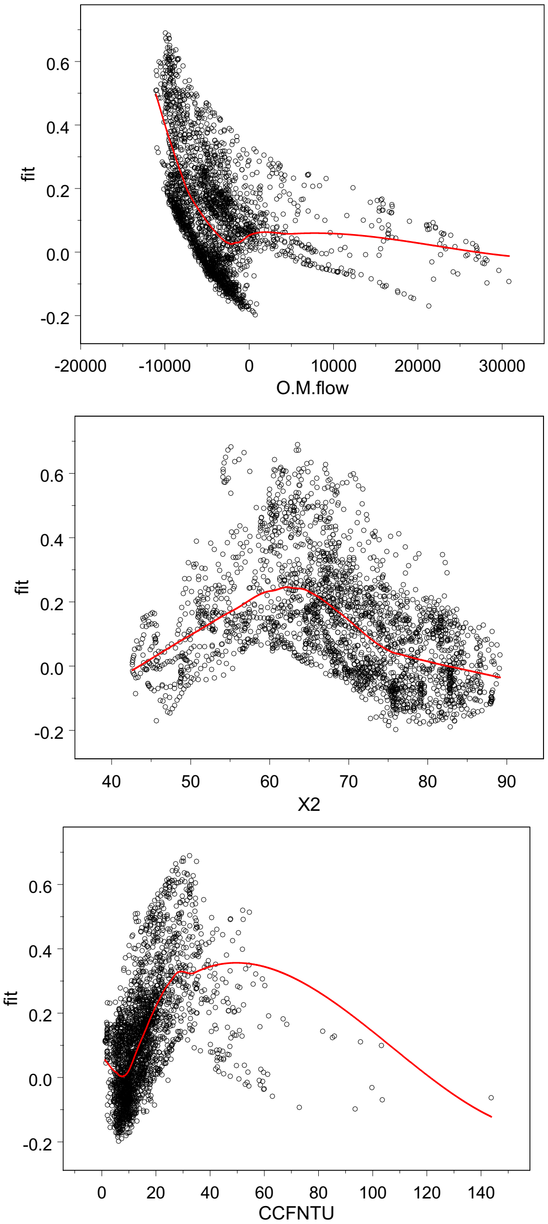
[13] The automated statistical procedure that Maunder and Deriso (2011) developed to choose a "best" life cycle model based on their input data determined that a model with strong density-dependence between generations and a very strong influence of adult entrainment was the best-fitting statistical model. However, the authors determined that the density-dependence was too strong and the parameter estimate for the entrainment effect was too high to be plausible, so they determined the second best-fitting model was the most believable LCM. This second best-fitting model did not retain entrainment as an important predictor of Delta Smelt population dynamics.

because flows are high enough to disperse turbidity around the Delta, but not so high that most Delta Smelt are distributed seaward of the Delta. Figure 6.1-4 shows that even when X2 and south Delta turbidity are accounted for, there is no OMR flow that assures Delta Smelt entrainment will or will not occur. The predicted relationship is a smooth, accelerating function with increasing normalized salvage as OMR flow becomes more negative (Figure 6.1-4).



Note: The scatter in each panel is caused by the interacting effects of the other two variables.

Figure 6.1-4. Empirical Trends in Predictions of Adult Delta Smelt Salvage (y-axis) During December–March, 1993–2013, as a Function of Old and Middle River Flow (O.M. flow, cfs), X2 (km from Golden Gate Bridge), and Turbidity at Clifton Court Forebay (CCFNTU, NTU)

The association of adult Delta Smelt with turbid water (see Figure 42 of U.S. Fish and Wildlife Service 2011a) can lead to greater entrainment by the south Delta export facilities when turbid conditions occur in the regions that are under the hydraulic influence of the export facilities (Grimaldo *et al.* 2009). Recognition of the combined importance of OMR flow and turbidity is provided in the USFWS proposal to set incidental take of Delta Smelt as a function of OMR flow and turbidity, given a population abundance estimate (U.S. Fish and Wildlife Service 2015b)[14].

Under the PA, OMR flows would be less negative than under the NAA during the months of concern for adult Delta Smelt (Figure 6.1-5, Figure 6.1-6, Figure 6.1-7, Figure 6.1-8; see Table 5.A.6-25 and Figures 5.A.6-25-1 to 5.A.6-25-19 in Appendix 5.A *CALSIM Methods and Results*). As described in Section 3.3.2.2 *Operational Criteria for South Delta CVP/SWP Export Facilities*, the OMR flow requirements would be those of USFWS (2008) and NMFS (2009) until completion of the NDD, after which the newly proposed criteria would generally improve OMR flows more in wetter years under the PA compared to the existing BiOps; provided, as discussed in Chapter 3, that the research and results of the Collaborative Science and Adaptive Management program show these criteria are required to avoid jeopardy of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat for those species. Real-time management of entrainment risk would also occur (if needed), in a manner similar to the existing Smelt Working Group process. It therefore would be expected that individual Delta Smelt would be less susceptible to entrainment under the PA than the NAA. This is analyzed at the population level in the next section.

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[14] The proposal is available at http://deltacouncil.ca.gov/sites/default/files/2015/10/Item%201%20USFWS%20reports%20-%20Past,%20Present%20and%20Future%20Approaches%20to%20Incidental%20Take.pdf (accessed October 24, 2015) and is one of the subjects of the 2015 Long-term Operations Biological Opinions Annual Science Review.

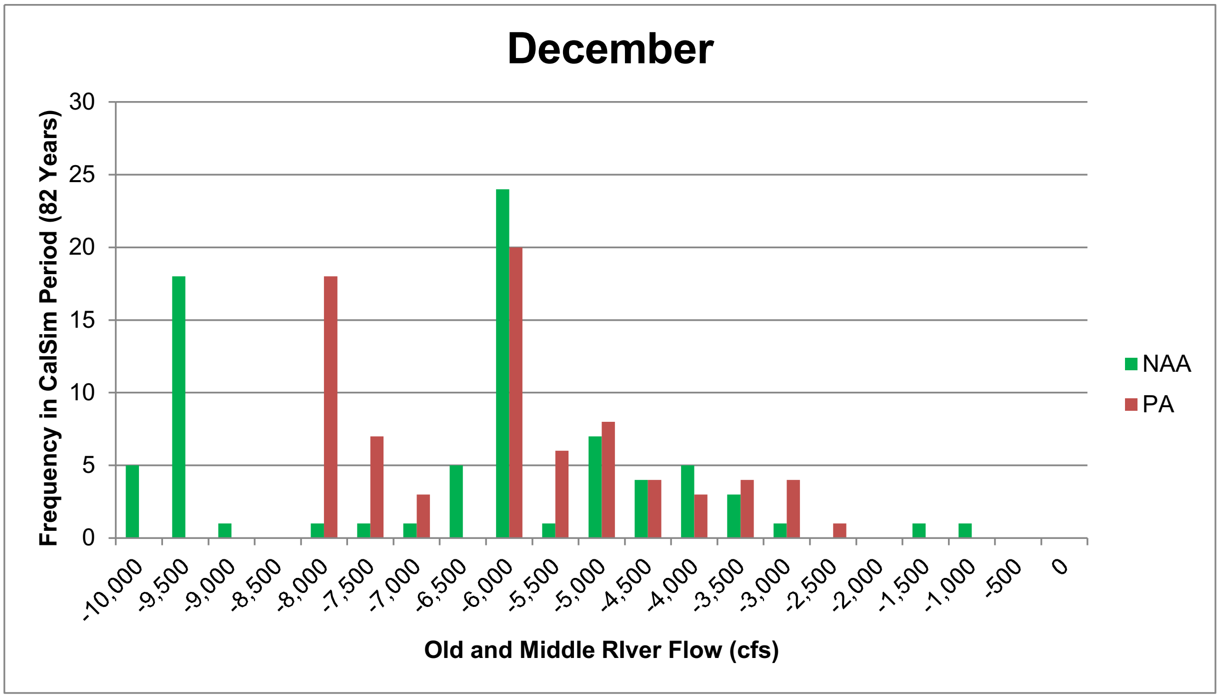


Figure 6.1-5. Frequency of December Old and Middle River Flows in Water-Year 1922–2003 Period Simulated with CalSim

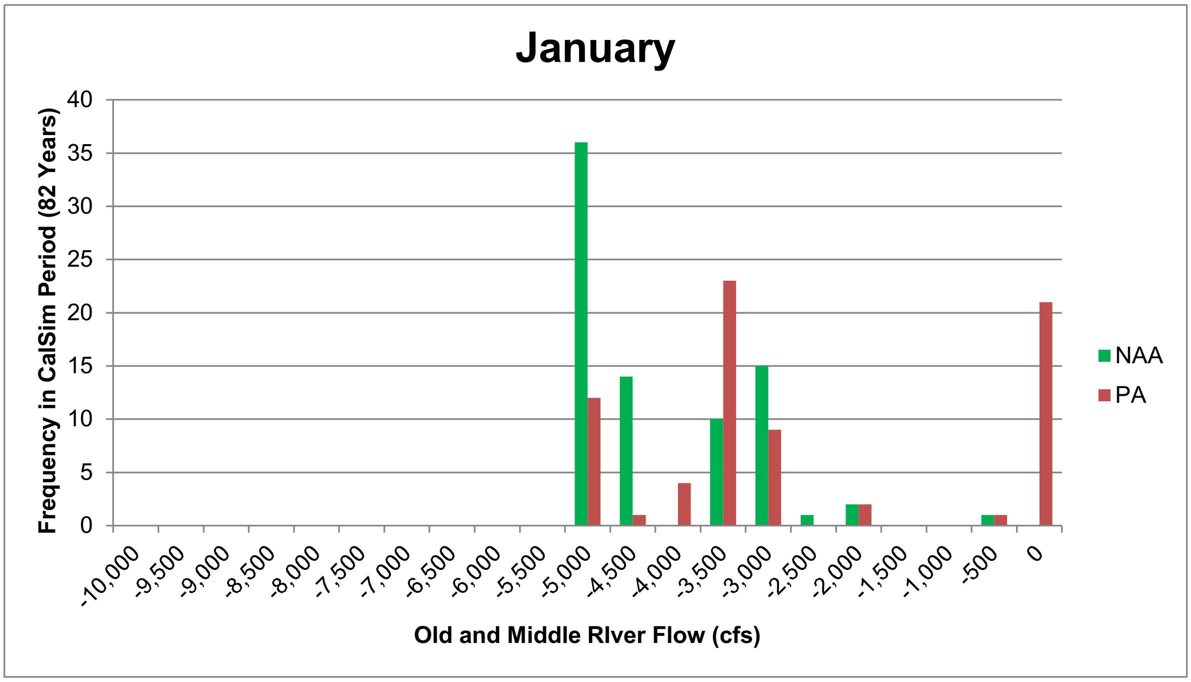


Figure 6.1-6. Frequency of December Old and Middle River Flows in Water-Year 1922–2003 Period Simulated with CalSim

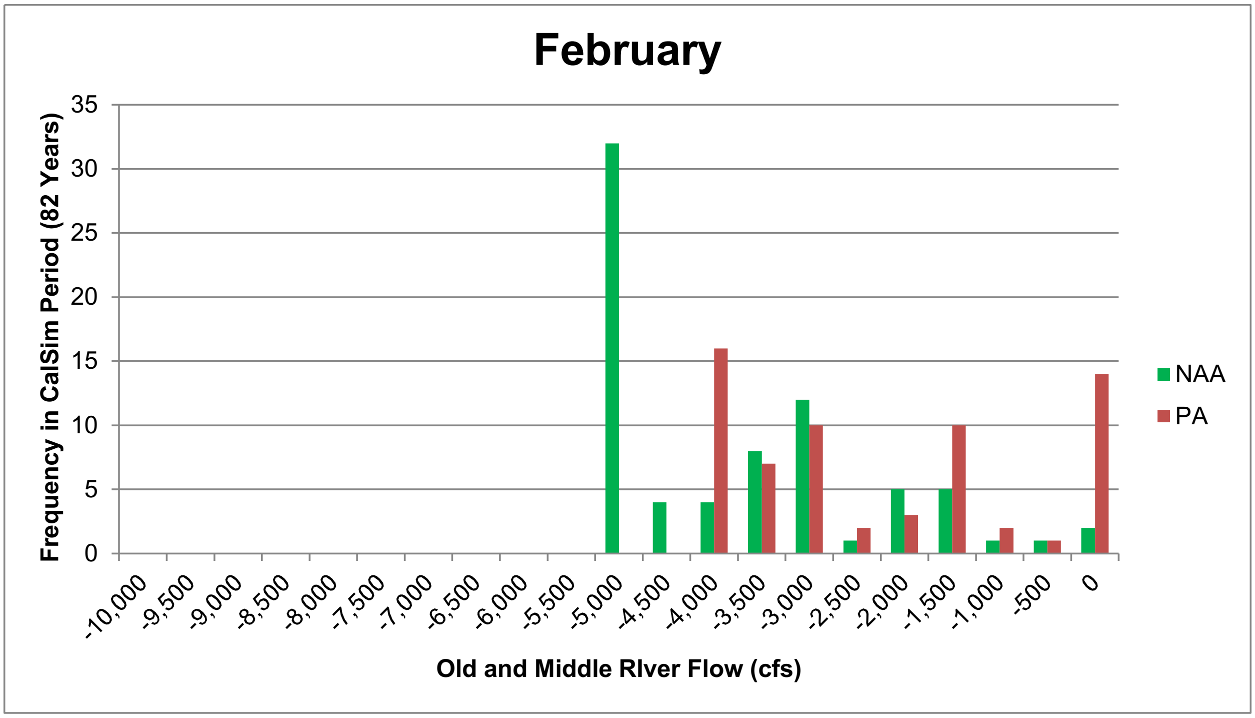


Figure 6.1-7. Frequency of February Old and Middle River Flows in Water-Year 1922–2003 Period Simulated with CalSim

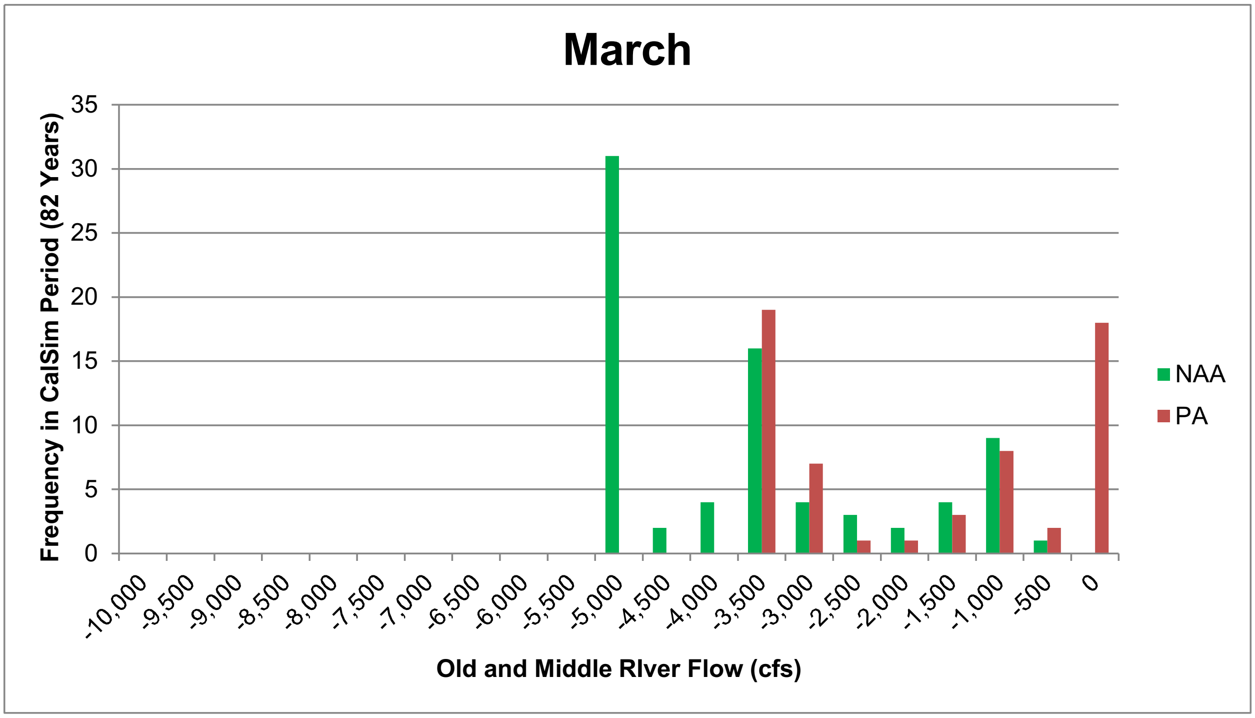


Figure 6.1-8. Frequency of March Old and Middle River Flows in Water-Year 1922–2003 Period Simulated with CalSim

6.1.3.3.1.1.2 Population-Level Effects

No tools are currently available with which to model adult entrainment risk at the south Delta export facilities in relation to future operations as well as it can be hindcast (*i.e.*, estimates of historical percentage loss as a function of historical OMR flows, for example), because of the difficulty in forecasting turbidity and abundance. For this effects analysis, the percentage entrainment of adult Delta Smelt was estimated using OMR flow predictions derived from CalSim II model outputs (U.S. Fish and Wildlife Service 2008; Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.3.1). As noted in Appendix 6.A, although much of the variability in percentage loss is left unexplained by this regression equation and the confidence intervals on the original estimates are relatively wide in some cases, the predictions in the models do follow the expected trend that salvage and population losses will decrease in response to the proposed action.

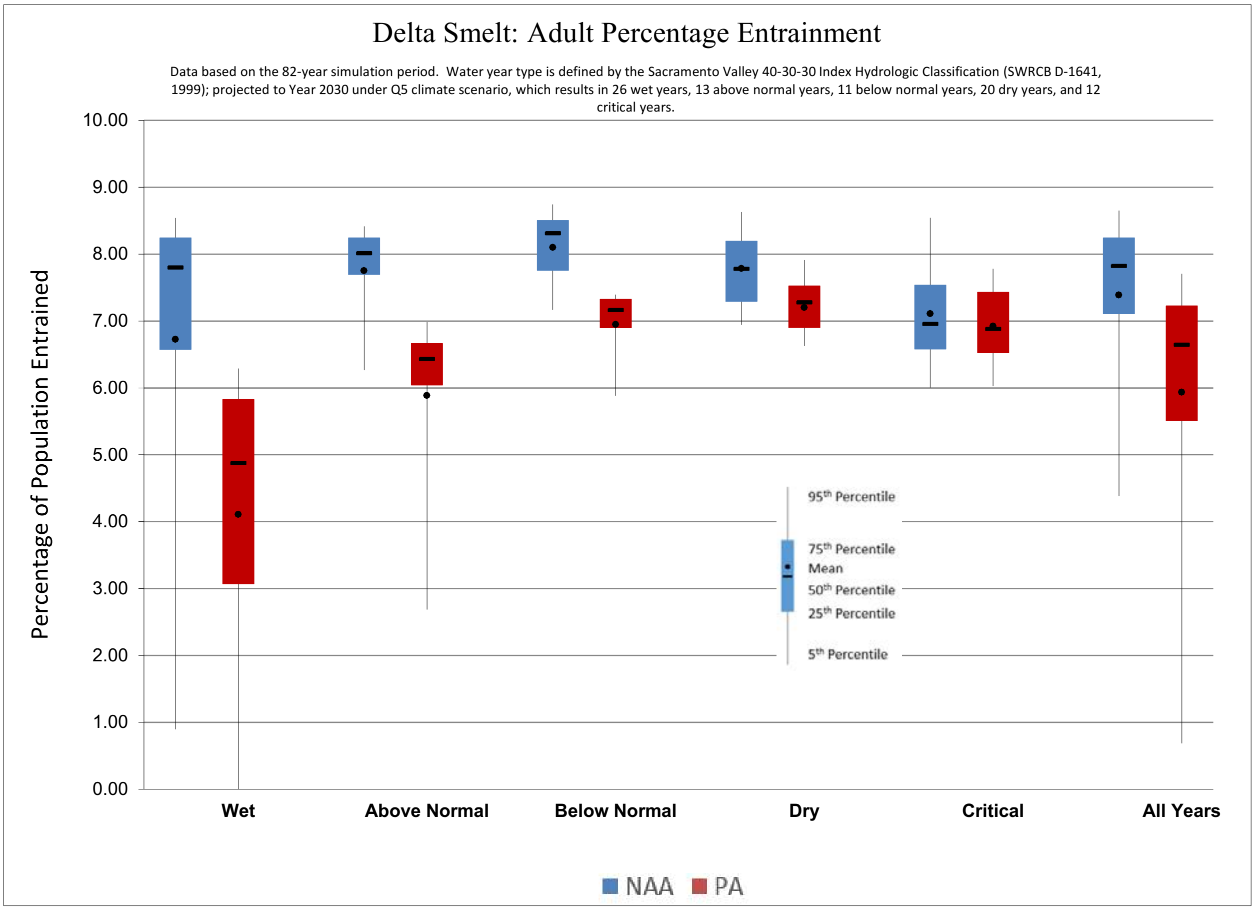
The analysis indicates that percentage entrainment loss of adult Delta Smelt would be lower under the PA than NAA, with variable differences when the results are summarized by water year type (Table 6.1-12; Figure 6.1-9). In drier years, the need to maintain suitable bypass flows in the Sacramento River and to maintain D-1641 compliant Delta outflows limits the use of the NDD. The result is predictions that there will be little difference between the NAA and PA in south Delta exports and entrainment loss of adult Delta Smelt. The USFWS (2008) and NMFS (2009) BiOps and their RPA actions related to south Delta entrainment have considerably reduced the potential for entrainment loss since 2008–2009. Therefore, even in drier water years, the predicted entrainment of adult Delta Smelt is considerably lower than what sometimes occurred historically. The overall conclusion is that the adverse effect of adult Delta Smelt entrainment in the south Delta could be appreciably lessened under the PA. Note, however, that there is appreciable uncertainty in the magnitude of the potential difference between NAA and PA, because there is considerable variability that is left unexplained by the regression equation, resulting in broad prediction intervals (Figure 6.1-10).

Less entrainment risk to migrating adults may result in a greater proportion of adults successfully spawning in the lower San Joaquin River. Spring Kodiak trawling in the lower San Joaquin River suggests frequent occurrence of spawning adults in this area (~10% of samples from 2002–2009 [Merz *et al.* 2011]; ~22% of samples during intensive sampling during extreme drought conditions in 2014 [Polansky *et al.* 2014]), which may imply a modest beneficial population-level effect. Recognition of the need to manage entrainment risk as a function of both OMR flows and south Delta turbidity is likely to guide management under both the NAA and PA, as illustrated by the previously mentioned USFWS proposal for the 2016 incidental take limit calculation.

Table 6.1-12. Mean Estimated Annual Percentage Entrainment Loss of Adult Delta Smelt at CVP/SWP South Delta Export Facilities by Water-Year Type for the No Action Alternative (NAA) and Proposed Action (PA), Based on the Percentage Entrainment Regression

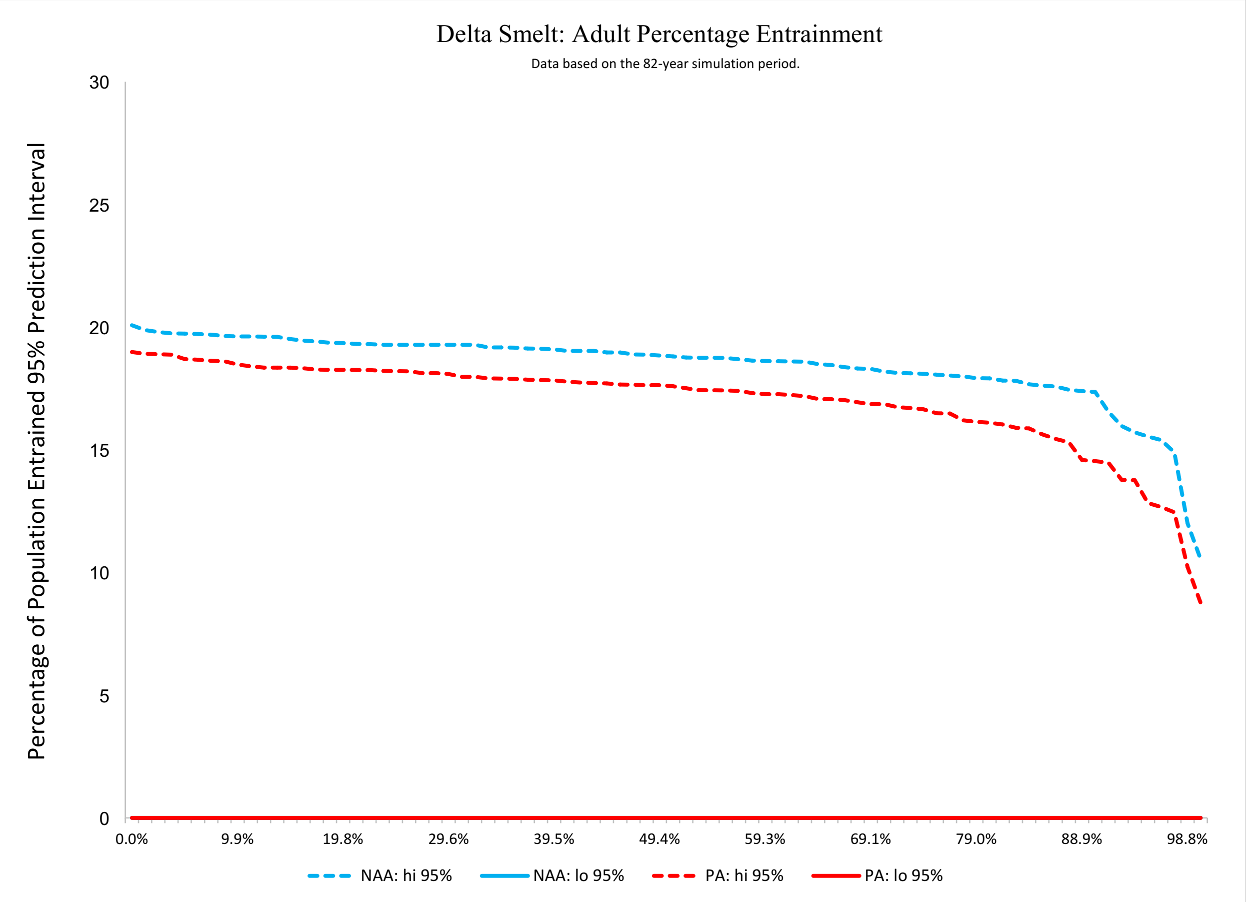
Water Year Type	NAA	PA	PA vs. NAA[1]
All	7.39	5.94	-1.45 (-20%)
Wet	6.73	4.11	-2.62 (-39%)
Above Normal	7.75	5.89	-1.87 (-24%)
Below Normal	8.10	6.95	-1.15 (-14%)
Dry	7.79	7.20	-0.59 (-8%)
Critical	7.11	6.92	-0.19 (-3%)

Note:
[1] Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).



Note: Plot only includes mean responses and does not consider model uncertainty.

Figure 6.1-9. Box Plots of Adult Delta Smelt Percentage Entrainment, Grouped by Water Year Type



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown. The lower bound of the 95% prediction interval is zero in all cases (following adjustment from negative values; see Section 6.A.3.1 *Percentage Loss Equations* in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*).

Figure 6.1-10. Exceedance Plot of Adult Delta Smelt Percentage Entrainment

6.1.3.3.1.2 Spawning Adults (February-June)

6.1.3.3.1.2.1 Individual-Level Effects

After completion of the migration to spawning areas, spawning adults presumably hold in a similar location prior to, during, and after spawning (possibly to spawn more than once). Therefore, there may not be appreciable risk of entrainment at the south Delta export facilities once the adults begin staging. The primary risk to adults occurs during the spawning migration, as described previously, but the persistently less negative OMR flows predicted for the PA suggest that entrainment risk will be reduced throughout the spawning season regardless of nuances about adult behavior and movements.

6.1.3.3.1.2.2 Population-Level Effects

Under the assumption that spawning adults are not undergoing broad-scale migrations, there would not be an adverse population-level effect of entrainment from south Delta exports to this life stage, but the persistently less negative OMR flows predicted for the PA suggest that percentage entrainment will be reduced and kept very similar to current conditions throughout the spawning season regardless of nuances about adult behavior and movements. As previously discussed, less entrainment risk for migrating adult Delta Smelt may increase the availability of lower San Joaquin River spawning habitat.

6.1.3.3.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.3.1.3.1 Individual-Level Effects

As noted for entrainment and impingement at the NDD, Delta Smelt eggs and embryos are demersal and adhesive, and so would not be subject to entrainment at the south Delta export facilities.

6.1.3.3.1.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs means that there would be no adverse population-level effects from south Delta exports with respect to entrainment.

6.1.3.3.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.3.1.4.1 Individual-Level Effects

Most age–0 Delta Smelt entrainment at the south Delta export facilities occurs during the true larval stage and is not observed and counted (Kimmerer 2008). The salvage of age-0 Delta Smelt reflects the tail end of the entrainment of age–0 cohorts that started before the fish were large enough to be observed in the fish salvage facilities. Delta smelt are not counted in fish salvage until they reach a minimum length of 20 mm. Kimmerer (2008) showed that Delta Smelt salvage was inefficient until the fish were 30 mm long (by which time they are morphologically juveniles; Mager *et al.* 2004). Delta Smelt typically reach 20-30 mm in May and June. Thus, April is likely to be the month of highest south Delta entrainment of age-0 Delta Smelt, while May-June are the months of highest salvage (Kimmerer 2008).

USFWS (2008) translated Kimmerer's (2008) data-intensive age-0 Delta Smelt entrainment estimates into multiple linear regression equations using multi-month averages of X2 and OMR flow as predictor variables. The regressions were a quantitative representation of the following conceptual model: (1) the geographic distribution of much of the population is strongly associated with Delta outflow (or its surrogate, X2; Dege and Brown 2004). Thus, Delta outflow may influence the proportion of the age-0 Delta Smelt population that rears in the Delta during the spring and early summer where it is potentially vulnerable to entrainment, and (2) OMR reflects the hydrodynamic influence of the water projects' diversions on the southern half of the Delta and thus the degree of entrainment risk for fishes in that region (Kimmerer 2008; Grimaldo *et al.* 2009). Long-term declines in April–May exports and E:I ratio, and April–June X2 (all results of State Board Decision 1641) may all have contributed to reduced entrainment risk of age-0 Delta Smelt; implementation of the RPAs from USFWS (2008) and NMFS (2009) has likely further reduced entrainment since 2008-2009, as a result of restrictions on export pumping that are made in consideration of environmental conditions that result in listed fishes being susceptible to entrainment (e.g., greater south Delta turbidity for Delta Smelt). In addition, entrainment risk may be continuing to decline due to a general shift in Delta Smelt spawning distribution toward the north Delta (Kimmerer 2011; Miller 2011).

Under the PA, individual larval/juvenile Delta Smelt would be susceptible to entrainment at the south Delta export facilities. The analysis presented below focuses on the population-level effect, by examining the percentage of the population that could be entrained under PA and NAA.

6.1.3.3.1.4.2 Population-Level Effects

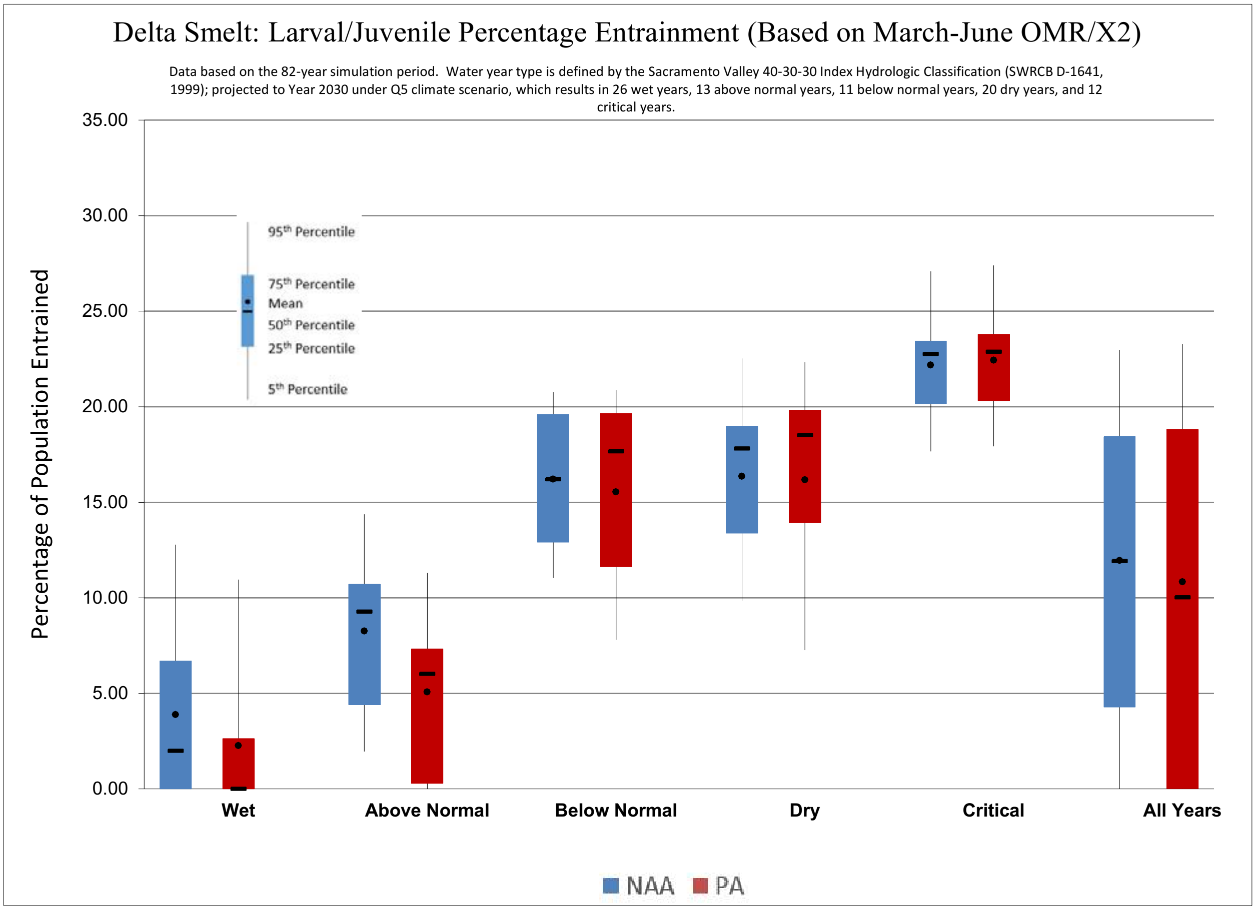
For this effects analysis, two approaches were used to estimate entrainment effects on larval/young juvenile Delta Smelt. First, percentage entrainment loss regression equations similar to those used by USFWS (2008) were used to estimate differences in potential larval/juvenile Delta Smelt entrainment at the south Delta export facilities given the basic operations simulated in CalSim II (Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt,* Section 6.A.3.1.2). These regressions used two averaging periods: March–June and April–May. The analyses indicate that the percentage entrainment of larval/juvenile Delta Smelt would tend to be very similar under the PA and the NAA (Table 6.1-13; Table 6.1-14; Figure 6.1-11; Figure 6.1-12; Figure 6.1-13; Figure 6.1-14). The NAA and PA had quite broad prediction intervals, which were overlapping across all exceedance values (Figure 6.1-12; Figure 6.1-14), as also illustrated when plotting the results as time series (Figure 6.1-15; Figure 6.1-16). As noted in the independent review panel report for the working draft BA, it is possible that the true annual values could lie near the bottom boundary of the prediction interval for PA and near the top boundary of the prediction interval for NAA (Simenstad et al. 2016). This would result in greater differences than suggested by the comparison of annual mean values. By the same rationale, it is also possible that the true annual values could lie near the top boundary of the prediction intervals for both PA and NAA, in which case the differences would be more similar to the differences between means.

Table 6.1-13. Mean Annual Percentage Entrainment Loss of Larval and Juvenile Delta Smelt at CVP/SWP South Delta Export Facilities by Water-Year Type for the No Action Alternative (NAA) and Proposed Action (PA), Based on the Percentage Entrainment Regression Using Mean March-June Old and Middle River Flows and X2.

Water Year Type	NAA	PA	PA vs. NAA[1]
All	11.95	10.83	-1.12 (-9%)
Wet	3.89	2.26	-1.63 (-42%)
Above Normal	8.26	5.07	-3.18 (-39%)
Below Normal	16.20	15.54	-0.66 (-4%)
Dry	16.36	16.17	-0.19 (-1%)
Critical	22.18	22.43	0.25 (1%)

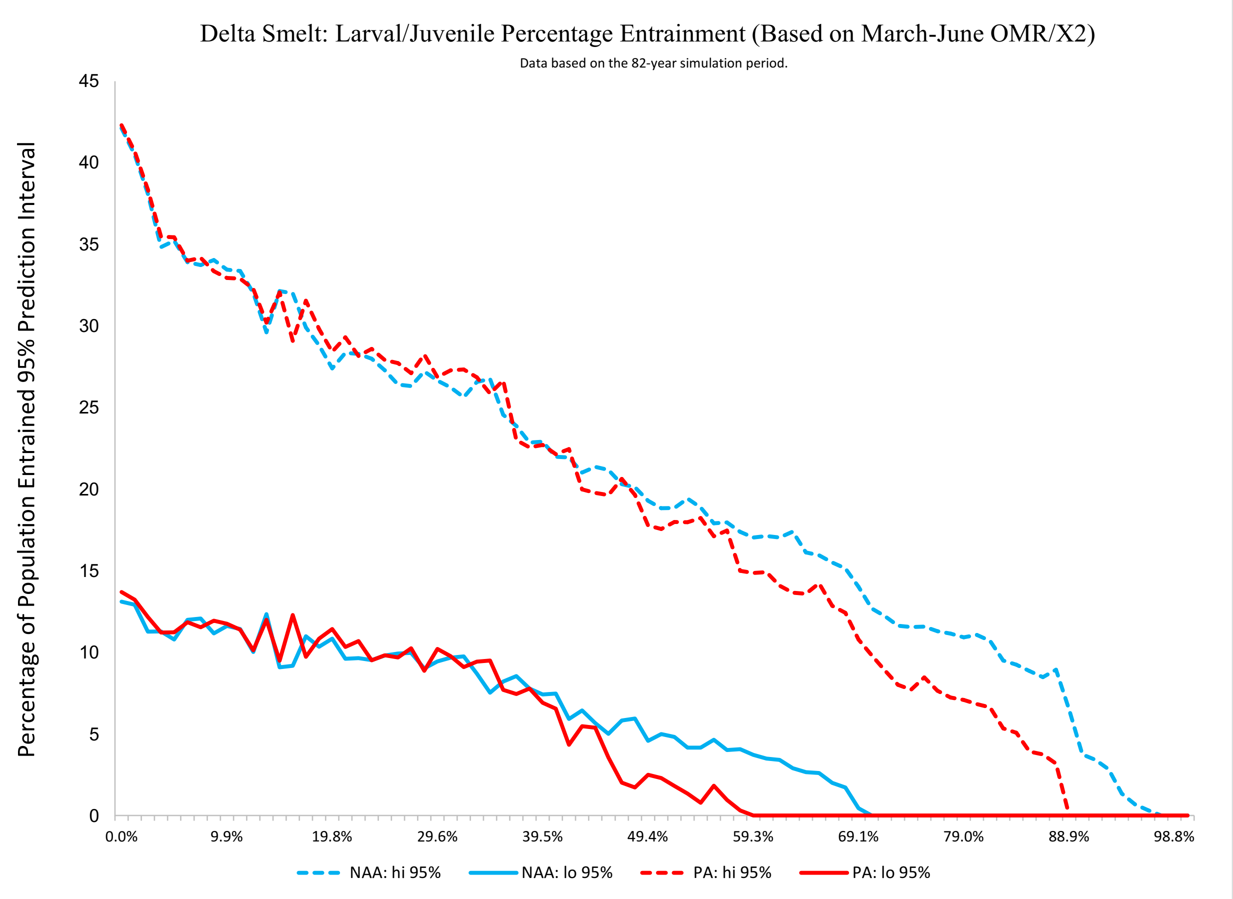
Note:

[1] Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).



Note: Plot only includes mean responses and does not consider model uncertainty.

Figure 6.1-11. Box Plots of Larval/Juvenile Delta Smelt Percentage Entrainment, Grouped by Water Year Type, Based on Mean March-June Old and Middle River Flows and X2



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown. When necessary, the lower bound of the 95% prediction is adjusted to zero from negative values (see Section 6.A.3.1 *Percentage Loss Equations* in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*).

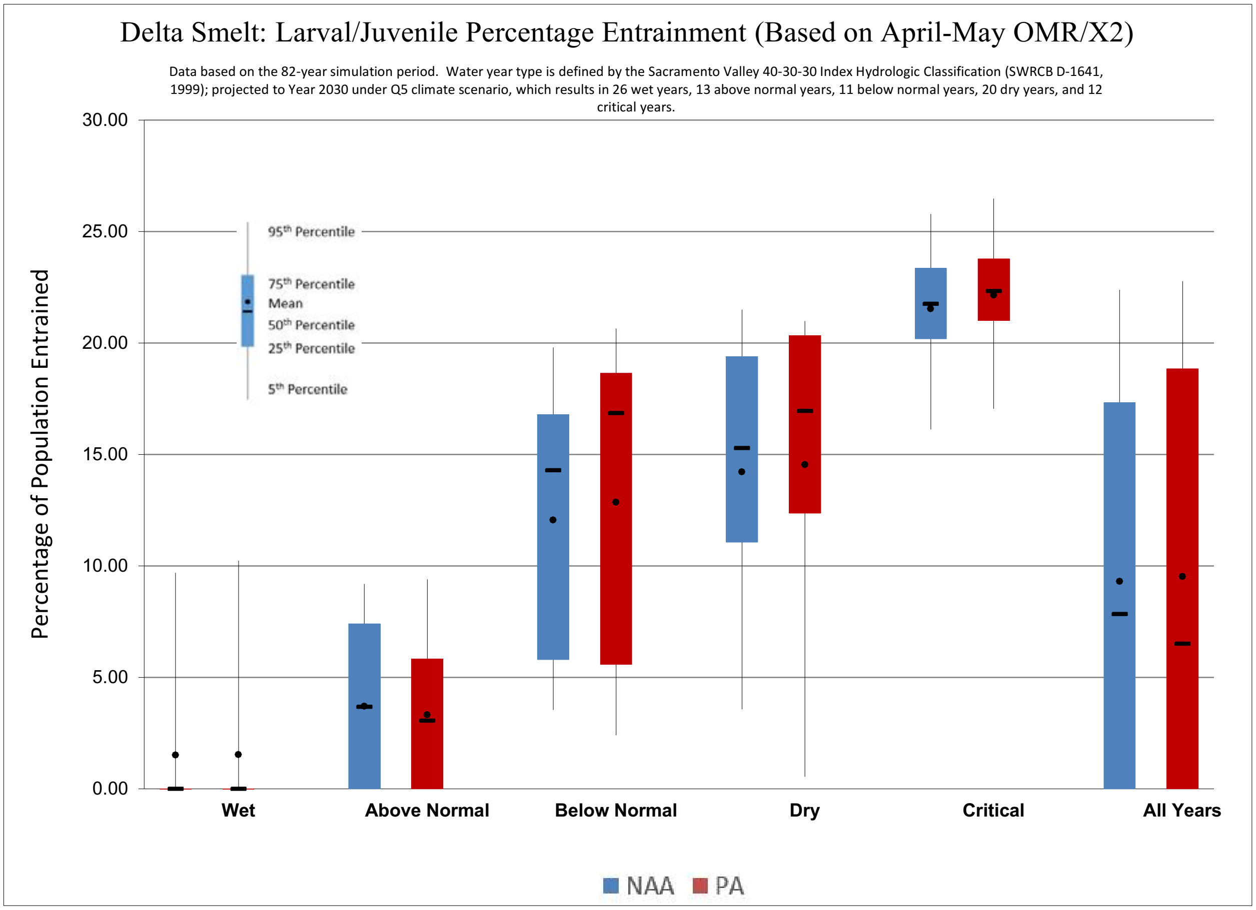
Figure 6.1-12. Exceedance Plot of Larval/Juvenile Delta Smelt Percentage Entrainment, Based on Mean March-June Old and Middle River Flows and X2

Table 6.1-14. Mean Annual Percentage Entrainment Loss of Larval and Juvenile Delta Smelt at CVP/SWP South Delta Export Facilities by Water-Year Type for the No Action Alternative (NAA) and Proposed Action (PA), Based on the Percentage Entrainment Regression Using Mean April-May Old and Middle River Flows and X2.

Water Year Type	NAA	PA	PA vs. NAA[1]
All	9.31	9.53	0.22 (2%)
Wet	1.52	1.54	0.02 (2%)
Above Normal	3.71	3.32	-0.38 (-10%)
Below Normal	12.06	12.86	0.80 (7%)
Dry	14.22	14.54	0.33 (2%)
Critical	21.54	22.15	0.61 (3%)

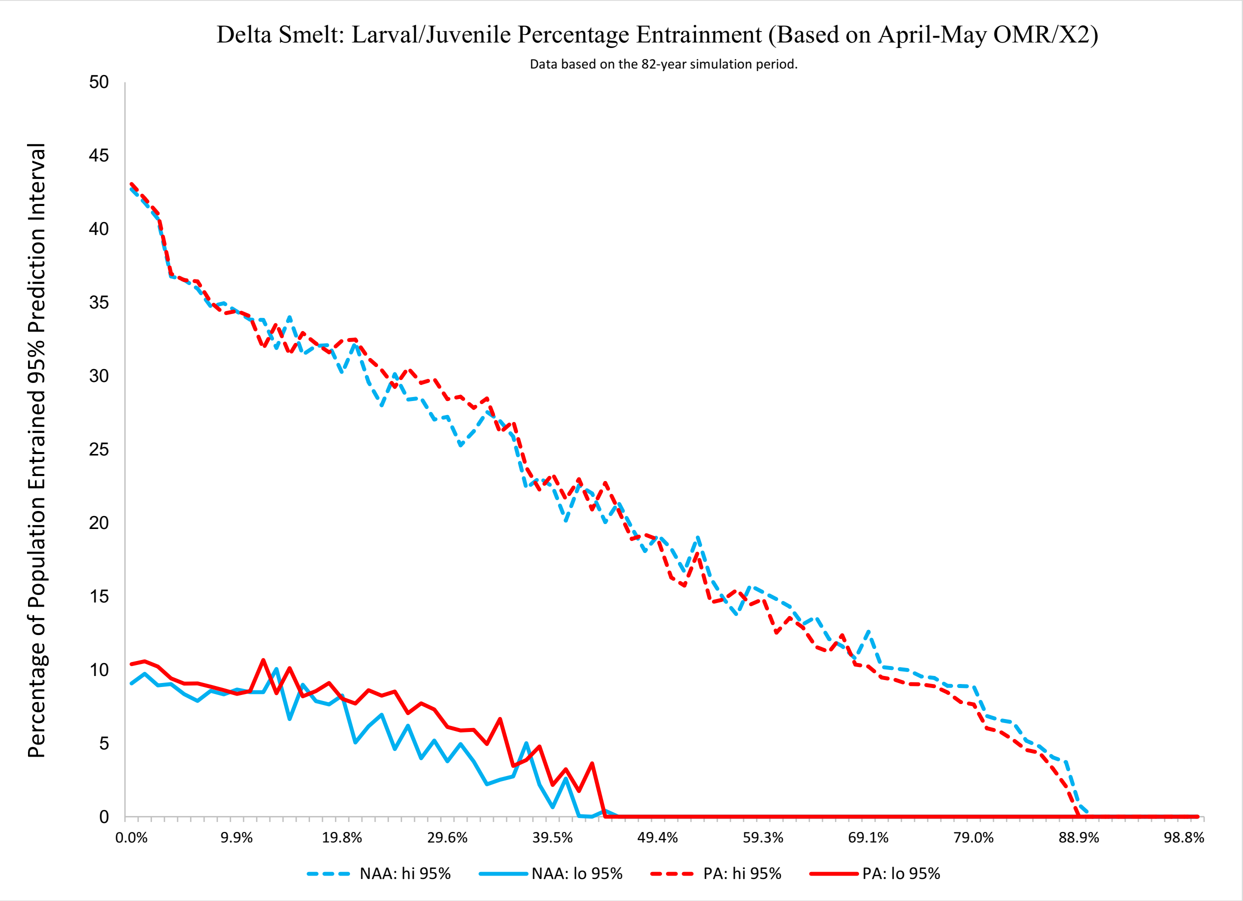
Note:

[1] Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).



Note: Plot only includes mean responses and does not consider model uncertainty.

Figure 6.1-13. Box Plots of Larval/Juvenile Delta Smelt Percentage Entrainment, Grouped by Water Year Type, Based on Mean April-May Old and Middle River Flows and X2



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown. When necessary, the lower bound of the 95% prediction is adjusted to zero from negative values (see Section 6.A.3.1 Percentage Loss Equations in Appendix 6.A Quantitative Methods for Biological Assessment of Delta Smelt).

Figure 6.1-14. Exceedance Plot of Larval/Juvenile Delta Smelt Percentage Entrainment, Based on Mean April-May Old and Middle River Flows and X2

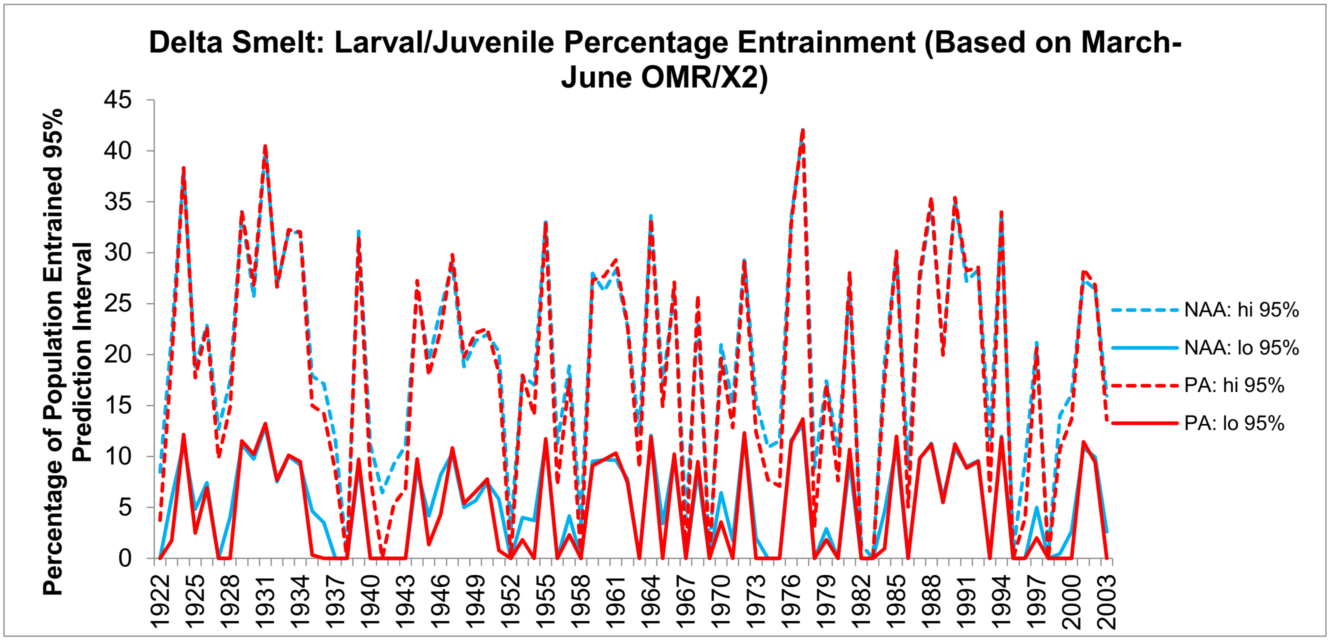


Figure 6.1-15. Time Series of 95% Prediction Interval Larval/Juvenile Delta Smelt Percentage Entrainment, Based on Mean March-June Old and Middle River Flows and X2.

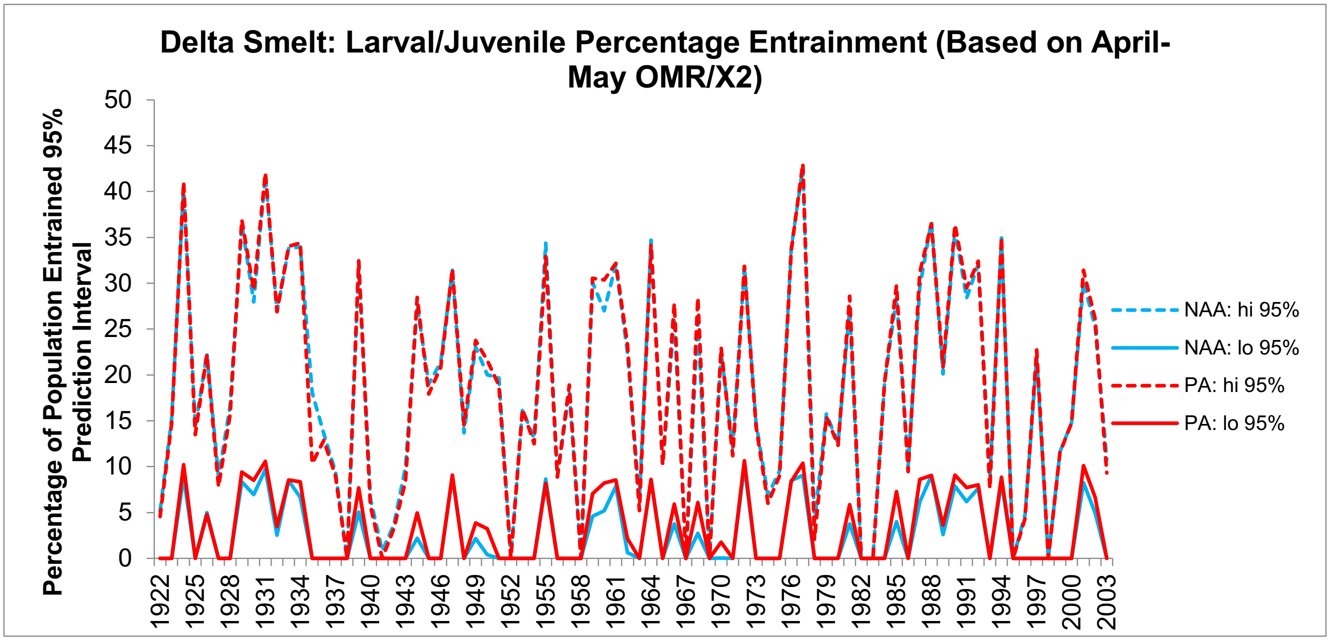


Figure 6.1-16. Time Series of 95% Prediction Interval Larval/Juvenile Delta Smelt Percentage Entrainment, Based on Mean April-May Old and Middle River Flows and X2.

The second approach used to estimate larval/juvenile entrainment was based on DSM2-PTM. Note that this alternative method is not expected to produce results that are dramatically different than the method used by USFWS (2008) because survey-based and PTM-based estimates are generally correlated (Kimmerer 2008). However, the PTM-based approach is a more spatially explicit way to estimate population-level entrainment loss because it accounts for particle fates throughout the Delta and considered losses not only at the south Delta export facilities, but also at the NDD and the North Bay Aqueduct (NBA).The previously described analyses of percentage entrainment at the south Delta export facilities and the NDD are limited in that they cannot be compared directly, for the calculations are not made with the same analytical tool. The PTM analysis summarized below addresses this shortcoming, and also allows assessment of the potential entrainment at the NDD and NBA. The method is described in detail in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt,* Section 6.A.3.2, and essentially involved the following steps:

- Use the historical 20-mm Survey(1995–2011) data to apply a post-processed weighting to DSM2-PTM particle release locations in order to represent assumed hatching distributions of larval Delta Smelt;

- Match the Delta outflows that occurred for the 20-mm Survey months from which the hatching distributions were derived to the closest Delta outflow for each month simulated in DSM2-PTM (March–June, 1922–2003);

- Calculate the percentage entrainment at the CVP/SWP south Delta export facilities, NDD, and NBA, while accounting for the percentage of the population that was not within the Delta (and therefore not vulnerable to entrainment in the SWP or CVP's diversions located in the Delta).

As described in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.3.2, it should be noted that there are two important limitations to this PTM-based analysis. First, a number of 20-mm Survey stations in the Cache Slough area were only sampled in the later years of the survey, and were not included when calculating the particle starting distributions. If NBA pumping is the same in the NAA and PA, then this could affect the absolute value of the entrainment predictions, but not their relative differences. Second, there are no 20-mm Survey stations above the NDD, so the NDD received the same weighting of particles as other stations in the north Delta: from the 1995-2011 20-mm Survey data, the mean percentage at each of these stations was 2.7% (range 0% to nearly 10%).

The percentage of Delta Smelt larvae assumed to occur downstream of the Delta decreased as water years became drier (Table 6.1-15), in keeping with the expectation that entrainment risk generally would be greater in drier years, when the population tends to be distributed further upstream. This is consistent with the influence of X2 on the regression method described above. The results of the entrainment analysis suggested that, accounting for the four main SWP and CVP entrainment locations in the Delta, there would be less entrainment under the PA than NAA, averaged over the March-June period, in wetter years, whereas in drier years, there would be little to no difference between PA and NAA. However, there were important differences by month (Table 6.1-15; Figure 6.1-17, Figure 6.1-18, Figure 6.1-19, Figure 6.1-20, Figure 6.1-21,

Figure 6.1-22, Figure 6.1-23, Figure 6.1-24). Total entrainment was driven by trends in south Delta entrainment, which, when examined month by month, suggested that under the PA there may be some increases in CVP entrainment (particularly in April/May) but generally greater decreases in SWP entrainment (except in April). The overall pattern of entrainment at the south Delta export facilities combined in terms of differences between PA and NAA across water year types matches the general pattern observed in the percentage entrainment regression analysis for March–June (Table 6.1-16) and April–May (Table 6.1-17). The relatively greater entrainment under PA suggested by the DSM2-PTM analysis in drier years in large part reflects not only slightly less (more negative) OMR flows because of the HOR gate (as well as modeling assumption differences related to the San Luis rule curve), but also that there has historically been a higher percentage of larvae in the central and south Delta in drier years (Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt,* Table 6.A-5). There is very little difference in Delta outflow between NAA and PA in April and May (Table 5.A.6-26 in Appendix 5.A *CALSIM Methods and Results*), which means that the influences of the NAA and PA on larval distribution would be expected to be broadly similar.

The percentage of particles entrained at the NDD under the PA always averaged well below 1% (Table 6.1-15); this percentage would be greater if it was assumed that a greater percentage of Delta Smelt larvae originate upstream of the NDD, or lower if it was assumed that a lower percentage originated upstream of the NDD. As described in Section 6.1.3.2.1.4.2, extrapolation of catch density in the egg and larval survey suggested that a small percentage (perhaps ~0.25%) of the larval Delta Smelt population might occur in the NDD reach. In addition, further perspective on the proportion of the Delta Smelt population that could occur near the NDD was provided by the DSM2-PTM analysis incorporating simplified model behavior to mimic hypothesized migration strategies (*i.e.* “tidal surfing”) suggests that the fraction of Delta Smelt expected to migrate past the NDDs is ~ 0.000 (see Section 6.1.3.2.2.1.2). Thus, it is possible that the fraction of Delta Smelt larvae assumed in this analysis to originate upstream of the NDDs could be too high. Adjusting the weighting percentage of particles representing Delta Smelt larvae that were inserted in the Sacramento River at Sacramento downward[15] to reflect lower occurrence than the other locations in the Cache Slough and North Delta area (see Table 6.A-5 in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*) gave considerably lower entrainment at the NDD under PA (water-year-type means of 0.00-0.01% in March-May, and 0.03-0.05% in June) than with the unadjusted original values, but only slightly less of a relative difference between NAA and PA in total entrainment: for example, in April, the mean total entrainment was 18% greater under PA in wet years (compared to 22% without the adjustment), 1% greater under PA in above normal years (compared to 2% without the adjustment), 35% greater under PA in above normal years (compared to 37% without the adjustment), 22% greater under PA in dry years (compared to 22% without the adjustment), and 13% greater under PA in above normal years (compared to 14% without the adjustment).

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[15] Specifically, the values were adjusted to be the minimum of 0.1 of the previous unadjusted value, or 0.25%; the percentages at the other locations in the Cache Slough and North Delta area were increased to give the same total percentage for the area as in the original, unadjusted analysis.

For the DSM2-PTM analysis described here for larval/juvenile Delta Smelt, there was little difference in entrainment at the NBA, reflecting similar operations under the PA and NAA (Table 6.1-15).

The results of the DSM2-PTM modeling do not incorporate real-time management that would occur under both the NAA and PA, incorporating the latest information gained from the results of coordinated monitoring and research under the Collaborative Science and Adaptive Management Program about fish distribution and other factors that would affect entrainment risk. Therefore, it may be possible to manage exports and HOR gate operations more carefully to avoid increasing entrainment. Additional discussion of HOR gate effects is provided in Section 6.1.3.4, *Head of Old River Gate Operations*.

Table 6.1-15. Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, from DSM2 Particle Tracking Modeling.

Month	Water Year Type[1]	% Downstream of Delta	Clifton Court Forebay (State Water Project)			Jones Pumping Plant (Central Valley Project)			North Delta Diversion			North Bay Aqueduct Barker Slough Pumping Plant			Total Entrainment		
			NAA	PA	PA vs. NAA[2]	NAA	PA	PA vs. NAA[2]	NAA	PA	PA vs. NAA[2]	NAA	PA	PA vs. NAA[2]	NAA	PA	PA vs. NAA[2]
March-June Monthly Mean	W	43.92	3.03	1.41	-1.62 (-53%)	2.06	1.07	-0.99 (-48%)	0.00	0.18	0.18	1.18	1.18	0.00 (0%)	6.27	3.85	-2.43 (-39%)
	AN	28.39	5.16	2.47	-2.70 (-52%)	3.77	2.49	-1.29 (-34%)	0.00	0.19	0.19	1.27	1.28	0.01 (1%)	10.21	6.42	-3.79 (-37%)
	BN	14.13	5.72	4.36	-1.35 (-24%)	4.04	4.36	0.32 (8%)	0.00	0.18	0.18	2.20	2.22	0.02 (1%)	11.96	11.12	-0.83 (-7%)
	D	13.77	7.37	5.51	-1.87 (-25%)	4.54	5.47	0.92 (20%)	0.00	0.19	0.19	1.71	1.72	0.02 (1%)	13.63	12.88	-0.74 (-5%)
	C	5.97	3.85	2.84	-1.01 (-26%)	3.20	4.22	1.02 (32%)	0.00	0.08	0.08	1.22	1.32	0.10 (8%)	8.27	8.46	0.18 (2%)
March	W	54.69	3.24	0.92	-2.32 (-72%)	1.68	0.28	-1.40 (-84%)	0.00	0.29	0.29	1.19	1.20	0.01 (1%)	6.11	2.68	-3.43 (-56%)
	AN	57.96	5.78	1.28	-4.50 (-78%)	3.38	0.77	-2.61 (-77%)	0.00	0.04	0.04	0.16	0.16	0.00 (2%)	9.32	2.25	-7.07 (-76%)
	BN	31.80	9.74	6.83	-2.91 (-30%)	5.48	5.67	0.19 (4%)	0.00	0.28	0.28	2.62	2.63	0.01 (0%)	17.84	15.41	-2.43 (-14%)
	D	23.27	9.61	8.20	-1.40 (-15%)	6.78	7.64	0.85 (13%)	0.00	0.34	0.34	1.36	1.30	-0.05 (-4%)	17.75	17.48	-0.27 (-2%)
	C	13.31	5.65	3.90	-1.75 (-31%)	3.62	5.01	1.40 (39%)	0.00	0.13	0.13	1.01	1.39	0.39 (39%)	10.27	10.44	0.17 (2%)
April	W	54.11	0.63	0.78	0.15 (25%)	0.18	0.40	0.22 (126%)	0.00	0.05	0.05	1.17	1.17	0.00 (0%)	1.98	2.40	0.43 (22%)
	AN	36.60	1.88	1.74	-0.14 (-7%)	0.54	0.70	0.16 (29%)	0.00	0.06	0.06	0.98	0.98	0.00 (0%)	3.39	3.47	0.08 (2%)
	BN	12.20	2.03	2.47	0.44 (22%)	0.55	1.64	1.09 (199%)	0.00	0.05	0.05	1.84	1.91	0.07 (4%)	4.41	6.07	1.65 (37%)
	D	22.43	4.38	4.29	-0.09 (-2%)	2.16	3.92	1.76 (81%)	0.00	0.02	0.02	1.38	1.47	0.08 (6%)	7.93	9.70	1.77 (22%)
	C	6.21	2.72	2.54	-0.18 (-7%)	2.27	3.23	0.96 (43%)	0.00	0.03	0.03	0.87	0.87	0.00 (0%)	5.85	6.66	0.81 (14%)
May	W	43.42	0.87	0.45	-0.42 (-48%)	0.27	0.21	-0.06 (-21%)	0.00	0.05	0.05	1.17	1.17	0.00 (0%)	2.31	1.88	-0.42 (-18%)
	AN	16.96	2.30	1.08	-1.22 (-53%)	0.72	0.73	0.02 (2%)	0.00	0.18	0.18	2.36	2.37	0.01 (0%)	5.38	4.36	-1.02 (-19%)
	BN	10.43	2.66	1.91	-0.76 (-28%)	0.70	1.85	1.15 (164%)	0.00	0.06	0.06	2.74	2.74	0.00 (0%)	6.10	6.56	0.45 (7%)
	D	8.14	5.13	3.64	-1.50 (-29%)	1.93	3.29	1.36 (71%)	0.00	0.07	0.07	2.41	2.44	0.03 (1%)	9.47	9.43	-0.04 (0%)
	C	2.06	4.25	3.29	-0.97 (-23%)	3.17	5.12	1.94 (61%)	0.00	0.05	0.05	1.49	1.50	0.01 (1%)	8.92	9.96	1.04 (12%)
June	W	23.48	7.39	3.50	-3.89 (-53%)	6.11	3.39	-2.73 (-45%)	0.00	0.33	0.33	1.19	1.20	0.01 (1%)	14.70	8.42	-6.28 (-43%)
	AN	2.04	10.69	5.77	-4.92 (-46%)	10.45	7.74	-2.71 (-26%)	0.00	0.46	0.46	1.60	1.62	0.02 (1%)	22.75	15.59	-7.16 (-31%)
	BN	2.07	8.43	6.25	-2.19 (-26%)	9.44	8.30	-1.14 (-12%)	0.00	0.32	0.32	1.60	1.60	-0.01 (0%)	19.48	16.46	-3.01 (-15%)
	D	1.25	10.37	5.89	-4.48 (-43%)	7.30	7.03	-0.27 (-4%)	0.00	0.31	0.31	1.68	1.69	0.01 (1%)	19.36	14.93	-4.43 (-23%)
	C	2.29	2.78	1.65	-1.13 (-41%)	3.73	3.50	-0.23 (-6%)	0.00	0.08	0.08	1.53	1.53	0.00 (0%)	8.05	6.77	-1.28 (-16%)

Note:

[1] W = Wet, AN = Above Normal, BN = Below Normal, D = Dry, C = Critical.

[2] Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

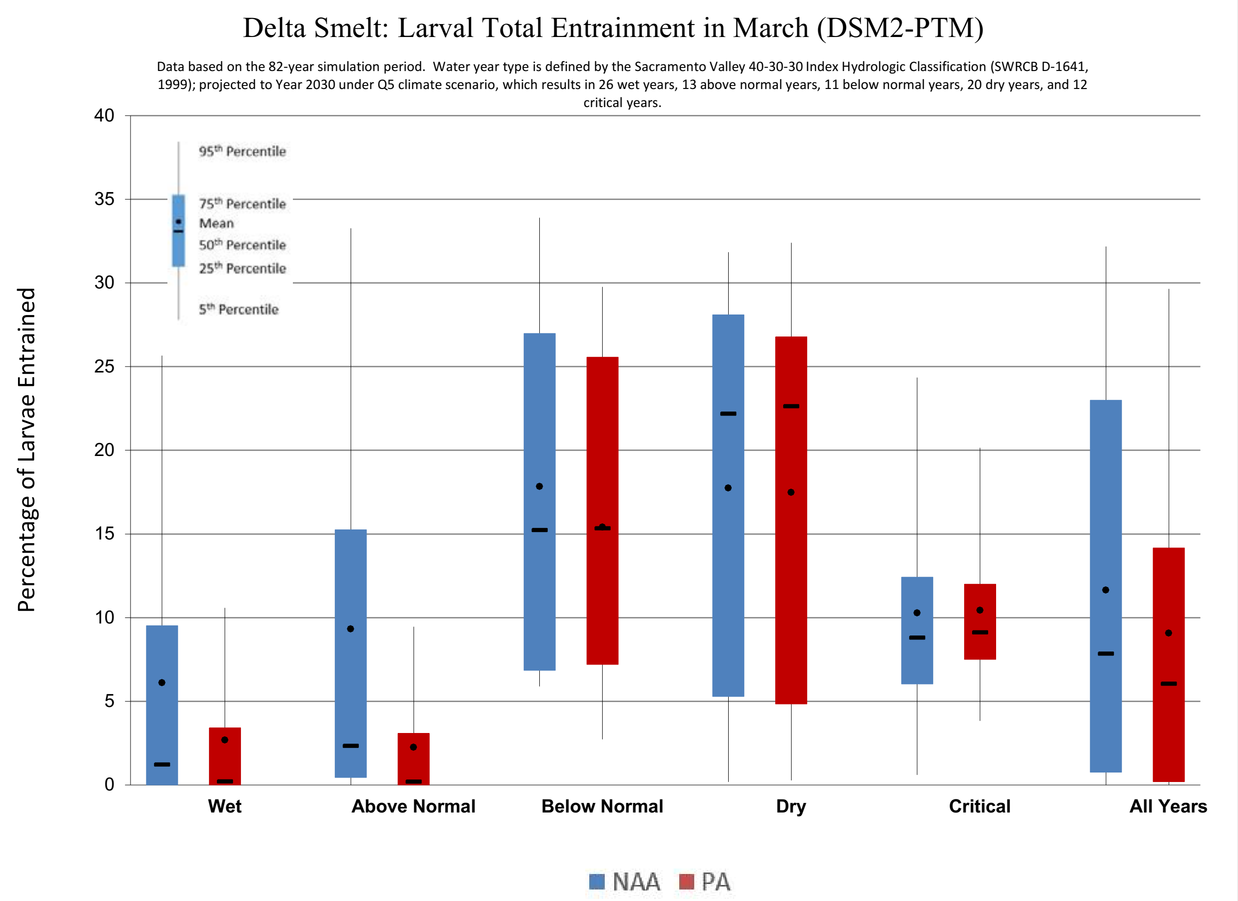

Figure 6.1-17. Box Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of March 1922–2003

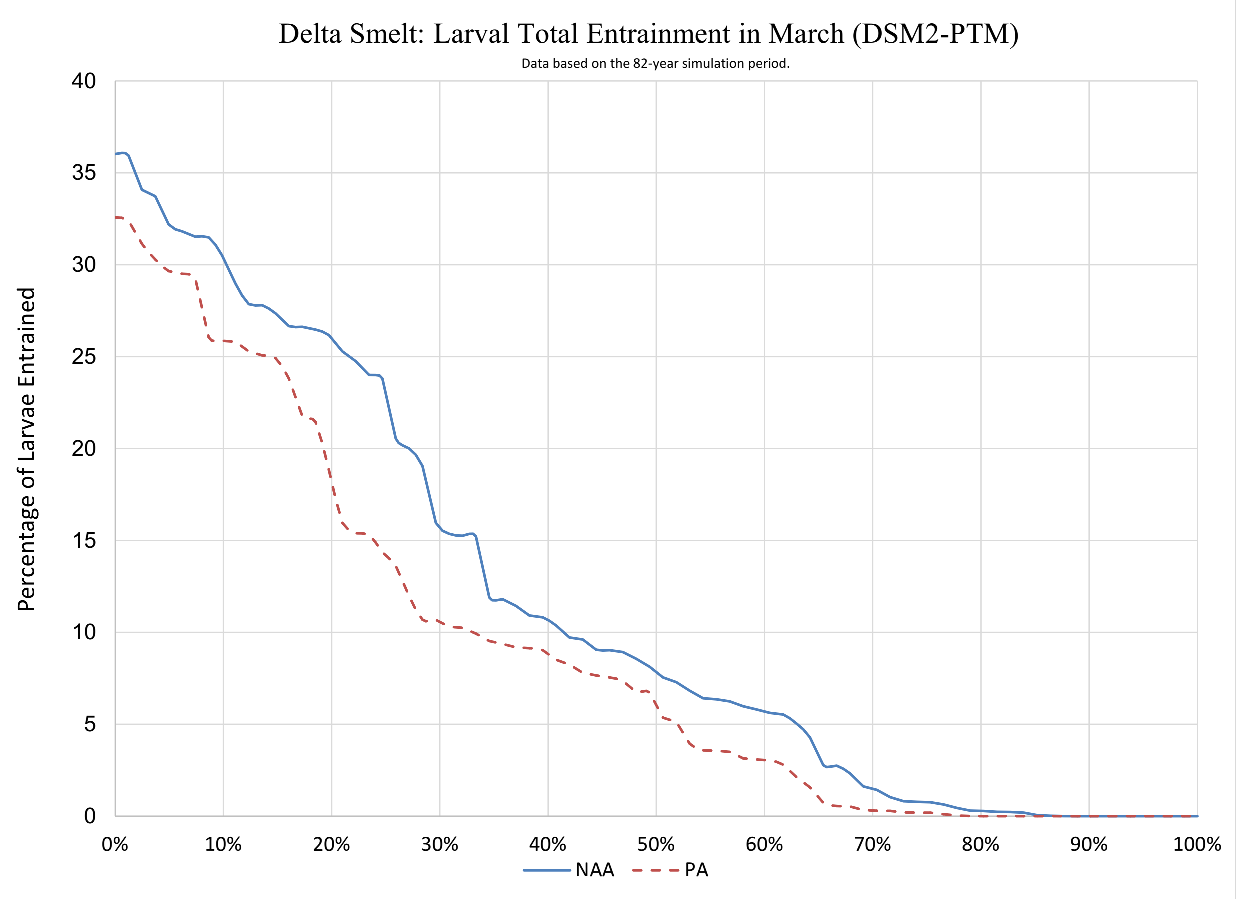

Figure 6.1-18. Exceedance Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of March 1922–2003

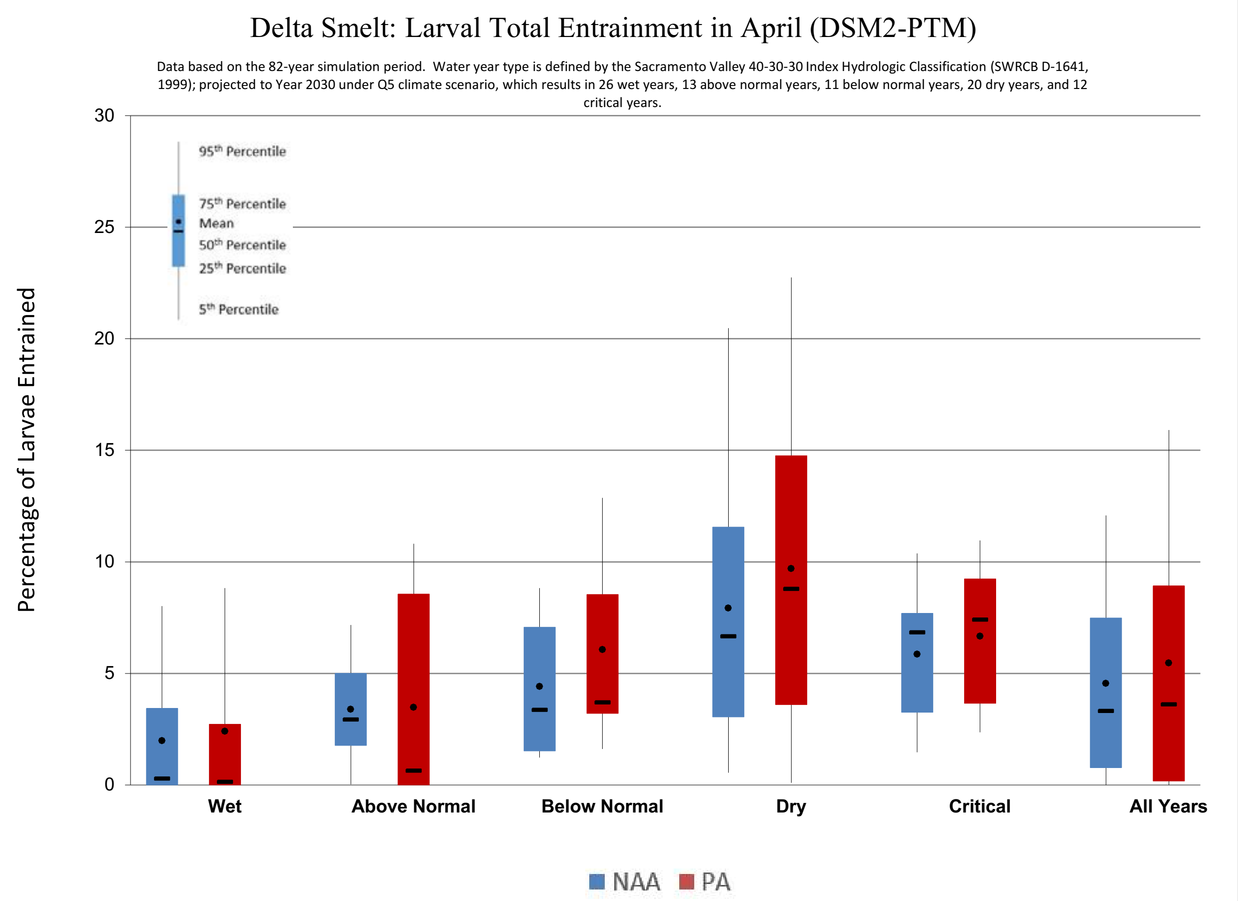

Figure 6.1-19. Box Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of April 1922–2003

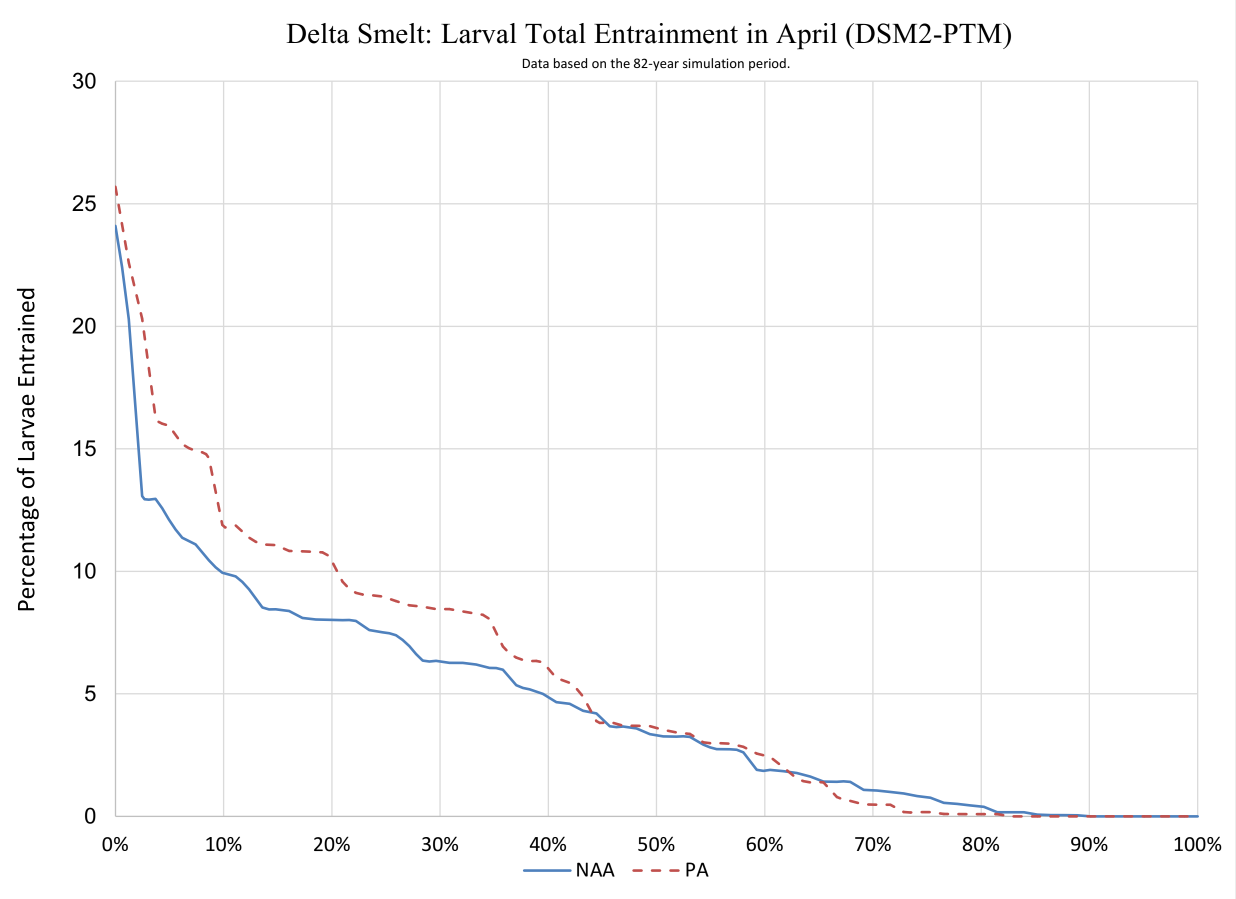

Figure 6.1-20. Exceedance Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of April 1922–2003

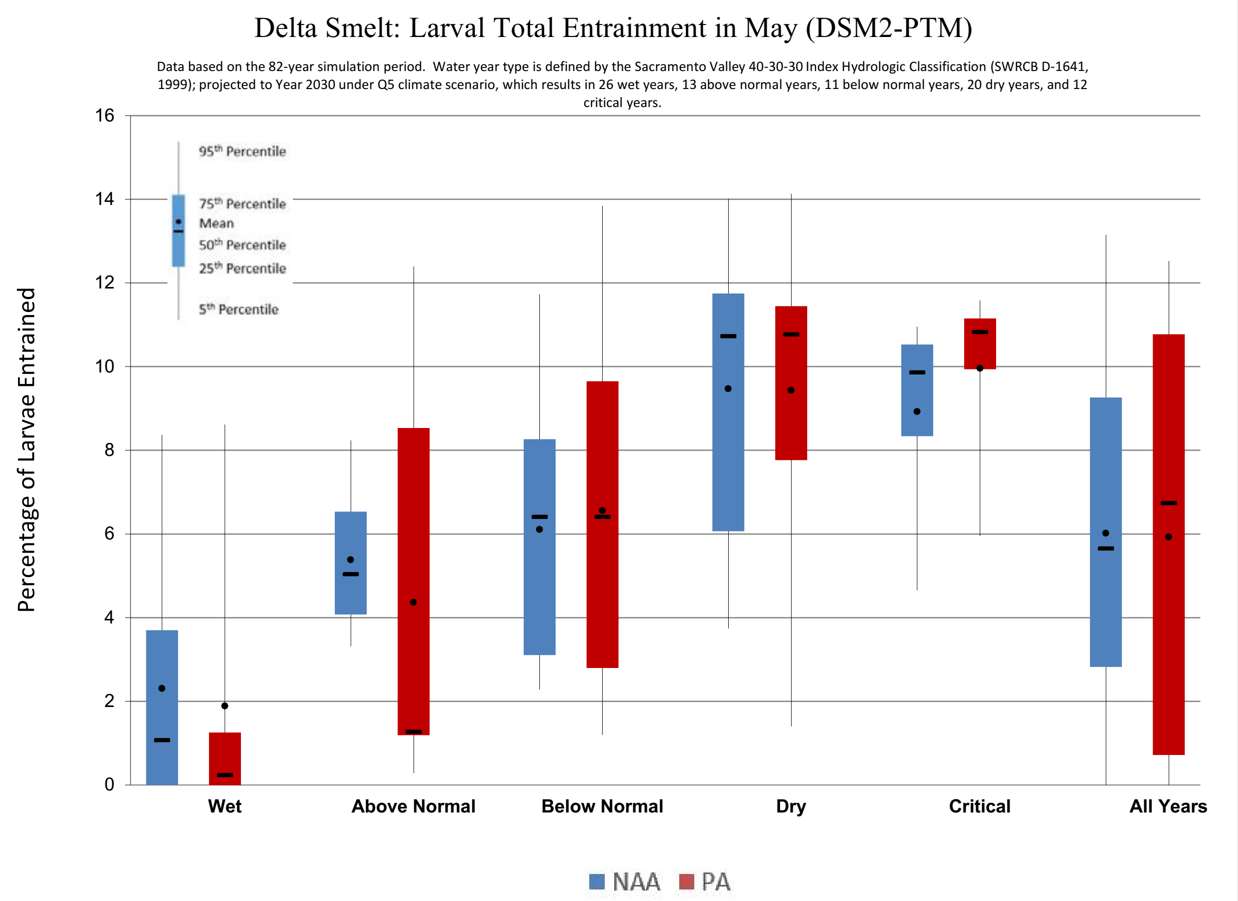

Figure 6.1-21. Box Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of May 1922–2003

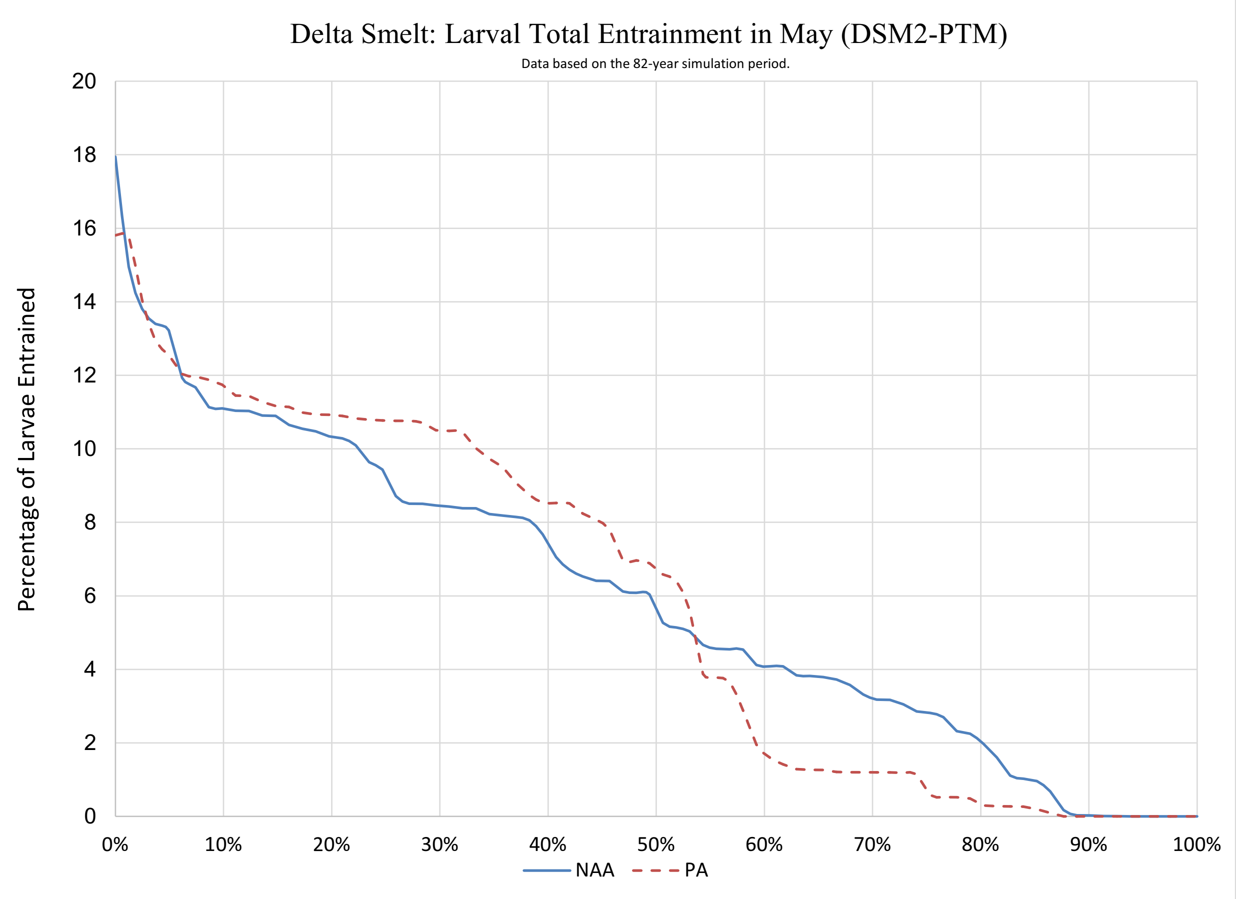

Figure 6.1-22. Exceedance Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of May 1922–2003

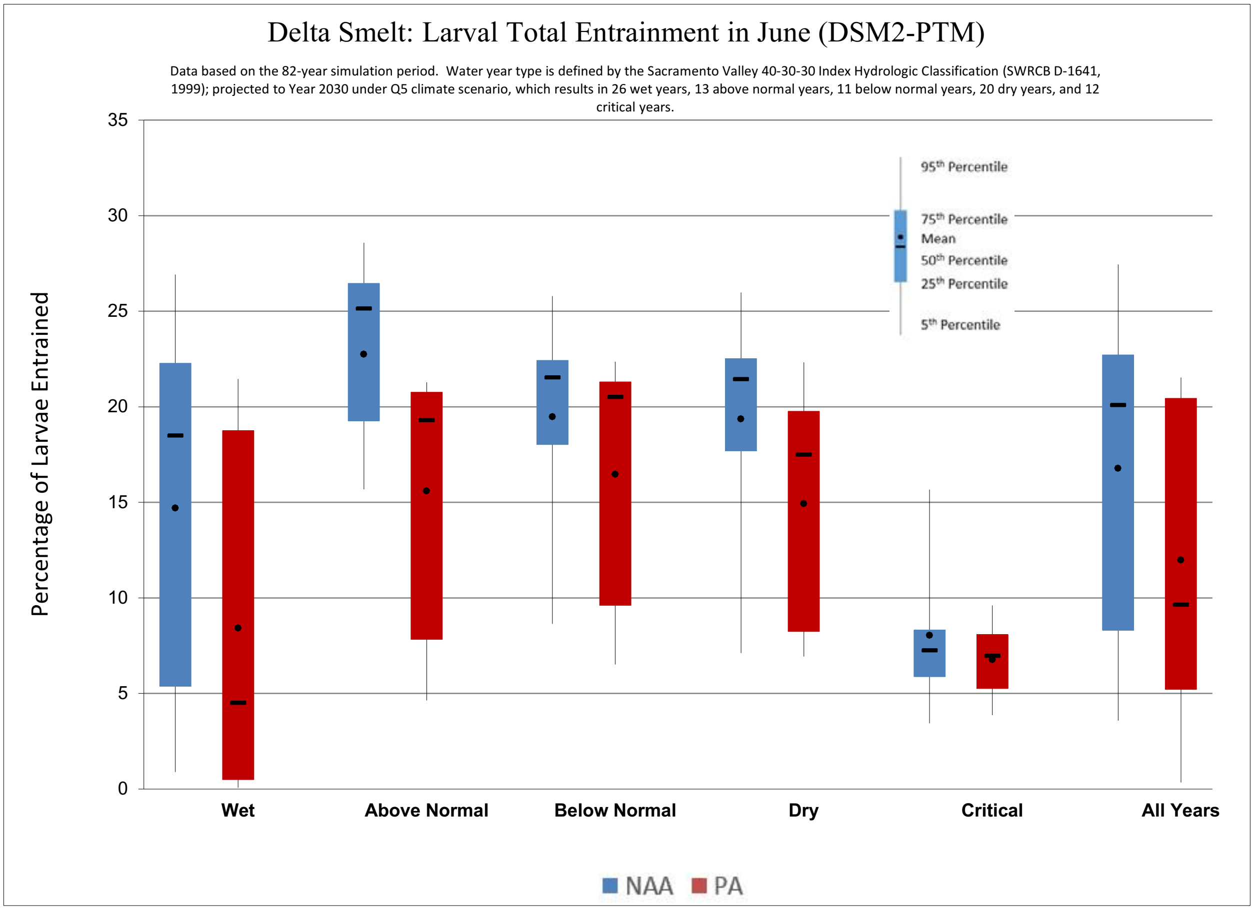

Figure 6.1-23. Box Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of June 1922–2003

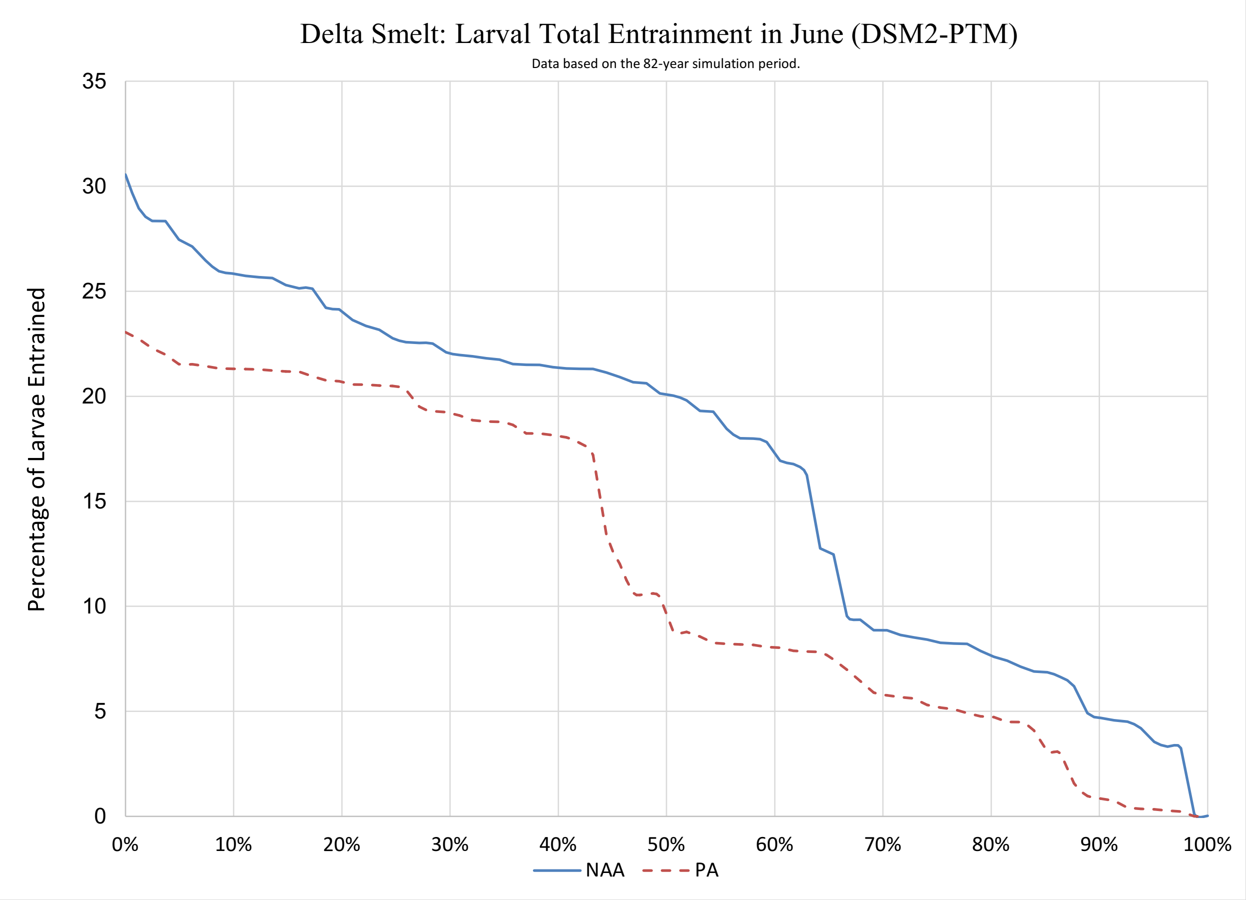

Figure 6.1-24. Exceedance Plot of Percentage of Particles Representing Delta Smelt Larvae Entrained over 30 Days into Clifton Court Forebay (State Water Project), Jones Pumping Plant (Central Valley Project), the North Delta Diversion, and the North Bay Aqueduct Barker Slough Pumping Plant, Grouped by Water Year Type, from DSM2 Particle Tracking Modeling of June 1922-2003

Table 6.1-16. Comparison of Trends in Delta Smelt Larval Entrainment Loss at the South Delta Export Facilities from the March-June Percentage Entrainment Regression and DSM2-PTM Results for March-June (Monthly Mean).

Water Year Type	Percentage Entrainment Regression			DSM2-PTM Results (% Entrained at South Delta Only)		
	NAA	PA	PA vs. NAA[1]	NAA	PA	PA vs. NAA[1]
Wet	3.89	2.26	-1.63 (-42%)	5.09	2.48	-2.61 (-51%)
Above Normal	8.26	5.07	-3.18 (-39%)	8.94	4.95	-3.98 (-45%)
Below Normal	16.20	15.54	-0.66 (-4%)	9.76	8.73	-1.03 (-11%)
Dry	16.36	16.17	-0.19 (-1%)	11.92	10.97	-0.94 (-8%)
Critical	22.18	22.43	0.25 (1%)	7.05	7.06	0.01 (0%)

Note:

[1] Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

Table 6.1-17. Comparison of Trends in Delta Smelt Larval Entrainment Loss at the South Delta Export Facilities from the April-May Percentage Entrainment Regression and DSM2-PTM Results for April-May (Monthly Mean).

Water Year Type	Percentage Entrainment Regression			DSM2-PTM Results (% Entrained at South Delta Only)		
	NAA	PA	PA vs. NAA[1]	NAA	PA	PA vs. NAA[1]
Wet	1.52	1.54	0.02 (2%)	0.97	0.92	-0.05 (-5%)
Above Normal	3.71	3.32	-0.38 (-10%)	2.72	2.12	-0.59 (-22%)
Below Normal	12.06	12.86	0.80 (7%)	2.97	3.93	0.96 (32%)
Dry	14.22	14.54	0.33 (2%)	6.80	7.56	0.76 (11%)
Critical	21.54	22.15	0.61 (3%)	6.21	7.08	0.88 (14%)

Note:

[1] Negative values indicated lower entrainment loss under the proposed action (PA) than under the no action alternative (NAA).

6.1.3.3.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.3.1.5.1 Individual-Level Effects

Juvenile Delta Smelt can be entrained at the south Delta export facilities after June, but patterns of salvage suggest that entrainment loss is very low after June (see Figure 3 of Kimmerer 2008). Recognizing this, USFWS (2008) established June 30 as the latest date to which restrictions on south Delta export pumping are presently applied to limit entrainment of larval/young juvenile Delta Smelt. The restrictions can end earlier than this if the daily mean water temperature at Clifton Court Forebay reaches 25°C for 3 consecutive days, because this indicates that conditions are no longer conducive to smelt survival (U.S. Fish and Wildlife Service 2008: 368), consistent with broad-scale observations on distribution (Nobriga *et al.* 2008).

6.1.3.3.1.5.2 Population-Level Effects

The entrainment of juvenile Delta Smelt during July-November is expected to be very low as it has been in the recent past, because the south Delta water is warmer and clearer than the habitat that Delta Smelt occupy (Nobriga *et al.* 2008). Thus, entrainment of juvenile Delta Smelt is not expected to impact the population.

6.1.3.3.2 Predation at the South Delta Export Facilities

6.1.3.3.2.1 Migrating Adults (December-March)

6.1.3.3.2.1.1 Individual-Level Effects

The previously presented analyses of entrainment effects of the PA on migrating adult Delta Smelt at the south Delta export facilities incorporated predation loss, e.g., prescreen losses across Clifton Court Forebay when estimating a percentage of the population that was ultimately lost due to changes in exports via their effect on OMR flow (Kimmerer and Nobriga 2008). For adult Delta Smelt, predation probably kills a large proportion of individuals before they actually reach the fish facilities or the export pumps behind them (Castillo *et al.* 2012; see Table 6.1-11). Thus, a lower entrainment risk to individual Delta Smelt under the PA in relation to NAA, should decrease mortality rates experienced by the adult stock[16]. To the extent that the localized reduction of predatory fishes, discussed further in Section 6.1.4.2, *Localized Reduction of Predatory Fishes to Minimize Predator Density at North and South Delta Export Facilities,* reduces predator abundance in Clifton Court Forebay, predation risk to adult Delta Smelt could be reduced under the PA. However, there is uncertainty in the efficacy of localized reduction of predatory fishes, given that previous efforts did not yield measurable changes in predator population size within the Forebay (Brown *et al.* 1996). Because there is uncertainty in the potential effectiveness of localized reduction of predatory fishes, it is assumed in this effects analysis that it would not be effective.

6.1.3.3.2.1.2 Population-Level Effects

Given that a measurable proportion of the migrating adult Delta Smelt population can be lost to entrainment and associated predation, lower entrainment under PA should translate into lower overall adult mortality, compared to NAA.

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[16] Note that the percentage loss regressions used to assess entrainment include losses from predation.

6.1.3.3.2.2 Spawning Adults (February-June)

6.1.3.3.2.2.1 Individual-Level Effects

It is not known whether an individual Delta Smelt occupying the south Delta faces a higher risk of predation than an individual occupying another staging or spawning location (e.g., Suisun Marsh, Decker Island, Sacramento Deepwater Shipping Channel).

6.1.3.3.2.2.2 Population-Level Effects

As described for entrainment, under the assumption that spawning adults are not undertaking broad-scale migrations, there are no data available to suggest they face an adverse population-level effect of predation beyond what occurs at the SWP and CVP facilities. Similar to migrating adults, lower entrainment under PA should translate into lower overall adult mortality, compared to NAA.

6.1.3.3.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.3.2.3.1 Individual-Level Effects

As noted for entrainment at the south Delta export facilities, Delta Smelt eggs and embryos are demersal and adhesive and would not be subject to changes in predation at the south Delta export facilities as a result of changes in south Delta water exports under the PA relative to NAA. There also would not be an effect of localized predatory fish reduction, as the sizes of fish targeted by this action would be larger than the sizes of fish that typically prey upon early life stages of Delta Smelt (e.g., silversides; Baerwald *et al.* 2012).

6.1.3.3.2.3.2 Population-Level Effects

Changes to exports are not expected to change the distribution of Delta Smelt eggs once they have been spawned. Thus, this is not a likely impact mechanism.

6.1.3.3.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.3.2.4.1 Individual-Level Effects

As summarized in Table 6.1-11, predation losses of larval Delta Smelt in association with the south Delta export facilities have not been quantified, whereas losses of juvenile Delta Smelt have been shown to be substantial, at least under some conditions (Castillo *et al.* 2012), as is the case with other species (Gingras 1997; Clark *et al.* 2009). The influence of water project operations on facility-associated predation on larval and small juvenile Delta Smelt is built into the percentage loss estimates described above, which were based on estimates from Kimmerer (2008). There is no additional effect to analyze under this impact mechanism.

6.1.3.3.2.4.2 Population-Level Effects

As described for the Individual-Level Effects, the influence of water project operations on facility-associated predation on larval and small juvenile Delta Smelt is built into the percentage loss estimates described above. There is no additional effect to analyze under this impact mechanism.

6.1.3.3.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.3.2.5.1 Individual-Level Effects

As discussed for entrainment, individual juvenile Delta Smelt would be expected to generally have left the south Delta as temperatures increase, so it is not anticipated that there would be changes in predation risk to individuals at or near the south Delta export facilities.

6.1.3.3.2.5.2 Population-Level Effects

There would be minimal population-level effects of changes in predation at the south Delta export facilities to juvenile Delta Smelt because this life stage is largely absent from the south Delta in summer/fall.

6.1.3.4 Head of Old River Gate Operations

6.1.3.4.1 Migrating Adults (December-March)

6.1.3.4.1.1 Individual-Level Effects

The potential for effects of the HOR gate is similar to the effects described for the south Delta Temporary Barriers Project (TBP), as previously noted by USFWS (2008: 225-226). Unlike the rock barrier currently used in some years, however, HOR gate operations would occur in the context of real-time changes in both gate position and management of north and south Delta exports in order to limit the potential for adverse hydraulic effects to adult Delta Smelt during their winter dispersal. In particular, careful management of OMR flows in consideration of fish distribution and turbidity cues (among other factors), would be undertaken to limit adverse effects to Delta Smelt. USFWS (2008: 225-226) noted the potential for negative effects of the TBP, including a HOR gate, on Delta Smelt:

> The TBP does not alter total Delta outflow, or the position of X2. However, the TBP causes changes in the hydraulics of the Delta, which may affect delta smelt. The HORB blocks San Joaquin River flow, which prevents it from entering Old River at that point. This situation increases the flow toward Banks and Jones from Turner and Columbia cuts, which can increase the predicted entrainment risk for particles in the East and Central Delta by up to about 10 percent (Kimmerer and Nobriga 2008). In most instances, net flow is directed towards the Banks and Jones pumps and local agricultural diversions. Computer simulations have shown that placement of the barriers changes South Delta hydrodynamics, increasing Central Delta flows toward the export facilities (Reclamation 2008). In years with substantial numbers of adult delta smelt moving into the Central Delta, increases in negative OMR flow caused by installation of the [temporary barriers] can increase entrainment. The directional flow towards Banks and Jones increases the vulnerability of fish to entrainment. Larval and juvenile delta smelt are especially susceptible to these flows.
>
> The varying proposed operational configurations of the TBP, natural variations in fish distribution, and a number of other physical and environmental variables limit statistical confidence in assessing fish salvage when the TBP is operational versus when it is not. In 1996, the installation of the spring HORB caused a sharp reversal of net flow in the South Delta to the upstream direction. Coincident with this change was a strong peak in delta smelt salvage (Nobriga *et al.* 2000). This observation indicates that short-term salvage can significantly increase when the HORB is installed in such a manner that it causes a sharp change or reversal of positive net daily flow in the South and Central Delta.

Based on the assessment by USFWS (2008), there is the potential for the HOR gate to result in short-term negative effects to Delta Smelt by influencing the hydraulics of Old and Middle

Rivers, particularly in terms of creating greater short-term increased reverse OMR flows when the HOR gate is initially closed. However, the general improvements to OMR flows because of less south Delta exports, combined with the flexibility to manage the proposed HOR gate in real time would limit the potential for adverse effects. If necessary, opening and closing of the HOR gate could be done in consideration of the most recent fish distribution information (e.g., Spring Kodiak Trawl or 20-mm Survey) as well as simulation (e.g., PTM) modeling of the likely effects of the HOR gate operational switches; adjustments to south Delta exports could then be done accordingly to avoid short-term increases in entrainment.

In addition to broad-scale, far-field effects of the HOR gate on south Delta hydrodynamics, there may be localized effects on migrating adult Delta Smelt. Studies of the rock barrier installed at the HOR in 2012 suggested the structure created eddies that could have resulted in enhanced predatory fish habitat and increased predation on juvenile salmonids (California Department of Water Resources 2015a); such adverse effects could also occur to Delta Smelt as a result of HOR gate operations.

6.1.3.4.1.2 Population-Level Effects

Over 2,300 beach seine samples[17] in the San Joaquin River between Dos Reis (river mile 51) and Weatherbee (river mile 58) between 1994 and 2015 yielded only four Delta Smelt (all during February–April). Nearly 30,000 trawl samples at Mossdale[18] from 1994 to 2011 resulted in the capture of 44 Delta Smelt, principally during March-June. As described in the individual-level effects sections, careful management of OMR flows and HOR gate operations will limit movement of adult Delta Smelt into the south Delta where they would be subject to high entrainment risk and impact mechanisms directly associated with the presence and operation of the HOR gates. Therefore, there should be no meaningful adverse effect to the population of migrating adult Delta Smelt.

6.1.3.4.2 Spawning Adults (February-June)

6.1.3.4.2.1 Individual-Level Effects

The effects to spawning adults are assumed to be the same as those described above for migrating individuals (Section 6.1.3.4.1.1).

6.1.3.4.2.2 Population-Level Effects

The effects to spawning adults are assumed to be the same as those described above for migrating individuals (Section 6.1.3.4.1.2).

6.1.3.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.4.3.1 Individual-Level Effects

As noted for other potential effects of the PA, Delta Smelt eggs and embryos are demersal and adhesive, and so the potential hydrodynamic effects of the HOR gate would not be expected to result in adverse effects to individuals.

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[17] Data were obtained from http://www.fws.gov/lodi/jfmp/, files <Beach Seines CHN _ POD Species 1976-2011.xlsx> and <Beach Seines CHN _ POD Species 2012-2015.xlsx> accessed September 14, 2015.

[18] Data were obtained from http://www.fws.gov/lodi/jfmp/, files < Mossdale Trawls CHN _ POD Species 1994-2011.xlsx> and < Mossdale Trawls CHN & POD Species 2012-2015.xlsx> accessed September 14, 2015.

6.1.3.4.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs means that there would be no adverse population-level effects from the HOR gate.

6.1.3.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.4.4.1 Individual-Level Effects

Larval/young juvenile Delta Smelt are inherently more vulnerable to far-field hydrodynamic effects of exports and barrier/gate operations (e.g., greater risk of south Delta entrainment with HOR gate closure). It is not known if they are more vulnerable than adults to near-field effects (e.g., greater predation because of near-field changes in hydraulics). As described above, modeling in support of the PA does not indicate that there will be a consistent decrease in the percentage entrainment of larval and small juvenile Delta Smelt, in part because of the modeling assumption about the frequency of HOR gate closures during spring.

6.1.3.4.4.2 Population-Level Effects

Based on the infrequent occurrence of adult Delta Smelt near the HOR gate, it is likely that larval and young juvenile Delta Smelt will only very rarely occur near the HOR gate. Thus, there should be no population impact of the structures themselves.

6.1.3.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.4.5.1 Individual-Level Effects

Effects to individual juvenile Delta Smelt from HOR gate operations would be similar to those for adult Delta Smelt, in terms of potential for broad-scale and local effects; however, as discussed in population-level effects next, these effects would apply to very few individuals.

6.1.3.4.5.2 Population-Level Effects

Based on the infrequent occurrence of adult Delta Smelt near the HOR gate, it is likely that larval and young juvenile Delta Smelt will only very rarely occur near the HOR gate. Thus, there should be no population impact of the structures themselves.

6.1.3.5 Habitat Effects

6.1.3.5.1 Abiotic Habitat

Conceptually, the freshwater flow regime and its interaction with the system bathymetry and landscape affect the quantity and quality of available habitat (e.g., Peterson 2003). The USFWS (2008) BiOp's RPA included an action to increase Delta outflow in fall following wet and above normal years based on specific targets for X2, the geographic location of the 2-ppt salinity isohaline in the estuary. This action aimed to restore a greater extent and quality of fall habitat for juvenile Delta Smelt in wetter years in order to counteract the lower variability and smaller size of the low-salinity zone during fall of recent years (fall abiotic habitat) that had been assessed by USFWS (2008) to have occurred as a result of CVP/SWP operations (see also Feyrer *et al.* 2011; Cloern and Jassby 2012). This RPA element has been included as part of the PA and this section compares results for PA versus NAA using the abiotic habitat index of Feyrer *et al.* (2011); there is scientific debate and uncertainty regarding this method, as described in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*. Year-around summaries of X2 are provided in Appendix 5.A *CALSIM Methods and Results* (box plots: 5.A.6-29-1 to 5.A.6-29-6; exceedance plots: Figures 5.A.6-29-7 to 5.A.6-29-19; Table 5.A.6-29). In addition, an analysis of the effect on critical habitat in terms of the frequency of occurrence of X2 in Suisun Bay is provided in Section 6.1.3.10.4.4 *PCE 4: Salinity (Low Salinity Zone)*.

6.1.3.5.1.1 Juveniles (Fall: ~September-December)

6.1.3.5.1.1.1 Individual-Level Effects

As described by USFWS (2008: 233), during the fall (September-December), Delta Smelt are maturing pre-adults that rely heavily on suitable habitat conditions in the low salinity portion of the estuary. USFWS (2008: 233) briefly defined suitable habitat for Delta Smelt during this time period as "the abiotic and biotic components of habitat that allow Delta Smelt to survive and grow to adulthood: biotic components of habitat include suitable amounts of food resources and sufficiently low predation pressures; abiotic components of habitat include the physical characteristics of water quality parameters, especially salinity and turbidity."

As noted by Feyrer *et al.* (2007; 2011), analyses conducted over this portion of the Delta Smelt life cycle provide support for a population-level effect of fall habitat conditions or indices of those conditions. In addition, analyses by Miller *et al.* (2012) and Rose *et al.* (2013a, b) suggest that prey density/food limitation during this part of the life cycle may also have population-level effects on Delta Smelt.

As previously noted, in the USFWS (2008) BiOp, the RPA included an action to increase Delta outflow in fall following wet and above normal years based on specific targets for X2. This action aimed to restore a greater extent of fall habitat for juvenile Delta Smelt following wetter years in order to counteract a trend toward lower variability and smaller size of the low-salinity zone during fall of recent years (Feyrer *et al.* 2011; Cloern and Jassby 2012). Feyrer *et al.* (2011) suggested that increased habitat area provides more space for individuals to safely live and reproduce, presumably lessening the likelihood of density-dependent effects (e.g., food limitation, disease, and predation), and lessening the probability of stochastic events increasing the risk of mortality (e.g., cropping by predators, contaminant events, or the direct/indirect effects of water diversions).

As described in Section 3.3.2 *Operational Criteria*, the fall X2 action from the USFWS (2008) BiOp has also been proposed to be included in the PA, provided that the research and results of the Collaborative Science and Adaptive Management program show it is necessary to avoid jeopardy of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat for those species. Thus, no meaningful difference in fall abiotic habitat index is expected to occur. To confirm this, a quantitative examination of the PA effects on abiotic habitat suitability was undertaken based on the abiotic habitat index method of Feyrer *et al.* (2011) (Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt,* Section 6A.4.1). The considerable similarity in mean fall abiotic habitat index by water-year type between NAA and PA emphasizes that there would be little difference in fall outflow management under the PA in all water year types, relative to NAA (Table 6.1-18; Figure

6.1-25 and Figure 6.1-26), as a result of the inclusion of the same water operations criteria for fall X2[19].

The independent review panel report for the working draft BA recommended that the more recent analysis of Bever et al. (2016) be adapted to assess the potential effects of the PA in relation to the NAA (Simenstad et al. 2016). Bever et al. (2016) found that in addition to salinity and water clarity, low current speed is also an important component of fall abiotic habitat for juvenile Delta Smelt. The independent review panel recommended that the abiotic station index of Bever et al. (2016) be modified to include only salinity and current speed, given that water clarity is not readily modeled. Such an analysis is not included herein for two main reasons. First, the inclusion of fall X2 water operations criteria for both the NAA and PA results in little difference in expected abiotic habitat, as illustrated above for the method based on Feyrer et. 2011. Second, the additional abiotic variable highlighted by Bever et al. (2016) as an important component of habitat is current speed, which would be essentially unaffected by operations, even if operations were markedly different; see Figure 11D-F of Bever et al. (2016). This is because of the considerable tidal influences on current speed in the low salinity areas of greatest importance to Delta Smelt, e.g., during a typical summer tidal cycle, the flow near Pittsburg can vary from 330,000 cfs upstream to 340,000 cfs downstream.[20]

Table 6.1-18. Mean Fall Abiotic Habitat Index, Based on the Method of Feyrer *et al.* (2011).

Water Year Type	NAA	PA	PA vs. NAA[1]
All	4,977	4,995	18 (0%)
Wet	7,131	7,126	-6 (0%)
Above Normal	5,366	5,406	40 (1%)
Below Normal	3,723	3,725	2 (0%)
Dry	3,822	3,889	67 (2%)
Critical	2,994	2,977	-17 (-1%)

Note:
[1] Negative values indicated abiotic habitat index under the proposed action (PA) than under the no action alternative (NAA).

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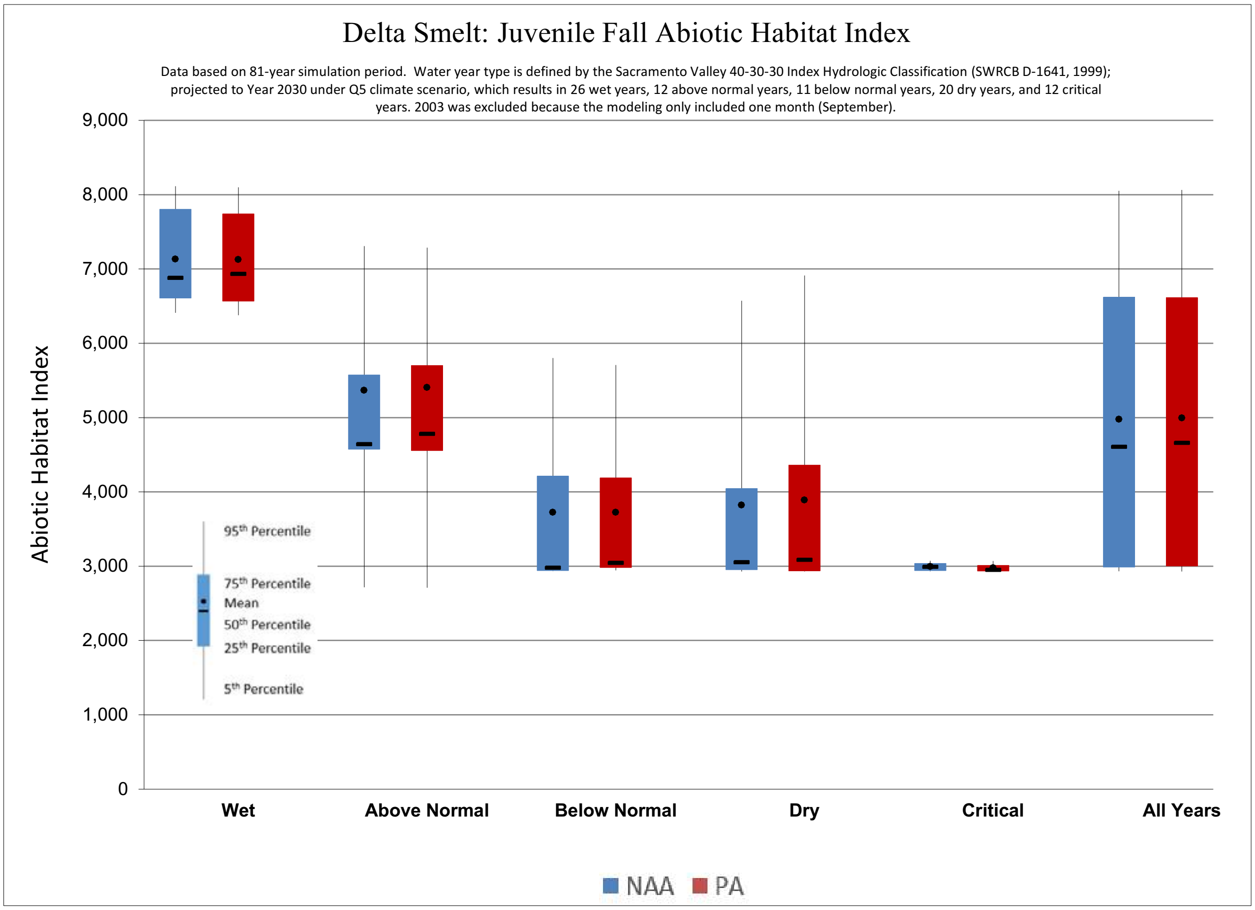
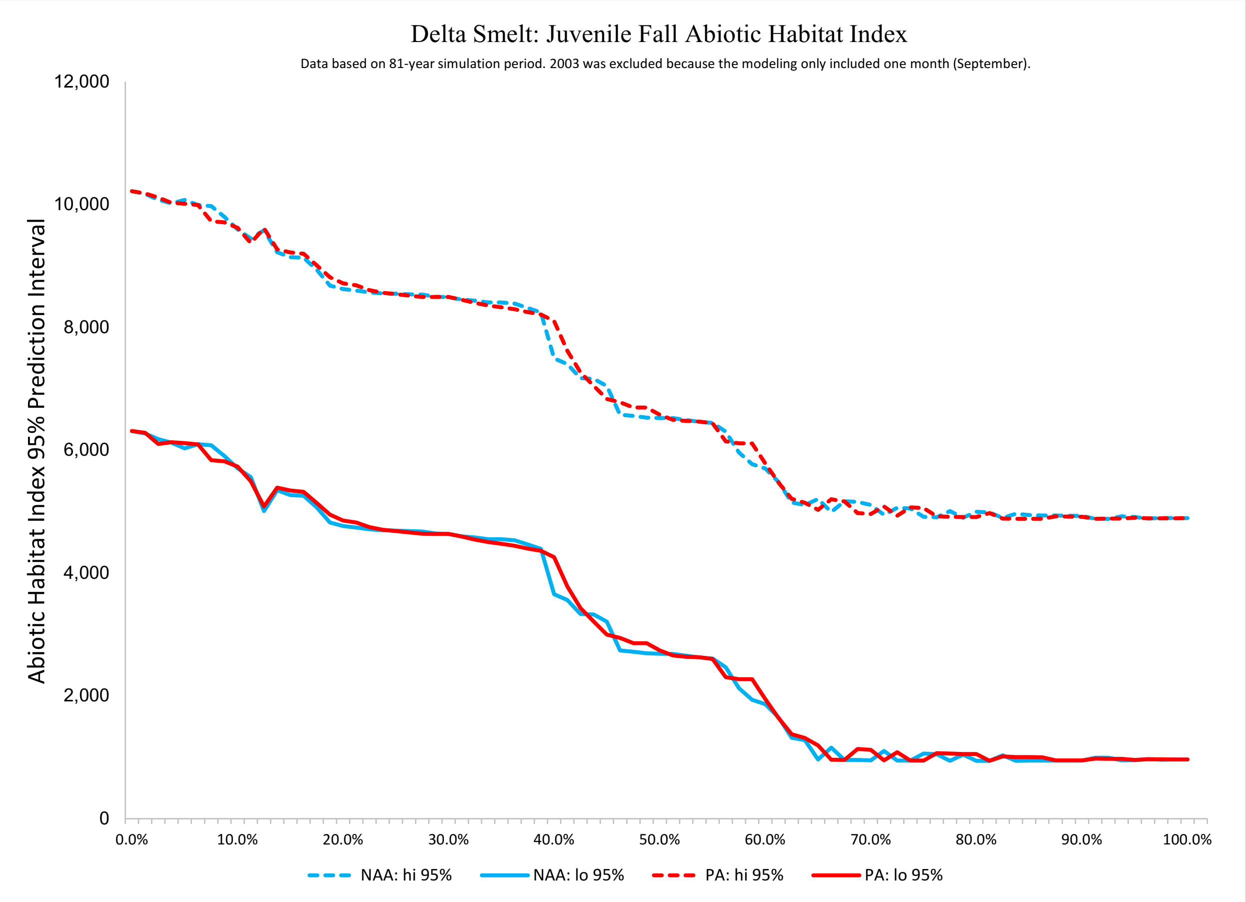
[19] The independent review panel report for the working draft BA noted—with respect to predictions based on regressions equations incorporating uncertainty, e.g., for prediction intervals such as those shown in Figure 6.1-24—that it is possible that the true annual values could lie near the bottom boundary of the prediction interval for PA and near the top boundary of the prediction interval for NAA (Simenstad et al. 2016). However, in this case, given that water operations in the fall have the same criteria for fall X2, it is expected that the abiotic habitat index would be similar between NAA and PA, as suggested by the mean values.

[20] http://baydeltaoffice.water.ca.gov/DeltaAtlas/03-Waterways.pdf. Accessed: July 13, 2016.



Note: Plot only includes mean responses and does not consider model uncertainty.

Figure 6.1-25. Box Plot of Mean Fall Abiotic Habitat Index, Grouped by Water Year Type, Based on the Method of Feyrer *et al.* (2011)



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown.

Figure 6.1-26. Exceedance Plot of Mean Fall Abiotic Habitat Index, Based on the Method of Feyrer *et al.* (2011).

6.1.3.5.1.1.2 Population-Level Effects

The PA would not have an adverse effect on Delta Smelt juveniles in the fall.

6.1.3.5.2 Water Temperature

As noted in the effects analysis for NMFS-managed species (Chapter 5, *Effects Analysis for Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*), Kimmerer (2004: 19-20) described water temperature in the San Francisco Estuary as depending mainly on air temperature, and that even in the Delta the relationship between air and water temperature is only slightly affected by freshwater inflow. As examples, Kimmerer (2004: 20) noted that at Freeport, high inflow reduces water temperature on warm days, presumably because water reaches the Delta before its temperature equilibrates with air temperature, and at Antioch, low inflow increases water temperature on cool days, probably because of the moderating effect of warmer estuarine water moving farther upstream. USFWS (2008: 194) suggested, based on Kimmerer (2004) that water temperatures at Freeport can be cooled up to about 3°C by high Sacramento River flows, but only by very high river flows that cannot be sustained by CVP/SWP operations. In general, flow-related effects on Delta water temperature are expected to be minor (Wagner *et al.* 2011). Specifically, Delta water temperatures are primarily driven by air temperatures and the lagged effects from previous days' conditions (Wagner et al. 2011). However, operational changes under the PA with respect to dual conveyance means that it is prudent to investigate whether water temperature is expected to differ between the NAA and the PA, and if so, why. To do this, DSM2-QUAL modeling was undertaken to predict water temperatures for the NAA and PA scenarios at four locations: Sacramento River at Rio Vista, San Joaquin River at Prisoners Point, Stockton Deep Water Ship Channel, and San Joaquin River at Brandt Bridge. Detailed methods are presented in Attachment 5.B.A.4, *DSM2 Temperature Modeling*, of Appendix 5.B *DSM2 Methods and Results*, with results in Section 5.B.5, *DSM2 Results*, of the same appendix. The analysis below focuses on the two stations of greatest relevance to Delta Smelt: Rio Vista and Prisoners Point. Note that the nature of the DSM2-QUAL modeling is such that absolute projections of water temperature must be made with caution (e.g., regional correction factors must be applied), but site-specific comparisons between scenarios can be made. As described in Attachment 5.B.A.4 *DSM2 Temperature Modeling*, of Appendix 5.B, the DSM2 QUAL simulations result in somewhat higher different water temperatures than historical conditions: For Rio Vista, the DSM2-QUAL estimates of water temperature are 0.3–0.6°C less than historical in April–June; 0.3–0.5°C greater than historical in July–August; and 0.1–0.5°C less than historical in September-November. No specific comparison was made for Prisoner's Point, but comparisons for nearby stations in the east Delta (Mokelumne River at San Joaquin River and Little Potato Slough) were always biased low, averaging -0.2°C to -0.8°C.

6.1.3.5.2.1 Migrating Adults (December-March)

6.1.3.5.2.1.1 Individual-Level

From examination of exceedance plots of Rio Vista mean water temperatures (Figure 5.B.5.40-1 in Appendix 5.B *DSM2 Methods and Results*, Section 5.B.5), the only discernible differences in water temperature were in March, and these were small differences (~0.1°C greater under PA). At Prisoners Point (Figure 5.B.5.41-1 in Appendix 5.B*,* Section 5.B.5), differences were evident in January-March, presumably as a result of the HOR gate retaining a greater proportion of slightly warmer San Joaquin River water in the main stem, combined with less Sacramento River inflow entering the interior Delta. Differences in March were of the order of 0.3–0.4°C. Although differences in water temperature between NAA and PA were modeled, these were during a relatively cool part of the year and therefore are not expected to have significant effects on migrating adults in that portion of the Delta.

From examination of exceedance plots of Rio Vista mean water temperatures (Figure 5.B.5.40-1 in Appendix 5.B *DSM2 Methods and Results*, Section 5.B.5), there were no discernible differences in water temperature (maximum "differences" were well within model noise, e.g., ~0.1°C greater under PA in March). At Prisoners Point (Figure 5.B.5.41-1 in Appendix 5.B*,* Section 5.B.5), modeled differences were comparable to model noise during January-March (+0.3 to +0.4°C), presumably as a result of the HOR gate retaining a greater proportion of the slightly warmer San Joaquin River water in the main stem, combined with less Sacramento River inflow entering the interior Delta. This may reflect a water temperature change that would actually occur, but if it did, it would occur during a cool part of the year and therefore should not affect Delta Smelt.

6.1.3.5.2.1.2 Population-Level Effects

Migrating adult Delta Smelt may experience slightly warmer temperatures in the lower San Joaquin River, but given that these temperatures would be expected to well within the tolerance of the species, there should not be any population level impact.

6.1.3.5.2.2 Spawning Adults (February-June)

6.1.3.5.2.2.1 Individual-Level Effects

As described previously for migrating adult Delta Smelt, there might be slightly greater water temperatures under PA compared to NAA in the San Joaquin River. Delta smelt may begin spawning in the San Joaquin River in February, and will spawn during March of most years (see California Department of Fish and Wildlife Spring Kodiak Trawling Data at https://www.wildlife.ca.gov/Conservation/Delta/Spring-Kodiak-Trawl). Previously published modeling studies have indicated that warmer temperatures (caused by climate change) would tend to result in earlier spawning, but they provide no indication that the duration of the spawning window would be affected (Wagner *et al.* 2011; Brown *et al.* 2013). Earlier spawning could result in spawning adults being of smaller mean size, as they would have had less time to grow to maturity (Brown *et al.* 2013).

6.1.3.5.2.2.2 Population-Level Effects

The recent simulation-based life cycle modeling by Rose *et al.* (2013a,b) indicates that egg supply has been a major factor affecting Delta Smelt abundance in the recent past. Climate change is anticipated to warm Delta water temperatures and as such could affect the length of time that Delta Smelt have to reach adulthood (Brown *et al.* 2013). If this occurs, it would affect egg supply. As described above, it is uncertain whether the PA will actually affect water temperature in the Delta, but if it does, that effect would be very minor and very localized. Thus, it is unlikely that project effects on water temperature would translate into a population-level effect on Delta Smelt. In general it is expected that air temperature is the main driver on water temperature in the Delta, as shown by detailed temperature modeling that does not include the effects of flow and has higher correspondence with observed temperatures than DSM2-QUAL estimates (Wagner *et al.* 2011).

6.1.3.5.2.3 Eggs/Embryos (Spring: ~March–June)

6.1.3.5.2.3.1 Individual-Level Effects

Most Delta Smelt hatch during March-May. In warm years, hatching can begin in February and in cool years, it can extend at least into June. Bennett (2005: 17) reviewed Delta Smelt embryo and larval survival data from laboratory studies and found that optimal hatching occurred at 15–17°C. As previously noted for adult Delta Smelt, there would be little if any difference in temperature between NAA and PA because river flows have such a minor influence on water temperatures in the Delta except at the inflowing river margins (Kimmerer 2004; Wagner *et al.* 2011). Although strict comparisons to absolute thresholds are not appropriate for the DSM2-QUAL data, the general pattern for Prisoners Point in March suggests that the greater water temperature under PA would be slightly closer toward optimum hatching temperature than under NAA (Figure 5.B.5.41-1 in Appendix 5.B *DSM2 Methods and Results*, Section 5.B.5), whereas in May, temperatures under PA may be marginally further away from optimum compared to NAA, although these differences were very small. Bennett (2005: 17) also noted that incubation time of embryos decreases with increasing water temperature, from around 18 days at 10°C to 9 days at 15°C and 7 days at 20°C. Therefore, for example, a 0.3°C greater water temperature under PA could give a 0.5-day shorter incubation time for Delta Smelt occurring in the lower San Joaquin River.

6.1.3.5.2.3.2 Population-Level Effects

The slightly greater Prisoners Point water temperature under PA that was estimated by DSM2-QUAL could result in shorter embryo incubation time, as well as slightly lower or higher hatching success, depending on the month. The effects would be limited to the portion of the Delta Smelt population occurring in the San Joaquin River which, as inferred from the spawning adult distribution (see previous discussion), generally would be expected to be a lower proportion of the population than would occur in the north Delta. As previously noted, in general it is expected that air temperature would be the main driver on water temperature in the Delta (Wagner *et al.* 2011), and the differences between PA and NAA scenarios were very small.

6.1.3.5.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.5.2.4.1 Individual-Level Effects

Bennett's (2005: 17) review of the laboratory studies on water temperature effects on larval Delta Smelt found that greater water temperature leads to smaller length at hatching and smaller length at first feeding. The marginally higher water temperatures estimated under the PA relative to NAA in at Prisoners Point (see discussion above) therefore could result in Delta Smelt that are slightly smaller, although the differences between scenarios was very small. There could be several effects to Delta Smelt from this smaller size (IEP MAST Team 2015: 37). First, small size would result in small gape size, which would limit the size of prey items that could be eaten. Second, there may be greater vulnerability to a wider range of predators. Third, smaller larvae could be more susceptible to hydrodynamic transport toward the south Delta export facilities for a given level of pumping. Bennett (2005: 11) noted that there is higher mortality of larvae above 20°C; the DSM2-QUAL modeling data for Prisoners Point in June suggested that there could be a slight increase in the number of days in this range (Figures 5.B.5.41-3 to 5.B.5.41-6 in Appendix 5.B *DSM2 Methods and Results,* Section 5.B.5; although as noted previously, it is not appropriate to examine more than general patterns when comparing the NAA and PA scenarios).

6.1.3.5.2.4.2 Population-Level Effects

Overall, the DSM2-QUAL analysis suggested that there may be slightly lower larval Delta Smelt survival in the lower San Joaquin River because of slightly higher water temperature. This would affect the portion of the population occupying this area. Data from the 20-mm survey indicate that larval Delta Smelt occur frequently in this area (see Table 7 of Merz *et al.* 2011), so an appreciable portion of the population could be subject to this adverse effect. However, as previously noted, in general it is expected that air temperature would be the main driver on water temperature in the Delta and flow effects would be of minor importance (Wagner *et al.* 2011).

6.1.3.5.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.5.2.5.1 Individual-Level Effects

Water temperatures above 20°C become increasingly stressful to juvenile Delta Smelt up to the range that has been observed to be lethal (~25–29°C; Swanson *et al.* 2000; Komoroske *et al.* 2014). The DSM2-QUAL modeling results suggested water temperature would be similar or slightly warmer under the PA compared to NAA, at both the Sacramento River at Rio Vista and San Joaquin River at Prisoners Point during the summer (July–September). The differences that occurred in the warmer 50% years indicated about 0.1–0.2°C greater temperature under the PA

(Figure 5.B.5.40-1 and Figure 5.B.5.41-1 in Appendix 5.B *DSM2 Methods and Results,* Section 5.B.7)

6.1.3.5.2.5.2 Population-Level Effects

As reviewed by the IEP MAST team (2015), high summer water temperature has a negative effect on the Delta Smelt population, as it has been linked to Delta Smelt subadult abundance in the fall (Mac Nally *et al.* 2010) and long-term population dynamics (Maunder and Deriso 2011; Rose *et al.* 2013a, b). The marginally greater water temperature in the summer could have a small adverse effect on the whole Delta Smelt population, through mechanisms such as reduced habitat extent, increased metabolic requirements (reduced energy intake for growth), and greater susceptibility to disease or the effects of contaminants (IEP MAST Team 2015). The difference in water temperature was small, however, perhaps suggesting limited adverse effects at the population level, particularly given that air temperature is the main driver of Delta water temperature and effects of flow have very little importance (Wagner *et al.* 2011).

6.1.3.5.3 Sediment Removal (Water Clarity)

Water clarity (turbidity) is a very important habitat characteristic for Delta Smelt and is a significant predictor of larval feeding success (presumably by providing a visual contrast to enable the larvae to locate and ingest prey; Baskerville-Bridges *et al.* 2004) and juvenile distribution (Nobriga *et al.* 2008; Feyrer *et al.* 2011) that has been correlated to long-term changes in abundance or survival either by itself or in combination with other factors (Thomson *et al.* 2010; Maunder and Deriso 2011). Cloern *et al.* (2011) noted the uncertainty in future turbidity trends in the Delta: specifically, it is unclear whether a 40-year average decline in turbidity of 1.6% per year will continue at this rate, slow down, or level off. Should such a trend continue, it presumably will further decrease the downward trend in Delta Smelt habitat quality estimated by Feyrer *et al.* (2011) (as described in Brown *et al.* (2013).

Most sediment entering the Delta comes from the Sacramento River (Wright and Schoellhamer 2004). The NDD is expected to divert a portion of the Sacramento River's sediment load, which could result in higher water clarity downstream because less sediment may over time allow greater erosion and less wind- and velocity-driven resuspension of sediment into the water column. The BDCP public draft included estimates of sediment diverted by the NDD at the late long term time frame (2060) based on historic sediment load estimates for 1991–2002 (see Section 5C.D.3 in the BDCP public draft, Attachment 5C.D to Appendix 5.C *Upstream Water Temperature Methods and Results*). For the present effects analysis of the PA, very similar analytical methods were used based on sediment load estimates for water years 1991–2003, matched to CalSim flow and NDD diversion estimates for the same years. The analysis suggested that a mean of 10% (range: 5–15%) of combined sediment load entering the Delta from combined inflow at Freeport and the Yolo Bypass would be removed by the NDD. Considering only the Sacramento River load at Freeport, it was estimated that a mean of 11% (range: 7–16%) of sediment load would be removed by the NDD. If this sediment, some of which will be collected in the sedimentation basins (described in Section 3.2.2 *North Delta Diversions*) is not returned to the system, it is possible that water transparency in the Delta will increase over time due to project operations. However, the extent of increases in water clarity cannot be accurately predicted without application of a full suspended sediment model incorporating the whole estuary; modeling has been noted to be necessary for assessment of the effects of managing regional transport of sediment in the Delta (Schoellhamer *et al.* 2012). Thus, the following effects analysis should be understood to have low certainty. Note that the analysis did not attempt to provide a quantitative estimate for sediment removal by the south Delta export facilities under the NAA or PA; based on the estimates by Wright and Schoellhamer (2005), sediment removal by the south Delta export facilities in 1999-2002 averaged around 2% of the sediment entering the Delta at Freeport, i.e., an order of magnitude less than estimated to be removed at the NDD, so the net sediment removal under the PA (NDD exports plus less south Delta exports than NAA) would be expected to be appreciably greater than sediment removal under NAA. As described in Section 3.2.10.6 *Dispose Spoils*, 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 Water Control Board and USACE). This would mitigate the effects of sediment removal by the NDD.

6.1.3.5.3.1 Migrating Adults (December-March)

6.1.3.5.3.1.1 Individual-Level Effects

As described previously for south Delta entrainment, some adult Delta Smelt migrate upstream in response to winter increases in suspended sediment and flow (Grimaldo *et al.* 2009). Suspended sediment may conceal Delta Smelt from visual predators (reviewed by Sommer and Mejia 2013), so that increases in water clarity may result in lower survival. Turbidity could also influence Delta Smelt's sampling gear avoidance, as suggested by Latour (2015). Given the timing of the upstream migration in the often high-flow winter months, during which suspended sediment concentration is greatest (Table 6.1-19), removal of sediment by the NDD may have limited adverse effects on individual Delta Smelt because the transparency of inflowing Sacramento River would not be expected to be altered in real-time. To the extent there is a concern for sediment removal affecting water clarity, it may be a long-term, population-level concern rather than a real-time concern for individual migrating adult Delta Smelt.

6.1.3.5.3.1.2 Population-Level Effects

Following from the discussion of individual-level effects, population-level adverse effects on migrating adult Delta Smelt from sediment removal by the NDD may be limited by the occurrence of this life stage in higher flow months, when suspended sediment concentration often is relatively high. The population-level impact of sediment removal at the NDD cannot be reliably predicted at this time. If there is an effect, it may be manifested in the long term. As previously described, 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.

Table 6.1-19. Mean Monthly Suspended Sediment in the Sacramento River at Freeport, 1957-2014 (mg/l).

Month	Concentration
January	99
February	104
March	86
April	63
May	51
June	34
July	32
August	29
September	33
October	28
November	40
December	77

Source: USGS 2015

6.1.3.5.3.2 Spawning Adults (February-June)

6.1.3.5.3.2.1 Individual-Level Effects

Given the timing of the upstream migration in the often high-flow winter months, during which suspended sediment concentration is greatest (Table 6.1-19), removal of sediment by the NDD may have limited adverse effects on individual Delta Smelt because the transparency of inflowing Sacramento River would not be expected to be altered in real-time. To the extent there is a concern for sediment removal affecting water clarity, it may be a long-term, population-level concern, not a real-time concern, for individual Delta Smelt. However, as described in Section 3.2.10.6, *Dispose Spoils*, DWR will collaborate with CDFW and USFWS to develop and implement a sediment reintroduction plan that would mitigate the effects of sediment removal by the NDD.

6.1.3.5.3.2.2 Population-Level Effects

The population-level impact of sediment removal at the NDDs cannot be reliably predicted at this time. If there is an effect, it may be manifested in the long term. The extent of this effect cannot be accurately estimated without use of a full suspended sediment model. As noted in the individual-level effects discussion, sediment reintroduction would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.5.3.3.1 Individual-Level Effects

Increases in water clarity during the latter parts of spring when river inflow's suspended sediment concentration goes down (Table 6.1-19) may have the potential to result in adverse effects to individual Delta Smelt eggs/embryos should they become more visible to predators. To the extent there is a concern for sediment removal affecting water clarity, it may be a long-term, population-level concern, not a real-time concern for individual Delta Smelt. As described for other life stages, development and implementation of a sediment reintroduction plan would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.3.2 Population-Level Effects

As noted for spawning Delta Smelt, the population-level impact of sediment removal at the NDDs cannot be reliably predicted at this time. If there is an effect, it may be manifested in the long term. The extent of this effect cannot be accurately estimated without use of a full suspended sediment model. As noted in the individual-level effects discussion, sediment reintroduction would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.5.3.4.1 Individual-Level Effects

As noted earlier, water clarity is related to larval/young juvenile Delta Smelt feeding success (Baskerville-Bridges *et al.* 2004) and spatial distribution (Sommer and Mejia 2013). As with eggs/embryos and the latter portion of the spawning adult life stage, the occurrence of larval/young juvenile Delta Smelt bridges the transition between higher flow winter months and lower flow summer months, during which time the suspended sediment concentration in inflowing Sacramento River water decreases and resuspension of sediment delivered in the higher flow months becomes more important. As noted for other life stages, to the extent there is a concern for sediment removal affecting water clarity, it may be a long-term, population-level concern, not a real-time concern for individual Delta Smelt. Development and implementation of a sediment reintroduction plan would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.4.2 Population-Level Effects

As noted for other life stages, the population-level impact of sediment removal at the NDDs cannot be reliably predicted at this time. If there is an effect, it may be manifested in the long term. The extent of this effect cannot be accurately estimated without use of a full suspended sediment model. As noted in the individual-level effects discussion, sediment reintroduction would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.5.3.5.1 Individual-Level Effects

Occurrence of juvenile Delta Smelt during the low-flow time of year when suspended sediment concentration in inflow is at a minimum (Table 6.1-19) suggests that the NDD's removal of sediment could affect individual juvenile Delta Smelt by increasing water clarity, given the importance of resuspension of sediment delivered to the estuary by higher flows in winter/early spring. As noted for other life stages, to the extent there is a concern for sediment removal affecting water clarity, it may be a long-term, population-level concern, not a real-time concern for individual Delta Smelt. Development and implementation of a sediment reintroduction plan would mitigate any effects of sediment removal by the NDD.

6.1.3.5.3.5.2 Population-Level Effects

As noted for other life stages, the population-level impact of sediment removal at the NDDs cannot be reliably predicted at this time. If there is an effect, it may be manifested in the long term. The extent of this effect cannot be accurately estimated without use of a full suspended sediment model. As noted in the individual-level effects discussion, sediment reintroduction would mitigate any effects of sediment removal by the NDD.

6.1.3.5.4 Entrainment of Food Web Materials

As highlighted by Arthur *et al.* (1996), Jassby and Cloern (2000) and Jassby *et al.* (2002), and the USFWS (2008) BiOp, CVP/SWP water exports directly entrain phytoplankton and zooplankton which are the base of the food web supporting the production of Delta Smelt. Although these food web materials are exported (and export-related hydrodynamics limit transport of a lot of production into Suisun Bay; Jassby and Cloern 2000), it is not known whether export losses greatly affect overall fish production because other large impacts are also occurring in tandem (clam grazing and ammonium inhibition of per capita diatom growth rates). Entrainment of phytoplankton and zooplankton by the south Delta export facilities generally would be expected to be somewhat less under the PA, but the NDD would add a new source of loss along the Sacramento River. The impact of this was examined using an assessment of phytoplankton carbon entrained, based on cholorophyll *a* concentration data for Hood (representing the load of entrained phytoplankton), in relation to the biomass of phytoplankton in the Delta (taken from Antioch chlorophyll *a* data, multiplied up to the volume of the Delta). The methods for this analysis are presented in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6A.4.2. This analysis is essentially an approximation of potential entrainment of phytoplankton carbon load that could be entrained by the NDD. Factors that could offset any potential effects to Delta Smelt include the in situ productivity of phytoplankton carbon within the Delta, which could be relatively large, and reduced entrainment of phytoplankton carbon by the south Delta export facilities under the PA. These factors are discussed qualitatively in the analysis.

Median (50th percentile) estimates of phytoplankton carbon load entrained by the NDD ranged from around 0.2 metric tons/day in April and May (5th to 95th percentile ranges were 0.00–0.02 to ~ 1.8 metric tons/day) to ~ 1.6 metric tons/day in February (5th to 95th percentile range ~ 0.13 to 5.7 metric tons/day) (Table 6.1-20). Estimates of phytoplankton carbon biomass in the Delta for 2004–2015 ranged from just under 23 metric tons (December 2011) to over 230 metric tons (May 2010) (Table 6.1-21). Thus, the percentage of Delta phytoplankton carbon biomass estimated to be entrained by the NDD ranged from 0.0% based on the 5th percentile of entrained load estimates at the NDD during several months up to 12% at the 95th percentile load estimate combined with the minimum biomass estimate in December (Table 6.1-22). The median estimates of total fraction of phytoplankton biomass removed by the NDDs ranged from ~ 0.5% to 2% per month when compared to minimum Delta phytoplankton carbon biomass estimates, down to ~ 0.1% to 1% when compared to maximum Delta phytoplankton carbon biomass estimates. On the basis of the 95th percentiles, it appears that the NDD would seldom if ever entrain more than ~5% of the Delta's standing stock of phytoplankton in any given month.

Table 6.1-20. Percentiles of Phytoplankton Carbon Load Estimated to be Entrained (metric tons/day) by the NDD.

Month	Min.	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	Max.
Jan.	0.00	0.11	0.13	0.17	0.21	0.29	0.50	1.20	1.88	2.28	3.18	4.31	35.16
Feb.	0.00	0.13	0.17	0.25	0.41	1.01	1.62	2.09	2.52	3.03	4.24	5.35	11.51
Mar.	0.00	0.11	0.17	0.26	0.45	0.91	1.33	1.85	2.38	2.89	3.48	3.90	8.51
Apr.	0.00	0.00	0.01	0.04	0.07	0.13	0.20	0.30	0.47	0.70	1.22	1.76	12.95
May	0.00	0.02	0.04	0.07	0.10	0.14	0.19	0.26	0.38	0.58	1.09	1.77	10.78
Jun.	0.05	0.11	0.13	0.17	0.24	0.40	0.65	0.93	1.20	1.48	2.01	2.51	4.80
Jul.	0.00	0.03	0.06	0.40	0.65	0.91	1.12	1.34	1.51	1.66	2.10	2.44	3.77
Aug.	0.00	0.02	0.03	0.07	0.20	0.47	0.64	0.82	0.99	1.27	1.56	1.89	3.15
Sep.	0.00	0.01	0.04	0.15	0.22	0.30	0.37	0.46	0.56	0.73	1.12	1.43	5.35
Oct.	0.00	0.00	0.01	0.04	0.13	0.24	0.33	0.43	0.55	0.69	0.92	1.13	2.82
Nov.	0.00	0.00	0.01	0.04	0.14	0.22	0.33	0.46	0.64	0.91	1.32	1.67	4.73
Dec.	0.00	0.03	0.07	0.13	0.17	0.20	0.24	0.30	0.42	0.81	2.08	2.76	9.72

Note: Values in shaded cells were used in subsequent estimation of percentage of Delta biomass entrained by the NDD.

Table 6.1-21. Mean Daily Biomass (metric tons) of Phytoplankton Carbon Estimated to be Present in the Delta During 2004-2015.

Month	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Min.	Max.
Jan.		125.3	109.2	62.9	139.3	92.3	127.0	71.3	66.7	104.6	66.7	140.1	62.9	140.1
Feb.		95.8	75.2	124.4	122.0	109.4	110.8	82.5	133.8	104.8	122.6	129.4	75.2	133.8
Mar.		132.6	81.6	107.0	116.8	110.1	106.1	123.4	117.8	162.3	125.7	174.8	81.6	174.8
Apr.		96.7	115.9	46.1	156.8	129.4	142.1	89.4	115.4	155.3	116.2	148.1	46.1	156.8
May		96.9	85.1	51.3	110.0	88.6	231.2	47.2	82.3	124.2	86.8	103.4	47.2	231.2
Jun.		90.1	78.1	53.7	95.9	81.1	81.5	46.5	80.3	69.2	66.4	104.7	46.5	104.7
Jul.		100.2	76.6	67.1	83.0	64.3	76.7	66.0	77.6	50.1	70.5	109.4	50.1	109.4
Aug.		74.4	60.2	83.0	76.0	63.6	62.9	89.7	66.7	46.2	84.2		46.2	89.7
Sep.	36.2	49.6	79.7	124.9	71.8	61.9	72.3	84.3	53.6	43.0	84.8		36.2	124.9
Oct.	31.6	75.8	76.2	112.5	59.4	88.3	63.5	106.6	106.8	42.2	73.6		31.6	112.5
Nov.	41.1	61.8	50.6	56.5	61.4	75.3	48.6	112.0	49.4	51.7	76.5		41.1	112.0
Dec.	41.5	71.6	58.3	78.7	72.9	72.5	56.5	22.8	106.0	69.2	121.6		22.8	121.6

Note: Values in shaded cells were used in subsequent estimation of percentage of Delta biomass entrained by the NDD.

Table 6.1-22. Range of Percentage of Phytoplankton Carbon Biomass in the Delta Estimated to be Entrained by the NDD.

Month	Based on Minimum Biomass				Based on Maximum Biomass		
	5%	50%	95%		5%	50%	95%
Jan.	0.2%	0.8%	6.8%		0.1%	0.4%	3.1%
Feb.	0.2%	2.2%	7.1%		0.1%	1.2%	4.0%
Mar.	0.1%	1.6%	4.8%		0.1%	0.8%	2.2%
Apr.	0.0%	0.4%	3.8%		0.0%	0.1%	1.1%
May	0.1%	0.4%	3.7%		0.0%	0.1%	0.8%
Jun.	0.2%	1.4%	5.4%		0.1%	0.6%	2.4%
Jul.	0.1%	2.2%	4.9%		0.0%	1.0%	2.2%
Aug.	0.0%	1.4%	4.1%		0.0%	0.7%	2.1%
Sep.	0.0%	1.0%	3.9%		0.0%	0.3%	1.1%
Oct.	0.0%	1.1%	3.6%		0.0%	0.3%	1.0%
Nov.	0.0%	0.8%	4.1%		0.0%	0.3%	1.5%
Dec.	0.1%	1.1%	12.1%		0.0%	0.2%	2.3%

The loss of phytoplankton carbon at the NDD also must be considered in the context of all CVP/SWP water diversions because inflows to and exports from the Delta strongly affect the flux of bioavailable carbon into the confluence and Suisun Bay (Arthur *et al.* 1996; Jassby and Cloern 2000). If used as the only source for Delta exports and without any change in total Delta exports, the NDD would in principle increase the export of biological productivity to the western Delta and Suisun Bay because the San Joaquin River is much richer in its organic matter load than the Sacramento River (Jassby and Cloern 2000). The PA does not cease exports from the south Delta, but it does reduce them considerably, generally by half or more: the long-term (1922–2003) average reduction compared to NAA from the CalSim modeling ranged from 45% less under PA in January to ~70% less in October; only in December (12% less under the PA) were the differences not close to half or more (Appendix 5.A *CALSIM Methods and Results*, Figures 5.A.6-27-1 to 5.A.6-27-19 and Table 5.A.6-27). Jassby *et al.* (2002) estimated that on average during spring through fall, the Delta produces 44 metric tons/day of phytoplankton carbon and another 12 metric tons/day flows into the Delta from its tributaries. Of that 56 tons/day, the south Delta export facilities remove ~8 metric tons/day or about 14% (Jassby *et al.* 2002)[21]. It is anticipated that the overall long-term ~50% reduction in south Delta exports will increase the loading of relatively productive San Joaquin River water to the western Delta and Suisun Bay (Table 6.1-23) and therefore should offset some or all of the loss attributable to the NDD, and perhaps could even provide a net beneficial effect.

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[21] An additional ~5 metric tons per day were estimated to be removed by agricultural diversions. Such losses would present under both the NAA and PA.

Table 6.1-23. Mean Percentage of Water at Collinsville Originating in the San Joaquin River, from DSM2-QUAL Fingerprinting.

Month	Wet				Above Normal				Below Normal				Dry				Critical		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
Jan	1.3	3.4	2.1 (63%)		0.1	0.8	0.7 (92%)		0.2	0.5	0.3 (68%)		0.4	1.2	0.7 (63%)		0.2	0.2	0.0 (24%)
Feb	2.1	5.5	3.4 (62%)		1.0	3.0	2.0 (67%)		0.5	2.8	2.3 (83%)		0.3	1.2	0.9 (79%)		0.1	0.3	0.2 (66%)
Mar	4.1	11.4	7.3 (64%)		1.9	6.8	4.9 (72%)		1.4	5.0	3.7 (72%)		0.9	2.7	1.8 (67%)		0.3	1.0	0.7 (71%)
Apr	8.5	15.6	7.0 (45%)		4.2	11.7	7.5 (64%)		2.0	6.0	4.1 (67%)		1.6	3.9	2.4 (61%)		0.6	1.7	1.2 (68%)
May	13.6	19.8	6.3 (32%)		10.0	16.6	6.6 (40%)		5.7	9.7	4.1 (42%)		3.7	6.5	2.8 (43%)		0.9	2.3	1.4 (60%)
Jun	11.3	21.4	10.0 (47%)		8.5	15.1	6.7 (44%)		4.9	8.5	3.6 (43%)		3.3	6.0	2.7 (45%)		1.1	2.4	1.3 (55%)
Jul	5.5	14.5	8.9 (62%)		2.0	6.3	4.3 (68%)		1.3	3.4	2.1 (62%)		0.9	2.4	1.5 (62%)		0.6	1.5	0.9 (58%)
Aug	1.8	6.3	4.5 (71%)		0.2	1.6	1.4 (85%)		0.2	0.9	0.7 (80%)		0.2	0.8	0.6 (75%)		0.2	0.6	0.4 (61%)
Sep	0.2	1.9	1.6 (89%)		0.0	0.5	0.4 (91%)		0.0	0.3	0.3 (86%)		0.1	0.3	0.2 (76%)		0.1	0.3	0.1 (58%)
Oct	0.1	3.1	3.0 (96%)		0.0	0.7	0.7 (98%)		0.0	0.3	0.3 (94%)		0.0	0.2	0.2 (85%)		0.1	0.1	0.1 (53%)
Nov	0.6	9.6	9.0 (94%)		0.1	3.9	3.8 (98%)		0.1	1.2	1.1 (95%)		0.1	0.7	0.6 (89%)		0.1	0.4	0.2 (59%)
Dec	0.8	5.1	4.3 (84%)		0.1	3.2	3.1 (98%)		0.1	0.7	0.6 (89%)		0.2	0.6	0.5 (71%)		0.2	0.3	0.1 (39%)

CalSim estimates of total Delta exports also provide context for the difference in potential food web productivity between PA and NAA: total Delta exports on average (1922–2003) would be somewhat greater under PA (almost 4.9 million acre feet/year) than under NAA (just under 4.7 million acre feet/year). In general, total Delta exports would be less under PA than NAA in September-November; similar in April-May and August; and generally lower under PA than NAA in the remaining months, to varying degrees (Appendix 5.A *CALSIM Methods and Results*, Figures 5.A.6-28-1 to 5.A.6-28-19 and Table 5.A.6-28). If phytoplankton availability was a linear function of SWP/CVP exports, then the annual average change in biomass would be around -4%. However, the timing of differences in exports in relation to different life stages is important, and consideration should also be made of the in situ productivity that would occur in the Delta, and the relative contribution of this to the Delta Smelt food web. This is addressed in the analyses of effects to the different Delta Smelt life stages, presented next.

6.1.3.5.4.1 Migrating Adults (December-March)

6.1.3.5.4.1.1 Individual-Level Effects

The primary mechanisms by which entrainment of planktonic organisms might affect individual Delta Smelt is by temporarily reducing density of zooplankton immediately downstream of the NDDs or by reducing the load of phytoplankton further into the estuary, causing some unknown reduction in food for the zooplankton that Delta Smelt eat. These are highly unlikely to cause starvation of any individual Delta Smelt and would most likely fall between no effect and some immeasurably small impact on growth rates of individual fish.

6.1.3.5.4.1.2 Population-Level Effects

At the population level, the effects of entrainment of phytoplankton carbon are likely to be low in terms of affecting Delta Smelt prey abundance. As noted by Baxter *et al.* (2010: 59) and the IEP MAST Team (2015: 76), there has been little study of prey importance for adult Delta Smelt, and there is no evidence for food limitation in the adult life stage.

6.1.3.5.4.2 Spawning Adults (February-June)

6.1.3.5.4.2.1 Individual-Level Effects

As described for migrating adults, the primary mechanisms by which entrainment of planktonic organisms might affect individual Delta Smelt is by temporarily reducing density of zooplankton immediately downstream of the NDDs or by reducing the load of phytoplankton further into the estuary causing some unknown reduction in food for the zooplankton that Delta Smelt eat. These are highly unlikely to cause starvation of any individual Delta Smelt and would most likely fall between no effect and some immeasurably small impact on growth rates of individual fish.

6.1.3.5.4.2.2 Population-Level Effects

As described for migrating adults, at the population level, the effects of entrainment of phytoplankton carbon are likely to be low in terms of affecting Delta Smelt prey abundance. As previously described, there has been little study of prey importance for adult Delta Smelt, and there is no evidence for food limitation in the adult life stage.

6.1.3.5.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.5.4.3.1 Individual-Level Effects

This life stage does not feed externally and so would not be affected by entrainment of food web materials.

6.1.3.5.4.3.2 Population-Level Effects

As stated for individual effects, this life stage does not feed externally and so would not be affected by entrainment of food web materials.

6.1.3.5.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.5.4.4.1 Individual-Level Effects

As with adult Delta Smelt, lower loads of phytoplankton carbon into the estuary because of NDD entrainment could translate into less food for individual Delta Smelt larvae and young juveniles, but this is not an assured outcome. It was estimated that a range from less than 0.1% to over 5% of phytoplankton carbon entering the Delta could be entrained by the NDD in March–June (Table 6.1-22). However, the phytoplankton has to be converted into copepod biomass to be prey for larval Delta Smelt and that process is not always directly related to phytoplankton density as indexed by chlorophyll *a* concentrations in the water (e.g., Kimmerer 2002). Given lower south Delta exports when north Delta exports are relatively high, there may be a net increase in phytoplankton carbon production in the Delta due to higher loading from the comparatively productive San Joaquin River that could offset some or possibly even all of the loss estimated for the NDD, and perhaps could even provide a net beneficial effect.

6.1.3.5.4.4.2 Population-Level Effects

The feeding success of Delta Smelt larvae appears to be related to prey density (Nobriga 2002). Some statistical analyses of Delta Smelt population dynamics have shown evidence that prey abundance for Delta Smelt during the larval and early juvenile life stage affects Delta Smelt abundance (Maunder and Deriso 2011; Miller *et al.* 2012), while others have found less support for this hypothesis (Mac Nally *et al.* 2010; Thomson *et al.* 2010). The hypothesis was also not supported in a recent empirical study of Delta Smelt feeding ecology and food limitation (Slater and Baxter 2014). In this study, evidence of food limitation was greater for juvenile fish in the late summer than it was for larvae or small juveniles during the late spring. Most likely, food limitation would act as a chronic problem extending across multiple life stages (Rose *et al.* 2013a,b). Less phytoplankton carbon loading to the estuary because of NDD entrainment could reduce the abundance of Delta Smelt's zooplankton prey. However, the estimates of phytoplankton carbon entrainment were not large (up to 5.4% at the higher end 95th percentile (Table 6.1-21). This, in conjunction with observations that in situ production of phytoplankton carbon within the Delta is several times greater than inputs from freshwater inflow (Jassby *et al.* 2002) and that this in situ production is the dominant supply to the planktonic food web that includes Delta Smelt (Sobczak *et al.* 2002), suggests that the entrainment of phytoplankton carbon by the NDD would only have a minor, if any, adverse population-level effect, particularly given the offsetting increases in relatively more productive San Joaquin River water during these months (Table 6.1-23).

6.1.3.5.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.5.4.5.1 Individual-Level Effects

The empirical evidence for food limitation during this life stage is generally stronger than it is for other life stages (Slater and Baxter 2014; Hammock *et al.* 2015). Thus, lower phytoplankton carbon load available to the food web (as a result of NDD entrainment) could result in less prey for individual juvenile Delta Smelt. During July-November, it was estimated that less than 5% of phytoplankton standing stock could be entrained by the NDD (95th percentile for high end estimates; Table 6.1-22). It is possible this loss will be offset by higher loading of phytoplankton from the San Joaquin River such that there is no effect to individual Delta Smelt.

6.1.3.5.4.5.2 Population-Level Effects

As described in the Individual-Level Effects section, there could be less prey available for juvenile Delta Smelt because of NDD exports. It is possible this loss will be offset by higher loading of phytoplankton from the San Joaquin River, as well as in situ production of phytoplankton, such that there is no effect to the Delta Smelt population.

6.1.3.5.5 Microcystis

The toxic cyanobacteria *Microcystis* has been shown to have negative effects on the aquatic foodweb of the Delta (Brooks *et al.* 2012), principally in the south Delta and the middle to upper portions of the west/central Delta near locations such as Antioch, and Franks Tract (Lehman *et al.* 2010). As reviewed by Brooks *et al.* (2012), *Microcystis* could affect Delta Smelt through direct ingestion, consumption of prey containing high concentrations of toxins, or toxic effects to prey leading to lower prey abundance. *Microcystis* blooms generally occur from June to October, when water temperature is at least 19°C (Lehman *et al.* 2013)[22]. However, this analysis focused on July-November to stay consistent with the general timing of Delta Smelt's juvenile life stage, which co-occurs with *Microcystis* blooms. Lehman *et al.* (2013) suggested that net flows are probably the most important factor maintaining *Microcystis* blooms because low flows with longer residence times allow the slow-growing colonies to accumulate into blooms. Other factors including nutrients are also of importance to *Microcystis* (Lehman *et al.* 2014), but these are not readily predictable for comparison of the NAA and PA scenarios, which introduces some uncertainty to the results.

The potential effects of PA water operations on *Microcystis* were assessed using two approaches. First, the frequency of flow conditions conducive to *Microcystis* occurrence (as defined by Lehman *et al.* 2013) was assessed in the San Joaquin River past Jersey Point (QWEST) and in the Sacramento River at Rio Vista (QRIO), based on DSM2-HYDRO modeling. Second, DSM2-QUAL water temperature modeling (Section 6.1.3.5.2, *Water Temperature*) and DSM2-PTM for estimates of residence time (Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt,* Section 6.A.4.3, methods discussion) were used to inform the potential for *Microcystis* occurrence, given the importance of water temperature and the probable importance of residence time (although there are no published relationships between *Microcystis* occurrence and residence time in the Delta). Note that more weight is placed on the analysis based on the

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[22] During the current drought conditions, *Microcystis* has been detected in appreciable quantities in December, presumably because relatively warm temperatures and low inflow have favored growth beyond the typical period of occurrence.

published flow conditions at which *Microcystis* occurs (Lehman *et al.* 2013), because there are no published analyses between *Microcystis* occurrence and residence time. Both sets of quantitative analyses (*i.e.*, the flow analysis and the residence time/temperature analysis) focused on the summer/fall (July-November) period because it is during this time of the year that *Microcystis* blooms are likely to occur. Note that other factors including nutrients are also of importance to *Microcystis* (Lehman *et al.* 2014), but these are not readily predictable for comparison of the NAA and PA scenarios, which introduces some uncertainty to the results based only on flow or residence time/temperature.

The first analysis examined the frequency of years during July-November in which mean monthly flows were within the range at which *Microcystis* has been shown to occur, per Lehman *et al.* (2013: 155): -240 to 50 m^3/s (approx. -8,500 to 1,800 cfs) for QWEST, and 100-450 m^3/s (approx. 3,500 to 15,900 cfs) for QRIO[23]. This analysis suggested that flow conditions conducive to *Microcystis* bloom occurrence would tend to occur less frequently under the PA than NAA in the San Joaquin River, based on QWEST. For NAA, the percentage of years with QWEST within the range for *Microcystis* occurrence ranged from 89% in October to 98% in August, whereas for PA, the range was from 9% of years in October to 99% of years in August (Table 6.1-24). In neither the NAA nor the PA scenario were mean monthly flows below the range noted for *Microcystis* occurrence, whereas for PA there were substantially more years above the range than for NAA. The results reflected greater mean QWEST flows under the NAA compared to PA, with monthly means under the PA ranging from just under 0 m^3/s (-100 cfs) in August (compared to -168 m^3/s or -5,900 cfs under NAA) to 245 m^3/s (8,600 cfs) in October (compared to 16 m^3/s or 570 cfs under NAA). These results are attributable to less south Delta export pumping under PA than NAA.

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[23] The DSM2-HYDRO output locations used for estimating QWEST were RSAN018 + SLTRM004 + SLDUT007; and for QRIO was RSAC101.

Table 6.1-24.Percentage of Modeled Years (1922-2003) in Which Mean Monthly Flow in the San Joaquin River Past Jersey Point (QWEST) Was Below, Within, and Above the Range for *Microcystis* Occurrence (Lehman *et al.* 2013).

	NAA					PA			
	Below Range (< -240 m^3/s)	**Within Range (-240 to 50 m^3/s)**	**Above Range (> 50 m^3/s)**	**Mean Flow, m^3/s (cfs)**		**Below Range (< -240 m^3/s)**	**Within Range (-240 to 50 m^3/s)**	**Above Range (> 50 m^3/s)**	**Mean Flow, m^3/s (cfs)**
July	0%	95%	5%	-162 (-5,714)		0%	78%	22%	68 (2,384)
August	0%	98%	2%	-168 (-5,931)		0%	99%	1%	-3 (-103)
September	0%	96%	4%	-128 (-4,531)		0%	52%	48%	191 (6,729)
October	0%	89%	11%	16 (568)		0%	9%	91%	245 (8,637)
November	0%	91%	9%	-39 (-1,391)		0%	53%	47%	178 (6,281)

Implementation of north Delta export pumping under the PA would result in less Sacramento River flow compared to NAA, as reflected in the examination of QRIO (Table 6.1-25). The percentage of years within the range at which *Microcystis* has been noted to occur ranged from 59% in September to 89% in August under NAA, compared to a range from 48% in September to 96% in July for PA (Table 6.1-25). Given that Lehman *et al.'s* (2013) suggested mechanism for the importance of flow was lower flows leading to sufficiently long residence time to allow *Microcystis* colonies to accumulate into blooms, flows below the range noted for *Microcystis* occurrence by Lehman *et al.* (100-450 m^3/s) could also be favorable for bloom occurrence, whereas flows above the range may reduce residence time sufficiently to limit bloom formation. The percentage of years in which mean monthly flow was above the range that Lehman *et al.* (2013) found for *Microcystis* occurrence was less under PA than NAA in July (0%, compared to 10% under NAA), September (0%, compared to 29% under NAA), and November (10%, compared to 16% under NAA). On the basis of differences in QRIO flow, therefore, there could be greater potential for *Microcystis* occurrence in the lower Sacramento River under the PA than NAA. However, this is presently not an area of intense *Microcystis* blooms and if it remains turbid in the future, it is expected that current conditions will continue.

Table 6.1-25. Percentage of Modeled Years (1922-2003) in Which Mean Monthly Flow in the Sacramento River at Rio Vista Was Below, Within, and Above the Range for *Microcystis* Occurrence (Lehman *et al.* 2013).

	NAA					PA			
	Below Range (< -100 m³/s)	**Within Range (-100 to 450 m³/s)**	**Above Range (> 450 m³/s)**	**Mean Flow, m³/s (cfs)**		**Below Range (< -100 m³/s)**	**Within Range (-100 to 450 m³/s)**	**Above Range (> 450 m³/s)**	**Mean Flow, m³/s (cfs)**
July	5%	85%	10%	702 (24,793)		4%	96%	0%	396 (13,984)
August	11%	89%	0%	462 (16,331)		11%	89%	0%	282 (9,942)
September	12%	59%	29%	754 (26,612)		52%	48%	0%	457 (16,136)
October	15%	84%	1%	420 (14,839)		15%	84%	1%	291 (10,275)
November	7%	77%	16%	769 (27,162)		0%	90%	10%	541 (19,097)

The results of the DSM2-PTM-based residence time analysis presented here focus only on the particle insertion locations upstream (east) of Suisun Bay and Suisun Marsh, because this is where effects of the proposed action (PA) on hydraulic residence time are highest. The effects of the PA on residence time varied by subregion. As previously described, there has been no published analysis of the relationship between *Microcystis* occurrence and residence time, so there is uncertainty as to what the differences described here may mean in terms of potential for *Microcystis* occurrence. The results showed that regions with short residence times sometimes are predicted to have large proportional changes in residence time (e.g., locations near the NDDs) and regions with comparatively long residence times typically had moderate to low proportional changes in residence time (Table 6.1-26 through Table 6.1-46). Differences between NAA and PA ranged from almost no change in the Sacramento River Deepwater Shipping Channel to sometimes substantial increases in predicted residence times (e.g., Disappointment Slough where median predictions ranged from -3.8 to + 11.9 days, Mildred Island where median predictions ranged from + 5.8 to + 16.5 days, and Victoria Canal where median predictions ranged from + 3.0 to + 11.7 days). These results indicate that *Microcystis* may have considerably more opportunity for growth in parts of the southern Delta where water temperatures are relatively high during the summer and present-day blooms are often observed.

Table 6.1-26. Summary Statistics of Residence Time (Days) in the Upper Sacramento River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.4	0.7	0.3 (65%)	0.6	1.2	0.6 (107%)	0.5	0.7	0.3 (57%)	0.5	1.1	0.7 (148%)	0.4	0.8	0.4 (99%)
25%	0.5	1.1	0.7 (135%)	0.6	1.5	0.8 (126%)	0.5	1.0	0.5 (83%)	0.8	1.4	0.7 (87%)	0.6	1.1	0.4 (69%)
50% (median)	0.5	1.2	0.7 (124%)	0.7	1.8	1.1 (164%)	1.2	2.2	1.0 (89%)	1.0	1.7	0.6 (63%)	1.0	1.4	0.4 (45%)
75%	0.8	1.4	0.6 (76%)	1.8	2.0	0.2 (14%)	2.4	2.7	0.4 (15%)	1.6	1.9	0.2 (13%)	1.8	1.7	0.0 (-2%)
95%	2.4	2.7	0.2 (9%)	3.2	3.1	0.0 (-1%)	20.1	11.5	-8.7 (-43%)	2.3	2.3	0.0 (0%)	16.2	10.6	-5.5 (-34%)

Table 6.1-27. Summary Statistics of Residence Time (Days) in the Sacramento River Near Ryde Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.3	0.4	0.1 (33%)	0.5	0.9	0.4 (69%)	0.5	0.6	0.1 (29%)	0.3	0.6	0.3 (76%)	0.4	0.7	0.3 (85%)
25%	0.5	0.8	0.4 (80%)	0.6	1.1	0.5 (89%)	0.5	0.7	0.2 (33%)	0.6	1.2	0.5 (83%)	0.5	0.9	0.4 (78%)
50% (median)	0.5	1.0	0.5 (89%)	0.7	1.3	0.6 (89%)	0.7	1.5	0.8 (113%)	0.9	1.5	0.6 (65%)	0.8	1.3	0.6 (72%)
75%	0.7	1.2	0.5 (65%)	1.3	1.8	0.5 (40%)	1.7	2.1	0.5 (29%)	1.4	1.7	0.2 (16%)	1.1	1.5	0.4 (32%)
95%	1.8	1.7	-0.1 (-6%)	2.4	2.7	0.2 (10%)	2.5	2.5	0.0 (0%)	2.1	2.3	0.2 (12%)	1.9	1.9	0.0 (-1%)

Table 6.1-28. Summary Statistics of Residence Time (Days) in the Sacramento River Ship Channel Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	43.3	43.4	0.1 (0%)	43.2	43.1	0.0 (0%)	43.2	43.2	0.0 (0%)	42.5	42.5	0.0 (0%)	39.8	39.7	-0.1 (0%)
25%	43.4	43.5	0.0 (0%)	43.3	43.4	0.1 (0%)	43.3	43.3	0.0 (0%)	43.4	43.3	0.0 (0%)	42.3	42.2	0.0 (0%)
50% (median)	43.6	43.6	0.0 (0%)	43.7	43.8	0.1 (0%)	43.7	43.7	0.1 (0%)	43.7	43.6	0.0 (0%)	43.1	43.1	0.0 (0%)
75%	44.0	44.1	0.0 (0%)	44.0	44.1	0.0 (0%)	43.9	44.0	0.0 (0%)	43.9	43.9	0.0 (0%)	44.1	44.0	0.0 (0%)
95%	44.3	44.3	0.0 (0%)	44.2	44.2	0.0 (0%)	44.3	44.3	0.1 (0%)	44.4	44.4	0.0 (0%)	44.3	44.3	0.0 (0%)

Table 6.1-29. Summary Statistics of Residence Time (Days) in the Cache Slough and Liberty Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	20.4	22.5	2.1 (10%)	16.5	19.5	3.0 (18%)	13.1	14.2	1.1 (8%)	11.4	13.8	2.4 (21%)	8.3	9.6	1.3 (15%)
25%	21.3	23.3	2.0 (9%)	17.2	20.8	3.6 (21%)	14.8	17.5	2.7 (18%)	14.6	17.1	2.4 (17%)	11.5	13.1	1.6 (14%)
50% (median)	22.0	23.8	1.8 (8%)	18.3	21.1	2.8 (15%)	16.1	18.7	2.7 (16%)	15.9	18.2	2.2 (14%)	13.4	14.5	1.2 (9%)
75%	22.7	25.1	2.4 (11%)	20.6	22.1	1.5 (7%)	18.2	21.1	2.9 (16%)	17.6	18.6	1.0 (6%)	14.9	15.6	0.7 (5%)
95%	25.8	27.0	1.2 (5%)	22.3	23.7	1.4 (6%)	22.5	22.3	-0.2 (-1%)	19.0	19.5	0.5 (3%)	16.7	16.4	-0.3 (-2%)

Table 6.1-30. Summary Statistics of Residence Time (Days) in the Sacramento River Near Rio Vista Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	1.4	2.0	0.7 (48%)	5.8	7.4	1.6 (27%)	3.2	1.8	-1.4 (-43%)	3.8	2.7	-1.1 (-29%)	3.6	3.9	0.3 (9%)
25%	6.6	7.7	1.2 (17%)	9.2	9.2	0.0 (0%)	5.0	2.7	-2.3 (-46%)	5.6	5.3	-0.3 (-5%)	5.0	5.3	0.3 (5%)
50% (median)	7.4	11.9	4.5 (60%)	10.4	13.6	3.2 (31%)	7.8	9.0	1.2 (16%)	9.2	8.1	-1.1 (-12%)	6.2	6.6	0.5 (7%)
75%	13.7	14.9	1.1 (8%)	14.7	17.0	2.3 (16%)	15.5	14.7	-0.8 (-5%)	11.9	10.2	-1.7 (-14%)	8.0	9.9	1.9 (24%)
95%	17.3	17.1	-0.2 (-1%)	17.9	19.6	1.7 (10%)	18.9	17.9	-1.0 (-5%)	15.9	14.7	-1.1 (-7%)	12.3	12.1	-0.2 (-2%)

Table 6.1-31. Summary Statistics of Residence Time (Days) in the Lower Sacramento River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.2	4.7	1.6 (49%)	10.1	12.2	2.1 (21%)	4.8	3.5	-1.3 (-26%)	6.7	6.7	0.0 (0%)	6.1	6.0	-0.1 (-2%)
25%	9.1	12.3	3.2 (35%)	13.5	13.6	0.1 (1%)	7.0	4.4	-2.6 (-37%)	8.8	8.4	-0.4 (-5%)	7.5	7.4	-0.1 (-1%)
50% (median)	12.9	15.0	2.1 (17%)	17.4	18.7	1.3 (8%)	13.4	12.5	-0.9 (-7%)	13.4	12.9	-0.5 (-4%)	10.2	10.8	0.6 (6%)
75%	20.9	21.0	0.2 (1%)	21.7	23.4	1.7 (8%)	22.6	21.2	-1.5 (-6%)	18.4	16.9	-1.5 (-8%)	13.2	14.6	1.4 (11%)
95%	22.4	22.2	-0.2 (-1%)	23.5	24.4	0.9 (4%)	24.3	23.4	-0.9 (-4%)	20.9	20.5	-0.4 (-2%)	18.7	18.4	-0.3 (-1%)

Table 6.1-32. Summary Statistics of Residence Time (Days) in the Lower San Joaquin River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.1	4.6	1.4 (45%)	12.0	12.7	0.7 (6%)	5.5	3.7	-1.8 (-32%)	7.5	6.8	-0.7 (-9%)	7.1	5.2	-2.0 (-27%)
25%	11.3	13.0	1.7 (15%)	15.4	14.2	-1.2 (-8%)	10.4	4.3	-6.1 (-58%)	9.8	7.8	-2.0 (-21%)	9.6	8.1	-1.5 (-15%)
50% (median)	14.1	16.0	2.0 (14%)	17.8	18.3	0.5 (3%)	14.5	11.9	-2.6 (-18%)	13.4	11.5	-1.9 (-14%)	12.2	10.9	-1.3 (-11%)
75%	20.4	21.5	1.1 (5%)	22.4	23.3	1.0 (4%)	22.9	20.7	-2.2 (-10%)	19.9	16.7	-3.2 (-16%)	14.5	15.7	1.2 (8%)
95%	22.7	23.4	0.7 (3%)	24.8	25.2	0.4 (2%)	25.5	24.3	-1.1 (-4%)	22.3	21.0	-1.3 (-6%)	19.3	20.1	0.8 (4%)

Table 6.1-33. Summary Statistics of Residence Time (Days) in the San Joaquin River at Twitchell Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	2.7	3.1	0.4 (14%)	9.5	12.1	2.6 (27%)	8.1	4.3	-3.8 (-47%)	8.4	5.3	-3.2 (-38%)	7.6	6.0	-1.6 (-21%)
25%	10.2	13.5	3.3 (32%)	10.8	13.6	2.8 (26%)	10.3	5.9	-4.3 (-42%)	12.4	8.0	-4.3 (-35%)	10.6	9.6	-1.0 (-9%)
50% (median)	12.0	16.1	4.1 (35%)	12.6	17.0	4.5 (36%)	11.6	13.3	1.6 (14%)	14.5	11.8	-2.7 (-18%)	12.6	11.8	-0.8 (-6%)
75%	13.6	18.1	4.5 (33%)	19.4	20.4	1.1 (6%)	19.0	20.0	1.0 (5%)	18.2	16.9	-1.4 (-8%)	15.3	15.9	0.6 (4%)
95%	21.0	21.1	0.1 (0%)	23.4	22.2	-1.2 (-5%)	23.0	22.6	-0.4 (-2%)	20.8	20.2	-0.6 (-3%)	18.9	19.7	0.8 (4%)

Table 6.1-34. Summary Statistics of Residence Time (Days) in the San Joaquin River at Prisoners Point from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	2.7	3.0	0.3 (10%)	4.3	8.4	4.1 (95%)	4.4	5.3	0.9 (20%)	7.5	6.5	-1.0 (-14%)	3.9	6.6	2.7 (68%)
25%	4.9	9.7	4.7 (96%)	5.0	10.5	5.5 (109%)	5.4	7.7	2.3 (43%)	9.8	8.3	-1.5 (-15%)	7.4	8.4	1.0 (14%)
50% (median)	6.0	10.7	4.7 (79%)	6.3	11.0	4.7 (74%)	7.4	11.0	3.7 (50%)	10.7	11.0	0.3 (3%)	8.6	10.6	2.0 (24%)
75%	7.3	12.2	4.9 (66%)	12.5	13.3	0.9 (7%)	10.9	15.0	4.1 (38%)	14.1	14.8	0.7 (5%)	11.1	12.4	1.3 (11%)
95%	13.6	14.8	1.2 (9%)	18.7	16.2	-2.5 (-13%)	16.8	16.7	-0.1 (-1%)	16.5	17.2	0.7 (4%)	14.6	15.0	0.4 (3%)

Table 6.1-35. Summary Statistics of Residence Time (Days) in the North and South Forks Mokelumne River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	4.9	8.7	3.8 (79%)	3.0	6.7	3.7 (126%)	3.9	5.8	1.9 (50%)	6.3	7.5	1.2 (18%)	5.6	5.3	-0.2 (-4%)
25%	12.6	15.6	3.0 (24%)	4.2	8.9	4.7 (112%)	6.7	8.7	2.0 (30%)	9.4	8.7	-0.7 (-7%)	7.1	9.7	2.6 (36%)
50% (median)	20.8	20.8	0.0 (0%)	8.3	11.9	3.6 (44%)	11.4	12.4	1.0 (9%)	10.0	10.7	0.7 (7%)	8.9	10.3	1.4 (16%)
75%	26.1	24.6	-1.5 (-6%)	17.2	17.9	0.7 (4%)	17.0	17.7	0.7 (4%)	13.6	14.0	0.4 (3%)	11.1	12.5	1.3 (12%)
95%	34.2	31.5	-2.7 (-8%)	27.2	20.1	-7.1 (-26%)	24.7	22.2	-2.5 (-10%)	21.5	16.6	-4.9 (-23%)	16.5	14.2	-2.3 (-14%)

Table 6.1-36. Summary Statistics of Residence Time (Days) in the Disappointment Slough Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	12.1	15.5	3.4 (29%)	10.9	18.2	7.2 (66%)	10.8	15.2	4.4 (40%)	13.2	9.5	-3.7 (-28%)	14.7	15.1	0.3 (2%)
25%	17.9	26.7	8.9 (50%)	20.8	20.9	0.1 (1%)	16.8	18.4	1.6 (9%)	15.8	17.8	2.0 (13%)	18.6	17.9	-0.6 (-3%)
50% (median)	25.0	36.9	11.8 (47%)	25.7	29.9	4.2 (16%)	20.6	23.0	2.4 (12%)	19.6	22.9	3.3 (17%)	24.8	21.0	-3.8 (-15%)
75%	34.0	39.4	5.5 (16%)	29.3	33.0	3.8 (13%)	23.3	25.1	1.8 (8%)	23.7	28.7	5.0 (21%)	29.0	29.6	0.7 (2%)
95%	38.2	41.9	3.7 (10%)	34.2	35.6	1.4 (4%)	27.5	29.3	1.8 (7%)	27.5	30.8	3.3 (12%)	34.9	33.2	-1.7 (-5%)

Table 6.1-37. Summary Statistics of Residence Time (Days) in the San Joaquin River Near Stockton Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	1.3	1.5	0.2 (12%)	3.2	3.9	0.7 (22%)	4.1	4.3	0.1 (4%)	3.0	3.5	0.5 (17%)	2.8	3.1	0.4 (13%)
25%	5.8	7.8	2.0 (35%)	6.5	8.0	1.5 (23%)	5.9	6.8	0.9 (16%)	4.1	5.1	1.0 (25%)	4.4	5.0	0.6 (14%)
50% (median)	13.9	11.7	-2.3 (-16%)	9.7	9.8	0.1 (1%)	6.7	8.6	1.9 (29%)	5.2	6.2	1.1 (21%)	5.7	6.8	1.1 (19%)
75%	18.1	13.0	-5.0 (-28%)	12.1	10.9	-1.1 (-9%)	8.7	9.8	1.1 (13%)	6.4	7.4	1.1 (17%)	7.5	7.6	0.2 (2%)
95%	29.2	23.0	-6.2 (-21%)	15.1	14.4	-0.7 (-5%)	10.0	11.0	1.1 (11%)	8.3	9.0	0.7 (8%)	8.7	9.3	0.6 (7%)

Table 6.1-38. Summary Statistics of Residence Time (Days) in the Mildred Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.0	7.1	4.1 (138%)	1.8	5.0	3.3 (183%)	2.0	7.4	5.4 (270%)	2.9	8.9	6.0 (205%)	2.1	4.1	2.0 (93%)
25%	4.4	15.5	11.1 (255%)	2.2	8.1	5.8 (262%)	3.2	9.2	6.0 (188%)	3.7	11.6	7.9 (215%)	3.0	6.1	3.1 (106%)
50% (median)	6.9	23.4	16.5 (238%)	3.7	9.5	5.9 (160%)	4.7	10.7	6.0 (127%)	5.2	13.0	7.8 (150%)	4.6	13.9	9.3 (205%)
75%	11.1	27.1	16.0 (144%)	13.6	11.9	-1.7 (-12%)	6.9	14.9	8.0 (115%)	9.5	16.5	7.0 (73%)	15.9	15.7	-0.2 (-1%)
95%	25.1	30.0	4.9 (20%)	19.3	19.6	0.3 (2%)	15.4	16.8	1.4 (9%)	21.6	22.6	1.0 (4%)	21.1	21.5	0.4 (2%)

Table 6.1-39. Summary Statistics of Residence Time (Days) in the Holland Cut Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	1.4	3.8	2.4 (169%)	1.2	3.7	2.4 (198%)	1.5	4.7	3.3 (225%)	2.5	6.5	3.9 (156%)	1.8	3.3	1.5 (81%)
25%	2.0	4.2	2.2 (114%)	1.6	5.1	3.5 (226%)	1.8	5.5	3.7 (208%)	3.4	8.0	4.6 (134%)	2.6	4.0	1.4 (52%)
50% (median)	2.5	4.8	2.3 (95%)	2.4	5.7	3.3 (139%)	3.0	7.5	4.5 (154%)	3.9	8.6	4.7 (123%)	3.3	5.8	2.5 (75%)
75%	3.5	6.0	2.5 (73%)	5.4	6.6	1.1 (21%)	5.7	8.8	3.1 (55%)	5.8	9.1	3.3 (57%)	4.9	8.5	3.7 (76%)
95%	5.6	6.8	1.2 (22%)	9.8	7.8	-2.0 (-21%)	9.7	9.7	-0.1 (-1%)	7.5	9.8	2.3 (31%)	6.9	9.6	2.8 (41%)

Table 6.1-40. Summary Statistics of Residence Time (Days) in the Franks Tract Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	9.4	10.7	1.2 (13%)	10.0	11.1	1.1 (11%)	9.0	8.2	-0.8 (-9%)	9.1	8.6	-0.5 (-5%)	8.1	8.0	-0.1 (-1%)
25%	10.9	12.2	1.3 (12%)	10.9	13.2	2.4 (22%)	10.3	9.4	-0.8 (-8%)	11.1	9.7	-1.5 (-13%)	11.2	10.3	-0.9 (-8%)
50% (median)	11.6	14.4	2.8 (24%)	11.9	16.1	4.3 (36%)	11.8	14.1	2.3 (20%)	13.9	12.5	-1.4 (-10%)	12.3	12.0	-0.3 (-3%)
75%	12.8	16.6	3.8 (30%)	17.0	17.8	0.8 (5%)	16.2	17.4	1.1 (7%)	15.4	13.8	-1.6 (-10%)	14.4	15.1	0.7 (5%)
95%	16.9	17.5	0.6 (3%)	18.0	19.9	1.9 (10%)	18.7	18.5	-0.2 (-1%)	18.6	17.0	-1.7 (-9%)	18.1	18.0	-0.1 (-1%)

Table 6.1-41. Summary Statistics of Residence Time (Days) in the Rock Slough and Discovery Bay Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	4.8	7.4	2.6 (54%)	3.9	8.5	4.6 (119%)	4.7	11.0	6.3 (135%)	5.4	8.4	3.0 (55%)	5.0	6.9	1.9 (37%)
25%	5.6	8.8	3.3 (59%)	5.3	9.7	4.4 (84%)	5.6	14.6	8.9 (159%)	7.3	10.0	2.8 (38%)	5.9	8.2	2.3 (39%)
50% (median)	6.4	10.0	3.7 (57%)	5.7	11.9	6.2 (109%)	6.8	17.5	10.7 (158%)	8.8	15.2	6.4 (72%)	7.5	9.8	2.2 (29%)
75%	7.3	11.4	4.1 (56%)	10.1	15.9	5.9 (58%)	16.6	19.3	2.7 (17%)	12.1	17.1	5.0 (42%)	10.8	12.1	1.3 (12%)
95%	10.7	13.9	3.1 (29%)	19.2	22.3	3.1 (16%)	19.8	25.2	5.4 (27%)	20.6	19.2	-1.4 (-7%)	12.2	13.6	1.5 (12%)

Table 6.1-42. Summary Statistics of Residence Time (Days) in the Old River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.5	1.5	1.0 (212%)	0.4	1.4	1.0 (275%)	0.6	1.7	1.1 (199%)	0.6	2.5	1.9 (304%)	0.7	1.3	0.6 (82%)
25%	0.7	1.8	1.1 (164%)	0.6	1.6	1.1 (189%)	0.8	2.5	1.7 (208%)	1.0	3.4	2.3 (228%)	0.9	1.7	0.8 (89%)
50% (median)	1.0	2.3	1.3 (131%)	1.0	2.0	1.0 (102%)	1.1	3.5	2.5 (231%)	1.3	5.9	4.6 (363%)	1.1	1.9	0.7 (64%)
75%	1.4	2.8	1.4 (101%)	2.0	2.5	0.5 (23%)	1.9	6.4	4.5 (243%)	1.7	8.0	6.4 (382%)	1.8	7.2	5.4 (299%)
95%	4.2	3.8	-0.3 (-8%)	4.1	4.8	0.7 (17%)	2.7	12.0	9.3 (347%)	2.4	12.0	9.6 (393%)	2.8	8.6	5.8 (205%)

Table 6.1-43. Summary Statistics of Residence Time (Days) in the Middle River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.5	0.8	0.3 (62%)	0.4	0.7	0.3 (78%)	0.4	1.1	0.7 (180%)	0.5	1.5	1.0 (196%)	0.4	0.7	0.3 (58%)
25%	0.6	1.1	0.6 (101%)	0.4	0.9	0.5 (114%)	0.4	1.2	0.7 (177%)	0.6	2.0	1.4 (228%)	0.6	0.9	0.3 (51%)
50% (median)	0.7	1.3	0.6 (93%)	0.5	1.0	0.5 (99%)	0.5	1.4	0.8 (155%)	0.7	2.8	2.1 (292%)	0.7	1.1	0.4 (63%)
75%	0.8	1.6	0.8 (100%)	0.9	1.1	0.3 (29%)	0.8	1.6	0.8 (95%)	1.0	7.9	7.0 (727%)	0.8	10.9	10.1 (1,218%)
95%	2.4	4.5	2.1 (88%)	1.9	1.7	-0.2 (-13%)	1.3	2.4	1.1 (84%)	1.2	18.0	16.8 (1351%)	1.1	11.8	10.7 (979%)

Table 6.1-44. Summary Statistics of Residence Time (Days) in the Victoria Canal Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.3	2.5	2.2 (713%)	0.2	0.5	0.3 (116%)	0.3	0.7	0.4 (170%)	0.3	3.7	3.4 (1082%)	0.3	0.5	0.2 (51%)
25%	0.3	7.4	7.0 (2074%)	0.3	2.2	2.0 (731%)	0.3	4.1	3.8 (1339%)	0.4	5.4	5.1 (1353%)	0.4	0.6	0.2 (57%)
50% (median)	1.3	13.0	11.7 (939%)	4.6	7.6	3.0 (64%)	1.2	7.2	5.9 (480%)	0.6	10.5	9.9 (1734%)	0.6	7.1	6.5 (1052%)
75%	10.0	19.9	9.9 (99%)	14.5	14.2	-0.3 (-2%)	10.6	11.6	1.0 (10%)	3.9	14.7	10.8 (278%)	4.9	11.1	6.2 (126%)
95%	16.8	25.4	8.7 (52%)	26.4	21.1	-5.3 (-20%)	20.4	19.9	-0.5 (-3%)	15.7	17.8	2.1 (13%)	12.3	14.1	1.8 (15%)

Table 6.1-45. Summary Statistics of Residence Time (Days) in the Grant Line Canal and Old River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	2.2	3.0	0.8 (35%)	9.3	9.3	-0.1 (-1%)	2.7	6.2	3.4 (125%)	3.6	3.1	-0.5 (-14%)	4.4	5.4	1.0 (23%)
25%	29.3	29.6	0.3 (1%)	20.2	23.5	3.2 (16%)	8.5	10.0	1.5 (18%)	6.7	4.3	-2.4 (-36%)	8.2	8.1	-0.1 (-1%)
50% (median)	38.7	40.0	1.4 (4%)	27.3	29.1	1.8 (6%)	16.9	23.3	6.4 (38%)	13.6	10.1	-3.4 (-25%)	11.8	9.2	-2.7 (-22%)
75%	40.4	41.0	0.6 (1%)	36.2	35.5	-0.7 (-2%)	32.9	35.8	3.0 (9%)	19.5	14.7	-4.8 (-24%)	14.4	11.2	-3.3 (-23%)
95%	42.8	42.0	-0.9 (-2%)	40.8	37.0	-3.8 (-9%)	38.1	38.0	-0.1 (0%)	24.2	24.8	0.6 (3%)	21.2	13.1	-8.0 (-38%)

Table 6.1-46. Summary Statistics of Residence Time (Days) in the Upper San Joaquin River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.2	0.2	0.0 (0%)	0.2	0.2	0.0 (-1%)	0.4	0.4	0.0 (-2%)	0.3	0.3	0.0 (16%)	0.3	0.3	0.0 (-8%)
25%	0.8	0.7	-0.1 (-11%)	0.9	0.8	-0.1 (-16%)	0.7	0.7	-0.1 (-10%)	0.5	0.6	0.1 (23%)	0.4	0.3	0.0 (-6%)
50% (median)	2.0	1.4	-0.7 (-33%)	1.5	1.2	-0.3 (-18%)	1.0	0.8	-0.1 (-13%)	0.6	0.7	0.1 (25%)	0.5	0.5	0.0 (-8%)
75%	3.3	1.8	-1.5 (-46%)	1.9	1.6	-0.3 (-15%)	1.2	1.1	-0.2 (-14%)	0.7	0.8	0.2 (27%)	0.6	0.6	0.0 (-7%)
95%	13.5	6.7	-6.8 (-50%)	2.8	2.4	-0.4 (-15%)	1.5	1.3	-0.2 (-16%)	0.8	0.9	0.1 (18%)	0.6	0.6	0.0 (-1%)

6.1.3.5.5.1 Migrating Adults (December–March)

6.1.3.5.5.1.1 Individual-Level Effects

Microcystis blooms occur during the summer and early fall so there will be no effect on migrating adult Delta Smelt during the winter months.

6.1.3.5.5.1.2 Population-Level Effects

As there would be no adverse effect to individual migrating adult Delta Smelt from *Microcystis*, there would likewise be no adverse population-level effect.

6.1.3.5.5.2 Spawning Adults (February–June)

6.1.3.5.5.2.1 Individual-Level Effects

Microcystis blooms occur during the summer and early fall so there will be no effect on adult Delta Smelt during the spring months. The general temperature threshold for *Microcystis* blooms (20°C) is a temperature at which egg hatch success for Delta Smelt is exceptionally low (Bennett 2005), so there is little if any opportunity for a *Microcystis* bloom to harm an individual spawning adult Delta Smelt.

6.1.3.5.5.2.2 Population-Level Effects

The general temperature threshold for *Microcystis* blooms (20°C) is a temperature at which egg hatch success for Delta Smelt is exceptionally low (Bennett 2005), so there is little if any opportunity for a *Microcystis* bloom to harm the population of spawning adult Delta Smelt.

6.1.3.5.5.3 Eggs/Embryos (Spring: ~March–June)

6.1.3.5.5.3.1 Individual-Level Effects

The general temperature threshold for *Microcystis* blooms (20°C) is a temperature at which egg hatch success for Delta Smelt is exceptionally low (Bennett 2005), so there is little if any opportunity for a *Microcystis* bloom to harm individual Delta Smelt eggs.

6.1.3.5.5.3.2 Population-Level Effects

The general temperature threshold for *Microcystis* blooms (20°C) is a temperature at which egg hatch success for Delta Smelt is exceptionally low (Bennett 2005), so there is little if any opportunity for a *Microcystis* bloom to harm Delta Smelt eggs.

6.1.3.5.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.5.5.4.1 Individual-Level Effects

There is some potential overlap in timing between larval life stages of Delta Smelt and *Microcystis* blooms. However, this impact is captured in the discussion of the juvenile stage which has most of the seasonal overlap with blooms.

6.1.3.5.5.4.2 Population-Level Effects

The very limited potential effects to individual larval/young juvenile Delta Smelt would be reflected in minimal population-level adverse effects to this life stage.

6.1.3.5.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.5.5.5.1 Individual-Level Effects

As previously discussed in the water temperature analysis, climate change is likely to increase summer water temperature but it is not clear whether the PA would change water temperature. The warming climate may however increase the length of the viable growing season for

Microcystis blooms and that effect would interact with PA-related changes in residence time and possibly other conditions (e.g., nutrient loads; Lehman *et al.* 2013) to affect the duration and intensity of blooms. The threshold could be reached earlier in the year under the PA (see previous discussion of timing shifts for spawning Delta Smelt), which would increase the length of exposure for Delta Smelt and their prey, although air temperature as opposed to flow (operations) is the primary driver of water temperature in the Delta (Wagner *et al.* 2011). On the basis of the previously presented analysis based on the published ranges of flows that *Microcystis* occurs at (Lehman *et al.* 2013), greater flows in the lower San Joaquin River (QWEST) under the PA generally would be expected to give somewhat less potential for *Microcystis* to occur in that area, relative to the NAA; under the PA, a greater percentage of years were above the range of flows at which *Microcystis* has occurred. Therefore, under the PA, individual juvenile Delta Smelt could experience a lower likelihood of lethal or sublethal effects, or have greater feeding opportunities if lower prevalence of *Microcystis* results in less toxicity to zooplankton prey or a greater abundance of phytoplankton available for zooplankton, for example (Lehman *et al.* 2010; Brooks *et al.* 2012). However, as summarized in the analysis of residence time presented at the start of this section, higher residence time was most evident in predictions for the central/south Delta subregions, but also occurred elsewhere to some extent, for instance in the lower Sacramento River (Chipps Island to Rio Vista) and the Cache Slough/Liberty Island area. With the possibility of longer duration and more intense *Microcystis* blooms resulting in part from longer residence time, individual juvenile Delta Smelt may experience a greater likelihood of lethal or sublethal toxicity, or have lower prey availability (Ger *et al.* 2009; 2010; Lehman *et al.* 2010; Acuña *et al.* 2012; Brooks *et al.* 2012).

6.1.3.5.5.5.2 Population-Level Effects

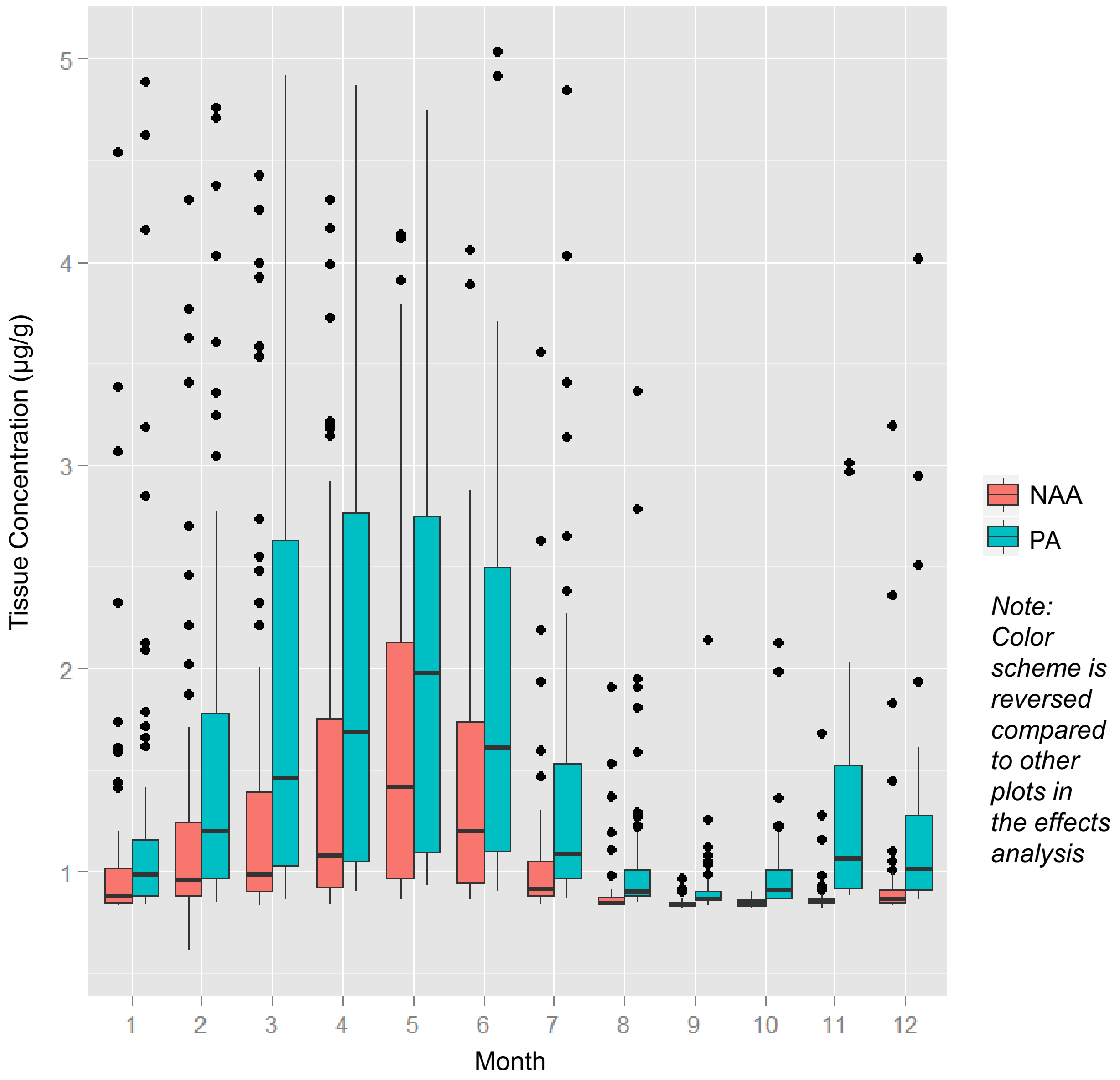
Most of the Delta Smelt population is not distributed in the southern Delta during the summer and fall because the water is too warm and too clear (Feyrer *et al.* 2007; Nobriga *et al.* 2008). Therefore, the Delta Smelt population does not overlap the peak of the ***Microcystis*** bloom in space and time. Nonetheless, there is overlap in the low-salinity zone and Microcystis can be toxic to copepods so there is potential for the regionally higher residence times to intensify blooms that harm or kill Delta Smelt directly, by killing their prey, or by increasing toxin concentrations within their prey. In the lower San Joaquin River, the analysis based on QWEST flow suggested that generally there would be less potential for *Microcystis* occurrence under the PA. The analysis based on residence time showed that in portions of the south Delta there may be potential for greater *Microcystis* occurrence because of greater residence time, although there are no published relationships between *Microcystis* and residence time from which to make firm conclusions. There is potential to mitigate such effects through preferential south Delta export pumping: the modeling currently assumes that in the summer months (July–September), the first 3,000 cfs of exports would be from the south Delta, with any additional allowable exports able to be diverted from either the north or the south Delta, and preference for this additional pumping generally being given to the north Delta (because of higher water quality); it would be possible to shift to additional south Delta pumping as opposed to north Delta pumping in order to reduce water residence time, for example. Given that multiple factors affect *Microcystis* bloom occurrence and maintenance, the analysis presented here has some uncertainty given that only two factors—albeit very important factors—were examined.

6.1.3.5.6 Selenium

The increase in the proportion of San Joaquin River water entering the Delta because of less south Delta exports under the PA would be expected to increase the selenium concentration in Delta water. The potential for this change to affect Delta Smelt through body deformities resulting from feeding on contaminated prey was investigated using the results of DSM2 volumetric fingerprinting estimates, Delta water source selenium input concentrations, conversions of water selenium concentration to particulate selenium concentration, and trophic transfer factors to estimate the concentration of selenium from Delta Smelt copepod prey to Delta Smelt tissue (see Section 6.A.4.4 *Selenium* in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*). As described in Section 6.A.4.4.4 *Modeling Assumptions*, this analysis has a number of assumptions leading to uncertainty in the results, including that the selenium toxicity threshold for Sacramento splittail (7.2 µg/g selenium whole-body tissue concentration) is representative of Delta Smelt, and the uncertainty around the concentration of selenium in the diet that results in toxic effects.

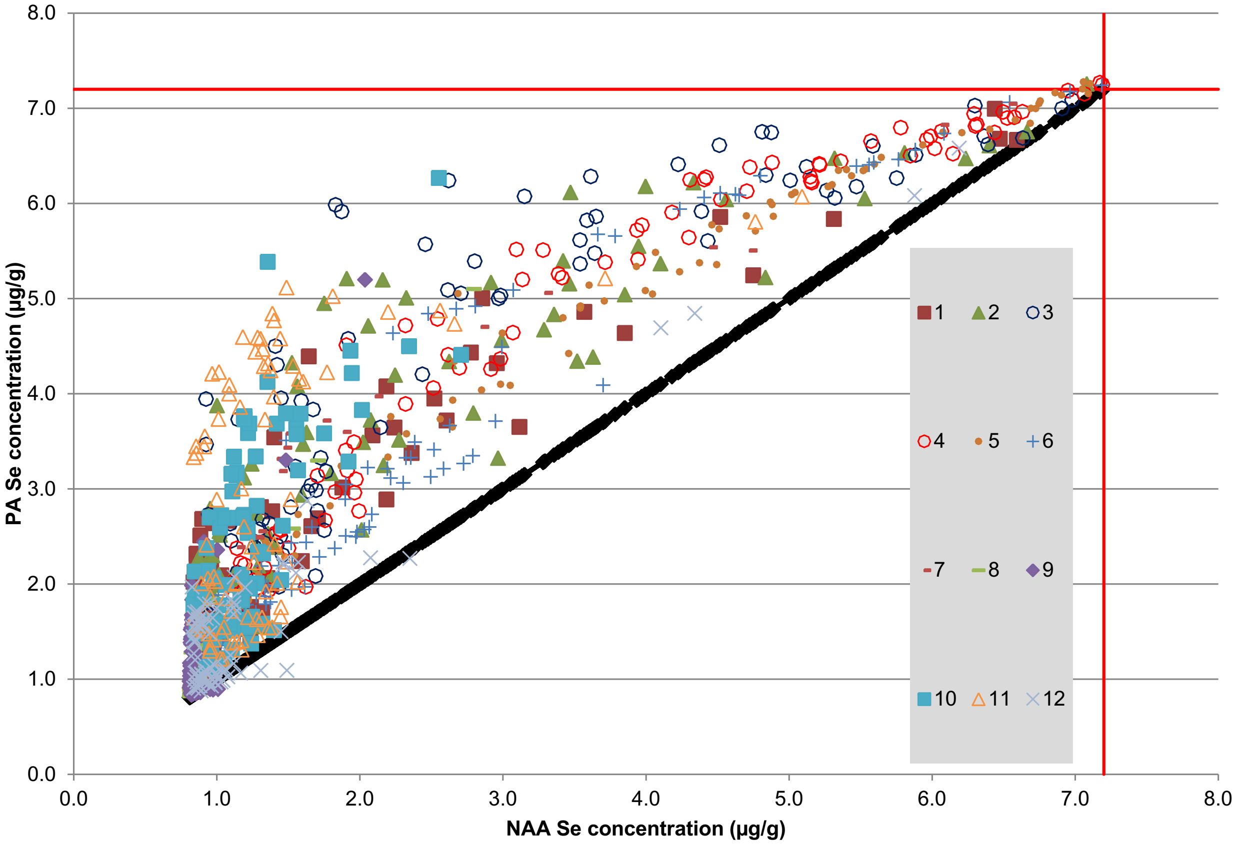
Monthly mean predicted Delta Smelt selenium tissue concentrations showed high variability at the five sites that were examined (San Joaquin River at Prisoners Point, Cache Slough at Ryer Island, Sacramento River at Emmaton, San Joaquin River at Antioch, and Suisun Bay at Mallard Island). The monthly selenium tissue concentrations were elevated in the PA relative to the NAA, sometimes as much as doubling the tissue concentrations compared to the NAA. However, even in those instances, the concentrations almost always remained well below the comparative effects threshold of 7.2 µg/g. Prisoners Point was the only one of the 5 sites at which tissue concentrations ever exceeded the chosen threshold of 7.2 µg/g. Because the predicted tissue concentrations are strongly influenced by the proportion of San Joaquin River water (see Table 6.A-12 in Section 6.A.4.4.1 *Selenium Concentrations in Water* in Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt*), data from Prisoners Point at a K_d of 6000 (higher bioavailable selenium) represent a conservative high end of selenium exposure to Delta Smelt from the PA.

Selenium concentration in Delta Smelt tissue at Prisoners Point had a broad peak from March through June (Figure 6.1-27), the months when the fraction of San Joaquin River water was often highest at those sites. Exceedance occurred in 7 out of 992 months (0.7%) and only when using the high bioavailable selenium estimate (high K_d) (Figure 6.1-28). The relatively small number of exceedances for the PA occurred primarily in the months of March, April, and May, where predicted NAA selenium tissue concentrations were observed to be close or at threshold exceedance. Based upon the modeling results, the PA is expected to increase San Joaquin River water contribution to 5 sites relevant to Delta Smelt. It is reasonable to conclude that there will be an increase in selenium bioavailability and potential for elevated tissue concentrations in Delta Smelt. However, based on modeled Delta Smelt tissue concentrations and the selected selenium toxicity threshold value, the PA is unlikely to increase tissue concentrations significantly enough to result in detrimental effects to Delta Smelt. The results are discussed in the following sections by life stage.



Note: Plot only includes mean responses and does not consider model uncertainty.

Figure 6.1-27. Box Plot of Predicted Monthly Mean Delta Smelt Tissue Selenium Concentration at Prisoners Point, Based on 1922-2003.



Note: Plot only includes mean responses and does not consider model uncertainty. Black diamonds indicate a 1:1 relationship.

Figure 6.1-28. Comparison of Predicted Monthly Mean Delta Smelt Tissue Selenium Concentration at Prisoners Point for NAA and PA Scenarios, In Relation to the 7.2-µg/g Effects Threshold (Red Line).

6.1.3.5.6.1 Migrating Adults (December-March)

6.1.3.5.6.1.1 Individual-Level

As illustrated in the foregoing analysis, the selenium concentration in migrating adult Delta Smelt would be expected to increase somewhat during the December-March period (Figure 6.1-27). However, the potential to exceed the assumed detrimental threshold of 7.2-µg/g selenium whole-body tissue concentration would be limited spatially (San Joaquin River at Prisoner’s Point) and in very few years (Figure 6.1-28).

6.1.3.5.6.1.2 Population-Level Effects

The very limited potential for individual-level effects to Delta Smelt would result in a very low potential for population-level effects.

6.1.3.5.6.2 Spawning Adults (February-June)

6.1.3.5.6.2.1 Individual-Level Effects

Similar to migrating adults, the selenium concentration in spawning adult Delta Smelt (assuming similar rates of selenium transfer as to other motile life stages; see Hung et al. 2014 for discussion of cessation of feeding in females prior to spawning, coupled with greater feeding leading to spawning) would be expected to increase somewhat during the December-March period (Figure 6.1-27). However, the potential to exceed the assumed detrimental threshold of 7.2- µg/g selenium whole-body tissue concentration would be limited spatially (San Joaquin River at Prisoner’s Point) and in very few years during spring (Figure 6.1-28).

6.1.3.5.6.2.2 Population-Level Effects

The very limited potential for individual-level effects to Delta Smelt would result in a very low potential for population-level effects.

6.1.3.5.6.3 Eggs/Embryos (Spring: ~March–June)

6.1.3.5.6.3.1 Individual-Level Effects

Eggs/embryos would not be feeding and therefore would not be exposed to selenium directly. To the extent that selenium is passed from female Delta Smelt to the eggs, the eggs/embryos would have greater selenium under the PA than NAA. However, as previously described for spawning adults, the incidence of exceedance of the 7.2-µg/g selenium whole-body tissue concentration threshold for spawning adults is extremely limited spatially and temporally, suggesting the likelihood of negative effects for eggs/embryos to also be extremely limited. There is, however, uncertainty in the extent to which selenium could be transferred from female Delta Smelt to their eggs.

6.1.3.5.6.3.2 Population-Level Effects

Reflecting the potential for extremely limited individual-level effects, it is concluded that the population-level effects on eggs/embryos would also be extremely limited, although there is uncertainty in the extent to which selenium could be transferred from female Delta Smelt to their eggs.

6.1.3.5.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.5.6.4.1 Individual-Level Effects

As illustrated in Figure 6.1-27, the spring months tend to result in the greatest concentrations of selenium in Delta Smelt tissue, as a result of San Joaquin River inflow to the Delta having the greatest contribution to Delta waters in these months (because of south Delta export restrictions and, in the case of the PA, the HOR gate). Young juvenile Delta Smelt (those that are exogenously feeding) therefore would have a greater risk of accumulating selenium under the PA than NAA. However, as previously described, the risk remains very low relative to the 7.2-µg/g selenium whole-body tissue concentration threshold, which is very rarely exceeded (Figure 6.1-28).

6.1.3.5.6.4.2 Population-Level Effects

Although the spring months have the greatest risk of potential effects compared to other months, and therefore some potential for effects to individual Delta Smelt, the limited spatial extent of the effect (1 of 5 locations) and frequency of occurrence (very few months of the 82 years that were modeled) suggests very little potential for population-level effects.

6.1.3.5.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.5.6.5.1 Individual-Level Effects

As shown in the Prisoner’s Point results broken down by month (Figure 6.1-28), the juvenile Delta Smelt tissue concentration during July–December would be greater under PA than NAA, but well below the 7.2-µg/g selenium whole-body tissue concentration threshold. This indicates the potential for detrimental effects on juvenile Delta Smelt from selenium during these months is extremely low.

6.1.3.5.6.5.2 Population-Level Effects

The potential for population-level effects would be extremely low, following from the extremely low potential for detrimental effects to individuals at 1 of 5 locations examined.

6.1.3.6 Delta Cross Channel

6.1.3.6.1 Migrating Adults (December-March)

6.1.3.6.1.1 Individual-Level Effects

USFWS (2008: 174) suggested that “closures of the DCC for juvenile salmonid protection are likely to create more natural hydrologies in the Delta, by keeping Sacramento River flows in the Sacramento River and Georgiana Slough, which provide flow cues for migrating adult Delta Smelt.” Closure of the DCC would occur during most, if not all, of the December-March upstream migration period of adult Delta Smelt, and essentially would not differ between NAA and PA (see Table 5.A.6-31 in Appendix 5.A *CALSIM Methods and Results*). Therefore any individual-level effects on adult Delta Smelt (e.g., flow cues for migration) would be similar between NAA and PA.

6.1.3.6.1.2 Population-Level Effects

As noted for individual-level effects, any population-level effects of DCC closure (e.g., providing flow cues for migrating adult Delta Smelt) would be similar between NAA and PA scenarios.

6.1.3.6.2 Spawning Adults (February-June)

6.1.3.6.2.1 Individual-Level Effects

Given that the main effect of DCC operations on adult Delta Smelt may be on migrating adults (U.S. Fish and Wildlife Service 2008: 174), as discussed above, there would be limited potential for DCC operations to affect individual spawning adults, which presumably would be much less limited in terms of movements and may be holding near spawning locations. Any effect would be very similar for NAA and PA (see Table 5.A.6-31 in Appendix 5.A *CALSIM Methods and Results*).

6.1.3.6.2.2 Population-Level Effects

The limited potential for individual-level effects of DCC operations on spawning adult Delta Smelt would result in minimal potential for population-level effects, with any effects being similar between NAA and PA.

6.1.3.6.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.6.3.1 Individual-Level Effects

Given that the DCC's principal effects would be on the motile life stages of Delta Smelt (by changing flows in Delta channels), the demersal and adhesive egg/embryo life stage would not be affected by DCC operations.

6.1.3.6.3.2 Population-Level Effects

Lack of individual-level effects from DCC operations on Delta Smelt eggs/embryos means that there would be no population-level effects.

6.1.3.6.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.6.4.1 Individual-Level Effects

USFWS (2008: 174) noted that "Larval and juvenile Delta Smelt are probably not strongly affected by the DCC if it is closed or open. Previous PTM modeling done for the [Smelt Working Group] has shown that having the DCC open or closed does not significantly affect flows in the Central Delta (Kimmerer and Nobriga 2008). There could be times, however, when the DCC closure affects Delta Smelt by generating flows that draw them into the South Delta." Any such effects are captured in the PTM modeling that was undertaken in relation to south Delta entrainment (Section 6.1.3.3.1.4, *Larvae/Young Juveniles (Spring: March-June)*). There would be little to no difference in DCC operations between NAA and PA, with the DCC only being for an average of 5 days more under PA in wet years (see Table 5.A.6-31 in Appendix 5.A *CALSIM Methods and Results*).

6.1.3.6.4.2 Population-Level Effects

Given the limited potential for DCC operations to affect individual larval/young juvenile Delta Smelt (U.S. Fish and Wildlife Service 2008: 174), there would be expected to be a minimal population-level effect which would essentially not differ between NAA and PA.

6.1.3.6.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.6.5.1 Individual-Level Effects

Given that the main effect of DCC operations would be to change the quantity of Sacramento River flow entering the interior Delta (central/south Delta), there would be expected to be minimal effects to juvenile Delta Smelt given that habitat suitability in this area is low during this portion of the life history (Nobriga *et al.* 2008). In the fall, the DCC may be open somewhat more often under the PA (see Section 6.1.3.3.1.4, *Larvae/Young Juveniles (Spring: March-June)*).). This is because of several operational criteria described in Section 5.A.5.1.4.2 of Appendix 5.A *CALSIM Methods and Results*. The CalSim modeling showed that in September of ~20% of years, sufficient water was exported by the NDD that the 25,000-cfs threshold for closure of the DCC is not exceeded, whereas it is exceeded under the NAA in the same years and results in closure of the DCC more than under PA (see Table 5.A.6-31 in Appendix 5.A). Additionally, in October-November, reservoir releases later in the year under the NAA triggered the 7,500-cfs Sacramento River at Wilkins Slough threshold assumed to coincide with juvenile salmon migration into the Delta, which resulted in a greater number of days with DCC closed under NAA. Last, the DCC may also have been open more under the PA to maintain water quality conditions per D-1641 (Rock Slough salinity standard). However, given that most juvenile Delta Smelt would be expected to be in the low-salinity zone or in the Cache Slough area during this time period, any effects would be expected to be limited; the extent and location of the low-salinity zone would not differ between NAA and PA during September-December, as shown in the analysis of abiotic habitat for juvenile Delta Smelt (Section 6.1.3.5.1.1, *Juveniles (Fall: September-December)*).

6.1.3.6.5.2 Population-Level Effects

The limited potential for DCC gate operations on individual juvenile Delta Smelt would result in minimal potential for effect at the population level, and this would be similar between NAA and PA.

6.1.3.7 Suisun Marsh Facilities[24]

6.1.3.7.1 Suisun Marsh Salinity Control Gates

6.1.3.7.1.1 Migrating Adults (December-March)

6.1.3.7.1.1.1 Individual-Level Effects

Migrating adult Delta Smelt may be entrained behind the SMSCG when the SMSCG are closed (U.S. Fish and Wildlife Service 2008: 218), with operations expected to occur during ~10-20 days per year based on recent historical observations (Section 3.3.2.5.1, *Suisun Marsh Salinity Control Gates*). As further described by USFWS (2008: 218), “Fish may enter Montezuma Slough from the Sacramento River when the gates are open to draw freshwater into the marsh and then may not be able to move back out when the gates are closed. It is not known whether this harms Delta Smelt in any way, but they could be exposed to predators hovering around the SMSCG or they could have an increased risk of exposure to water diversions in the marsh” (see subsequent sections for effects of the RRDS, MIDS, and Goodyear Slough outfall). USFWS (2008: 218) also noted that “The degree to which movement around the LSZ is constrained by opening and closing the SMSCG is unknown.” Any effects of the SMSCG on Delta Smelt

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[24] The independent review panel report for the working draft BA recommended 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 (Simenstad et al. 2016). The analysis included herein considers the main aspects of the Suisun Marsh facilities that were identified to be of relevance to Delta Smelt by USFWS (2008). Although further analysis of the type recommended by the independent review panel report is possible, such an analysis is not included herein because of the overall similarity in Suisun Marsh facility operations between the NAA and PA.

movement in Montezuma Slough would be similar between NAA and PA, based on the December-March flows in Montezuma Slough just upstream of the SMSCG being similar (see Table 5.B.5-29 in Appendix 5.B *DSM2 Modeling and Results*).

USFWS (2008: 219) also noted that SMSCG affects the distribution of the LSZ (indexed by X2), causing it to shift upstream for a given level of Delta inflow and exports, which could affect susceptibility to entrainment at the south Delta export facilities. However, as noted by USFWS (2008: 219), operations to meet D-1641 would limit such potential effects; these operations would be undertaken under the NAA and PA, and are reflected in there being little meaningful difference between NAA and PA in X2 during December-March (see Table 5.A.6-29 in Appendix 5.A, *CALSIM Methods and Results*).

6.1.3.7.1.1.2 Population-Level Effects

Given that the SMSCG would be expected to be operated for no more than around 10-20 days per year, this may limit potential population-level effects on migrating adult Delta Smelt. As described in the individual-level effects, any effects would be expected to be similar between NAA and PA.

6.1.3.7.1.2 Spawning Adults (February-June)

6.1.3.7.1.2.1 Individual-Level Effects

Spawning adult Delta Smelt would be less susceptible to the effects of the SMSCG than migrating adult Delta Smelt because they would not be undertaking the broad-scale movements of migrating adults. Movement may still be restricted, however, and near-field effects (e.g., predation) similar to those suggested by USFWS (2008: 218) could occur. Any such effects would be similar for NAA and PA based on the February-June flows in Montezuma Slough just upstream of the SMSCG being similar (see Table 5.B.5-29 in Appendix 5.B, *DSM2 Modeling and Results*).

6.1.3.7.1.2.2 Population-Level Effects

Given the relatively limited area of effect for the SMSCG in terms of affecting spawning adult Delta Smelt, relative to the overall area of potential spawning habitat, it may be that there would be minimal population-level effects on spawning adult Delta Smelt from the SMSCG; the magnitude of any effects would be similar for the NAA and PA.

6.1.3.7.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.7.1.3.1 Individual-Level Effects

Operation of the SMSCG would not affect Delta Smelt eggs/embryos, which as previously noted are demersal and adhesive.

6.1.3.7.1.3.2 Population-Level Effects

The lack of individual-level effects means that there would be no population-level effects of the SMSCG on Delta Smelt eggs/embryos.

6.1.3.7.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.7.1.4.1 Individual-Level Effects

As noted for adult Delta Smelt life stages, operation of the SMSCG could trap larval/young juvenile Delta Smelt in Montezuma Slough downstream of the SMSCG, with resultant near-field (e.g., predation) and far-field (greater entrainment susceptibility at diversions within Suisun Marsh; see subsequent sections). Any such effects would be similar for NAA and PA based on the March-June flows in Montezuma Slough just upstream of the SMSCG being similar (see Table 5.B.5-29 in Appendix 5.B, *DSM2 Modeling and Results*).

6.1.3.7.1.4.2 Population-Level Effects

Given that the range of habitat that can be occupied by larval/young juvenile Delta Smelt is large compared to the area affected by the SMSCG, as well as the similarity of NAA and PA operations of the SMSCG in a manner consistent with recent operations, any population-level effects of the SMSCG on larval/young juvenile Delta Smelt would be expected to be small and would not differ between NAA and PA.

6.1.3.7.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.7.1.5.1 Individual-Level Effects

Similar effects to those noted for adult Delta Smelt could also occur for juvenile Delta Smelt with respect to SMSCG operations, *i.e.*, near-field predation or movement blockage, as well as susceptibility to effects of Suisun Marsh diversions. Any such effects would be similar for NAA and PA based on the July-December flows in Montezuma Slough just upstream of the SMSCG being similar (see Table 5.B.5-29 in Appendix 5.B, *DSM2 Modeling and Results*). As described for migrating adult Delta Smelt, USFWS (2008: 218) emphasized the potential upstream shift in the low salinity zone (indexed by X2) that is associated with SMSCG operations, for a given Delta inflow and exports. However, the analysis of abiotic fall rearing habitat presented in Section 6.1.3.5.1.1, *Juveniles (Fall: September-December)* illustrated that X2 and the low salinity zone would be similar between NAA and PA, reflecting adherence of both scenarios to the USFWS (2008) BiOp RPA requiring fall X2 management.

6.1.3.7.1.5.2 Population-Level Effects

The relatively few days (~10-20) which the SMSCG might be operated, coupled with SWP/CVP management of X2 for juvenile Delta Smelt fall rearing habitat per the USFWS (2008) BiOp RPA, suggests that there would be minimal population-level effects of the SMSCG on juvenile Delta Smelt, and that these would not differ between NAA and PA.

6.1.3.7.2 Roaring River Distribution System

6.1.3.7.2.1 Migrating Adults (December-March)

6.1.3.7.2.1.1 Individual-Level Effects

The Roaring River Distribution System (RRDS)'s water intake (eight 60-inch-diameter culverts) is equipped with fish screens (3/32-inch opening, or 2.4 mm) operated to maintain screen approach velocity of 0.2 ft/s for Delta Smelt protection, eliminating the risk of entrainment and minimizing the risk of impingement, so that any potential adverse effects to individual migrating adult Delta Smelt would be minimal.

6.1.3.7.2.1.2 Population-Level Effects

There would be expected to be essentially no population-level effects from the RRDS on migrating adult Delta Smelt.

6.1.3.7.2.2 Spawning Adults (February-June)

6.1.3.7.2.2.1 Individual-Level Effects

As with migrating adult Delta Smelt, the screens on the RRDS intake would be expected to minimize any potential adverse effects to individual spawning adult Delta Smelt.

6.1.3.7.2.2.2 Population-Level Effects

There would be expected to be essentially no population-level effects from the RRDS on spawning adult Delta Smelt.

6.1.3.7.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.7.2.3.1 Individual-Level Effects

As previously noted, Delta Smelt eggs and embryos are demersal and adhesive, attaching to substrates with an adhesive stalk formed by the outer layer of the egg (Bennett 2005). As such, individual eggs would not be subject to entrainment and there would be no individual-level adverse effect from the RRDS.

6.1.3.7.2.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs means that there would be no adverse population-level effects from the RRDS with respect to entrainment.

6.1.3.7.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.7.2.4.1 Individual-Level Effects

Based on the RRDS screen specifications and applying the methods used for the NDD (Appendix 6.A, *Quantitative Methods for Biological Assessment of Delta Smelt*, Section 6.A.2.2), individual larval and young juvenile Delta Smelt smaller than around 30 mm (SL) could be susceptible to entrainment by the three RRDS intake culverts. Small juveniles slightly larger than this size could be impinged on the screens without being entrained. Prior to screening of the intakes, Pickard *et al.* (1982) found appreciable number of older life stages were entrained[25] which, although partly a function of greater overall abundance of Delta Smelt at the time of the study (1980-1982), suggests that larval/juvenile entrainment also occurs.

6.1.3.7.2.4.2 Population-Level Effects

Any population-level effects on larval/young juvenile Delta Smelt from the RRDS that do occur would be expected to be similar between NAA and PA, and would represent a continuation of existing operations; as previously noted, flows in Montezuma Slough as a result of SMSCG operations were similar for NAA and PA. Entrainment risk into RRDS appears limited, given that DSM2-PTM modeling for the DFG (2009) longfin smelt incidental take permit application did not observe any particles entering RRDS. Therefore, the population-level effect of the RRDS would be expected to be minimal.

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[25] Sampled individuals were 30-100 mm FL, which to some extent would have been a function of the mesh size (3.2 mm) on the fyke nets used on the culverts.

6.1.3.7.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.7.2.5.1 Individual-Level Effects

As with migrating adult Delta Smelt, the screens on the RRDS intake would be expected to minimize any potential adverse effects to individual juvenile Delta Smelt.

6.1.3.7.2.5.2 Population-Level Effects

There would be expected to be minimal, if any, population-level effects from the RRDS on juvenile Delta Smelt.

6.1.3.7.3 Morrow Island Distribution System

6.1.3.7.3.1 Migrating Adults (December-March)

6.1.3.7.3.1.1 Individual-Level Effects

Individual migrating adult Delta Smelt could be entrained by the three unscreened 48-inch intakes that form the MIDS intake. However, Enos *et al.* (2007:17) noted that this would generally only occur in wet years, per Hobbs *et al.* (2005); Enos *et al.* (2007) did not collect any adult Delta Smelt during sampling of the MIDS intake in 2004-2006, although they did capture adult Delta Smelt with purse seines during sampling in the adjacent Goodyear Slough.

6.1.3.7.3.1.2 Population-Level Effects

The population-level effects of the MIDS to migrating adult Delta Smelt would be minimal, if any, given that entrainment would only be expected to occur in wet years. Any entrainment under the PA would also be likely to occur under the NAA, given that operations of the MIDS would not be changing (see Tables 5.B.5-31, 5.B.5-32, and 5.B.5-33 in Appendix 5.B, *DSM2 Modeling and Results*).

6.1.3.7.3.2 Spawning Adults (February-June)

6.1.3.7.3.2.1 Individual-Level Effects

As with migrating adult Delta Smelt, spawning adults would only be susceptible to entrainment at the MIDS in wet years.

6.1.3.7.3.2.2 Population-Level Effects

As with migrating adult Delta Smelt, the population-level effects of the MIDS to spawning adult Delta Smelt would be minimal, if any, given that entrainment would only be expected to occur in wet years; any entrainment would be expected to be similar under NAA and PA.

6.1.3.7.3.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.7.3.3.1 Individual-Level Effects

As previously noted, the demersal and adhesive nature of Delta Smelt eggs/embryos means that they would not be subject to entrainment and there would be no individual-level adverse effect from the MIDS.

6.1.3.7.3.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs/embryos means that there would be no adverse population-level effects from the RRDS with respect to entrainment.

6.1.3.7.3.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.7.3.4.1 Individual-Level Effects

Individual larval/young juvenile Delta Smelt could be entrained by the MIDS, although Enos *et al.* (2007) did not collect any individuals during sampling in 2004-2006. Enos *et al.* (2007: 17) noted that under normal operations, MIDS is often closed or diverting very little during spring, which may provide some protection of spring-spawning and spring-migrating fish, particularly open-water fish like Delta Smelt that do not aggregate around in-stream structures such as diversions.

6.1.3.7.3.4.2 Population-Level Effects

As noted by USFWS (2008: 218), entrainment into MIDS may be unlikely based on particle tracking studies that have demonstrated low entrainment vulnerability for particles released at random locations throughout Suisun Marsh (3.7 percent), and almost no vulnerability (<0.1 percent) to particles released at Rio Vista (Culberson *et al.* 2004). This suggests at most a minimal population-level adverse effect, which would be similar under NAA and PA (see Tables 5.B.5-31, 5.B.5-32, and 5.B.5-33 in Appendix 5.B, *DSM2 Modeling and Results*).

6.1.3.7.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.7.3.5.1 Individual-Level Effects

To the extent that juvenile Delta Smelt occur near the MIDS, they could be entrained, as with other life stages; none were collected during the extensive sampling by Enos *et al.* (2007) during 2004-2006, however.

6.1.3.7.3.5.2 Population-Level Effects

Given the absence of juvenile Delta Smelt in entrainment samples at MIDS by Enos *et al.* (2007), the population-level effect of the MIDS would be expected to be minimal. Any effect would be similar between NAA and PA.

6.1.3.7.4 Goodyear Slough Outfall

6.1.3.7.4.1 Migrating Adults (December-March)

6.1.3.7.4.1.1 Individual-Level Effects

Opening of the Goodyear Slough outfall culvert flap gates results in a small net flow south, with fresher water from Suisun Slough being drawn into Goodyear Slough. Although this may increase the possibility of entry of migrating adult Delta Smelt into Goodyear Slough, and therefore increases the potential for entrainment by the MIDS intakes (as previously discussed), operation of the flap gates also improves circulation and therefore may provide a beneficial effect.

6.1.3.7.4.1.2 Population-Level Effects

As discussed previously for MIDS, the available sampling data in the area suggest that migrating adult Delta Smelt would only be susceptible to effects from the Goodyear Slough outfall in wet years (Enos *et al.* 2007), and at most only a minimal population-level effect would therefore be likely to occur, with this effect being common to NAA and PA on the basis of similar flows in Goodyear Slough (see Table 5.B.5-34 in Appendix 5.B, *DSM2 Modeling and Results*).

6.1.3.7.4.2 Spawning Adults (February-June)

6.1.3.7.4.2.1 Individual-Level Effects

As with migrating adults, potential effects to individuals include entrainment into Goodyear Slough and therefore more potential for entrainment by MIDS, as well as beneficial effects from improved circulation.

6.1.3.7.4.2.2 Population-Level Effects

As discussed for migrating adults, the available information suggests that the population-level effect of the Goodyear Slough outfall would be minimal because of infrequent Delta Smelt occurrence in the area, with the effect not differing between NAA and PA.

6.1.3.7.4.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.7.4.3.1 Individual-Level Effects

Eggs/embryos would not be susceptible to any entrainment effects from the Goodyear Slough outfall, but may experience improved circulation because of flap gate operations which may be beneficial during incubation.

6.1.3.7.4.3.2 Population-Level Effects

As noted for adult Delta Smelt, only a small portion of Delta Smelt eggs/embryos would be expected to occur in Goodyear Slough (*i.e.*, possibly only in wet years), so the population-level effects of the Goodyear Slough outfall would be small and similar between NAA and PA.

6.1.3.7.4.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.7.4.4.1 Individual-Level Effects

As with adult Delta Smelt, operation of the Goodyear Slough outfall could increase entrainment into Goodyear Slough and therefore give more potential for entrainment by MIDS, as well as providing beneficial effects from improved circulation.

6.1.3.7.4.4.2 Population-Level Effects

As noted for adult Delta Smelt and in the analysis of the effects of the MIDS, only a small portion of Delta Smelt larvae/young juveniles would be expected to occur in Goodyear Slough, at most resulting in small population-level effects that would be similar between NAA and PA.

6.1.3.7.4.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.7.4.5.1 Individual-Level Effects

Similar to adult Delta Smelt, operation of the Goodyear Slough outfall could increase entrainment into Goodyear Slough of juvenile Delta Smelt and therefore give more potential for entrainment by MIDS, as well as providing beneficial effects from improved circulation.

6.1.3.7.4.5.2 Population-Level Effects

As concluded for other life stages, only a small portion of Delta Smelt juveniles would be expected to occur in Goodyear Slough, resulting in no more than a small population-level effect that would be similar between NAA and PA.

6.1.3.8 North Bay Aqueduct

6.1.3.8.1 Migrating Adults (December-March)

6.1.3.8.1.1 Individual-Level Effects

As noted by USFWS (2008: 217), the NBA fish screen at the Barker Slough pumping plant was designed to exclude Delta Smelt larger than 25 mm and as such would be expected to exclude migrating adult Delta Smelt from being entrained by the NBA. As described in section 3.3.2.6, *Operational Criteria for the North Bay Aqueduct Intake*, the intake is screened to comply with Delta Smelt screening criteria, which would be expected to limit the potential for entrainment and impingement. If predatory fish are concentrated near the fish screen, Delta Smelt that are excluded from being screened could be susceptible to increased predation. Pumping rates at the North Bay Aqueduct Barker Slough Intake generally would be similar under the NAA and PA (see Table 5.B.5-35 in Appendix 5.B, *DSM2 Modeling and Results*), so the potential risk of impingement and predation may also be similar.

6.1.3.8.1.2 Population-Level Effects

Exclusion of migrating adult Delta Smelt by the fish screens at the Barker Slough pumping plant, coupled with predation risk being similar between the NAA and PA, would greatly limit the potential for adverse effects from the NBA, so that population-level effects would be minimal.

6.1.3.8.2 Spawning Adults (February-June)

6.1.3.8.2.1 Individual-Level Effects

As with migrating adult Delta Smelt, the Barker Slough pumping plant’s fish screen would exclude spawning adult Delta Smelt from entrainment into the NBA, with some potential for impingement and predation that would be similar between NAA and PA.

6.1.3.8.2.2 Population-Level Effects

As with migrating adult Delta Smelt, exclusion of spawning adult Delta Smelt by the fish screens at the Barker Slough pumping plant, coupled with impingement and predation risk being similar between the NAA and PA, so that population-level effects would be minimal.

6.1.3.8.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.8.3.1 Individual-Level Effects

As previously noted, the demersal and adhesive nature of Delta Smelt eggs/embryos means that they would not be subject to entrainment and there would be no individual-level adverse effect from the NBA.

6.1.3.8.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs/embryos means that there would be no adverse population-level effects from the NBA with respect to entrainment.

6.1.3.8.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.8.4.1 Individual-Level Effects

Larval and young juvenile Delta Smelt could be subject to entrainment at the Barker Slough pumping plant, given that the fish screen excludes Delta Smelt of 25 mm and greater; as noted for the NDD, individuals slightly greater than 25 mm could experience adverse effects from impingement. However, as noted by USFWS (2008: 217), a study of a fish screen built to Delta

Smelt standards in Horseshoe Bend on the Sacramento River found that over 99% of fish were excluded from entrainment, even though most fish were only 15-25 mm long (Nobriga *et al.* 2004); USFWS (2008: 217) concluded on that basis that the fish screen at the NBA may protect many, if not most, of the Delta Smelt larvae that hatch and rear in Barker Slough.

6.1.3.8.4.2 Population-Level Effects

As previously discussed in Section 6.1.3.3.1.4, *Larvae/Young Juveniles (Spring: March-June)*). the DSM2-PTM analysis of larval Delta Smelt entrainment showed that in general, estimated entrainment at the NBA under the PA and NAA was similar (Table 6.1-14), reflecting the fact that operational criteria would not differ between NAA and PA. Therefore any adverse effects would be similar between scenarios.

6.1.3.8.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.8.5.1 Individual-Level Effects

As with adult Delta Smelt, juvenile Delta Smelt would be expected to be excluded from entrainment at the NBA by the fish screens of the Barker Slough pumping plant, although some impingement and near-field predation could occur. Pumping rates at the North Bay Aqueduct Barker Slough Intake generally would be similar under the NAA and PA (see Table 5.B.5-35 in Appendix 5.B, *DSM2 Modeling and Results*), so the potential risk of impingement and predation may also be similar.

6.1.3.8.5.2 Population-Level Effects

Exclusion of juvenile Delta Smelt by the fish screens at the Barker Slough pumping plant would avoid adverse population-level effects from NBA diversions in terms of entrainment, and generally similar pumping between NAA and PA would limit the potential for near-field predation and impingement risk.

6.1.3.9 Other Facilities

6.1.3.9.1 Contra Costa Canal Rock Slough Intake

6.1.3.9.1.1 Migrating Adults (December-March)

6.1.3.9.1.1.1 Individual-Level Effects

The 1.75-mm-opening, 0.2 ft/s-approach-velocity fish screen installed at the Rock Slough intake is intended to prevent entrainment of Delta Smelt into the Contra Costa Canal. However, the 4 mechanical rakes making up the screen cleaning system are unable to handle the large amount of aquatic vegetation that ends up on the fish screen (National Marine Fisheries Service 2015a: 2), leading to operation of the fish screen only on ebb tides (National Marine Fisheries Service 2015b). At these times, migrating adult Delta Smelt could be susceptible to entrainment. The operational issues with the fish screen have led Reclamation to test alternative technology (a prototype rake) to improve vegetation removal, an action that NMFS (2015a: 4) concluded would improve fish protection (*i.e.*, screen efficiency) by minimizing the chance a listed fish would be entrained or impinged on the fish screen. In addition, mechanical removal of aquatic weeds within Rock Slough in 2015 to facilitate testing of the new rake design was expected by NMFS (2015b: 4) to improve screen efficiency, reduce predation of juvenile salmonids by vegetation-associated predatory fishes, and reduce adult salmonid mortality during screen maintenance. During the December-March period of most relevance to migrating adult Delta Smelt, Rock Slough intake diversions would be very similar between NAA and PA, indicating that the potential for adverse effects to migrating adult Delta Smelt would be similar under the PA compared to NAA. Resolution of the aforementioned issues with screen effectiveness would be expected to minimize the potential for any adverse effects to individual migrating adult Delta Smelt.

6.1.3.9.1.1.2 Population-Level Effects

USFWS (2008: 217) noted that Rock Slough is a dead-end slough with poor habitat for Delta Smelt, so the numbers of Delta Smelt using Rock Slough are usually low, as reflected in very few Delta Smelt having been collected during sampling at the intake. This, combined with relatively small diversions that are very similar between NAA and PA (see discussion in the Individual-Level Effects) suggests that any population-level effect of the Rock Slough intake on migrating adult Delta Smelt would be minimal.

6.1.3.9.1.2 Spawning Adults (February-June)

6.1.3.9.1.2.1 Individual-Level Effects

The issues discussed for migrating adult Delta Smelt with respect to screen effectiveness of the Rock Slough intake also apply to spawning adult Delta Smelt. Modeled pumping of the Rock Slough intake suggested that diversions under the PA generally would be similar to NAA in February, March and June, but not in April and May, when diversions were modeled to be greater under the PA (see Table 5.B.5-36 in Appendix 5.B, *DSM2 Modeling and Results*). The overall diversions for the Rock Slough intake and the other CCWD intakes on Old River and Middle River do not differ greatly between NAA and PA, suggesting that Rock Slough may have been favored in the modeling of PA for operational reasons, e.g., Old and Middle River flow criteria, for example. This could indicate greater potential for adverse effects to spawning adult Delta Smelt under the PA compared to NAA. However, as noted for migrating adult Delta Smelt, resolution of the aforementioned issues with screen effectiveness would be expected to minimize the potential for any adverse effects to individual spawning adult Delta Smelt.

6.1.3.9.1.2.2 Population-Level Effects

As described for migrating adult Delta Smelt, it would be expected that there would be minimal, if any, population-level effects on spawning adult Delta Smelt because Delta Smelt appear to occur in low numbers in Rock Slough, as a result of poor habitat (U.S. Fish and Wildlife Service 2008: 217).

6.1.3.9.1.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.9.1.3.1 Individual-Level Effects

As previously noted, the demersal and adhesive nature of Delta Smelt eggs/embryos means that they would not be subject to entrainment and there would be no individual-level adverse effect from the Rock Slough intake.

6.1.3.9.1.3.2 Population-Level Effects

The demersal and adhesive nature of Delta Smelt eggs/embryos means that there would be no adverse population-level effects from the NBA with respect to entrainment.

6.1.3.9.1.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.9.1.4.1 Individual-Level Effects

As noted in the previous discussions for adult Delta Smelt, there have been operational issues with the Rock Slough intake's effectiveness. Regardless of these issues, some larval and juvenile Delta Smelt could be sufficiently small to not be screened by the Rock Slough intake's fish screen, which would be expected to exclude fish of ~22 mm (see Section 6.1.3.2.1.1.1, *Individual-Level Effects*, related to the NDD). Modeled pumping of the Rock Slough intake suggested that diversions under the PA generally would be similar to NAA in March and June, but not in April and May, when diversions would be greater under the PA (see Table 5.B.5-36 in Appendix 5.B, *DSM2 Modeling and Results*). The overall diversions for the Rock Slough intake and the other CCWD intakes on Old River and Middle River do not differ greatly between NAA and PA, suggesting that Rock Slough may have been favored in the modeling of PA for operational reasons, e.g., Old and Middle River flow criteria, for example. Operation of the Rock Slough intake would be included in the no-fill and no-diversion periods associated with all diversions for CCWD, which would minimize the potential for larval entrainment.

6.1.3.9.1.4.2 Population-Level Effects

As noted by USFWS (2008: 224), larval fish monitoring found few larval Delta Smelt being entrained at the Rock Slough intake, which suggests that any population-level effect of the intake would be very small, particularly in light of the no-fill and no-diversion criteria that are in place to protect listed species during spring.

6.1.3.9.1.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.9.1.5.1 Individual-Level Effects

Potential effects to juvenile Delta Smelt would be similar to those previously discussed for adult Delta Smelt in terms of potential entrainment. Diversions at the Rock Slough intake would be essentially the same under PA as NAA during July-December (see Table 5.B.5-36 in Appendix 5.B, *DSM2 Modeling and Results*), so any entrainment would be expected to be similar.

6.1.3.9.1.5.2 Population-Level Effects

There would be expected to be minimal, if any, population-level effect from diversions at the Rock Slough intake during the juvenile Delta Smelt life stage because habitat suitability in Rock Slough generally is poor for Delta Smelt (USFWS: 217), and abiotic habitat conditions in the summer in the south Delta also are poor for Delta Smelt (Nobriga *et al.* 2008).

6.1.3.9.2 Clifton Court Forebay Aquatic Weed Control Program

6.1.3.9.2.1 Migrating Adults (December-March)

6.1.3.9.2.1.1 Individual-Level Effects

Herbicide treatment of aquatic weeds in Clifton Court Forebay in July/August would avoid potential effects to Delta Smelt migrating adults because treatment would occur well after migration was complete. Mechanical removal of aquatic weeds in Clifton Court Forebay would occur on an as needed basis and therefore could coincide with occurrence of migrating adult Delta Smelt. Delta Smelt generally would not be expected to found near aquatic weeds (Ferrari *et al.* 2014), but may occur near the weeds if both fish and weeds are concentrated into particular areas by prevailing water movement in the Forebay. Any potential adverse effects to individual Delta Smelt from mechanical removal of water hyacinth or other aquatic weeds (e.g., injury from contact with cutting blades) possibly would be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency at the Skinner Fish Delta Fish Protective Facility because of reduced smothering by weeds.

6.1.3.9.2.1.2 Population-Level Effects

Given the mixture of potential adverse and beneficial effects from mechanical removal of aquatic weeds in Clifton Court Forebay, it is unlikely that there would be a population-level effect on migrating adult Delta Smelt.

6.1.3.9.2.2 Spawning Adults (February-June)

6.1.3.9.2.2.1 Individual-Level Effects

Herbicide treatment of aquatic weeds in Clifton Court Forebay in July/August would avoid potential effects to Delta Smelt spawning adults because any spawning adults present in the Forebay would occur earlier in the year. Any mechanical removal effects would be as described for migrating adults.

6.1.3.9.2.2.2 Population-Level Effects

As described for migrating adults, it is unlikely that there would be a population-level effect on spawning adult Delta Smelt from mechanical removal of aquatic weeds in Clifton Court Forebay.

6.1.3.9.2.3 Eggs/Embryos (Spring: ~March-June)

6.1.3.9.2.3.1 Individual-Level Effects

Herbicide treatment of aquatic weeds in Clifton Court Forebay in July/August would avoid potential effects to Delta Smelt eggs/embryos because eggs/embryos would occur earlier in the year. Mechanical removal of aquatic weeds on an as-needed basis could coincide with egg/embryo occurrence, but may be limited in effect if focusing on water hyacinth in the upper water column, which would avoid eggs/embryos adhering to benthic substrates.

6.1.3.9.2.3.2 Population-Level Effects

Any population-level adverse effects from physical predator reduction methods at Clifton Court Forebay would be minimal to nil, given the lack of temporal and spatial overlap for potential individual-level effects and the low probability of eggs/embryos to survive the salvage process in subsequent life stages.

6.1.3.9.2.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.3.9.2.4.1 Individual-Level Effects

As with adults and eggs/embryos, larval/young juvenile Delta Smelt would not temporally overlap the period of herbicide treatment of aquatic weeds in Clifton Court Forebay (July-August). Mechanical removal effects may be similar to those noted previously for migrating adult Delta Smelt.

6.1.3.9.2.4.2 Population-Level Effects

Population-level effects from mechanical removal at Clifton Court Forebay would be essentially zero, given the mixture of potential adverse and beneficial effects and the low probability of larvae/young juveniles to survive the salvage process.

6.1.3.9.2.5 Juveniles (Summer/Fall: ~July-December)

6.1.3.9.2.5.1 Individual-Level Effects

There would be essentially no potential for individual juvenile Delta Smelt to be adversely affected by either herbicide treatment or mechanical removal of aquatic weeds because this life stage occurs outside of Clifton Court Forebay; Delta Smelt that are susceptible to entrainment into Clifton Court Forebay are either migrating adults or larvae/young juveniles, and the waters in the Forebay would be expected to become too warm for juvenile Delta Smelt by July.

6.1.3.9.2.5.2 Population-Level Effects

Following from the lack of individual-level effects, there would be no population-level effect on juvenile Delta Smelt.

6.1.3.10 Effects from Water Facility Operations on Delta Smelt Critical Habitat

The assessment of effects from water facility operations on Delta Smelt critical habitat presented in this section follows the basic structure of the analyses of Individual-Level and Population-Level effects presented in Sections 6.1.3.2 to 6.1.3.9, with the effects generally analyzed by facility. One exception is Section 6.1.3.10.4, *Habitat Effects*, which discusses the effects to critical habitat in relation to the factors discussed in Section 6.1.3.5, *Habitat Effects, i.e.*, abiotic habitat, water temperature, sediment removal, and *Microcystis*.

6.1.3.10.1 North Delta Exports

6.1.3.10.1.1 PCE 1: Physical Habitat (Spawning Substrate)

The potential effect of north Delta exports on spawning substrate could occur only if the NDD remove enough sand from the inflowing sediment load (over several decades of operation) to significantly change the location or quantity of existing sandy beaches, as discussed further in Section 6.1.3.10.4.1. The ability of migrating adult Delta Smelt to access spawning substrate upstream of the NDD could be affected by changes in river flow/velocity near the NDD; see discussion for PCE 3.

6.1.3.10.1.2 PCE 2: Water (Quality)

Water that otherwise would be of suitable quality for Delta Smelt may be affected by the loss of low-velocity habitat to the NDD, which make them susceptible to injury or death by entrainment, impingement, or screen contact, and could affect access to habitat at and upstream of the NDD. This is discussed further in relation to PCE 3. In addition, enhanced predation along the NDD could affect the function of PCE 2. Potential effects to other aspects of PCE 2 such as sediment removal (influencing water clarity) and entrainment of food web materials are discussed in Section 6.1.3.10.4, *Habitat Effects*.

6.1.3.10.1.3 PCE 3: River Flow (Facilitating Movement)

The NDD would affect the river flow PCE 3 by changing water velocity, which could make Delta Smelt susceptible to entrainment (smaller life stages), impingement, or screen contact, which could result in injury or death, although their potential to occur in the vicinity of the NDD is very low. Any effects would be avoided and minimized by the location of the NDD, as well as screen design and operational criteria (e.g., 0.2 ft/s approach velocity), with final design subject to review and approval by the fish and wildlife agencies (i.e., USFWS, NMFS, and CDFW) (see Section 3.2.2.2 *Fish Screen Design*). As assessed in Section 6.1.3.2.2.1 *Migrating Adults*

(December-March), for effects to migrating adult Delta Smelt, the higher velocity habitat along the screens of the NDD would be likely to reduce, along the east bank of the Sacramento River, the probability of accessing upstream designated critical habitat—which extends to the upstream boundary of the statutory Delta at the I Street Bridge in Sacramento—for Delta Smelt. This habitat is likely to have limited value to Delta Smelt, other than perhaps providing a relatively small area of spawning habitat. The extent to which the PA could limit access to the relatively small area of upstream critical habitat would depend on the extent that Delta Smelt would use lower velocity habitat on the right (west) bank of the river (opposite the NDD), near the channel bottom, or within the refugia along the intakes. Due to these considerations, the PA is not considered to appreciably diminish the overall critical habitat value for both survival and recovery of Delta Smelt in regards to PCE 3. However, recognizing the potential effect to partially limit access of designated critical habitat upstream of the NDD, the PA includes compensation by providing 245 acres of shallow water habitat restoration, of which 108 acres would be sandy beach habitat (see Section 3.4.2 *Conservation Measures*). The 108 acres represents a 3:1 mitigation ratio of an estimate of 36 acres of sandy beach habitat (PCE 1) from the lowermost extent of intake 5 to the upstream boundary of designated critical habitat, based on examination of aerial photographs.

6.1.3.10.1.4 PCE 4: Salinity (Low Salinity Zone)

The location and extent of the low salinity zone is determined by Delta outflow, which would be affected by north and south Delta exports combined. See the discussion related to PCE 4 in Section 6.1.3.10.4.4 *PCE 4: Salinity (Low Salinity Zone).*

6.1.3.10.2 South Delta Exports

6.1.3.10.2.1 PCE 1: Physical Habitat (Spawning Substrate)

Spawning substrate would not be affected by operations of the south Delta export facilities.

6.1.3.10.2.2 PCE 2: Water (Quality)

The general reduction in entrainment risk for Delta Smelt under the PA with respect to the south Delta export facilities, as a result of less south Delta pumping and improved south Delta hydrodynamic conditions, would be expected to beneficially affect the water quality PCE. Although there would still be an effect to PCE 3 because of the PA, it would be less than under NAA.

6.1.3.10.2.3 PCE 3: River Flow (Facilitating Movement)

As with PCE 2, less south Delta pumping and improved south Delta hydrodynamic conditions would be expected to beneficially modify the river flow PCE. Although there would still be an effect to PCE 3 because of the PA, it would be less than under NAA.

6.1.3.10.2.4 PCE 4: Salinity (Low Salinity Zone)

The location and extent of the low salinity zone is determined by Delta outflow, which would be affected by north and south Delta exports combined. See the discussion related to PCE 4 in Section 6.1.3.10.4.4, *PCE 4: Salinity (Low Salinity Zone).*

6.1.3.10.3 Head of Old River Gate Operations

6.1.3.10.3.1 PCE 1: Physical Habitat (Spawning Substrate)

Spawning substrate would not be affected by operations of the HOR gate.

6.1.3.10.3.2 PCE 2: Water (Quality)

Operations of the HOR gate have some potential to affect the water PCE, e.g., by affecting susceptibility to entrainment at the south Delta export facilities (see PCE 3 discussion) when water quality is otherwise suitable, and affecting water temperature (see discussion for PCE 2 in Section 6.3.10.4, *Habitat Effects (Combined North/South Delta Exports*).

6.1.3.10.3.3 PCE 3: River Flow (Facilitating Movement)

As demonstrated in the analysis of larval/young juvenile entrainment, closure of the HOR gate has the potential to affect river flow in the south Delta, and therefore the risk of entrainment. The CALSIM II modeling to support the PA indicates that OMR flow rules can be met with the proposed HOR gates closed up to 50% of the time during the spring months.

6.1.3.10.3.4 PCE 4: Salinity (Low Salinity Zone)

Head of Old River gate operations would not affect the extent or location of the low salinity zone nursery habitat.

6.1.3.10.4 Habitat Effects

6.1.3.10.4.1 PCE 1: Physical Habitat (Spawning Substrate)

The spawning microhabitat of Delta Smelt is not presently known, but the current conceptual model is that it is sandy beaches (Bennett 2005). If this conceptual model is correct, spawning substrate would only be modified by water operations if they remove enough sand from the inflowing sediment load (over several decades of operation) to significantly change the location or quantity of existing sandy beaches. Whether or not this would happen cannot be accurately estimated without use of a full suspended sediment model. As described in 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 Water Control Board and USACE). This would mitigate the effects of sediment removal by the NDD.

6.1.3.10.4.2 PCE 2: Water (Quality)

As noted in the effects by life stages presented in Section 6.1.3.5.2, *Water Temperature*, water temperature under the PA could be somewhat greater than under the NAA for spawning, larval/young juvenile, and juvenile Delta Smelt. In general it is expected that air temperature is the main driver on water temperature in the Delta, as shown by detailed temperature modeling that does not include the effects of flow and has higher correspondence with observed temperatures than DSM2-QUAL estimates (Wagner *et al.* 2011); therefore, the effects to PCE 2 may be limited.

Water transparency is a key habitat attribute for Delta Smelt. Thus, any reduction in sediment entering the Delta because of entrainment at the NDD that is sufficient to increase water clarity would affect the water quality PCE. Whether or not this would happen cannot be accurately estimated without use of a full suspended sediment model, and may be a long-term effect. As noted for PCE 1, 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, which would be intended to minimize potential effects to PCE 2.

Entrainment of phytoplankton carbon by the NDD, if not sufficiently offset by potential decreases in south Delta entrainment of the same materials and in-Delta production, would have the potential to decrease the availability of prey for Delta Smelt by reducing food available for Delta Smelt prey. As described in Section 6.1.3.5.4, *Entrainment of Food Web Materials*, in general only a small percentage (5% or less) of the standing stock of phytoplankton would be expected to be entrained in this manner, so the effect to PCE 2 may be limited.

Greater prevalence of *Microcystis* because of operational effects under the PA relative to NAA has the potential to affect the water quality PCE in some Delta channels (see Section 6.1.3.5.5, *Microcystis*). As noted in Section 6.1.3.5.5.5.2, *Population-Level Effects,* the modeling currently assumes that in the summer months (July–September), the first 3,000 cfs of exports would be from the south Delta, with any additional allowable exports able to be diverted from either the north or the south Delta, and preference for this additional pumping generally is given to the north Delta (because of higher water quality); it would be possible to shift to additional south Delta pumping as opposed to north Delta pumping in order to reduce water residence time, which may reduce the potential for effects of *Microcystis*.

6.1.3.10.4.3 PCE 3: River Flow (Facilitating Movement)

The potential effects to PCE 3 with respect to the winter/spring periods during which time Delta Smelt may be susceptible to entrainment, impingement, and other effects from north and south Delta exports were presented in Sections 6.1.3.10.1.3, *PCE3: River Flow (Facilitating Movement)* and 6.1.3.10.2.3. During the fall rearing period for juvenile Delta Smelt, the PA proposes essentially the same Delta outflow as the NAA, so this PCE would not be affected (see Section 6.1.3.5.1, *Abiotic Habitat*).

6.1.3.10.4.4 PCE 4: Salinity (Low Salinity Zone)

As discussed for PCE 3, the PA proposes the same Delta outflow criteria as the NAA during the period of juvenile fall rearing that may occur within the low salinity zone, so this PCE would not be affected during this period (i.e., mean September-December conditions). As previously described in the introduction to section 6.1, *Effects on Delta Smelt*, USFWS noted with respect to PCE 4 that “At all times of year, the location of X2 influences both the area and quality of habitat available for Delta Smelt to successfully complete their life cycle. In general, Delta Smelt habitat quality and surface area are greater when X2 is located in Suisun Bay.” To assess the extent to which PCE 4 would be affected, CalSim model outputs for the PA and NAA were examined to assess the frequency of years that X2 would be located within Suisun Bay, which was taken to be X2 ≤ 74.1 km[26]. The results showed that there generally was little difference between NAA and PA in the percentage of years with X2 in Suisun Bay (Table 6.1-47). In most months (10 of 12), the differences were 1% or less. The greatest differences in X2 were in April (4% fewer years with X2 in Suisun Bay under the PA), whereas 2% more years had X2 in Suisun

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[26] Review of the CalSim outputs showed that even in fall months in wet years when X2 should have been 74 km or less (per the USFWS [2008] BiOp), it was sometimes the case that X2 slightly exceeded 74 km, e.g., in October 1922, X2 was 74.06 km for the NAA and 74.05 km for the PA. To capture all such small exceedances, 74.1 km was used as the cutoff to indicate X2 being located in Suisun Bay. This is justified by the considerable increase in habitat area with movement from 75 km to 74 km (see Figure 1 of Unger [1994] and Figure 1 of Dege and Brown [2004]), as the confluence of the Sacramento and San Joaquin Rivers opens out into Suisun Bay (more, specifically, Honker Bay).

Bay under the PA in May. This indicates that in general, the differences are insignificant, particularly when examined in consideration of the full range of X2 rather than just occurrence of X2 in Suisun Bay (see exceedance plots in Figure 5.A.6-29-7 of Appendix 5.A, *CalSim II Modeling and Results*).

Table 6.1-47. Comparison of Number of Years with X2 in Suisun Bay (≤ 74.1 km), By Month, from CalSim Outputs for 1922-2003.

Month	Total Number of Years[1]	Number of Years With X2 ≤ 74.1 km		% of Years With X2 ≤ 74.1 km		Difference[2]
		NAA	PA	NAA	PA	PA - NAA
Feb.	82	68	69	83%	84%	1%
Mar.	82	69	69	84%	84%	0%
Apr.	82	66	63	80%	77%	-4%
May	82	51	53	62%	65%	2%
Jun.	82	25	24	30%	29%	-1%
Jul.	82	8	8	10%	10%	0%
Aug.	82	1	1	1%	1%	0%
Sep.	81	26	26	32%	32%	0%
Oct.	81	27	27	33%	33%	0%
Nov.	81	19	19	23%	23%	0%
Dec.	81	27	28	33%	35%	1%
Jan.	81	50	51	62%	63%	1%

Notes:

[1] Some months have only 81 years because of the modeled water years began in February and ended in January, and X2 was lagged back by 1 month because the CalSim output is for the previous month.

[2] Positive values indicate a greater frequency of years with X2 in Suisun Bay under the PA; negative values indicate a lower frequency of years with X2 in Suisun Bay under the PA.

6.1.3.10.5 Suisun Marsh Facilities

6.1.3.10.5.1 PCE 1: Physical Habitat (Spawning Substrate)

Operations of the Suisun Marsh facilities (SMSCG, MIDS, RRDS, and Goodyear Slough Outfall) would not affect the spawning substrate PCE for Delta Smelt.

6.1.3.10.5.2 PCE 2: Water (Quality)

In general, the Suisun Marsh facilities would have little effect on water quality for Delta Smelt. Although water quality in Montezuma Slough may otherwise be suitable for Delta Smelt close to the RRDS intake, the risk of entrainment of larval/young juvenile Delta Smelt through the RRDS intake screens (or impingement on the screens) would produce a localized effect to this PCE, in combination with PCE 3. This would also be true for the unscreened MIDS in Goodyear Slough. Operation of the Goodyear Slough outfall is intended to improve water circulation in Suisun Marsh and therefore would be expected to provide beneficial effects to the water quality PCE for Delta Smelt critical habitat.

6.1.3.10.5.3 PCE 3: River Flow (Facilitating Movement)

As noted in the discussion for migrating adult Delta Smelt, operation of the SMSCG could entrain Delta Smelt into Montezuma Slough downstream of the SMSCG during ebb tide, and not allow return with the flood tide as the gates are closed. The DSM2-HYDRO modeling data demonstrated that these effects would be very similar between NAA and PA, and the extent to which movement around the low salinity zone is constrained is unknown (U.S. Fish and Wildlife Service 2008: 218). Operation of the RRDS and MIDS intakes results in a localized effect on channel flow in Montezuma Slough for larval/early juvenile Delta Smelt and Goodyear Slough for Delta Smelt, which may result in entrainment into the RRDS and/or MIDS, respectively. This effect would be similar under the NAA and PA, and represents a continuation of ongoing operations.

6.1.3.10.5.4 PCE 4: Salinity (Low Salinity Zone)

As discussed in the analysis of effects to juvenile Delta Smelt, although operation of the SMSCG moves the low salinity zone (indexed by X2) upstream for a given Delta outflow, operations would be managed in such a way that X2 would be very similar between NAA and PA, so there would be no effect on the salinity PCE.

6.1.3.10.6 North Bay Aqueduct

6.1.3.10.6.1 PCE 1: Physical Habitat (Spawning Substrate)

Operation of the NBA would not modify the spawning substrate PCE for Delta Smelt.

6.1.3.10.6.2 PCE 2: Water (Quality)

Diversions to the NBA could produce a localized effect on otherwise suitable water quality by increasing susceptibility of larval Delta Smelt to entrainment by the NBA; however, as previously noted in Individual-Level and Population-Level Effects sections, such effects would be similar between the NAA and PA.

6.1.3.10.6.3 PCE 3: River Flow (Facilitating Movement)

As with PCE 2, diversions to the NBA could produce a localized effect on flow in Barker Slough which could increase susceptibility of larval Delta Smelt to entrainment by the NBA. Such effects would be similar between the NAA and PA.

6.1.3.10.6.4 PCE 4: Salinity (Low Salinity Zone)

The small size of the diversions to the NBA would produce minimal changes to the low salinity zone and, as shown in the analysis of fall rearing abiotic habitat for juvenile Delta Smelt, there would be little difference between NAA and PA in the low salinity zone extent as indexed by the fall abiotic habitat index, because of overall management of exports in the Delta.

6.1.3.10.7 Other Facilities

6.1.3.10.7.1 Contra Costa Canal Rock Slough Intake

6.1.3.10.7.1.1 PCE 1: Physical Habitat (Spawning Substrate)

Operation of the Rock Slough intake would not modify the spawning substrate PCE for Delta Smelt.

6.1.3.10.7.1.2 PCE 2: Water (Quality)

Diversions to the Rock Slough intake could produce a localized effect to otherwise suitable water quality by increasing susceptibility of Delta Smelt to entrainment; however, as previously noted in Section 6.1.3.9.1, *Contra Costa Canal Rock Slough Intake*, Rock Slough generally has low habitat quality for Delta Smelt.

6.1.3.10.7.1.3 PCE 3: River Flow (Facilitating Movement)

As with PCE 2, diversions by the Rock Slough intake could produce a localized effect on flow in Rock Slough which could increase susceptibility of larval Delta Smelt to entrainment. Modeled diversions during April and May were greater under the PA, although the no-fill and no-diversion periods discussed in Section 6.1.3.9.1, *Contra Costa Canal Rock Slough Intake*, are intended to minimize the potential for effects to Delta Smelt and other listed species and adverse modification of critical habitat.

6.1.3.10.7.1.4 PCE 4: Salinity (Low Salinity Zone)

The small size of the diversions to the Rock Slough intake would produce minimal changes to the low salinity zone and, as shown in the analysis of fall rearing abiotic habitat for juvenile Delta Smelt, there would be little difference between NAA and PA in the low salinity zone extent as indexed by the fall abiotic habitat index, because of overall management of exports in the Delta.

6.1.3.10.7.2 Clifton Court Forebay Aquatic Weed Control Program

6.1.3.10.7.2.1 PCE 1: Physical Habitat (Spawning Substrate)

Spawning substrate would not be adversely modified by herbicide treatment and is unlikely to be adversely modified by mechanical removal of aquatic weeds. Any effects on spawning substrate in Clifton Court Forebay are not considered important, given that the water quality PCE is severely modified by the risk of entrainment, with low prospects of survival to any successfully spawned Delta Smelt.

6.1.3.10.7.2.2 PCE 2: Water (Quality)

As described for motile life stages such as migrating adult Delta Smelt in Section 6.1.3.7.2, *Clifton Court Forebay Aquatic Weed Control Program*, water quality effects would not be expected from herbicide treatment because there would not be a temporal overlap in treatment (July-August) with Delta Smelt occurrence (December-June). The potential for adverse modification of this PCE because of mechanical removal of aquatic weeds (e.g., injury from contact with cutting blades) may be offset to some extent by the reduced probability of predation by weed-associated predatory fishes and increases in salvage efficiency at the Skinner Fish Delta Fish Protective Facility because of reduced smothering by weeds.

6.1.3.10.7.2.3 PCE 3: River Flow (Facilitating Movement)

The Clifton Court Forebay Aquatic Weed Control Program would not modify river flows that facilitate movement of Delta Smelt life stages.

6.1.3.10.7.2.4 PCE 4: Salinity (Low Salinity Zone)

The Clifton Court Forebay Aquatic Weed Control Program would not modify the extent or location of low salinity zone nursery habitat.

6.1.4 Effects of Conservation Measures on Delta Smelt[27]

6.1.4.1 Tidal and Channel Margin Habitat Restoration

6.1.4.1.1 Migrating Adults (December-March)

6.1.4.1.1.1 Individual-Level Effects

Construction at habitat restoration sites would be undertaken during approved in-water work windows (summer/fall) and therefore would not affect individual migrating adult Delta Smelt. To the extent that individual Delta Smelt encounter restoration sites (e.g., when occupying nearshore areas during ebb tides of upstream migrations; Bennett and Burau 2015), the restoration is intended to enhance habitat value in these areas, relative to the unrestored state of the habitat where the restoration is undertaken, e.g., by increasing production of zooplankton prey or increasing subtidal habitat diversity. As suggested for the Lower Yolo Ranch Restoration Project (National Marine Fisheries Service 2014), potential adverse effects to migrating adult Delta Smelt at habitat restoration sites under construction include degraded water quality (e.g., liberation of contaminants from soils, if such contaminants have not been removed by soil grading activities) and increased predation risk depending on site characteristics, although the latter can be avoided by careful design of restoration sites to limit potential for colonization by invasive aquatic vegetation.

6.1.4.1.1.2 Population-Level Effects

The intention of habitat restoration projects is to improve habitat conditions so the population-level effect on migrating adult Delta Smelt, if there is one, should be beneficial.

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[27] Although not a conservation measure, localized reduction of predatory fishes to minimize predator density at north and south Delta export facilities is considered in this section (see also Appendix 3.H).

6.1.4.1.2 Spawning Adults (February-June)

6.1.4.1.2.1 Individual-Level Effects

As with migrating adult Delta Smelt, construction at habitat restoration sites would be undertaken during approved in-water work windows (summer/fall) and therefore individual spawners would not be affected by construction per se. Should restored habitat include suitable holding and spawning microhabitat for Delta Smelt (the latter being hypothesized to be sandy shallow areas, per Bennett [2005]), completed restoration projects may provide greater spawning opportunities to individual adult Delta Smelt than NAA; they may also increase feeding opportunities if zooplankton prey production increases. As described in Section 3.4.3.4.2 *Conservation Measures*, shallow water tidal habitat restoration is proposed to occur at 273 acres, of which 108 acres would be sandy beach spawning habitat (a 3:1 mitigation ratio for potential reduced access to critical habitat upstream of the NDD; see Section 6.1.3.10.1.3 *PCE 3: River Flow (Facilitating Movement)*). As with migrating adults, there may be water quality and predation risks associated with habitat restoration that could result in some adverse effects to individual fish.

6.1.4.1.2.2 Population-Level Effects

The intention of habitat restoration projects is to improve habitat conditions so the population-level effect on spawning adult Delta Smelt, if there is one, should be beneficial.

6.1.4.1.3 Eggs/Embryos (Spring: ~March–June)

6.1.4.1.3.1 Individual-Level Effects

As stated above, construction at habitat restoration sites would be undertaken during approved in-water work windows (summer/fall) and therefore would not affect eggs/embryos in spring. When construction is completed, and if suitable spawning microhabitat was successfully provided, individual Delta Smelt may spawn eggs at the site, producing a positive individual impact.

6.1.4.1.3.2 Population-Level Effects

The intention of habitat restoration projects is to improve habitat conditions so the population-level effect on Delta Smelt eggs/embryos, if there is one, should be beneficial.

6.1.4.1.4 Larvae/Young Juveniles (Spring: ~March–June)

6.1.4.1.4.1 Individual-Level Effects

Given that habitat restoration work would occur during a summer/fall work window there would be limited potential for effects of construction on individual Delta Smelt larvae using the temporal definition applied in this effects analysis. The types of effects described for juvenile Delta Smelt could occur for larval Delta Smelt occurring near construction of habitat restoration.

6.1.4.1.4.2 Population-Level Effects

The intention of habitat restoration projects is to improve habitat conditions so the population-level effect on Delta Smelt larvae/young juveniles, if there is one, should be beneficial.

6.1.4.1.5 Juveniles (Summer/Fall: ~July–December)

6.1.4.1.5.1 Individual-Level Effects

Habitat restoration projects intended to ultimately benefit Delta Smelt have to be located where Delta Smelt are likely to occur. Thus, there is the potential for adverse effects on individuals during construction. Juveniles are the only Delta Smelt life stage that would be affected by construction at habitat restoration sites, on the basis of temporal overlap with the summer/fall in-water work windows. As with other life stages, there would be long-term positive effects once habitat restoration is complete. Potential short-term adverse effects from tidal habitat restoration are exemplified by those described as potential effects for the Lower Yolo Tidal Restoration Project (National Marine Fisheries Service 2014). To the extent practicable, grading and excavation of marsh plains and tidal channels would be done prior to excavation of levee perimeter notches, to minimize adverse effects on juvenile Delta Smelt. Excavation of levee perimeter notches to allow tidal exchange could result in several effects to juvenile Delta Smelt: temporary loss of aquatic and riparian habitat (e.g., increasing predation potential because of reduced cover, reduced substrate for prey, and increased water temperature); degraded water quality from contaminants liberated from soils and increased suspended sediment which could affect fish directly if in very high concentration, as well as affecting prey availability; heavy machinery noise resulting in fish being inhibited from movements near the work areas, and possibly being startled away from work areas and therefore becoming more susceptible to predation as a result; direct strikes to fish from construction equipment performing notch excavation; and stranding of fish within dewatered areas (e.g., within cofferdams) that may be required during construction. However, as shown for the Lower Yolo Tidal Restoration Project, such potential adverse effects can be minimized by construction techniques such as not operating heavy machinery from the water; limiting construction to only the small areas necessary to restore tidal connections; limiting work to low tide and daylight hours; and installing sheet pile exclusion barriers with vibratory hammers.

6.1.4.1.5.2 Population-Level Effects

The intention of habitat restoration projects is to improve habitat conditions so the population-level effect on juvenile Delta Smelt, if there is one, should be beneficial.

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

Localized reduction of predatory fishes is proposed to occur at the NDD and Clifton Court Forebay using physical reduction methods, 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). The goal of this measure is to reduce predation on juvenile salmonids occurring at the north Delta and south Delta export facilities, and as such would be focused on the winter/spring period (~December-June) when juvenile salmonids are migrating through the Delta. As described in the predation effects assessments for Delta Smelt at the north Delta (Section 6.1.3.2.3 *Predation at the North Delta Export Facilities*) and south Delta (Section 6.1.3.3.2 *Predation* at the *South Delta Export Facilities*, this conservation measure could also potentially reduce predation on Delta Smelt, but predator removal in CCF has no meaningful capacity to impact Delta Smelt and if Delta Smelt numbers at the NDD are very low (as described above), predator removal from in front of the NDD fish screens will also have no meaningful impact. Because there is uncertainty in the potential effectiveness of localized reduction of predatory fishes, it is assumed in this effects analysis that it would not be effective.

6.1.4.2.1 Migrating Adults (December-March)

6.1.4.2.1.1 Individual-Level Effects

The methods that could be used to minimize the local abundance of predatory fish at the NDD and Clifton Court Forebay would have some potential to adversely affect migrating adult Delta Smelt. The main effect perhaps being startling of individuals during gear deployment (which could ironically increase predation susceptibility, assuming predators in the vicinity are not also startled) or injure fish if they contacted nets trying to escape through the mesh. Capture of adult Delta Smelt by hook-and-line fishing would not occur, and passive or active capture methods involving traps or nets would involve mesh sizes through which Delta Smelt would be able to escape. Electrofishing gear would be set to target fish of the size likely to be predators on juvenile salmonids and as such would have lesser impact on Delta Smelt than large-bodied fish because at a given voltage gradient, total body voltage increases with length, resulting in greater potential to capture larger fish without effects to smaller fish (Reynolds and Kolz 2012). As described in the predation effects assessments for Delta Smelt at the north Delta (Section 6.1.3.2.3, *Predation at the North Delta Export Facilities*) and south Delta (Section 6.1.3.3.2, *Predation* at the *South Delta Export Facilities*), to the extent that predatory fish density reduction is successful, it could reduce predation on Delta Smelt adults occurring near the NDD and in Clifton Court Forebay. Because there is uncertainty in the potential effectiveness of localized reduction of predatory fishes, it is assumed in this effects analysis that it would not be effective.

6.1.4.2.1.2 Population-Level Effects

As previously described in the analysis of entrainment and impingement at the NDD (Section 6.1.3.2, *North Delta Exports*), it is anticipated that very low numbers of migrating adult Delta Smelt would occur near the NDD, so predator removal in front of the NDD fish screens would be expected to have no meaningful effect on migrating adult Delta Smelt at the population level. In addition, the survival of Delta Smelt reaching the south Delta fish facilities is likely to be very low, so predator removal in CCF has no meaningful capacity to affect the Delta Smelt population.

6.1.4.2.2 Spawning Adults (February-June)

6.1.4.2.2.1 Individual-Level Effects

The analysis presented in Section 6.1.4.2.1.1, *Individual-Level Effects,* for migrating adult Delta Smelt would also apply to spawning adults.

6.1.4.2.2.2 Population-Level Effects

As previously described in the analysis of entrainment and impingement at the NDD (Section 6.1.3.2, *North Delta Exports*) and discussed for migrating adults, it is anticipated that very low numbers of spawning adult Delta Smelt would occur near the NDD, so predator removal in front of the NDD fish screens would be expected to have no meaningful effect on spawning adult Delta Smelt at the population level. In addition, the survival of Delta Smelt reaching the south Delta fish facilities is likely to be very low, so predator removal in CCF has no meaningful capacity to affect the Delta Smelt population

6.1.4.2.3 Eggs/Embryos (Spring: ~March–June)

6.1.4.2.3.1 Individual-Level Effects

If Delta Smelt spawned in Clifton Court Forebay, the survival of the progeny once they hatched would be likely to be close to zero. The proposed predator removal tactics are designed to catch larger piscivorous fishes and not the small fishes and shrimp that likely comprise the major predators of Delta Smelt eggs. The capture techniques generally are not anticipated to catch eggs attached to sandy substrates. Thus, there is unlikely to be an effect on individual Delta Smelt eggs.

6.1.4.2.3.2 Population-Level Effects

The lack of effects on individual eggs/embryos from predator reduction would result in no population-level effects on this life stage. Larvae/Young Juveniles (Spring: ~March–June)

6.1.4.2.3.3 Individual-Level Effects

The biggest known predator of Delta Smelt larvae is inland (a.k.a. Mississippi) silverside (Baerwald *et al.* 2012). This fish is the same size as Delta Smelt and therefore will not be vulnerable to the methods proposed to catch large piscivorous fishes. Therefore it is unlikely that there would be an effect on individual larval and young juvenile Delta Smelt from predator capture.

6.1.4.2.3.4 Population-Level Effects

Adverse population-level effects to larval/young juvenile Delta Smelt from predatory fish reduction would not occur because of the limited prospect of individual-level effects, the small proportion of the population likely to occur near the NDD, and the low probability of individuals occurring in Clifton Court Forebay surviving the salvage process.

6.1.4.2.4 Juveniles (Summer/Fall: ~July-December)

6.1.4.2.4.1 Individual-Level Effects

The December-June period in which predator reduction activities are proposed to be focused essentially does not overlap the period of occurrence of juvenile Delta Smelt, so the types of effects noted for other life stages are unlikely.

6.1.4.2.4.2 Population-Level Effects

The lack of temporal overlap of this life stage with predator reduction activities means that there would be no population-level effect.

6.1.4.3 Georgiana Slough Nonphysical Fish Barrier

As described in Appendix 3.F *General Avoidance and Minimization Measures*, the Georgiana Slough Nonphysical Fish Barrier (NPB) would consist of an NPB to reduce the likelihood of Sacramento River-origin juvenile salmonids entering the interior Delta through Georgiana Slough. Based on a recent evaluation of different technology to achieve this goal, a bioacoustic fish fence (BAFF) appears to offer more potential than a floating fish guidance structure (FFGS) for this location (DWR 2015b), although these and other options are possibilities. The analysis presented herein focuses on the potential effects of these types of NPB, as there is precedent for their installation at this location: a BAFF was tested in 2011 and 2012, and a FFGS was tested in 2014. Both technologies block the upper portion of the water column[28] because the focus for

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[28] In the case of the BAFF, the top half of the water column (~10–12 feet); in the case of the FFGS, 5 feet for the 2014 pilot study because of lower water levels caused by drought conditions, whereas 10 feet would be possible with greater river flow.

protection is surface-oriented juvenile salmonids, but the BAFF consists of acoustic deterrence stimuli broadcast from loudspeakers and contained within a bubble curtain that is illuminated with strobe lights (to allow the fish to orient away from the sound stimulus better), whereas the FFGS is a floating series of metal plates that deters fish based on them seeing the barrier and sensing the change in flow. Whereas the pilot studies of these technologies and their construction occurred in winter/spring, for the PA construction and removal would be done outside the main period of juvenile salmonid occurrence (November/December-June).

6.1.4.3.1 Migrating Adults (December-March)

6.1.4.3.1.1 Individual-Level Effects

Individual Delta Smelt migrating upstream via Georgiana Slough or the Sacramento River would not be affected by the construction of this NPB because construction would occur before any smelt moved this far upstream. The operational effects could include enhanced risk of predation near the NPB, as they include in-water structures that predatory fish may use as ambush habitat, and the NPB is designed to startle fish to cause them to change their course (particularly the BAFF, with its acoustic deterrence). However, there was no evidence from acoustic tracking that juvenile salmonids were being preyed upon at higher rates near the BAFF compared to sites farther away in 2011 and 2012, and little evidence from acoustic tracking of predators that they occupied areas near the BAFF more frequently than other areas (DWR 2012, 2015a). Indeed, the 2011 and 2012 BAFF pilot studies provided evidence that predatory fish were deterred by the BAFF,[29] with general evidence for increasing avoidance over time for all species combined, although some species may have become conditioned to the BAFF over time and therefore would not have been deterred. Studies of the 2014 FFGS have not been completed to address these topics. Migrating adult Delta Smelt encountering the NPB could be dissuaded from moving further upstream or startled by the NPB particularly if attempting to move upstream from Georgiana Slough to the Sacramento River, although based on the configurations used during the pilot studies[30], they would be able to swim under/around the FFGS, or under the BAFF. Further, there is no known reason that Delta Smelt need to move beyond this junction to spawn. Most fish spawn in places distant from the junction of Georgiana Slough and the Sacramento River.

6.1.4.3.1.2 Population-Level Effects

Few Delta Smelt are known to spawn in the Sacramento River and Georgiana Slough where the NPB will be located. There should be little if any population impact of this proposed salmonid fish conservation measure.

6.1.4.3.2 Spawning Adults (February–June)

6.1.4.3.2.1 Individual-Level Effects

The potential effects to spawning adult Delta Smelt from NPB would be similar to those noted for migrating adult Delta Smelt. However, these effects would be less likely to occur because spawning adult Delta Smelt would not be undergoing the broad-scale movements of migrating adults and therefore would have less potential to encounter the NPBs.

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[29] The BAFF was switched on and off every ~25 hours in order to test its effectiveness in deterring migrating juvenile salmonids.

[30] The BAFF pilot studies in 2011 and 2012 blocked the entire entrance to Georgiana Slough, whereas the FFGS pilot study in 2014 had the FFGS slightly upstream of the entrance to Georgiana Slough to deter juvenile salmonids away from the left bank.

6.1.4.3.2.2 Population-Level Effects

As described for migrating adult Delta Smelt, few Delta Smelt are known to spawn in the Sacramento River and Georgiana Slough where the NPB will be located. There should be little if any population impact of this proposed salmonid fish conservation measure.

6.1.4.3.3 Eggs/Embryos (Spring: ~March–June)

6.1.4.3.3.1 Individual-Level Effects

Delta smelt eggs/embryos would not overlap the construction or removal periods of the NPB and there would be no potential for adverse individual-level effects from operations.

6.1.4.3.3.2 Population-Level Effects

The lack of individual-level effects from the NPB on eggs/embryos means there would be no population-level effect.

6.1.4.3.4 Larvae/Young Juveniles (Spring: ~March–June)

6.1.4.3.4.1 Individual-Level Effects

Larval/young juvenile Delta Smelt moving down the Sacramento River could encounter the NPB. Given their weak swimming abilities, they may be subject to near-field hydraulic effects such as slight alterations of direction in response to changes in flows, and possibly injury when contacting the structures associated with the NPB.

6.1.4.3.4.2 Population-Level Effects

Few Delta Smelt are known to spawn in the Sacramento River and Georgiana Slough where the NPB will be located, resulting in few larvae/young juveniles in the area. There should be little if any population impact of this proposed salmonid fish conservation measure.

6.1.4.3.5 Juveniles (Summer/Fall: ~July-December)

6.1.4.3.5.1 Individual-Level Effects

The Delta Smelt juvenile life stage would be the only part of the life cycle that would have the potential to experience adverse effects to individuals from construction and removal of the NPB. Any pile-driving that would occur would be done with a vibratory hammer, which would minimize the potential for injury and probably limit adverse effects by deterring fish from the construction site. In-water work would be performed consistent with the biological opinions for the pilot implementations of the BAFF (U.S. Fish and Wildlife Service 2011b) and FFGS (U.S. Fish and Wildlife Service 2014). As with adults, altered behavior and locally elevated predation could occur.

6.1.4.3.5.2 Population-Level Effects

Few juvenile Delta Smelt are known to rear in the Sacramento River and Georgiana Slough where the NPB will be located. There should be little if any population impact of this proposed salmonid fish conservation measure.

6.1.4.4 Effects of Conservation Measures on Delta Smelt Critical Habitat

6.1.4.4.1 PCE 1: Physical Habitat (Spawning Substrate)

Although minimal, if any, effects to spawning substrate are anticipated, restoration of tidal habitat and channel margin habitat would have the potential to offset losses in spawning substrate and other shallow-water habitat, as well as losses of tidal perennial habitat.

As described above for effects to eggs/embryos, substrate-disturbing localized predatory fish reduction methods (e.g., beach seining) would have the potential to affect the spawning substrate PCE. However, such methods would only seem to be feasible in Clifton Court Forebay and not near the NDD (because of the deep-water habitat and steeply sloping banks in the vicinity), and effects on spawning substrate in Clifton Court Forebay are not considered important, given that the water quality PCE is severely modified by the risk of entrainment, with low prospects of survival to any successfully spawned Delta Smelt.

Implementation of a NPB at Georgiana Slough would have minimal effects on Delta Smelt spawning substrate, which most likely would be limited to piles driven into the substrate, or anchoring of associated structures.

6.1.4.4.2 PCE 2: Water (Quality)

Construction-related effects to water quality (e.g., increases in suspended sediment during earth-moving activities) would of similar nature to construction related effects described above, but would be limited in duration, would occur during work windows to minimize exposure of Delta Smelt, and minimized with standard AMMs. Therefore there would not be effects on the water quality PCE.

Sediment disturbance and releases of contaminants (e.g., fuel spills) during construction/removal activities of NPB would have the potential to result in effects on the water quality PCE (e.g., by liberating contaminants), but the implementation of standard AMMs and the limited duration of the work would minimize effects on this PCE, as concluded for the pilot projects (U.S. Fish and Wildlife Service 2011b, 2014).

6.1.4.4.3 PCE 3: River Flow (Facilitating Movement)

None of the conservation measures would affect river flow.

6.1.4.4.4 PCE 4: Salinity (Low Salinity Zone)

None of the conservation measures would affect salinity.

6.1.5 Effects of Monitoring Activities

As described in Section 3.4.9.2.4, effectiveness monitoring for fish would consist of a combination of continuation of existing monitoring authorized under the 2008/2009 BiOps (*i.e.*, principally salvage and larval smelt monitoring at the south Delta export facilities), as well as additional monitoring of the NDD (principally entrainment and impingement monitoring). Entrainment monitoring at the NDD would consist of sampling entrained fish behind the fish screens with a fyke net (see Table 3.4-5); impingement monitoring methods are not specified at this time, but on the basis of existing monitoring (e.g., Freeport Regional Water Authority intake's fish screen), would be likely to consist of visual observation by diver survey or acoustic imaging camera. Other monitoring activities that are part of the PA would be unlikely to affect Delta Smelt and are not discussed here. Existing monitoring activities that would inform operations of the PA (e.g., trawl and seines surveys by DFW and USFWS) are not part of the PA. Although monitoring activities at restoration sites have not been determined, they are not expected to include in-water work with any potential to harm Delta Smelt or any other listed fishes.

6.1.5.1 Migrating Adults (December-March)

6.1.5.1.1 Individual-Level Effects

As discussed in Section 6.1.3.2.1.1, *Migrating Adults (December-March*) for the NDD, the NDD fish screens would exclude migrating adult Delta Smelt from entrainment, so there would be no effect from entrainment monitoring at the NDD. If impingement monitoring were to consist of visual observation by diver survey, there would be minor potential for individual migrating adult Delta Smelt occurring immediately adjacent to the fish screens to be startled and leave the immediate area if encountering the divers; there would be no effect if conducting observations with an acoustic imaging camera. At the south Delta export facilities, salvage of migrating adult Delta Smelt would be done in the same way under NAA and PA. Individual migrating adult Delta Smelt collected during sampling of salvaged fish would die; however, as shown in Section 6.1.3.3.1.1, entrainment at the south Delta export facilities is expected to be lower under the PA than NAA, therefore any effects to individual Delta Smelt from salvage monitoring would be lower under the PA than NAA.

6.1.5.1.2 Population-Level Effects

Given the low percentage of the migrating adult Delta Smelt population expected to be near the NDD (Section 6.1.3.2.2.1.2*, Population-Level Effects*), any effects of impingement monitoring at the NDD would be inconsequential at the population level. South Delta exports salvage monitoring also would be expected to have essentially no population-level effect, given that only a subsample of fish would be collected, entrainment would be limited (and would be less under the PA than NAA), and that for the SWP, the main source of mortality (pre-screen loss) occurs before salvage sampling. Given that monitoring informs adjustments to operations to protect migrating adult Delta Smelt, the ultimate net effect of monitoring should be positive to the population.

6.1.5.2 Spawning Adults (February-June)

6.1.5.2.1 Individual-Level Effects

The potential effects of monitoring on individual spawning adult Delta Smelt would be similar to those effects noted for migrating adult Delta Smelt (*i.e.*, principally the lethal take during south Delta salvage monitoring), although spawning adults would be less likely to be sampled during monitoring activities if primarily holding near spawning sites.

6.1.5.2.2 Population-Level Effects

As discussed for migrating adult Delta Smelt, there would be essentially no population-level effects of monitoring on spawning adult Delta Smelt.

6.1.5.3 Eggs/Embryos (Spring: ~March-June)

6.1.5.3.1 Individual-Level Effects

As noted for other potential effects of the PA, the demersal and adhesive nature of Delta Smelt eggs/embryos means that they would not affected by the monitoring proposed under the PA.

6.1.5.3.2 Population-Level Effects

The lack of individual-level effects from monitoring of the PA on Delta Smelt eggs/embryos means that there would be no population-level effects.

6.1.5.4 Larvae/Young Juveniles (Spring: ~March-June)

6.1.5.4.1 Individual-Level Effects

At the NDD, entrainment sampling behind the fish screens would result in lethal take of individual larval and young juvenile Delta Smelt that are small enough to pass through the screens. These fish might otherwise survive passage to the Intermediate Forebay or the north cell of the reconfigured Clifton Court Forebay. Entrainment surveys of young smelt at the south Delta export facilities would also result in lethal take of any sampled larval or young juvenile Delta Smelt, and would occur under NAA and PA.

6.1.5.4.2 Population-Level Effects

Any collections of larval or young juvenile Delta Smelt during entrainment monitoring at the NDD or south Delta export facilities would have no effect at the population level because these fish would die anyway, either immediately (through injury during passage through conveyance infrastructure) or subsequently (e.g., if surviving and growing in Clifton Court Forebay, they would be expected to either die from predation or from excessive water temperatures in the summer).

6.1.5.5 Juveniles (Summer/Fall: ~July-December)

6.1.5.5.1 Individual-Level Effects

Effects to juvenile Delta Smelt would be as discussed for migrating adult Delta Smelt in terms of the potential to be lethally taken during salvage monitoring at the south Delta export facilities; however, as discussed in Section 6.1.3.3.1.5*, Juveniles: (Summer/Fall: July-December),* few juvenile Delta Smelt would be expected to occur at this time. Less south Delta exports under the PA than NAA would results in this being less of an effect. It is unlikely that monitoring of impingement potential at the NDD would be undertaken during the summer/fall, given the periods of occurrence of listed fishes, so there would be no effect from diver surveys.

6.1.5.5.2 Population-Level Effects

As discussed in the individual-level effects, the minimal temporal and spatial overlap of juvenile Delta Smelt with south Delta salvage monitoring means that there would be no population-level effect on juvenile Delta Smelt from monitoring.

6.1.5.6 Effects of Monitoring Activities on Delta Smelt Critical Habitat

6.1.5.6.1 PCE 1: Physical Habitat (Spawning Substrate)

There would be no effect of monitoring on the physical habitat PCE.

6.1.5.6.2 PCE 2: Water (Quality)

There would be no effect of monitoring on the water PCE.

6.1.5.6.3 PCE 3: River Flow (Facilitating Movement)

There would be no effect of monitoring on the river flow PCE.

6.1.5.6.4 PCE 4: Salinity (Low Salinity Zone)

There would be no effect of monitoring on the salinity PCE.

6.1.6 Cumulative Effects on Delta Smelt

Cumulative effects include the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area (50 CFR 402.02). Future Federal actions that are unrelated to the PA are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA. A list of specific projects considered for the cumulative effects analysis is included as Appendix 5.G *Projects to Be Included in Cumulative Effects Analysis for the Conveyance Section 7 Biological Assessment*.

6.1.6.1 Water Diversions

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Delta, and many of them remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions have the potential to entrain and kill many life stages of aquatic species, including Delta Smelt. However, the vast majority of private unscreened diversions in the Delta are small pipes in large channels that do not operate every day of the year. As a result, even where they do regularly co-occur with these diversions, Delta Smelt appear to have low vulnerability to entrainment (Nobriga *et al.* 2004). Most of the 370 water diversions operating in Suisun Marsh are likewise unscreened (Herren and Kawasaki 2001). However the two major Suisun Marsh distribution systems, both part of the SWP, divert most of the water into the marsh that is subsequently redistributed further by the many smaller diversions. Of the two SWP distribution systems, Roaring River is screened while Morrow Island is not. Delta smelt entrainment into the Morrow Island Distribution system is very low due to high salinity in western Suisun Marsh (Enos *et al.* 2007); the effects of these systems on Delta Smelt was analyzed in Section 6.1.3.7, *Suisun Marsh Facilities.*

New municipal water diversions in the Delta are routinely screened per biological opinions. Private irrigation diversions in the Delta are mostly unscreened but the total amount of water diverted onto Delta farms has remained very stable for decades (Culberson *et al.* 2008) so the cumulative impact should remain similar to baseline. Ongoing non-Federal diversions of water within the action area (e.g., municipal and industrial uses, as well as diversions through intakes serving numerous small, private agricultural lands) are not likely to entrain very many Delta Smelt based on the results of a study by Nobriga *et al.* (2004). Nobriga *et al.* reasoned that the littoral location and low-flow operational characteristics of these diversions reduced their risk of entraining Delta Smelt. A study of the Morrow Island Distribution System by DWR produced similar results, with 1 demersal species and 1 species that associates with structural environmental features, together accounting for 97–98% of entrainment; only 1 Delta Smelt was observed to be entrained during the 2 years of the study (Enos *et al.* 2007).

6.1.6.2 Agricultural Practices

Farming occurs throughout the Delta adjacent to waterways used by Delta Smelt. Agricultural practices introduce nitrogen, ammonium, and other nutrients into the watershed, which then flow into receiving waters, adding to other inputs such as wastewater treatment (Lehman *et al.* 2014); however, wastewater treatment provides the bulk of ammonium loading, for example (Jassby 2008). Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may negatively affect Delta Smelt reproductive success and survival rates (Dubrovsky *et al.* 1998; Kuivila *et al.* 2004; Scholz *et al.* 2012). Discharges occurring outside the action area that flow into the action area also contribute to cumulative effects of contaminant exposure.

6.1.6.3 Increased Urbanization

The Delta Protection Commission's Economic Sustainability Plan for the Delta reported an urban growth rate of about 54% within the statutory Delta between 1990 and 2010, as compared with a 25% growth rate statewide during the same period (Delta Protection Commission 2012). The report also indicated that population growth had occurred in the Secondary Zone of the Delta but not in the Primary Zone and that population in the central and south Delta areas had decreased since 2000. Growth projections through 2050 indicate that all counties overlapping the Delta are projected to grow at a faster rate than the state as a whole. Total population in the Delta counties is projected to grow at an average annual rate of 1.2% through 2030 ((California Department of Finance 2012). Table 6.1-48 illustrates past, current, and projected population trends for the five counties in the Delta. As of 2010, the combined population of the Delta counties was approximately 3.8 million. Sacramento County contributed 37.7% of the population of the Delta counties, and Contra Costa County contributed 27.8%. Yolo County had the smallest population (200,849 or 5.3%) of all the Delta counties.

Table 6.1-48. Delta Counties and California Population, 2000–2050

Area	2000 Population (millions)	2010 Population (millions)	2020 Projected Population (millions)	2025 Projected Population (millions)	2050 Projected Population (millions)
Contra Costa County	0.95	1.05	1.16	1.21	1.50
Sacramento County	1.23	1.42	1.56	1.64	2.09
San Joaquin County	0.57	0.69	0.80	0.86	1.29
Solano County	0.40	0.41	0.45	0.47	0.57
Yolo County	0.17	0.20	0.22	0.24	0.30
Delta Counties	3.32	3.77	4.18	4.42	5.75
California	34.00	37.31	40.82	42.72	51.01
Sources: California Department of Finance 2012.					

Table 6.1-49 presents more detailed information on populations of individual communities in the Delta. Growth rates from 2000 to 2010 were generally higher in the smaller communities than in larger cities such as Antioch and Sacramento. This is likely a result of these communities having lower property and housing prices, and their growth being less constrained by geography and adjacent communities.

Table 6.1-49. Delta Communities Population, 2000 and 2010

Community	2000	2010	Average Annual Growth Rate 2000–2010
Contra Costa County			
Incorporated Cities and Towns			
Antioch	90,532	102,372	1.3%
Brentwood	23,302	51,481	12.1%
Oakley	25,619	35,432	3.8%
Pittsburg	56,769	63,264	1.1%
Small or Unincorporated Communities			
Bay Point	21,415	21,349	-0.0%
Bethel Island	2,252	2,137	-0.5%
Byron	884	1,277	4.5%
Discovery Bay	8,847	13,352	5.1%
Knightsen	861	1,568	8.2%
Sacramento County			
Incorporated Cities and Towns			
Isleton	828	804	-0.3%
Sacramento	407,018	466,488	1.5%
Small or Unincorporated Communities			
Courtland	632	355	-4.4%
Freeport and Hood	467	309[a]	-3.4%
Locke	1,003	Not available	—
Walnut Grove	646	1,542	13.9%
San Joaquin County			
Incorporated Cities and Towns			
Lathrop	10,445	18,023	7.3%
Stockton	243,771	291,707	2.0%
Tracy	56,929	82,922	4.6%
Small or Unincorporated Communities			
Terminous	1,576	381	-7.6%
Solano County			
Incorporated Cities and Towns			
Rio Vista	4,571	7,360	6.1%
Yolo County			
Incorporated Cities and Towns			
West Sacramento	31,615	48,744	5.4%
Small or Unincorporated Communities			
Clarksburg	681	418	-3.9%

Sources: U.S. Census Bureau 2000; U.S. Census Bureau 2011.

[a] Freeport had a population of 38; Hood had a population of 271.

Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. Increased growth will place additional burdens on resource allocations, including natural gas, electricity, and water, as well as on infrastructure such as wastewater sanitation plants, roads and highways, and public utilities. Some of these actions will not require Federal permits and thus will not undergo review through the Section 7 consultation process.

Adverse effects on Delta Smelt and their critical habitat may result from urbanization-induced point and non-point source chemical contaminant discharges within the action area. These contaminants include, but are not limited to, ammonia and free ammonium ion, numerous pesticides and herbicides, and oil and gasoline product discharges. Increased urbanization also is expected to result in increased recreational activities in the region.

6.1.6.4 Waste Water Treatment Plants

Two wastewater treatment plants (one located on the Sacramento River near Freeport and the other on the San Joaquin River near Stockton) have received special attention because of the magnitude of their discharge of ammonia. The Sacramento Regional Wastewater Treatment Plan (SRWTP), in order to comply with Order no. R5-2013-0124, has begun implementing compliance measures to reduce ammonia discharges. Construction of treatment facilities for three of the major projects required for ammonia and nitrate reduction was initiated in March 2015 (Sacramento Regional County Sanitation District 2015). Order no. R5-2013-0124, which was modified on October 4, 2013, by the Central Valley Regional Water Quality Control Board imposed new interim and final effluent limitations, which must be met by May 11, 2021 (Central Valley Regional Water Quality Control Board 2013). By May 11, 2021, the SRWTP must reach a final effluent limit of 2.0 milligrams per liter (mg/L total ammonia nitrogen) per day from April to October, and 3.3 mg/L per day from November to March (Central Valley Regional Water Quality Control Board 2013). However, the treatment plant is currently releasing several tons of ammonia in the Sacramento River each day. A study by Werner *et al.* in 2008 concluded that ammonia concentrations present in the Sacramento River below the SRWTP are not acutely toxic to 55-day-old Delta Smelt. However, based on information provided by EPA (1999) and other related studies, it is possible that concentrations below the SRWTP may be chronically toxic to Delta Smelt and other sensitive fish species (Werner *et al.* 2010). In 2010 the same group conducted three exposure experiments to measure the effect concentration of SRWTP effluent. No significant effects of effluent on the survival of larval Delta Smelt or rainbow trout was found. More recent studies (which used concentrations of ammonia higher than typically experienced by Delta Smelt) have shown that Delta Smelt that are exposed to ammonia exhibit membrane destabilizations. This results in increased membrane permeability and increased susceptibility to synergistic effects of multi-contaminant exposures (Connon *et al.* 2009; Hasenbein *et al.* 2014). Results are unclear at this time as to what the effect of ammonia exposure is on Delta smelt, and research is ongoing. EPA published revised national recommended ambient water quality criteria for the protection of aquatic life from the toxic effects of ammonia in 2013. Studies are ongoing to further determine the effect of ammonia on Delta Smelt and other fish populations. The Freeport location of the SRCSD discharge places it upstream of the confluence of Cache Slough and the mainstem Sacramento River, a location just upstream of where Delta Smelt have been observed to congregate in recent years during the spawning season. The potential for exposure of a substantial fraction of Delta Smelt spawners to elevated ammonia levels has heightened the importance of this investigation.

In addition to concerns about direct toxicity of ammonia to Delta Smelt, another important concern is that ammonium inputs have suppressed diatom blooms in the Delta and Suisun Bay, thereby reducing the productivity in the Delta Smelt food web. The IEP MAST Team (2015: 71) provided the following summary: "Dugdale *et al.* (2007) and Wilkerson *et al.* (2006) found that high ammonium concentrations prevented the formation of diatom blooms but stimulated flagellate blooms in the lower estuary. They propose that this occurs because diatoms preferentially utilize ammonium in their physiological processes even though it is used less efficiently and at high concentrations ammonium can prevent uptake of nitrate (Dugdale *et al.* 2007). Thus, diatom populations must consume available ammonium before nitrate, which supports higher growth rates, can be utilized or concentrations of ammonium need to be diluted. A recent independent review panel (Reed *et al.* 2014) found that there is good evidence for preferential uptake of ammonium and sequential uptake of first ammonium and then nitrate, but that a large amount of uncertainty remains regarding the growth rates on ammonium relative to nitrate and the role of ammonium in suppressing spring blooms." The IEP MAST Team (2015: 71-72) further discussed this issue as follows: "Glibert (2011) analyzed long-term data (from 1975 or 1979 to 2006 depending on the variable considered) from the Delta and Suisun Bay and related changing forms and ratios of nutrients, particularly changes in ammonium, to declines in diatoms and increases in flagellates and cyanobacteria. Similar shifts in species composition were noted by Brown (2009), with loss of diatom species, such as *Thalassiosira* sp., an important food for calanoid copepods, including *Eurytemora affinis* and *Sinocalanus doerri* (Orsi 1995). More recently, Parker *et al.* (2012) found that the region where blooms are suppressed extends upstream into the Sacramento River to the SRWTP, the source of the majority of the ammonium in the river (Jassby 2008). Parker *et al.* (2012) found that at high ambient ammonium concentrations, river phytoplankton cannot efficiently take up any form of nitrogen including ammonium, leading to often extremely low biomass in the river. A study using multiple stable isotope tracers (Lehman *et al.* 2014) found that the cyanobacteria *M. aeruginosa* utilized ammonium, not nitrate, as the primary source of nitrogen in the central and western Delta. In 2009, the ammonia concentration in effluent from SRWTP was reduced by approximately 10%, due to changes in operation (K. Ohlinger, Sacramento Regional County Sanitation District, personal communication). In spring 2010 unusually strong spring diatom blooms were observed in Suisun Bay that co-occurred with low ammonia concentrations (Dugdale *et al.* 2013)."

Ammonia discharge concerns have also been expressed with respect to the City of Stockton Regional Water Quality Control Plant, but its remoteness from the parts of the Estuary frequented by Delta Smelt and its recent upgrades suggest that it is more a potential issue for migrating salmonids than for Delta Smelt.

6.1.6.5 Other Activities

Other future, non-Federal actions within the action area that are likely to occur and may adversely affect Delta Smelt and their critical habitat include: the dumping of domestic and industrial garbage that decreases water quality; oil and gas development and production that may affect aquatic habitat and may introduce pollutants into the water; and state or local levee maintenance that may also destroy or adversely affect habitat and interfere with natural, long-term habitat-maintaining processes. The Contra Costa Power Plant, which was owned and operated by NRG Delta, LLC, was retired in 2013 and replaced with the new natural gas power plant, Marsh Landing Generating Station. The Pittsburg Generating Station (PGS) remains in operation and consisted of seven once-through cooling systems, four of which have been retired, one of which is in the process of being retired, and two of which remain in operation. The once-through cooling system intake process can cause the impingement and entrainment of marine animals, kill organisms from all levels of the food chain, and disrupt the normal processes of the ecosystem. Additionally, the plant can discharge heated water that can reach temperatures as high as 100°F into the action area. This sudden influx of hot water can adversely affect the ecosystem and the animals living in it (San Francisco Baykeeper 2010).

On May 4, 2010, the SWRCB adopted a Statewide Policy on the Use of Coastal and Estuarine Water for Power Plant Cooling under Resolution No. 2010–0020 which required existing cooling water intake structures to reflect the best technology available for minimizing adverse environmental impacts (State Water Resources Control Board 2010). The PGS was required to submit an implementation plan to comply with this policy by December 31, 2017. The PGS chose to comply by retrofitting two of the existing units and retiring one unit. The retrofit and retirement of these units is underway (a).

6.2 Effects on Riparian Brush Rabbit

Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.5.7 *Head of Old River Gate Habitat Assessment*, provides the results of a survey to identify suitable riparian brush rabbit habitat within the vicinity of the PA. The survey found the nearest potentially suitable habitat to be 1,260 feet from the activity area. Figure 6.2-1 shows the location of the HOR gate relative to riparian brush rabbit occurrences. See Appendix 4.A, Section 4.A.5.6, S*uitable Habitat Definition,* for a description of suitable riparian brush rabbit habitat.

6.2.1 Geotechnical Exploration

Geotechnical exploration activities will not overlap with suitable riparian brush rabbit habitat therefore activities associated with geotechnical exploration will not affect riparian brush rabbit. Suitable habitat for riparian brush rabbit is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.5.6 *Suitable Habitat Definition.*

6.2.2 Safe Haven Work Areas

The construction footprint for the tunnel alignment does not overlap with any suitable riparian brush rabbit habitat therefore the construction of safe haven work areas will not affect riparian brush rabbit.

6.2.3 North Delta Intake Construction

There is no suitable riparian brush rabbit habitat within or near the construction footprint for the north Delta intakes therefore activities associated with the intakes will not affect this species.

6.2.4 Tunneled Conveyance Facilities

There is no suitable riparian brush rabbit habitat within or near the construction footprint for the water conveyance facilities therefore activities associated with the water conveyance facilities will not affect this species.

6.2.5 Clifton Court Forebay Modification

There is no suitable riparian brush rabbit habitat within or near the construction footprint for the water conveyance facilities therefore activities associated with the Clifton Court Forebay modifications will not affect this species.

6.2.6 Power Supply and Grid Connection

The transmission lines will not be constructed within or near riparian brush rabbit suitable habitat and therefore activities associated with constructing and stringing the transmission lines will not affect this species.

6.2.7 Head of Old River Gate

6.2.7.1 Habitat Loss and Fragmentation

A habitat assessment performed at the HOR gate found no suitable habitat within the proposed HOR gate activity area (Figure 6.2-2). The results of the habitat assessment can be found in Appendix 4.A *Status of the Species and Critical Habitat Accounts,* Section 4.A.5.7 *Head Old River Gate Habitat Assessment*.

6.2.7.2 Construction Related Effects

The HOR gate will be constructed between Stewart Tract and Roberts Island, where a temporary barrier currently exists. HOR gate construction has two major components: dredging and construction. 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. Dredging would occur at a time between August 1 and November 30, lasting approximately 15 days, and would otherwise occur as described in Section 3.2.10.8 *Dredging and Riprap Placement*. Dredging and riprap placement equipment will be operated from a barge in the channel.

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 construction duration is estimated to be up to 32 months. A temporary work area of up to 15 acres will be sited in the vicinity of the barrier. 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. The installation of the cofferdam will require up to 700 strikes per pile over an estimated 40 day period. The installment of the foundation for the operable barrier will require 15 piles to be set per day with up to 1,050 strikes per pile over an estimated 7-day period.

Construction of the HOR gate will avoid direct injury or mortality to individual riparian brush rabbits because there is no suitable habitat in the activity area. To avoid effects from noise or light, lighting and pile driving will be excluded to an area at least 1,400 feet from the edge of any potentially suitable habitat. In addition, a 1,200-foot nondisturbance buffer will be established between any project activities and suitable habitat, pile driving will be limited to daytime hours, and when night lighting is necessary, the lights will be screened and directed down and away from habitat. These measures are described in Section 3.3.2.3, *Head of Old River Gate*. With these measures in place, and given the distance to the nearest patch of known suitable habitat and occurrences, any potential effect to an individual riparian brush rabbit from noise or light would be so small as to be immeasurable and is therefore considered insignificant and would not result in take of riparian brush rabbit.

6.2.7.3 Operations and Maintenance

Operation of the HOR gate could vary from completely open (lying flat on the channel bed) to be 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 would allow partial flow. The new HOR gate will replace the temporary rock barrier that is typically installed at the same location. Because the HOR gate is replacing an existing temporary barrier, no adverse effects to the potentially suitable habitat from hydrological changes are expected.

Periodic maintenance of the HOR gates would occur every 5 to 10 years. Depending on the rate of sedimentation, maintenance would occur every 3 to 5 years. Effects on riparian brush rabbit are not expected because all maintenance activities would take place within the developed footprint, which is primarily in the channel areas, and any noise generated would not be expected to be significant in the suitable habitat, at least 1,200 feet from the project footprint. No terrestrial habitats would be disturbed by maintenance activities. Therefore, the operations and maintenance of the HOR gate will not adversely affect the riparian brush rabbit.

6.2.8 Reusable Tunnel Material

There is no riparian brush rabbit habitat within or near the construction footprint for the North Delta intakes (Figure 6.2-1), therefore activities associated with reusable tunnel material will not affect this species.

6.2.9 Restoration

Restoration activities will be sited in the north, west, and east Delta. Since these areas do not overlap with any suitable riparian brush rabbit habitat, and because these areas are not known to support riparian brush rabbit, restoration activities are not expected to affect riparian brush rabbit. Furthermore, as described in Section 3.4.6.1.2 *Restoration Activities*, the restoration activities will be sited to avoid effects on riparian brush rabbit habitat, with a 100-foot buffer between restoration areas and suitable riparian brush rabbit habitat. Suitable habitat for riparian brush rabbit is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, in Section 4.A.5.6 *Suitable Habitat Definition.*

6.2.10 Effects on Critical Habitat

Critical habitat has not been designated for the riparian brush rabbit.

6.2.11 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of riparian brush rabbit will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect riparian brush rabbit in the action area when foraging habitat degradation occurs without USFWS authorization. The most likely activity to affect riparian brush rabbit habitat would be unauthorized removal of riparian habitat on private lands. Climate change threatens to modify annual weather patterns and is likely to reduce the frequency of flooding. While flooding can result in the mortality of individual of riparian brush rabbits, it is also necessary to maintain the early-successional riparian habitat used for cover and foraging for riparian brush rabbit. Because the proposed action is expected to avoid effects on riparian brush rabbit habitat and individuals, cumulative effects in the action area are not expected to appreciably diminish the likelihood of the species' long-term survival and recovery.

6.3 Effects on San Joaquin Kit Fox

Appendix 6.B *Terrestrial Effects Analysis Methods* describes the methods and assumptions used to analyze the effects of the proposed action (PA) on wildlife species. Appendix 4.A *Status of the Species and Critical Habitat Accounts,* Section 4.A.8.6 *Suitable Habitat Definition*, provides a definition of suitable San Joaquin kit fox habitat. Appendix 4.A, Section 4.A.8.7 *Species Habitat Suitability Model*, provides a description of the suitable habitat model for San Joaquin kit fox.

Activities associated with geotechnical exploration, tunneled conveyance facility construction, Clifton Court Forebay modifications, power supply and grid connections, reusable tunnel material (RTM) storage areas, and habitat restoration may affect San Joaquin kit fox, as described below. Figure 6.3-1 provides an overview of the locations of surface impacts relative to San Joaquin kit fox modeled habitat. An estimated 57 acres of San Joaquin kit fox modeled habitat will be permanently lost as a result of the PA. Table 6.3-1 and Table 6.3-2 summarize the total estimated loss of San Joaquin kit fox modeled habitat.

Table 6.3-1. Maximum Habitat Loss on Modeled Habitat for San Joaquin Kit Fox by Activity Type (Acres)

San Joaquin Kit Fox Modeled Habitat	Permanent Habitat Loss								Temporary Habitat Loss	
	Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	RTM Storage Area	Power Supply and Connection	Total Maximum Habitat Loss	Geotechnical Exploration	Power Supply and Connection
Modeled Habitat	0	0	0	46	0	0	<1	47[1]	2	9

Notes

[1] This total does not include loss of an estimated 12 acres of habitat potentially resulting from vernal pool restoration, because take associated with this habitat loss is not being requested in this BA, and will be addressed through a separate Section 7 consultation process

Table 6.3-2. Maximum Direct Effects on and Conservation of Modeled Habitat for San Joaquin Kit Fox

San Joaquin Kit Fox Modeled Habitat	Permanent Habit Loss	Compensation Ratios		Total Compensation (Acres)	
	Total Maximum Habitat Loss (Acres)	Protection	Restoration	Protection	Restoration
Modeled Habitat	47	3:1	0	141	0

6.3.1 Geotechnical Exploration

6.3.1.1 Habitat Loss and Fragmentation

The only permanent loss of San Joaquin kit fox habitat resulting from geotechnical exploration inside the footprint will be boreholes, which will be grouted upon completion. These holes are very small (approximately 8 inches in diameter) and would have no or negligible effects on the San Joaquin kit fox. Temporary habitat disturbance occurring during construction are described in Section 6.3.1.2, *Construction Related Effects.*

6.3.1.2 Construction Related Effects

Geotechnical exploration activities will temporarily affect up to 2 acres San Joaquin kit fox habitat during the geotechnical exploration. This effect will consist of driving overland to access the boring sites, and storing equipment for short time periods (several hours to 5 days at the locations where kit fox habitat occurs). Given the low likelihood of San Joaquin kit fox being present in the areas to be affected, effects on San Joaquin kit fox from geotechnical exploration will be minimal. Construction related actions are not expected to injure or kill San Joaquin kit fox if individuals are present, as the potential for injuring or killing San Joaquin kit fox will be avoided by limiting activity to the day time, monitoring by a USFWS-approved biologist, and other measures as described in described in Section 3.4.5.2.2.2.1 *Geotechnical Exploration*.

6.3.1.3 Operations and Maintenance

There will be no ongoing operations and maintenance associated with the geotechnical exploration activities, therefore no effects on San Joaquin kit fox.

6.3.2 Safe Haven Work Areas

Safe haven work areas are not expected to be needed in any areas of San Joaquin kit fox modeled habitat, therefore this activity is not expected to affect San Joaquin kit fox.

6.3.3 North Delta Intake Construction

The north Delta intake construction area does not overlap with San Joaquin kit fox modeled habitat. Thus north Delta intake construction will not affect the species (Figure 6.3-1).

6.3.4 Tunneled Conveyance Facilities

Tunneled conveyance facilities construction does not overlap with San Joaquin kit fox modeled habitat. Activities in this area will not affect the species (Figure 6.3-1).

6.3.5 Clifton Court Forebay Modification

6.3.5.1 Habitat Loss and Fragmentation

An estimated 46 acres of San Joaquin kit fox modeled habitat overlaps with the mapped Clifton Court Forebay modifications (Figures 6.3-2 through 6.3-4). The habitat to be removed is surrounded by cultivated lands and disconnected from the contiguous grassland habitat to the west, and therefore has low habitat value for San Joaquin kit fox. As shown on Figure 6.3-1, the forebay is at the easternmost edge of San Joaquin kit fox habitat in the action area, and therefore effects to this habitat will not result in habitat fragmentation or isolation.

As described in Section 3.4.7.2.1.1 *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. The loss of 46 acres of habitat will be compensated through protection and management of San Joaquin kit fox habitat at a 2:1 ratio, for a total of 92 acres. As detailed in Section 3.4.7.2.3 *Siting Criteria for Compensation for Effects*, the conservation lands will be sited in a location that provides high habitat values for the species, consisting of large, contiguous blocks of habitat suitable for San Joaquin kit fox. As detailed in Section 3.4.7.2.4 *Management and Enhancement,* these lands will be protected and managed for the species in perpetuity.

6.3.5.2 Construction Related Effects

Construction activities at Clifton Court Forebay include vegetation clearing, pile driving, excavation, dredging, and cofferdam and embankment construction. Construction at Clifton Court Forebay will be phased by location and the duration of construction will be approximately 6 years. The concurrent use of the six loudest pieces of construction equipment varies by activity types at Clifton Court Forebay. The construction of the divider wall, embankment, and siphons at Clifton Court Forebay will all require pile driving, in combination with the six loudest pieces of construction equipment, noise at these construction areas could reach 60 dBA at up to 2,000 feet from the edge of the footprint. For complete details on construction activities and phasing, see Section 3.2.5 *Clifton Court Forebay*, for more details on schedule, see Appendix 3.D *Construction Schedule for the Proposed Action*.

Construction noise up to 60 dBA (the standard noise threshold for avian species [Dooling and Popper 2007]) will occur within 1,200 feet of the footprints for tunnel work areas, conveyors, and vent shafts. Light associated with nighttime activities is also possible. San Joaquin kit foxes, however, are known to occur in abundance in areas where ongoing noise and lighting exists, such as urban areas in Bakersfield, California, and the oil fields in the Central Valley. There is no evidence that kit foxes will avoid areas affected by noise or lighting, and USFWS' standard recommendations for avoiding and minimizing construction related effects on kit foxes do not address noise or lighting. Noise and lighting from the project are not expected to adversely affect San Joaquin kit fox.

Construction activities will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed. In the absence of avoidance and minimization measures, vehicles and heavy equipment used to clear the site and transport equipment and material could injure or kill San Joaquin kit foxes if individuals are present within the construction footprint. Kit foxes could be struck by moving vehicles, or could be entrapped in trenches, pipes, or culverts. As described in Section 3.5.2.2.1, *Activities with Fixed Locations,* however, dens will be avoided and speed limits will be observed (20 mph during daytime and 10 mph during nighttime hours) to avoid collisions with kit foxes. Also, the construction site will be fenced after a biological monitor makes sure there are no kit foxes in the construction area, and the biological monitor will check trenches, pipes, and culverts to ensure kit foxes are not trapped. With these measures in place, and given the very low likelihood of kit foxes occurring in the area, construction related activities will most likely not cause injury or mortality of San Joaquin kit fox.

6.3.5.3 Operations and Maintenance

The operational components of the modified Clifton Court Forebay include the pumping plant, control structures, and siphons. The features will not be operated in or near San Joaquin kit fox habitat and are not expected to affect the species.

Maintenance of the forebay and canals will entail control of vegetation and rodents, and embankment repairs. Maintenance of control structures could entail removal or installation of roller gates, radial gates, and stop logs. Maintenance of the spillway would entail removal and disposal of any debris blocking the outlet culverts. Use of heavy equipment for maintenance may injure San Joaquin kit foxes. Removal of vegetation, embankment repairs, and rodent control measures may result in injury or mortality of San Joaquin kit fox. As described in Section 3.4.5.2.2.1.4, *Clifton Court Forebay Operations and Maintenance,* the area to be operated and maintained will be fenced with chain link fencing to prevent San Joaquin kit fox entry. With this measure in place, and given the low likelihood of kit fox occurrence in the area, harassment, injury, or mortality of San Joaquin kit fox resulting from these activities will be avoided. Power Supply and Grid Connections

6.3.5.4 Habitat Loss and Fragmentation

To conservatively assess impacts from transmission line placement due to the flexibility of the final alignment, a 50-foot wide disturbance area along the length of the transmission line corridor was assumed (see Appendix 6.B *Terrestrial Effects Analysis Methods*, for additional details about the impact assessment method). Based on this method, an estimated 9 acres of San Joaquin kit fox modeled habitat will be temporarily affected as a result of the construction of both temporary and permanent transmission lines, substations, and transmission line relocation (Figures 6.3-1 through 6.3-6 and Table 6.3-1). Most of the effect from transmission line construction will be temporary. Temporary impacts are incurred from activities that will not last more than one year and include access routes (vehicles driving over ground to access the site), temporary staging areas for poles or placement, and reconductoring areas. Less than 1 acre of habitat is expected to be permanently affected by placement of power poles or towers.

Because the disturbance is primarily from short-term, temporary effects, specific compensation for the 9 acres of San Joaquin kit fox habitat disturbance will be offset by returning these areas to pre-project conditions. One acre of permanent effect will be offset through habitat protection at a 2:1 ratio. As detailed in Section 3.4.7.2.3 *Siting Criteria for Compensation for Effects*, the conservation lands will be sited in a location that provides high habitat values for the species, consisting of large, contiguous blocks of habitat suitable for San Joaquin kit fox. As detailed in Section 3.4.7.2.4 *Management and Enhancement,* these lands will be protected and managed for the species in perpetuity.

6.3.5.5 Construction Related Effects

New temporary power 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 power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, 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.

Construction of new transmission lines will require 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-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at 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 will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than 1 year at any 1 location. See Section 3.2.7.2 *Construction*, for a full description of the construction activities.

In the absence of the impact minimization measures, operation of equipment during construction of the transmission lines could injure or kill San Joaquin kit fox if individuals are present. The construction related effects and measures to minimize them are similar to those described above for construction of the Clifton Court Forebay modifications under Section 6.3.5.5 *Construction Related Effects*. Construction associated with the transmission lines is expected to fully avoid injury or mortality of San Joaquin kit foxes, and to avoid take of kit fox in the form of harassment.

6.3.5.6 Operations and Maintenance

The temporary transmission lines will be in place for the duration of conveyance facility construction (approximately 10 years); the permanent transmission lines will remain to supply power to the pumping plant. Maintenance activities at the transmission lines will include vegetation management and overland travel for some emergency repairs. Ongoing vegetation management around the poles and under the lines is expected to be minimal (mechanical mowing and/or trimming) in San Joaquin kit fox habitat because grassland areas seldom if ever need to be cleared to maintain transmission line corridors. As described in Section 3.4.5.2.2.2 *Power Supply and Grid Connections,* measures will be implemented during transmission line maintenance in San Joaquin kit fox habitat to avoid injuring or killing San Joaquin kit fox. Effects on San Joaquin kit fox from transmission line operations and maintenance, if any, are expected to be negligible, and would not constitute take of kit fox.

6.3.6 Reusable Tunnel Material Storage Area

The RTM sites do not overlap with San Joaquin kit fox habitat. Activities associated with RTM placement will not affect the species.

6.3.7 Head of Old River Gate

The HOR gate construction area does not overlap with San Joaquin kit fox modeled habitat and activities associated with HOR gate construction will not affect the species (Figure 6.3-1).

6.3.8 Restoration/Mitigation

Any take associated with restoration activities described below will not be authorized through this biological opinion, and would need to be addressed through a separate Section 7 consultation process.

6.3.8.1 Habitat Loss and Fragmentation

Restoration activities will avoid effects on San Joaquin kit fox and its habitat with the exception of vernal pool complex restoration which may result in loss of 12 acres of San Joaquin kit fox habitat, unless DWR uses a conservation bank to compensate for effects to vernal pool species. The USFWS will not authorize take of San Joaquin kit fox associated with this activity, therefore the loss of 12 acres of San Joaquin kit fox habitat would need to be addressed through a separate Section 7 consultation process. While the exact location of vernal pool restoration is not known, it is likely that it will be in the region directly west, north, or south of CCF where San Joaquin kit fox modeled habitat exists. Although vernal pool restoration in grasslands will result in some loss of San Joaquin kit fox habitat, protection and management of surrounding grasslands associated with the vernal pools is expected to benefit San Joaquin kit fox.

6.3.8.2 Construction Related Effects

Vernal pool restoration, if needed, will involve use of heavy equipment to excavate areas within grasslands to create topographic depressions. San Joaquin kit foxes would not be injured or killed by heavy equipment or struck by vehicles associated with vernal pool construction because such take would be avoided as described in Section 3.4.5.2.2.1, *Avoidance and Minimization Measures*. As described in Section 6.3.5.5, *Construction Related Effects*, noise and lighting associated with this activity are not expected to adversely affect San Joaquin kit fox. With the avoidance and minimization measures in place, construction related effects on San Joaquin kit fox from vernal pool restoration, if any, are expected to be negligible and will not result in take of San Joaquin kit fox.

6.3.8.3 Operations and Maintenance

A variety of management actions to be implemented within restored vernal pool complex may result in localized ground disturbances within San Joaquin kit fox habitat: these activities may include ground disturbance such as removal of nonnative vegetation and road and other infrastructure maintenance activities. San Joaquin kit foxes would not be injured or killed by vehicles or other activities associated with vernal pool management because such take would be avoided as described in Section 3.4.5.2.2.1, *Avoidance and Minimization Measures*. As described in Section 6.3.5.5, *Construction Related Effects*, noise and lighting associated with this activity are not expected to adversely affect San Joaquin kit fox. With the avoidance and minimization measures in place, construction related effects on San Joaquin kit fox from vernal pool management, if any, are expected to be negligible and will not result in take of San Joaquin kit fox.

6.3.9 Effectiveness Monitoring

On lands protected to benefit San Joaquin kit fox, monitoring will be performed to determine the effectiveness of conservation. Monitoring for San Joaquin kit fox 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. For additional details about monitoring see Section 3.4.9.2.3 *Effectiveness Monitoring for Wildlife Species*. Bait stations have potential to alter typical behavior of individual San Joaquin kit fox. As such, effectiveness monitoring for San Joaquin kit fox will be performed by a USFWS approved biologist.

6.3.10 Effects on Critical Habitat

Critical habitat has not been designated for the San Joaquin kit fox

6.3.11 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of San Joaquin kit fox will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect San Joaquin kit fox in the action area when habitat loss and degradation occurs without USFWS authorization. The most likely activity of this type is conversion of rangeland to urban uses. Unauthorized take as a result of urbanization is unlikely where most of the habitat occurs west of CCF because urbanization within the cities of Brentwood, Pittsburg, Oakley, and Clayton is covered by the East Contra Costa County HCP/NCCP. Urban development outside these incorporated cities (i.e., in the jurisdiction of Contra Costa County) is not covered by the East Contra Costa County HCP/NCCP. Although unlikely to occur due to land use controls, if urban development was proposed in or near the community of Byron it could contribute to a cumulative adverse effect on San Joaquin kit fox in the action area.

Climate change also threatens to modify annual weather patterns. Climate change may result in a loss of San Joaquin kit fox and/or prey, and/or increased numbers of their predators, parasites, and disease. Since the habitat in the action area with the highest likelihood of supporting San Joaquin kit fox is within the East Contra Costa County HCP/NCCP, where large scale conservation efforts will be implemented, cumulative effects in the action area are not expected to appreciably diminish the likelihood of the species' long-term survival and recovery.

6.4 Effects on California Least Tern

Appendix 6.B *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the proposed action (PA) on terrestrial species. Appendix 4.A *Status of the Species and Critical Habitat Accounts,* Section 4.A.7.6 *Species Habitat Suitability Model*, provides a description of the suitable habitat model for California least tern.

Activities associated with geotechnical exploration, safe haven work areas, the NDDs, tunneled conveyance facilities, CCF modifications, power supply and grid connections, the HOR gate, and RTM storage areas, have the potential to affect California least tern, as described below. Figure 6.4-1 provides an overview of the locations of surface impacts relative to California least tern modeled habitat. See Appendix 4.A *Status of the Species and Critical Habitat Accounts,* Section 4.A.7.6 *Species Habitat Suitability*, for the definition of suitable California least tern habitat.

Three California least tern nesting sites have been reported from the general vicinity of the action area:

- Pittsburg Power Plant. The Pittsburg Power Plant nesting location in Pittsburg is over 15 miles from the nearest water conveyance facility on the very western edge of the Delta. This nesting location is not considered successful, in 2010, Marschalek (2011) documented no breeding pairs at this site. This was the third time in the last 4 years that least terns did not nest at this site. \

- The Bufferlands. The Bufferlands, a part of the Sacramento Regional Wastewater Treatment Facility, is approximately 3 miles from the northernmost extent of the water conveyance facility. This site supported one successful breeding pair for 3 years (2009, 2010, and 2011) (Marschalek 2010 and 2011; Frost 2013). In 2012, one breeding pair created two unsuccessful nests and in 2013, no nesting was attempted (Frost 2014). One successful breeding pair was observed in 2016 (pers. comm. Chris Conard, Sacramento Regional County Sanitation District Bufferlands). Because this site hosted only one nesting pair, it is not considered a colony.

- Montezuma Wetlands. California least terns have nested at the Montezuma Wetlands on the eastern edge of Suisun Marsh near Collinsville since 2006. This colony is over 15 miles from the nearest covered activity location. This colony site was unintentionally created as part of a wetlands restoration project that requires increasing the elevation of certain areas prior to flooding (Marschalek 2008). A pile of sand and shells, formed during excavation of the wetland restoration site, attracted terns to the site, which to date has prevented completion of the restoration project. Marschalek (2011) reports 23 breeding pairs (0.036%), 17 nests, and at least five fledglings from this breeding colony in 2010.

There is no California least tern modeled nesting habitat within the action area; any nesting habitat that may have once been present along the natural shoreline of the Delta has been modified or removed. Surveys will be conducted on occupied nesting habitat as described in Section 3.4.7.3, *Avoidance and Minimization Measures*. Because nesting occurs in the vicinity of the action area, there is some potential for California least tern to forage within the action area.

The potential, however, is low, because the nearest presumed extant nesting colony is over 15 miles from the action area, and typical California least tern foraging habitat is within 2 miles of their colonies (Atwood and Minsky 1983). There are 61,751 acres of modeled foraging habitat (open water) in the Delta. The project would result in loss of 269 acres of foraging habitat, but would also result in creation of 677 acres of foraging habitat at Clifton Court Forebay, for a net gain of 408 acres of California least tern foraging habitat. An estimated 1,930 acres of California least tern modeled habitat will be temporarily affected by dredging at Clifton Court Forebay. Table 6.4-1 summarizes the maximum affected acreage of California least tern foraging habitat.

Table 6.4-1. Maximum Habitat Loss on Modeled Foraging Habitat for California Least Tern by Activity Type (Acres)

Least Tern Modeled Habitat	Total Modeled Habitat in Action Area	Permanent Habitat Loss							Temporary Habitat Loss or Disturbance		
		Safe Haven Work Sites	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Total Maximum Habitat Loss	Clifton Court Forebay Dredging	Geotechnical Exploration	Power Supply and Connection
California Least Tern Potential Foraging Habitat	61,751	0	14	21	231[1]	3	0	269[1]	1,930	72[2]	0

Notes

[1] CCF modifications will also create 677 acres of open water, resulting in a net gain of 408 acres of foraging habitat for California least tern.

[2] Assumes 100 in-water borings and a 100-foot radius around each bore hole as a conservation estimate for the area foraging terns might be excluded during the 5-day period when work occurs.

6.4.1 Geotechnical Exploration

6.4.1.1 Habitat Loss and Fragmentation

Over-water geotechnical exploration activities will not result in any permanent loss of California least tern foraging habitat. Temporary habitat disturbance during exploration activities is described below in section 6.4.1.2, *Construction Related Effects.*

6.4.1.2 Construction Related Effects

An estimated 72 acres of California least tern foraging habitat could be temporarily disturbed during geotechnical exploration. This assumes up to 100 in-water exploration sites, and conservatively assumes a 100-foot radius around each bore hole where terns might avoid foraging during the activity. No more than 3 acres are expected to be affected by this activity at any given point of time, and the activity is only expected to last 3 to 5 days at each site. Because the potential for terns to occur within the vicinity of the tunnel alignment is low, and the effects would have a short duration and cover a small area at any given time, effects on California least tern from geotechnical activities, if any, are expected to be negligible.

6.4.1.3 Operations and Maintenance

There will be no operations and maintenance associated with geotechnical activities.

6.4.2 Safe Haven Work Areas

The placement of safe haven work areas is currently unknown because they are constructed “as needed” along the alignment, but they will avoid open water areas and will therefore not affect California least tern habitat.

6.4.3 North Delta Intake Construction

6.4.3.1 Habitat Loss and Fragmentation

The construction of the north Delta intakes will result in the permanent loss of 14 acres of California least tern modeled foraging habitat (<0.1% of modeled foraging habitat within the action area). The impact will occur where intakes 2, 3, and 5 encroach on the Sacramento River’s east bank between Clarksburg and Courtland (Figure 6.4-2 through 6.4-4). The intake construction area is greater than 25 miles from the nearest breeding colony (Montezuma Wetlands[31]), and typical California least tern foraging habitat is 2 miles from colonies (Atwood and Minsky 1983), therefore there is a very low probability that these areas would be used for foraging by California least tern. In addition, the tern is not limited by foraging habitat and the habitat loss from intake construction comprises less than 0.1% of foraging habitat in the action area.

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[31] The Sacramento Regional Wastewater treatment facility (Bufferlands) is closer to the intake construction location, that site has only supported one successful breeding pair and since 2013 has not supported nesting. As such, this site is not considered a breeding colony. See Section 4.5.9, *California Least Tern*, for more details.

6.4.3.2 Construction Related Effects

Construction activities at each intake will include ground clearing and grading, in-water construction of crib walls, in-water pile driving, excavation, and drilling. These activities will require the use of loud, heavy equipment within the construction site as well as along the access roads to the site. Pile driving will create noise and vibration effects. The duration of the effect will be approximately 5 years as each intake will take approximately 5 years to construct. Implementation of intake construction at each location will be staggered by approximately 6 months. Intake 3, the middle intake, will begin construction first; approximately 6 months later, construction will begin at intake 5, the southernmost intake. Construction at intake 2, the northernmost intake, will begin approximately 1 year after having begun at intake 5. The result is that construction will overlap at all three sites for approximately 4 years.

Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting colonies is at least 20 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where construction, dredging, or drilling activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in the open water that could be present under baseline conditions.

Noise is the construction-related effect with potential to reach furthest from the project footprint. The standard noise threshold for avian species is 60 dBA (Dooling and Popper 2007). The combined use of the six loudest pieces of construction equipment and pile driving will be no more than 60 dBA at 2,000 feet from the edge of the project footprint. Noise, light, or vibration effects on California least tern foraging habitat in the vicinity of the north Delta intakes construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 20 miles) from known breeding colonies and the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983).

6.4.3.3 Operations and Maintenance

6.4.3.3.1 Operations

6.4.3.3.1.1 Microcystis

The operation of the north Delta intakes have potential to affect streamflows, temperature, and residence times, all variables with potential to affect the occurrence of *Microcystis* blooms. *Microcystis* is a toxic blue-green alga shown to have negative effects on the aquatic foodweb of the Delta (Brooks et al. 2012), with blooms generally occurring from between June to October, when water temperature is 19°C or more. There is potential for some small increase in the frequency of *Microcystis* blooms in the Delta as a result of the operation of the north delta intakes (see Section 6.1.3.5.5 *Microcystis)*, but effects on California least tern are expected to be very small and therefore very difficult to measure. There is only one known, active colony of California least tern’s in the Sacramento-San Joaquin Delta, which on the eastern edge of their known range. This colony is located on the Montezuma wetlands in eastern Suisun Marsh and as of 2013 there were a maximum of 25 breeding pairs and 29 nests with a maximum of four fledglings (Frost 2014). While these nesting birds will forage within the Sacramento-San Joaquin

Delta, any incremental effects from potentially slight increases in microcystin concentrations on nesting success would be very difficult to detect given the lack of information regarding the effects of microcystins on California least tern, the existing low reproductive rate of the colony, and the inability to isolate potentially small increases in microcystin as causing an effect distinct from all other potential threats.

6.4.3.3.1.2 Selenium

Selenium exposure has been found to cause reproductive and other physiological effects such as liver lesions, emaciation, developmental abnormalities, etc. in wild aquatic birds that use agricultural drainage water storage areas in the San Joaquin Valley of California (Ohlendorf et al. 2009; Ohlendorf 1986). The selenium concentrations found in these regions are far greater than those found in the Delta today (Presser and Luoma 2006).

A current mass balance of selenium, as a function of source and conveyance, is not available for the San Francisco Estuary (Presser and Luoma 2010). Annual and seasonal variations of selenium concentrations in the Delta and estuary are influenced by discharges in rivers and anthropogenic sources (Presser and Luoma 2006). Water inflow to the Delta comes primarily from the Sacramento and San Joaquin rivers of which the Sacramento River provides the largest water volume contribution and dilution of selenium inputs from other sources. Factors affecting selenium contribution and dilution include total river inflow, water diversions and/or exports, the proportion of the San Joaquin River that is diverted south before entering the estuary, and total outflow of the estuary to the Pacific Ocean (Presser and Luoma 2010).

Selenium contamination in soils and water of the Sacramento Valley is not high and thus not considered a threat in this part of the California least tern's range (Seiler *et al.* 2003). In the San Joaquin River basin, implementation of both regulatory controls and the Grassland Bypass Project, which manages agricultural drainage south and west of the Grassland Ecological Area, have significantly improved water quality in the San Joaquin River and adjacent channels. However, irrigation drainage into Mud Slough and the San Joaquin River results in non-compliance with the selenium water quality objective. Achieving water quality compliance for this segment of the river is not anticipated until 2019 or later. Continued inputs from precipitation runoff from selenium-laden soils, irrigation drainage, and existing riverbed loads still provide inputs of selenium to the Delta where California least tern are potentially exposed to selenium through their diet consisting principally of amphibians and small fish.

There are currently no predictive modeling tools, nor is there an understanding of effects thresholds, that would enable predicting direct effects of dietary selenium exposure on California least tern. However, inferences about the effects of selenium exposure are possible using Delta Smelt as a surrogate for California least tern prey.

In the Delta Smelt effects analysis (Section 6.1, *Effects on Delta Smelt*) DSM2 volumetric fingerprinting was used to estimate the source water contribution of Delta water sources, including the San Joaquin River, that are the primary source of selenium loading to the Delta. Aqueous and Delta Smelt selenium tissue concentrations were modeled at five sites: San Joaquin River at Prisoners Point, Cache Slough at Ryer Island, Sacramento River at Emmaton, San Joaquin River at Antioch, and Suisun Bay at Mallard Island. Modeling results indicated that, of these five sites, the highest proportion of San Joaquin River water and its selenium load (and thus resulting fish tissue selenium) occurred at Prisoners Point. Thus, of the Delta sites modeled for Delta Smelt, Prisoners Point represents the worst-case scenario for selenium exposure.

Results for the PA selenium bioaccumulation modeling for Delta Smelt at Prisoners Point showed increases of as much as twice the modeled tissue concentration, in Delta Smelt foraging at that location. Despite the predicted increases, all but 0.7% of modeled tissue concentrations were below the effects threshold for fish deformities. Based on these modeling results, the PA is unlikely to increase tissue concentrations significantly enough to result in detrimental effects to Delta Smelt. The PA would be expected to have similar effects on fishes with diets and habitat preferences similar to Delta Smelt (e.g., silversides). However, this assumption would not apply to young sunfishes or Sacramento splittail, whose parental diet may include other fish or bivalves that bioaccumulate selenium at substantially higher rate than crustaceans. Our surrogate Delta Smelt tissue modeling also does not represent the risk to California least tern foraging in locations upstream of Prisoners Point with higher San Joaquin River water and selenium contributions, although given the distance to the only active colony, foraging in this area is highly unlikely.

A significant factor in the bioavailability of selenium is water residence time. Biogeochemical modeling suggests that increasing the San Joaquin River discharge could result in increased bioavailable selenium during “low flow” conditions (Meseck and Cutter 2006). Low flow conditions modeled were 70-day residence times. For the PA, residence times were estimated using DSM2-PTM to evaluate the effects of water operations on water quality. Residence time changes under for the PA varied greatly by model site. The highest residence times for the both the NAA and the PA occurred at Grant Line Canal and Old River. The modeling predicted for the PA a 95% percentile, July water residence time of 42.8 days, a reduction of 0.8 days compared to the NAA. Residence time estimates did not meet or exceed the 70-day residence times used in the Meseck and Cutter (2006) biogeochemical modeling that predicted in increased selenium bioavailability. This would suggest that the PA would not result in the same increase of bioavailable, particulate selenium predicted by the hydrologic conditions modeling of Meseck and Cutter (2006).

Thus, using Delta Smelt as a surrogate for California least tern fish prey, selenium bioaccumulation modeling suggests that reductions in fish prey for fish feeding at the same trophic level as Delta Smelt are unlikely to result from the PA. Prey fishes that feed on bivalves or at a higher trophic level may represent an increased risk. Effects of the PA on California least tern, either directly to the bird via increased dietary selenium, or indirectly through reduced fish prey availability, are currently unquantifiable. If risk were increased because of the PA, it would most likely occur for California least tern residing and feeding in the South Delta and the San Joaquin River upstream from Prisoners Point to Vernalis or from California least tern that consumed Sacramento splittail or piscivorous fishes. Given that the only active California least tern colony in the Sacramento-San Joaquin Delta is in Montezuma Wetlands, far from the South Delta, and the fact that California least terns forage on small, top-feeding pelagic fishes such as silversides and topsmelt, the potential for effects from selenium on California least tern is considered so small as to be immeasureable and therefore insignificant.

6.4.3.3.2 Maintenance

Ongoing maintenance activities at the intakes include intake dewatering, sediment removal, debris removal, and biofouling and corrosion removal. These activities will occur from water-based equipment approximately annually. The 60-dBA noise threshold from maintenance activities will not exceed 1,200 feet. Because the intakes are gravity fed, with all pumping being done at the pumping plant at Clifton Court Forebay, no effects from noise will occur as a result of intake operation. Noise, light, or vibration effects on California least tern foraging habitat from operations and maintenance of the north Delta intakes are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 20 miles) from known breeding locations.

6.4.4 Tunneled Conveyance Facilities

6.4.4.1 Habitat Loss and Fragmentation

The tunneled conveyance facilities that would result in 21 acres of impacts on modeled California least tern foraging habitat (<.1% of modeled foraging habitat within action area) include tunnel work areas, vent shafts, tunnel conveyors, access roads, and barge landing (Figures 6.4-5 through 6.4-8). Each of these water conveyance facility structures are located greater than 19 miles from known California least tern breeding locations (Pittsburg Power Plant and Montezuma Wetlands) [32], and there is a very low probability that these areas would be used for foraging by California least tern. In addition, the tern is not limited by foraging habitat and the habitat loss from water conveyance facilities construction comprises less than 0.1% of the foraging habitat in the action area.

6.4.4.2 Construction Related Effects

The duration of active tunnel construction areas is expected to be approximately 8 years. See Section 3.2.3 *Tunneled Conveyance*, and Appendix 3.D *Construction Schedule for the Proposed Action*, for complete construction activity and timing details.

Construction noise up to 60 dBA (the standard noise threshold for avian species; Dooling and Popper 2007) will occur within 1,200 feet of the footprints for tunnel work areas, tunnel conveyors, and vent shafts. Construction and pile driving noise up to 60 dBA will occur 2,000 feet from the edge of the barge landing construction footprint. Light associated with nighttime activities is also possible.

Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting colonies is at least 19 miles, the potential for birds to occur is very low as the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). In addition, if a bird were to forage in a region where construction, dredging, or drilling activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would

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[32] The Sacramento Regional Wastewater treatment facility (Bufferlands) is closer to the intake construction location, that site has only supported one successful breeding pair and since 2013 has not supported nesting. As such, this site is not considered a breeding colony. See Section 4.5.9, *California Least Tern*, for more details.

adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in the open water that could be present under baseline conditions.

Noise or light effects on California least tern foraging habitat in the vicinity of the tunneled conveyance facilities construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 19 miles) from known breeding colonies. No permanent effects on this species from the construction of the tunneled conveyance facilities are anticipated.

6.4.4.3 Operations and Maintenance

The intermediate forebay and spillway and the pumping plant will require operations and maintenance. Intermediate forebay maintenance includes dredging, control of vegetation and rodents, embankment repairs, and monitoring of seepage flows. Dredging at the intermediate forebay will be infrequent as the sediment storage capacity is designed to last 50 years.

Operations and maintenance related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting colonies is at least 19 miles, the potential for birds to occur is very low as the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). In addition, if a bird were to forage in a region where dredging activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in open water that could be present under baseline conditions.

Noise or light effects on California least tern foraging habitat in the vicinity of the tunneled conveyance facilities construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 19 miles) from known breeding colonies. No permanent effects on this species from the operations and maintenance of the water conveyance facilities are anticipated.

6.4.5 Clifton Court Forebay Modification

6.4.5.1 Habitat Loss and Fragmentation

Clifton Court Forebay (CCF) Modification includes dredging, the expansion of the forebay through the creation of a new embankment, and the creation of a new canal and siphon will result in the loss of 261 acres of California least tern foraging habitat, but it will also result in the creation of 677 acres of foraging habitat before this loss occurs, for a net gain of 460 acres of California least tern foraging habitat. Additional habitat disturbance resulting from dredging of the forebay is described in Section 6.4.5.1, *Construction Related Effects*

6.4.5.2 Construction Related Effects

Construction activities at Clifton Court Forebay include pile driving, excavation, dredging, and cofferdam and embankment construction. Construction at Clifton Court Forebay will be phased by location and the duration of construction will be approximately 6 years. The duration of dredging is expected to be approximately 4 years. For complete details on construction activities and phasing, see Section 3.2.5 *Clifton Court Forebay*; for more details on schedule, see Appendix 3.D *Construction Schedule for the Proposed Action*.

Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from CCF to known nesting colonies is at least 20 miles, the potential for birds to occur is very low, as the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). There is one record, from 1994, of a California least tern foraging in CCF (Yee et al. 1995). However, if a bird were to forage in a region where construction, dredging, or drilling activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would be expected to adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in the open water that could be present under baseline conditions.

The combined use of the six loudest pieces of construction equipment and pile driving will be no more than 60 dBA at 2,000 feet from the edge of CCF. Noise, light, or vibration effects on California least tern foraging habitat in the vicinity of the construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 20 miles) from known breeding locations and the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983).

6.4.5.3 Operations and Maintenance

The operational components of the modified Clifton Court Forebay include the control structures and the siphons. The forebay and the canals will require erosion control, control of vegetation and rodents, embankment repairs, and monitoring of seepage flows. Maintenance of control structures could include roller gates, radial gates, and stop logs. Maintenance requirements for the spillway would include the removal and disposal of any debris blocking the outlet culverts. Dredging may be necessary to remove sediments in the forebays though this is expected to be infrequent as it is designed to hold 50 years of sediment.

Operations and maintenance related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 20 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where dredging activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in open water that could be present under baseline conditions.

Because these activities generate small levels of noise, any potential effect on California least tern would be insignificant and undetectable. Therefore, no noise related effects on California least tern are anticipated from the operations and maintenance associated with the modification of Clifton Court Forebay.

6.4.6 Power Supply and Grid Connections

6.4.6.1 Habitat Loss and Fragmentation

Mapped construction footprints for power supply and grid connections overlap with modeled California least tern foraging habitat in several locations along the alignment (Figure 6.4-1 through 6.4-11, Figure 6.4-13, and 6.4-14). Transmission lines poles or towers would not be placed within open water habitats, and therefore no permanent impacts are expected on California least tern foraging habitat, therefore no habitat loss is expected from this activity.

6.4.6.2 Construction Related Effects

New temporary power 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 power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, 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, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Construction of new transmission lines will require 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-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at 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 will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than 1 year at any one location. See Section 3.2.7.2 *Construction*, for a full description of the construction activities.

Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 19 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where transmission line construction was occurring, the bird would be expected to avoid the equipment and the construction area. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other structure that could be present under baseline conditions.

Noise or light effects on California least tern foraging habitat in the vicinity of the power supply and grid connection construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 19 miles) from known breeding locations as the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983).

6.4.6.3 Operations and Maintenance

The temporary transmission lines will be in place for the duration of conveyance facility construction (approximately 10 years); the permanent transmission lines will remain to supply power to the pumping plant. Maintenance activities at the transmission lines will include vegetation management and overland travel for some emergency repairs, but no operation or maintenance is expected in open water habitats. Therefore, operations and maintenance activities for transmission lines will not adversely affect California least tern foraging habitat.

6.4.7 Head of Old River Gate (HOR gate)

6.4.7.1 Habitat Loss and Fragmentation

The construction of the HOR gate will result in the permanent loss of 3 acres (<0.01% of modeled foraging habitat in the action area) of modeled California least tern foraging habitat (Figure 6.4-12). The HOR gate construction area is greater than 35 miles from the nearest breeding colony (Pittsburg Power Plant), and the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). Therefore, there is a very low probability that the area around the HOR gate would be used for foraging by California least tern. In addition, the Pittsburg Power Plant nesting location is no longer active. The habitat loss from HOR gate construction comprises less than 0.1% of foraging habitat in the action area.

6.4.7.2 Construction Related Effects

HOR gate construction will include dredging along 500 feet of channel to prepare it for gate construction, which will last approximately 15 days (Section 3.2.10.8, *Dredging and Riprap Placement*). Dredging equipment will be operated from a barge in the channel. It will also include construction of a cofferdam and foundation for the HOR gate, which will require in-water pile driving and will last up to 32 months (3.2.10.11, *Pile Driving*). The installation of the cofferdam will require up to 700 strikes per pile over an estimated 40-day period. The installment of the foundation for the operable barrier will require 15 piles to be set per day with up to 1,050 strikes per pile over an estimated 7-day period.

Construction related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 35 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where construction, dredging, or drilling activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in the open water that could be present under baseline conditions.

Noise is the construction-related effect with potential to reach furthest from the project footprint. The standard noise threshold for avian species is 60 dBA (Dooling and Popper 2007). The combined use of the six loudest pieces of construction equipment and pile driving will be no more than 60 dBA at 2,000 feet from the edge of the project footprint. Noise, light, or vibration effects on California least tern foraging habitat in the vicinity of the HOR gate construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 35 miles) from known breeding locations as the typical foraging habitat for California least tern is within 2 miles of their colonies (Atwood and Minsky 1983). No permanent effects on this species from the construction of the HOR gate are anticipated.

6.4.7.3 Operations and Maintenance

The new HOR gate will replace the temporary rock barrier that is typically installed at the same location. Because the HOR gate is replacing an existing temporary barrier, no adverse effects to the potentially suitable habitat from hydrological changes are expected.

Periodic maintenance of the HOR gates would occur every 5 to 10 years. Maintenance dredging around the gate would be necessary to clear out sediment deposits. Depending on the rate of sedimentation, maintenance would occur every 3 to 5 years. Noise generated by the service truck nor the dredging machinery will exceed 60 dBA (standard threshold for avian species; Dooling and Popper 2007) at 1,200 feet (See Section 3.3, *Operations and Maintenance of New and Existing Facilities* for further detail).

Operations and maintenance related actions are not expected to injure or kill California least tern individuals. Because the distance from known nesting locations is at least 35 miles, the potential for birds to occur is very low. In addition, if a bird were to forage in a region where operations and maintenance activities were occurring, the bird would be expected to avoid the equipment. This avoidance would not constitute a behavioral modification that would adversely affect the species because individuals would avoid construction equipment as they would any other boat or floating object in open water that could be present under baseline conditions.

Noise, light, or vibration effects on California least tern foraging habitat in the vicinity of the HOR gate construction footprint are expected to be insignificant because the species is very unlikely to occur in the region due to the distance (greater than 35 miles) from known breeding locations. No permanent effects on this species from the operations and maintenance of the HOR gate are anticipated.

6.4.8 Reusable Tunnel Material Storage Area

As described in Section 3.4.6.3.2, *Avoidance and Minimization Measures*, RTM sites will avoid California least term foraging habitat.

6.4.9 Restoration

The placement of restoration sites is currently unknown. However, tidal, non-tidal, and riparian restoration and channel margin enhancement to offset effects on species habitat and wetlands will not result in conversion of modeled California least tern foraging habitat to other habitat types. All restoration sites will be selected by DWR, subject to approval by the jurisdictional fish and wildlife agencies (CDFW, NMFS, USFWS).

6.4.10 Effects on Critical Habitat

Critical habitat has not been designated for the California least tern.

6.4.11 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of California least tern will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect California least tern in the action area when foraging habitat degradation occurs without USFWS authorization; the likelihood of open-water habitat loss is very unlikely. The most likely activity to affect the quality of open-water habitat is unauthorized water pollution and climate change. Poor water quality may decrease prey species density or increase toxin loading such that nesting success and survivorship are affected. Climate change threatens to modify annual weather patterns; it may result in a loss of California least tern prey, and/or increased numbers of their predators, parasites, and disease. Since the habitat near the action area with the highest likelihood of supporting nesting California least terns is within Suisun Marsh area where development is prohibited or highly restricted, cumulative effects in the action area are not expected to appreciably diminish the likelihood of the species' long-term survival and recovery.

6.5 Effects on Western Yellow-Billed Cuckoo

Appendix 6.B *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the proposed action (PA) on wildlife species. Field surveys of the entire action area were not possible because many of the properties are in private ownership. For this reason, GIS-based habitat models were used to identify areas of potential effect. Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.11.7 *Species Habitat Suitability Model*, provides a description of the habitat suitability model for western yellow-billed cuckoo. That model identifies migratory habitat for western yellow-billed cuckoo in the action area. Western yellow-billed cuckoos are not known to nest in the action area, therefore the PA will not affect nesting western yellow-billed cuckoos. The nearest CNDDB nesting occurrence for this species is 43 miles from the location where modeled habitat would be removed by project related activities.

Activities associated with geotechnical exploration, safe haven work areas, north Delta intakes, tunneled conveyance facilities, and power supply and grid connection activities may affect migrating western yellow-billed cuckoos, as described below. Figure 6.5-1 provides an overview of the locations of surface impacts relative to western yellow-billed cuckoo habitat and occurrences. An estimated 32 acres of western yellow-billed cuckoo habitat will be lost as a result of project implementation. There is a total of approximately 11,224 acres of western yellow-billed cuckoo habitat in the action area. Therefore, the loss of 32 acres would result an impact on 0.3% of the habitat in the action area (Table 6.5-1). As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the loss will be offset through riparian creation or restoration at a 2:1 ratio for a total of 64 acres of riparian creation or restoration.

Table 6.5-1. Maximum Habitat Loss on Habitat for Western Yellow-Billed Cuckoo by Activity Type (Acres)

Western Yellow-Billed Cuckoo Habitat	Total Habitat in Action Area	Permanent Habitat Loss								
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Power Supply and Connection	Geotechnical Exploration	Total Habitat Loss
Total Habitat	11,224	0	5	11	0	0	12	4	0	32

6.5.1 Geotechnical Exploration

Geotechnical exploration sites are currently undetermined but will occur along the tunnel alignment. A USFWS approved biologist will work with the geotechnical exploration team to identify and avoid adverse effects on western yellow-billed cuckoo migratory habitat as described in Section 3.4.5.4.2.2.1, *Geotechnical Exploration*. Therefore, geotechnical exploration will not affect western yellow-billed cuckoo.

6.5.2 Safe Haven Work Areas

The placement of safe haven work areas is currently unknown because they are constructed "as needed" along the alignment. As described in Section 3.4.6.4.2.2.2, *Save Haven Work Areas,* safe havens will avoid western yellow-billed cuckoo habitat. Therefore, safe havens will not affect western yellow-billed cuckoo.

6.5.3 North Delta Intake Construction

6.5.3.1 Habitat Loss and Fragmentation

The north delta intakes will result in the loss of an estimated 5 acres of western yellow-billed cuckoo habitat (Table 6.5-1; Figures 6.5-2, 6.5-3, and 6.5-4). Fragmentation is not expected to affect migratory western yellow-billed cuckoos in this area because migratory habitat is not limited in the area, and migrating birds can use small habitat patches and easily move from one location to the next during migration. As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the loss of habitat will be offset through riparian creation or restoration at a 1:1 ratio.

6.5.3.2 Construction Related Effects

Construction activities at each intake are described in Section 3.3.6.1, *North Delta Intakes*. Intake construction will require the use of loud, heavy equipment within the construction site as well as along the access roads to the site. Pile driving will create noise and vibration effects.

Construction activities will create noise up to 60 dBA at no more than 1,200 feet from the edge of the noise generating activity unless pile driving is required, in which case noise up to 60 dBA could reach up to 2,000 feet from the edge of the noise generating activity. While 60 dBA is the standard noise threshold for birds (Dooling and Popper 2007), this standard is generally applied during the nesting season, when birds are more vulnerable to behavioral modifications that can cause nest failure. There is evidence, however, that migrating birds will avoid noisy areas during migration (McClure et al. 2013). To minimize this effect, DWR will reduce noise in the vicinity of western yellow-billed cuckoo habitat as described in Section 3.4.7.5.1, *Avoidance and Minimization Measures*. This will include surveying for western yellow-billed cuckoo within the 60 dBA noise contour around the construction footprint, and if a yellow-billed cuckoo is found, limiting noise to less than 60 dBA where the bird occurs until it has left the area. DWR will also limit pile driving to daytime hours within 1,200 feet of western yellow-billed cuckoo habitat. With these measures in place, western yellow-billed cuckoo is not expected to be affected by noise.

Night lighting may also have the potential to affect migrating western yellow-billed cuckoos. While there is no data on effects of night lighting on migration for this species, studies show that migrating birds of other species are attracted to artificial lights and this may disrupt their migratory patterns or cause collision-related fatalities (Gauthreaux and Belser 2006). To minimize this effect, DWR will screen all lights and direct them away from western yellow-billed cuckoo habitat as described in Section 3.4.7.5.1, *Avoidance and Minimization Measures*. With this measure in effect, and given that migrating western yellow-billed cuckoos are expected to occur in the vicinity of project activities seldom if at all, residual lighting effects on the species are expected to be negligible and is not expected to result in take of the species.

6.5.3.3 Operations and Maintenance

Ongoing maintenance activities at the intakes include intake dewatering, sediment removal, debris removal, and biofouling and corrosion removal. These activities will occur from water-based equipment approximately annually. Noise and lighting effects from maintenance activities and permanent facility lighting could adversely affect migrating western yellow-billed cuckoos if they use habitat in the vicinity. Permanent and maintenance-related lighting will be minimized as described in Section 3.4.7.5.1 *Avoidance and Minimization Measures.* Although there may be residual noise and lighting extending into western yellow-billed cuckoo habitat, this is not likely to result in injury of western yellow-billed cuckoos as a result of impairing essential behavioral patterns because migratory habitat is plentiful in the action area and individuals can readily avoid the disturbance during migration.

Because the intakes are gravity fed, with all pumping being done at the pumping plant at Clifton Court Forebay, no effects from noise will occur as a result of intake operation.

6.5.4 Tunneled Conveyance Facilities

Tunneled conveyance facilities include tunnel work areas, vent shafts, the pumping plant and shaft location, a new forebay and spillway, tunnel conveyors, barge unloading facilities, fuel stations, and concrete batch plants (Figures 6.5-1, 6.5-2, 6.5-5, 6.5-8, and 6.5-9).

6.5.4.1 Habitat Loss and Fragmentation

An estimated 11 acres of western yellow-billed cuckoo habitat (0.1% of migratory habitat in the action area) will be removed for tunneled conveyance facility construction (Table 6.5-1). Fragmentation is not expected to be an effect for migratory western yellow-billed cuckoos in this area because migratory habitat is not limited in the area, and migrating birds can use small habitat patches and easily move from one location to the next during migration. As described in Section 3.4.7.5.3 *Compensation to Offset Impacts*, the loss will be offset through riparian creation or restoration at a 1:1 ratio.

6.5.4.2 Construction Related Effects

Construction activities associated with conveyance facility activities are described in Section 3.2, *Conveyance Facility Construction.* Western yellow-billed cuckoo habitat occurs in the vicinity of the forebay and spillway and may be affected by construction noise and light. Construction noise up to 60 dBA will occur at up to 2,000 feet from the forebay and spillway construction footprint.

Light effects from nighttime activities are also possible. Noise and lighting associated with conveyance facility construction may affect western yellow-billed cuckoos as described in Section 6.5.3.2, *Construction Related Effects*. With the avoidance and minimization measures in place, noise effects on the species will be avoided and lighting effects, if any, will be negligible and are not expected to result in take of the species.

6.5.4.3 Operations and Maintenance

The intermediate forebay and spillway will require operations and maintenance. Intermediate forebay maintenance includes dredging, control of vegetation and rodents, embankment repairs, and monitoring of seepage flows. As described in Section 6.5.4.1 *Habitat Loss and Fragmentation*, western yellow-billed cuckoo habitat occurs in the vicinity of construction. However, this habitat is greater than 4,000 feet south of the forebay and spillway. Therefore, adverse effects on western yellow-billed cuckoo from operations and maintenance activity noise are not expected.

6.5.5 Clifton Court Forebay Modification

Clifton Court Forebay (CCF) modification includes dredging, the expansion of the forebay through the creation of a new embankment, and creating a new canal and siphon. The CCF modification footprint does not overlap with western yellow-billed cuckoo habitat. Furthermore, there is no western yellow-billed cuckoo habitat in the vicinity of the CCF modification footprint. Therefore, activities associated with CCF modification will not affect western yellow-billed cuckoos.

6.5.6 Power Supply and Grid Connections

6.5.6.1 Habitat Loss and Fragmentation

Mapped construction footprints for the transmission lines will result in loss of up to 4 acres of western yellow-billed cuckoo habitat (Figures 6.5-1 through 6.5-4 and 6.5-6 through 6.5-9). Fragmentation is not expected to be an effect for migratory western yellow-billed cuckoos in this area because migratory habitat is not limited in the area, and migrating birds can use small habitat patches and easily move from one location to the next during migration. As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the loss will be offset through riparian creation or restoration at a 1:1 ratio.

6.5.6.2 Construction Related Effects

New temporary power 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 power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, 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.

Construction of new transmission lines will require 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-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at 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 will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. Section 3.2.7.2, *Construction*, provides a full description of the construction activities related to transmission line installation. The duration of transmission line construction activities will not be more than 1 year at any one location.

Western yellow-billed cuckoo habitat occurs in the vicinity of the transmission lines, and may be affected by construction noise and light. Light effects from nighttime activities are also possible. Noise and lighting associated with transmission line construction may affect western yellow-billed cuckoo as described in Section 6.5.3.2 *Construction Related Effects*. For details on the avoidance and minimization measures, see Section 3.4.7.5.1.1 *Activities with Fixed Locations*. With the avoidance and minimization measures in place, noise related effects will be avoided and lighting effects on the species, if any, will be negligible and are not expected to result in take of the species.

6.5.6.3 Operations and Maintenance

The temporary transmission lines will be in place for the duration of conveyance facility construction (approximately 10 years); the permanent transmission lines will remain to supply power to the pumping plant. Maintenance activities at the transmission lines will include vegetation management and overland travel for some emergency repairs. Loss of habitat associated with the transmission line is counted under permanent habitat loss, therefore vegetation control is not likely to result in any additional effects on western yellow-billed cuckoo.

Migrating western yellow-billed cuckoos may be subject to bird strikes at the transmission lines. However, 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, as described in Section 3.4.7.4.1 *Avoidance and Minimization Measures*. With the avoidance and minimization measures in place, and in view of the rarity of migrating western yellow-billed cuckoos in the action area, it is highly unlikely that this species will experience bird strikes at project transmission lines.

6.5.7 Head of Old River Gate

The HOR gate construction footprint does not overlap with western yellow-billed cuckoo habitat. Furthermore, there is no western yellow-billed cuckoo habitat in the vicinity of the HOR gate. Therefore, activities associated with the HOR gate will not affect western yellow-billed cuckoo.

6.5.8 Reusable Tunnel Material

6.5.8.1 Habitat Loss and Fragmentation

An estimated 12 acres of western yellow-billed cuckoo habitat (0.1% of habitat in the action area) will be removed for reusable tunnel material placement (Table 6.5-1; Figures 6.5-2, 6.5-5, 6.5-6, and 6.5-10). Fragmentation is not expected to be an effect for migratory western yellow-billed cuckoos in this area because migratory habitat is not limited in the area, and migrating birds can use small habitat patches and easily move from one location to the next during migration. As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the habitat loss will be offset through riparian creation or restoration at a 1:1 ratio.

6.5.8.2 Construction Related Effects

Each RTM storage area will take 5 to 8 years to construct and fill. Construction activities at each RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt for long-term on-site storage. The movement of the material to another site is not an activity covered in the assessment. For more details about the activities associated with RTM placement see Section 3.2.10.6, *Dispose Soils*.

Western yellow-billed cuckoo habitat occurs in the vicinity of several RTM sites. Noise and lighting associated with RTM construction may affect migrating western yellow-billed cuckoos as described in Section 6.5.3.2, *Construction Related Effects*. With the avoidance and minimization measures in place, noise related effects will be avoided and lighting effects on the species, if any, will be negligible and are not expected to result in take of the species.

6.5.8.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM storage areas and therefore no effects to western yellow-billed cuckoo. While reuse of the RTM is possible, end uses for the 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.

6.5.9 Habitat Restoration/Mitigation

A USFWS approved biologist will work with DWR and BOR to avoid the loss of suitable habitat. As such, no western yellow-billed cuckoo habitat will be removed to construct restoration sites. Take of western yellow-billed cuckoo that could result from habitat restoration, if any, will not be authorized through the biological opinion for this proposed action.

6.5.9.1 Effects on Critical Habitat

There is no critical habitat for western yellow-billed cuckoo in the action area.

6.6 Effects on Giant Garter Snake

Appendix 6.B *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the proposed action (PA) on terrestrial species. Section 4.A.12.7 *Species Habitat Suitability Model*, provides a description of the suitable habitat model for giant garter snake. Suitable habitat for giant garter snake is defined in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.12.6 *Suitable Habitat Definition.*

Activities associated with geotechnical exploration, safe haven work areas, north delta intakes, tunneled conveyance facilities, Clifton Court Forebay modifications, power supply and grid connections, Head of Old River (HOR) Gate, reusable tunnel material, and habitat restoration activities may affect giant garter snake, as described below. Figure 6.6-1 provides an overview of the locations of surface impacts relative to giant garter snake modeled habitat and occurrences. Section 4.A.12.6 *Suitable Habitat Definition,* for the definition of suitable giant garter snake habitat. There are 88,947 acres (26,328 acres of aquatic habitat and 62,619 acres of upland habitat) of modeled giant garter snake habitat in the action area. An estimated 775 acres (<1% of total modeled habitat in action area) of modeled giant garter snake habitat will be lost as a result of project implementation. This includes 205 acres of modeled aquatic habitat (<1% of modeled aquatic habitat in action area) and 570 acres of modeled upland habitat (<1% of modeled upland habitat in action area). Effects from these activities will be described in detail below. Table 6.6-1 and Table 6.6-2 summarize the total estimated habitat loss of giant garter snake modeled habitat.

Table 6.6-1. Maximum Habitat Loss of Modeled Habitat for Giant Garter Snake by Activity Type (Acres)

Giant Garter Snake Modeled Habitat	Total Modeled Habitat in Action Area	Permanent Habitat Loss								Temporary Habitat Loss	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Power Supply and Connection	Total Maximum Permanent Habitat Loss	Geotechnical Exploration	Power Supply and Connection
Aquatic	26,328	0	12	93	16	1	83	0	205	0[1]	0[1]
Upland	62,619	0	62	127	219	2	159	1	570	98	67
Total	**88,947**	**0**	**74**	**220**	**235**	**3**	**242**	**1**	**775**	**98**	**67**

Notes

[1] Geotechnical exploration and power supply and grid connections will avoid suitable aquatic giant garter snake habitat; see Section 3.4.5.5.2, *Avoidance and Minimization Measures*

Table 6.6-2. Maximum Direct Effects on and Conservation of Modeled Habitat for Giant Garter Snake

	Permanent Habitat Loss	**Compensation Ratios**		**Total Compensation**	
	Total Maximum Habitat Loss (Acres)	**Protection**	**Restoration**	**Protection[2]**	**Restoration[2]**
Aquatic Total	205	3:1 or 2:1[1]		615 or 410	
Upland Total	570			1,710 or 1,140	
TOTAL	**775**			**2,325 or 1,550**	

Notes

[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.11.6, *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.

6.6.1 Geotechnical Exploration

6.6.1.1 Habitat Loss and Fragmentation

The only permanent loss of giant garter snake habitat resulting from geotechnical exploration will be boreholes, which will be grouted upon completion. These holes are very small (approximately 8 inches diameter) and this permanent loss will have no or negligible effects on the giant garter snake. Temporary habitat disturbance that is expected to occur during the exploration is described below in Section 6.6.1.2, *Construction Related Effects.*

6.6.1.2 Construction Related Effects

Geotechnical exploration will avoid effects on giant garter snake aquatic habitat but may temporarily affect up to 98 acres of upland habitat during geotechnical exploration. Except for the habitat loss associated with boreholes described above, this temporary effect will consist of driving overland to access the boring sites, and storing equipment for short time periods (a few hours to 12 days). The operation of equipment during construction could result in injury or mortality of giant garter snakes associated with the 98 acres of upland habitat, if any are present. The potential for this effect will be minimized by confining activities within giant garter upland habitat to the active season, confining movement of heavy equipment to existing access roads or to locations outside giant garter snake upland habitat, and requiring that all construction personnel receive worker awareness training, as described in Section 3.4.5.5.2.2, *Activities with Flexible Locations.*

6.6.1.3 Operations and Maintenance

There will be no ongoing operations or maintenance associated with geotechnical exploration, therefore no effect on giant garter snake.

6.6.2 Safe Haven Work Areas

As described in Section 3.4.6.5.2, *Activities with Flexible Locations,* safe haven work areas will avoid giant garter snake habitat. Therefore, construction and operation of safe haven work areas will not affect this species.

6.6.3 North Delta Intake Construction

6.6.3.1 Habitat Loss and Fragmentation

An estimated 74 acres of giant garter snake modeled habitat overlap with the mapped north delta intakes 2, 3, and 5 along the Sacramento River (Figures 6.6-2, 6.6-3, 6.6-4), where land will be cleared for permanent facilities and temporary work areas. The 74 acres of modeled habitat (<0.01% of modeled habitat in the action area) includes 12 acres of aquatic habitat (<0.01% of modeled aquatic habitat in the action area) and 62 acres of upland habitat (<0.01% of modeled upland habitat in action area). Of the estimated 74 acres of modeled habitat to be removed, 47 acres (3 acres of aquatic and 44 acres of upland) will result from construction of permanent facilities such as intake structures and associated electrical buildings and facilities, and permanent access roads. The remaining 27 acres (9 acres of aquatic and 18 acres of upland) of loss will result from use of the work areas, which will last for approximately 5 years at each intake: because the duration of this effect is greater than 1 year, this effect will be compensated as if it were a permanent effect.

As shown on Figures 6.6-2, 6.6-3, and 6.6-4, the modeled habitat to be lost as a result of intake construction is modeled upland habitat along the Sacramento River. Per the Draft 2015 *Recovery Plan for Giant Garter Snake*, the Sacramento River at the intake locations does not meet the definition of either aquatic habitat or a corridor (U.S. Fish and Wildlife Service 2015c). Therefore, neither the intakes nor their construction are likely to obstruct giant garter snake movement in the Sacramento River.

Table 6.6-2 shows the compensation acreage to offset the total loss of giant garter snake habitat. As described in Section 3.4.6.6.2.1 *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal in the vicinity of suitable habitat to the minimal area necessary to facilitate construction activities.

6.6.3.2 Construction Related Effects

Construction activities at each intake that may affect giant garter snake include ground clearing and grading, construction of the intakes and associated facilities, vehicular use including transport of construction equipment and materials, in-water construction of crib walls, and in-water pile driving. It is unlikely that the in-water activity will affect giant garter snakes because the activities will occur in the Sacramento River, where the species is very unlikely to be present, based on the definitions of aquatic and corridor habitat presented in the Draft 2015 *Recovery Plan for Giant Garter Snake* (U.S. Fish and Wildlife Service 2015c).

The duration of construction at each intake facility will be approximately 5 years. Implementation of intake construction at each location will be staggered by approximately 6 months. Construction for Intake 3, the middle intake, will begin first; approximately 6 months later, construction will begin at intake 5, the southernmost intake. Construction at intake 2, the northernmost intake, will begin approximately 1 year after having begun at intake 5. The result is that construction will overlap at all three sites for approximately 4 years.

Vehicles and heavy equipment used to clear the construction sites and transport equipment and material could injure or kill giant garter snakes if individuals are present within the construction footprint. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for giant garter snakes to enter the work area. To avoid crushing giant garter snakes in their burrows during brumation, site clearing will occur during the active season, and the site will be fenced with exclusionary fencing to prevent snakes from entering the work area. A biological monitor will inspect the construction area prior to and during construction, and if a giant garter snake is encountered during surveys or construction, activities will cease 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. Additional measures to minimize this effect include limiting vehicle speed to 10 miles per hour within and in the vicinity of giant garter snake habitat where practical and safe to do so, visually checking for giant garter snakes under vehicles and equipment prior to moving them, and checking crevices or cavities in the work area including stockpiles which have been left for more than 24 hours where cracks or crevice may have formed. Equipment will be stored in designated staging areas, and these staging areas will have exclusion fencing where giant garter snakes have potential to occur. These measures are described in detail in Section 3.4.7.6.1.1 *Activities with Fixed Locations.* With these measures in place, there is still potential for giant garter snakes to be injured or killed within the 62 acres of upland habitat if, for example, vehicles must travel greater than 10 miles per hour and are unable to avoid giant garter snakes or if a snake is able to get through the construction fencing and is undetected by the biological monitor.

Giant garter snakes could potentially become entangled, trapped, or injured as a result of erosion control measures that use plastic or synthetic monofilament netting in construction areas within the construction footprint. This effect is not likely given that the construction area will be fenced and monitored after the biological monitor has relocated any giant garter snakes found in the construction area. This effect will be further avoided as described in Appendix 3.F *General Avoidance and Minimization Measures*, AMM2 *Construction Best Management Practices and Monitoring* by prohibiting use of these materials and limiting erosion control materials silt fencing. With these measures in place, the potential for giant garter snakes to be affected in this manner is minimal to none.

Giant garter snakes may be trapped in pipes or other structures used for construction. To avoid this effect, as described in Section 3.4.7.6.1.1 *Activities with Fixed Locations,* workers will inspect any conduits or other features where giant garter snakes may be trapped, and workers will properly contain and remove all trash and waste items generated during construction. With these measures in place, the potential for giant garter snakes to become trapped is minimal to none.

Giant garter snakes may be injured or killed, or their habitat may be contaminated, as a result of the use of toxic materials during construction. To avoid this effect, all construction equipment will be maintained to prevent leaks of fuel, lubricant, or other fluids, and workers will exercise extreme caution when handling or storing materials. Workers will keep appropriate materials on site to contain and clean up any spills as described in Appendix 3.F *General Avoidance and Minimization Measures*, AMM5 *Spill Prevention, Containment, and Countermeasure Plan.* With these measures in place, the potential for giant garter snakes to become injured or killed, or their habitat to be contaminated, is minimal to none.

Construction related effects on aquatic habitat outside the development footprint include decreased water quality during construction activities due to runoff, dewatering, and minor ground disturbance. Construction related water quality effects will be avoided, however, through standard water quality protection measures as described in Appendix 3.F *General Avoidance and Minimization Measures*, AMM3 *Stormwater Pollution Prevention Plan* and AMM4 *Erosion and Sediment Control Plan*.

Construction related light is not expected to affect giant garter snakes because they are diurnal and spent nighttime hours in burrows. Additionally, all lighting within construction areas will be screened and directed away from habitat areas.

Noise and vibrations in and near habitat could result in harm and/or harassment of giant garter snakes by interfering with normal activities such as feeding, sheltering, movement between refugia and foraging grounds, and other essential behaviors. Little is known regarding the effects noise and vibrations on GGS. Giant garter snakes could potentially avoid otherwise usable habitat close to construction sites where intense vibrations were being created, but are unlikely to be affected by noise alone. Snake ear anatomy only allows them to detect vibrations from the ground, unless noise is extensive enough to create vibrations. Typical construction activities that would occur close to the edge of the construction footprint and create enough vibration for snakes to perceive would be dozing and grading of staging areas and access roads and transfer of construction materials to and from the construction sites. These construction activities are unlikely to transmit vibration at an intensity significant enough for giant garter snakes to perceive it at a distance greater than 50 feet, and it is unknown if the species would avoid the habitat because of the vibration. In addition, the level of potential disturbance at the edge of the construction footprint will vary by construction activity, from period to period, from no disturbance to the estimated maximum. The result would be a temporary habitat loss at most, typically hours, days or weeks, followed by periods of no disturbance. Noise effects will be minimized as described in Appendix 3.F *General Avoidance and Minimization Measures*, AMM13 *Noise Abatement.* However, since these measures will only be implemented where practicable, some residual effects resulting from noise and vibrations are anticipated near giant garter snake habitat. Due to the long-term nature of the activities, giant garter snakes may habituate to these disturbances. DWR will monitor giant garter snake habitat immediately adjacent to the construction footprint prior to and during construction activities that could produce significant vibration outside the project footprint to determine if giant garter snakes are present and if they appear to be affected and report those findings to USFWs and CDFW.

6.6.3.3 Operations and Maintenance

6.6.3.3.1 Maintenance

Ongoing maintenance activities at the intakes include intake dewatering, sediment removal, debris removal, and biofouling and corrosion removal. These activities will occur from water-based equipment approximately annually. These activities are not expected to affect giant garter snake or its habitat because, as stated above, giant garter snakes are not likely to be present in the open water portion of the Sacramento River.

6.6.3.3.2 Operations

6.6.3.3.2.1 Microcystis

The operation of the north Delta intakes has potential to affect streamflows, temperature, and residence times, all off which may affect the occurrence of *Microcystis* blooms. *Microcystis* is a toxic blue-green alga shown to have negative effects on the aquatic foodweb of the Delta (Brooks et al. 2012), with blooms generally occurring from between June to October, when water temperature is 19°C or more. The sensitivity to microcystins, the toxins produced by *Microcystis*, varies by species and life stage (Butler et al. 2009; Schmidt et al. 2013). During *Microcystis* blooms, microcystins may accumulate in tissues of small planktivorous (plankton-eating) fish through the consumption of *Microcystis* or through foodweb transfer, i.e., consumption of prey that have consumed *Microcystis* (Schmidt et al. 2013); to a lesser extent, microcystins may be absorbed directly from the water (Butler et al. 2009). Microcystins are actively absorbed into the tissues and organs of vertebrates, particularly the liver, where they disrupt cellular activity (Butler at al. 2009; Schmidt et al. 2013). Although microcystins have been found in various aquatic organisms, including phytoplankton, zooplankton, crayfish, shrimp, mussel, snail, fish, and frogs, and are known to accumulate in several fish species (Schmidt et al. 2013; Smith and Haney 2006), some research indicates that the toxins may be excreted by the kidneys or metabolized into less toxic forms (Gupta and Guha 2006; Schmidt et al. 2013; Smith and Haney 2006). A study on sunfish found microcystin concentrations decreased after exposure, however, some persisted in organs.

The potential operational effects of the PA on *Microcystis* were assessed using two approaches. First, the frequency of flow conditions conducive to *Microcystis* occurrence (as defined by Lehman et al. 2013) was assessed in the San Joaquin River past Jersey Point (QWEST) and in the Sacramento River at Rio Vista (QRIO), based on DSM2-HYDRO modeling. Second, DSM2-QUAL water temperature modeling (Section 6.1.3.5.2, *Water Temperature*) and DSM2-PTM for estimates of residence time (Appendix 6.A *Quantitative Methods for Biological Assessment of Delta Smelt,* Section 6.A.4.3, methods discussion) were used to inform the potential for *Microcystis* occurrence, given the importance of water temperature and the probable importance of residence time (although there are no published relationships between *Microcystis* occurrence and residence time in the Delta). Note that more weight is placed on the analysis based on the published flow conditions at which *Microcystis* occurs (Lehman et al. 2013), because there are no published analyses of the relationship between *Microcystis* occurrence and residence time. Both sets of quantitative analyses (i.e., the flow analysis and the residence time/temperature analysis) focused on the summer/fall (July-November) period because it is during this time of the year that *Microcystis* blooms are likely to occur. Note that other environmental factors, such as nutrients, also affect the abundance of *Microcystis* (Lehman et al. 2014), but these factors are not readily predictable for comparison of the NAA and PA scenarios. This introduces some uncertainty to results based only on flow or residence time/temperature.

The first analysis examined the frequency of years during July-November in which mean monthly flows were within the range at which *Microcystis* has been shown to occur, per Lehman et al. (2013: 155): -240 to 50 m^3/s (approx. -8,500 to 1,800 cfs) for QWEST, and 100-450 m^3/s

(approx. 3,500 to 15,900 cfs) for QRIO[33]. This analysis suggested that flow conditions conducive to *Microcystis* bloom occurrence would tend to occur less frequently under the PA than NAA in the San Joaquin River, based on QWEST. For NAA, the percentage of years with QWEST within the range for *Microcystis* occurrence ranged from 89% in October to 98% in August, whereas for PA, the range was from 9% of years in October to 99% of years in August (Table 6.6-3). Neither the NAA nor the PA yielded mean monthly flows below the range noted for *Microcystis* occurrence, whereas for the PA there were substantially more years above the range than for NAA. The results reflected greater mean QWEST flows under the NAA compared to PA, with monthly means under the PA ranging from just under 0 m^3/s (-100 cfs) in August (compared to -168 m^3/s or -5,900 cfs under NAA) to 245 m^3/s (8,600 cfs) in October (compared to 16 m^3/s or 570 cfs under NAA). These results are attributable to less south Delta export pumping under the PA than under the NAA.

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[33] The DSM2-HYDRO output locations used for estimating QWEST were RSAN018 + SLTRM004 + SLDUT007; and for QRIO was RSAC101.

Table 6.6-3. Percentage of Modeled Years (1922-2003) in Which Mean Monthly Flow in the San Joaquin River Past Jersey Point (QWEST) Was Below, Within, and Above the Range for *Microcystis* Occurrence (Lehman et al. 2013).

	NAA				PA			
	Below Range (< -240 m^3/s)	**Within Range (-240 to 50 m^3/s)**	**Above Range (> 50 m^3/s)**	**Mean Flow, m^3/s (cfs)**	**Below Range (< -240 m^3/s)**	**Within Range (-240 to 50 m^3/s)**	**Above Range (> 50 m^3/s)**	**Mean Flow, m^3/s (cfs)**
July	0%	95%	5%	-162 (-5,714)	0%	78%	22%	68 (2,384)
August	0%	98%	2%	-168 (-5,931)	0%	99%	1%	-3 (-103)
September	0%	96%	4%	-128 (-4,531)	0%	52%	48%	191 (6,729)
October	0%	89%	11%	16 (568)	0%	9%	91%	245 (8,637)
November	0%	91%	9%	-39 (-1,391)	0%	53%	47%	178 (6,281)

Implementation of north Delta export pumping under the PA would result in reduced Sacramento River flow compared to the NAA, as reflected in the examination of QRIO (Table 6.6-3). The percentage of years within the range at which *Microcystis* has been noted to occur ranged from 59% in September to 89% in August under NAA, compared to a range from 48% in September to 96% in July for PA (Table 6.6-4). Given that Lehman et al.'s (2013) suggested mechanism for the importance of flow was lower flows leading to sufficiently long residence time to allow *Microcystis* colonies to accumulate into blooms, flows below the range noted for *Microcystis* occurrence by Lehman et al. (100-450 m^3/s) could also be favorable for bloom occurrence, whereas flows above the range may reduce residence time sufficiently to limit bloom formation. The percentage of years in which mean monthly flow was above the range that Lehman et al. (2013) found for *Microcystis* occurrence was less under PA than NAA in July (0%, compared to 10% under NAA), September (0%, compared to 29% under NAA), and November (10%, compared to 16% under NAA). On the basis of differences in QRIO flow, therefore, there could be greater potential for *Microcystis* occurrence in the lower Sacramento River under the PA than NAA. However, this is currently not an area of intense *Microcystis* blooms and if it remains turbid in the future, it is expected that current conditions will continue.

Table 6.6-4. Percentage of Modeled Years (1922-2003) in Which Mean Monthly Flow in the Sacramento River at Rio Vista Was Below, Within, and Above the Range for *Microcystis* Occurrence (Lehman et al. 2013).

	NAA				PA			
	Below Range (< -100 m^3/s)	**Within Range (-100 to 450 m^3/s)**	**Above Range (> 450 m^3/s)**	**Mean Flow, m^3/s (cfs)**	**Below Range (< -100 m^3/s)**	**Within Range (-100 to 450 m^3/s)**	**Above Range (> 450 m^3/s)**	**Mean Flow, m^3/s (cfs)**
July	5%	85%	10%	702 (24,793)	4%	96%	0%	396 (13,984)
August	11%	89%	0%	462 (16,331)	11%	89%	0%	282 (9,942)
September	12%	59%	29%	754 (26,612)	52%	48%	0%	457 (16,136)
October	15%	84%	1%	420 (14,839)	15%	84%	1%	291 (10,275)
November	7%	77%	16%	769 (27,162)	0%	90%	10%	541 (19,097)

The results of the DSM2-PTM-based residence time analysis presented here focus only on the particle insertion locations upstream (east) of Suisun Bay and Suisun Marsh, because this is where effects of the proposed action (PA) on hydraulic residence time are highest. The effects of the PA on residence time varied by subregion of the Delta. As previously described, there has been no published analysis of the relationship between *Microcystis* occurrence and residence time, so there is uncertainty as to what the differences described here may mean in terms of potential for *Microcystis* occurrence. In the riverine portions of the Sacramento River, residence time is short under both scenarios and so there is little potential for the PA to influence the growth potential of *Microcystis* (Table 6.1-27 and Table 6.1-28). During summer and fall, residence time in the Sacramento Ship Channel subregion is usually strongly tidally driven, with a relatively minor component of riverine flow, so there is little difference in residence time between NAA and PA (Table 6.1-29). Residence time generally was estimated to be 1-4 days longer under PA than under NAA in the Cache Slough and Liberty Island subregion during July to November (Table 6.1-30); this generally was also true for Rio Vista and the lower Sacramento River in July and August, whereas the residence time in September to November in these subregions generally was similar or slightly lower under PA than under NAA (Table 6.1-31 and Table 6.1-32). As noted in the analysis of QRIO based on Lehman et al. (2013), this is currently not an area of intense *Microcystis* blooms and if it remains turbid in the future, it is expected that current conditions will continue.

In the Lower San Joaquin River and Twitchell Island subregions, residence time generally was greater under the PA than under NAA in July and August, but was similar or less under the PA than under NAA in September to November (Table 6.1-33 and Table 6.1-34). This is in general agreement with the analysis of QWEST that was previously presented: in July and August, QWEST mean values below -5,000 cfs (Table QWEST_microcystis) under NAA reflects high south Delta export pumping that would cause particles to leave the area rapidly (towards the south Delta export facilities) compared to PA. Residence time in the eastern portion of the Delta (San Joaquin River at Prisoners Point and near Stockton, Mokelumne River, and Disappointment Slough) generally was estimated to be greater under the PA (Table 6.1-35, Table 6.1-36, Table 6.1-37, Table 6.1-38), in some cases 4-12 days longer, e.g., Disappointment Slough in July. Substantially greater residence times under the PA also were estimated for Mildred Island, e.g., over 10 days at the 25%–75% percentiles (Table 6.1-39). Increases in residence time were apparent over much of the central/south Delta subregions examined, including Holland Cut (Table 6.1-40), Franks Tract (Table 6.1-41), and Rock Slough and Discovery Bay (Table 6.1-42). Low residence times in Old River and Middle River reflect the relatively short duration before particles are entrained, but lower south Delta export pumping under the PA leads to longer residence times even in these channels, particularly in September–November (Table 6.1-43 and Table 6.1-44). Additional factors increasing residence time in these months under the PA include no export pumping and HOR gate closure during and prior to the fall pulse flow period (Section 3.3.2, *Operational Criteria*, Appendix 5.A *CALSIM Methods and Results,* Section 5.A.5.2). Considerably increased residence times in Victoria Canal under the PA (compared to NAA) in some months likely reflects the modeled operations of Contra Costa Water District diversions; particles that are entrained relatively quickly by the diversion under the NAA are not moved as quickly in the PA because the Rock Slough diversion is used preferentially, in response to higher EC (Table 6.1-45). Relatively long residence times in the Grant Line Canal and Old River subregion reflect the influence of the south Delta temporary barriers, with similar or longer residence times under the PA in July–August (Table 6.1-46); shorter residence times under the PA in October/November are a result of differing assumptions regarding the fall operations of the HOR gate under the PA compared to the rock barrier under the NAA. In general, there were relatively small differences in residence time for the Upper San Joaquin River subregion (Table 6.1-47).

Table 6.6-5. Summary Statistics of Residence Time (Days) in the Upper Sacramento River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.4	0.7	0.3 (65%)	0.6	1.2	0.6 (107%)	0.5	0.7	0.3 (57%)	0.5	1.1	0.7 (148%)	0.4	0.8	0.4 (99%)
25%	0.5	1.1	0.7 (135%)	0.6	1.5	0.8 (126%)	0.5	1.0	0.5 (83%)	0.8	1.4	0.7 (87%)	0.6	1.1	0.4 (69%)
50% (median)	0.5	1.2	0.7 (124%)	0.7	1.8	1.1 (164%)	1.2	2.2	1.0 (89%)	1.0	1.7	0.6 (63%)	1.0	1.4	0.4 (45%)
75%	0.8	1.4	0.6 (76%)	1.8	2.0	0.2 (14%)	2.4	2.7	0.4 (15%)	1.6	1.9	0.2 (13%)	1.8	1.7	0.0 (-2%)
95%	2.4	2.7	0.2 (9%)	3.2	3.1	0.0 (-1%)	20.1	11.5	-8.7 (-43%)	2.3	2.3	0.0 (0%)	16.2	10.6	-5.5 (-34%)

Table 6.6-6. Summary Statistics of Residence Time (Days) in the Sacramento River Near Ryde Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.3	0.4	0.1 (33%)	0.5	0.9	0.4 (69%)	0.5	0.6	0.1 (29%)	0.3	0.6	0.3 (76%)	0.4	0.7	0.3 (85%)
25%	0.5	0.8	0.4 (80%)	0.6	1.1	0.5 (89%)	0.5	0.7	0.2 (33%)	0.6	1.2	0.5 (83%)	0.5	0.9	0.4 (78%)
50% (median)	0.5	1.0	0.5 (89%)	0.7	1.3	0.6 (89%)	0.7	1.5	0.8 (113%)	0.9	1.5	0.6 (65%)	0.8	1.3	0.6 (72%)
75%	0.7	1.2	0.5 (65%)	1.3	1.8	0.5 (40%)	1.7	2.1	0.5 (29%)	1.4	1.7	0.2 (16%)	1.1	1.5	0.4 (32%)
95%	1.8	1.7	-0.1 (-6%)	2.4	2.7	0.2 (10%)	2.5	2.5	0.0 (0%)	2.1	2.3	0.2 (12%)	1.9	1.9	0.0 (-1%)

Table 6.6-7. Summary Statistics of Residence Time (Days) in the Sacramento River Ship Channel Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	43.3	43.4	0.1 (0%)	43.2	43.1	0.0 (0%)	43.2	43.2	0.0 (0%)	42.5	42.5	0.0 (0%)	39.8	39.7	-0.1 (0%)
25%	43.4	43.5	0.0 (0%)	43.3	43.4	0.1 (0%)	43.3	43.3	0.0 (0%)	43.4	43.3	0.0 (0%)	42.3	42.2	0.0 (0%)
50% (median)	43.6	43.6	0.0 (0%)	43.7	43.8	0.1 (0%)	43.7	43.7	0.1 (0%)	43.7	43.6	0.0 (0%)	43.1	43.1	0.0 (0%)
75%	44.0	44.1	0.0 (0%)	44.0	44.1	0.0 (0%)	43.9	44.0	0.0 (0%)	43.9	43.9	0.0 (0%)	44.1	44.0	0.0 (0%)
95%	44.3	44.3	0.0 (0%)	44.2	44.2	0.0 (0%)	44.3	44.3	0.1 (0%)	44.4	44.4	0.0 (0%)	44.3	44.3	0.0 (0%)

Table 6.6-8. Summary Statistics of Residence Time (Days) in the Cache Slough and Liberty Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	20.4	22.5	2.1 (10%)	16.5	19.5	3.0 (18%)	13.1	14.2	1.1 (8%)	11.4	13.8	2.4 (21%)	8.3	9.6	1.3 (15%)
25%	21.3	23.3	2.0 (9%)	17.2	20.8	3.6 (21%)	14.8	17.5	2.7 (18%)	14.6	17.1	2.4 (17%)	11.5	13.1	1.6 (14%)
50% (median)	22.0	23.8	1.8 (8%)	18.3	21.1	2.8 (15%)	16.1	18.7	2.7 (16%)	15.9	18.2	2.2 (14%)	13.4	14.5	1.2 (9%)
75%	22.7	25.1	2.4 (11%)	20.6	22.1	1.5 (7%)	18.2	21.1	2.9 (16%)	17.6	18.6	1.0 (6%)	14.9	15.6	0.7 (5%)
95%	25.8	27.0	1.2 (5%)	22.3	23.7	1.4 (6%)	22.5	22.3	-0.2 (-1%)	19.0	19.5	0.5 (3%)	16.7	16.4	-0.3 (-2%)

Table 6.6-9. Summary Statistics of Residence Time (Days) in the Sacramento River Near Rio Vista Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	1.4	2.0	0.7 (48%)	5.8	7.4	1.6 (27%)	3.2	1.8	-1.4 (-43%)	3.8	2.7	-1.1 (-29%)	3.6	3.9	0.3 (9%)
25%	6.6	7.7	1.2 (17%)	9.2	9.2	0.0 (0%)	5.0	2.7	-2.3 (-46%)	5.6	5.3	-0.3 (-5%)	5.0	5.3	0.3 (5%)
50% (median)	7.4	11.9	4.5 (60%)	10.4	13.6	3.2 (31%)	7.8	9.0	1.2 (16%)	9.2	8.1	-1.1 (-12%)	6.2	6.6	0.5 (7%)
75%	13.7	14.9	1.1 (8%)	14.7	17.0	2.3 (16%)	15.5	14.7	-0.8 (-5%)	11.9	10.2	-1.7 (-14%)	8.0	9.9	1.9 (24%)
95%	17.3	17.1	-0.2 (-1%)	17.9	19.6	1.7 (10%)	18.9	17.9	-1.0 (-5%)	15.9	14.7	-1.1 (-7%)	12.3	12.1	-0.2 (-2%)

Table 6.6-10. Summary Statistics of Residence Time (Days) in the Lower Sacramento River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.2	4.7	1.6 (49%)	10.1	12.2	2.1 (21%)	4.8	3.5	-1.3 (-26%)	6.7	6.7	0.0 (0%)	6.1	6.0	-0.1 (-2%)
25%	9.1	12.3	3.2 (35%)	13.5	13.6	0.1 (1%)	7.0	4.4	-2.6 (-37%)	8.8	8.4	-0.4 (-5%)	7.5	7.4	-0.1 (-1%)
50% (median)	12.9	15.0	2.1 (17%)	17.4	18.7	1.3 (8%)	13.4	12.5	-0.9 (-7%)	13.4	12.9	-0.5 (-4%)	10.2	10.8	0.6 (6%)
75%	20.9	21.0	0.2 (1%)	21.7	23.4	1.7 (8%)	22.6	21.2	-1.5 (-6%)	18.4	16.9	-1.5 (-8%)	13.2	14.6	1.4 (11%)
95%	22.4	22.2	-0.2 (-1%)	23.5	24.4	0.9 (4%)	24.3	23.4	-0.9 (-4%)	20.9	20.5	-0.4 (-2%)	18.7	18.4	-0.3 (-1%)

Table 6.6-11. Summary Statistics of Residence Time (Days) in the Lower San Joaquin River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	3.1	4.6	1.4 (45%)	12.0	12.7	0.7 (6%)	5.5	3.7	-1.8 (-32%)	7.5	6.8	-0.7 (-9%)	7.1	5.2	-2.0 (-27%)
25%	11.3	13.0	1.7 (15%)	15.4	14.2	-1.2 (-8%)	10.4	4.3	-6.1 (-58%)	9.8	7.8	-2.0 (-21%)	9.6	8.1	-1.5 (-15%)
50% (median)	14.1	16.0	2.0 (14%)	17.8	18.3	0.5 (3%)	14.5	11.9	-2.6 (-18%)	13.4	11.5	-1.9 (-14%)	12.2	10.9	-1.3 (-11%)
75%	20.4	21.5	1.1 (5%)	22.4	23.3	1.0 (4%)	22.9	20.7	-2.2 (-10%)	19.9	16.7	-3.2 (-16%)	14.5	15.7	1.2 (8%)
95%	22.7	23.4	0.7 (3%)	24.8	25.2	0.4 (2%)	25.5	24.3	-1.1 (-4%)	22.3	21.0	-1.3 (-6%)	19.3	20.1	0.8 (4%)

Table 6.6-12. Summary Statistics of Residence Time (Days) in the San Joaquin River at Twitchell Island Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	2.7	3.1	0.4 (14%)	9.5	12.1	2.6 (27%)	8.1	4.3	-3.8 (-47%)	8.4	5.3	-3.2 (-38%)	7.6	6.0	-1.6 (-21%)
25%	10.2	13.5	3.3 (32%)	10.8	13.6	2.8 (26%)	10.3	5.9	-4.3 (-42%)	12.4	8.0	-4.3 (-35%)	10.6	9.6	-1.0 (-9%)
50% (median)	12.0	16.1	4.1 (35%)	12.6	17.0	4.5 (36%)	11.6	13.3	1.6 (14%)	14.5	11.8	-2.7 (-18%)	12.6	11.8	-0.8 (-6%)
75%	13.6	18.1	4.5 (33%)	19.4	20.4	1.1 (6%)	19.0	20.0	1.0 (5%)	18.2	16.9	-1.4 (-8%)	15.3	15.9	0.6 (4%)
95%	21.0	21.1	0.1 (0%)	23.4	22.2	-1.2 (-5%)	23.0	22.6	-0.4 (-2%)	20.8	20.2	-0.6 (-3%)	18.9	19.7	0.8 (4%)

Table 6.6-13. Summary Statistics of Residence Time (Days) in the San Joaquin River at Prisoners Point from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	2.7	3.0	0.3 (10%)		4.3	8.4	4.1 (95%)		4.4	5.3	0.9 (20%)		7.5	6.5	-1.0 (-14%)		3.9	6.6	2.7 (68%)
25%	4.9	9.7	4.7 (96%)		5.0	10.5	5.5 (109%)		5.4	7.7	2.3 (43%)		9.8	8.3	-1.5 (-15%)		7.4	8.4	1.0 (14%)
50% (median)	6.0	10.7	4.7 (79%)		6.3	11.0	4.7 (74%)		7.4	11.0	3.7 (50%)		10.7	11.0	0.3 (3%)		8.6	10.6	2.0 (24%)
75%	7.3	12.2	4.9 (66%)		12.5	13.3	0.9 (7%)		10.9	15.0	4.1 (38%)		14.1	14.8	0.7 (5%)		11.1	12.4	1.3 (11%)
95%	13.6	14.8	1.2 (9%)		18.7	16.2	-2.5 (-13%)		16.8	16.7	-0.1 (-1%)		16.5	17.2	0.7 (4%)		14.6	15.0	0.4 (3%)

Table 6.6-14. Summary Statistics of Residence Time (Days) in the North and South Forks Mokelumne River Subregion from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	4.9	8.7	3.8 (79%)		3.0	6.7	3.7 (126%)		3.9	5.8	1.9 (50%)		6.3	7.5	1.2 (18%)		5.6	5.3	-0.2 (-4%)
25%	12.6	15.6	3.0 (24%)		4.2	8.9	4.7 (112%)		6.7	8.7	2.0 (30%)		9.4	8.7	-0.7 (-7%)		7.1	9.7	2.6 (36%)
50% (median)	20.8	20.8	0.0 (0%)		8.3	11.9	3.6 (44%)		11.4	12.4	1.0 (9%)		10.0	10.7	0.7 (7%)		8.9	10.3	1.4 (16%)
75%	26.1	24.6	-1.5 (-6%)		17.2	17.9	0.7 (4%)		17.0	17.7	0.7 (4%)		13.6	14.0	0.4 (3%)		11.1	12.5	1.3 (12%)
95%	34.2	31.5	-2.7 (-8%)		27.2	20.1	-7.1 (-26%)		24.7	22.2	-2.5 (-10%)		21.5	16.6	-4.9 (-23%)		16.5	14.2	-2.3 (-14%)

Table 6.6-15. Summary Statistics of Residence Time (Days) in the Disappointment Slough Subregion from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	12.1	15.5	3.4 (29%)		10.9	18.2	7.2 (66%)		10.8	15.2	4.4 (40%)		13.2	9.5	-3.7 (-28%)		14.7	15.1	0.3 (2%)
25%	17.9	26.7	8.9 (50%)		20.8	20.9	0.1 (1%)		16.8	18.4	1.6 (9%)		15.8	17.8	2.0 (13%)		18.6	17.9	-0.6 (-3%)
50% (median)	25.0	36.9	11.8 (47%)		25.7	29.9	4.2 (16%)		20.6	23.0	2.4 (12%)		19.6	22.9	3.3 (17%)		24.8	21.0	-3.8 (-15%)
75%	34.0	39.4	5.5 (16%)		29.3	33.0	3.8 (13%)		23.3	25.1	1.8 (8%)		23.7	28.7	5.0 (21%)		29.0	29.6	0.7 (2%)
95%	38.2	41.9	3.7 (10%)		34.2	35.6	1.4 (4%)		27.5	29.3	1.8 (7%)		27.5	30.8	3.3 (12%)		34.9	33.2	-1.7 (-5%)

Table 6.6-16. Summary Statistics of Residence Time (Days) in the San Joaquin River Near Stockton Subregion from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	1.3	1.5	0.2 (12%)		3.2	3.9	0.7 (22%)		4.1	4.3	0.1 (4%)		3.0	3.5	0.5 (17%)		2.8	3.1	0.4 (13%)
25%	5.8	7.8	2.0 (35%)		6.5	8.0	1.5 (23%)		5.9	6.8	0.9 (16%)		4.1	5.1	1.0 (25%)		4.4	5.0	0.6 (14%)
50% (median)	13.9	11.7	-2.3 (-16%)		9.7	9.8	0.1 (1%)		6.7	8.6	1.9 (29%)		5.2	6.2	1.1 (21%)		5.7	6.8	1.1 (19%)
75%	18.1	13.0	-5.0 (-28%)		12.1	10.9	-1.1 (-9%)		8.7	9.8	1.1 (13%)		6.4	7.4	1.1 (17%)		7.5	7.6	0.2 (2%)
95%	29.2	23.0	-6.2 (-21%)		15.1	14.4	-0.7 (-5%)		10.0	11.0	1.1 (11%)		8.3	9.0	0.7 (8%)		8.7	9.3	0.6 (7%)

Table 6.6-17. Summary Statistics of Residence Time (Days) in the Mildred Island Subregion from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	3.0	7.1	4.1 (138%)		1.8	5.0	3.3 (183%)		2.0	7.4	5.4 (270%)		2.9	8.9	6.0 (205%)		2.1	4.1	2.0 (93%)
25%	4.4	15.5	11.1 (255%)		2.2	8.1	5.8 (262%)		3.2	9.2	6.0 (188%)		3.7	11.6	7.9 (215%)		3.0	6.1	3.1 (106%)
50% (median)	6.9	23.4	16.5 (238%)		3.7	9.5	5.9 (160%)		4.7	10.7	6.0 (127%)		5.2	13.0	7.8 (150%)		4.6	13.9	9.3 (205%)
75%	11.1	27.1	16.0 (144%)		13.6	11.9	-1.7 (-12%)		6.9	14.9	8.0 (115%)		9.5	16.5	7.0 (73%)		15.9	15.7	-0.2 (-1%)
95%	25.1	30.0	4.9 (20%)		19.3	19.6	0.3 (2%)		15.4	16.8	1.4 (9%)		21.6	22.6	1.0 (4%)		21.1	21.5	0.4 (2%)

Table 6.6-18. Summary Statistics of Residence Time (Days) in the Holland Cut Subregion from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	1.4	3.8	2.4 (169%)		1.2	3.7	2.4 (198%)		1.5	4.7	3.3 (225%)		2.5	6.5	3.9 (156%)		1.8	3.3	1.5 (81%)
25%	2.0	4.2	2.2 (114%)		1.6	5.1	3.5 (226%)		1.8	5.5	3.7 (208%)		3.4	8.0	4.6 (134%)		2.6	4.0	1.4 (52%)
50% (median)	2.5	4.8	2.3 (95%)		2.4	5.7	3.3 (139%)		3.0	7.5	4.5 (154%)		3.9	8.6	4.7 (123%)		3.3	5.8	2.5 (75%)
75%	3.5	6.0	2.5 (73%)		5.4	6.6	1.1 (21%)		5.7	8.8	3.1 (55%)		5.8	9.1	3.3 (57%)		4.9	8.5	3.7 (76%)
95%	5.6	6.8	1.2 (22%)		9.8	7.8	-2.0 (-21%)		9.7	9.7	-0.1 (-1%)		7.5	9.8	2.3 (31%)		6.9	9.6	2.8 (41%)

Table 6.6-19. Summary Statistics of Residence Time (Days) in the Franks Tract Subregion from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	9.4	10.7	1.2 (13%)		10.0	11.1	1.1 (11%)		9.0	8.2	-0.8 (-9%)		9.1	8.6	-0.5 (-5%)		8.1	8.0	-0.1 (-1%)
25%	10.9	12.2	1.3 (12%)		10.9	13.2	2.4 (22%)		10.3	9.4	-0.8 (-8%)		11.1	9.7	-1.5 (-13%)		11.2	10.3	-0.9 (-8%)
50% (median)	11.6	14.4	2.8 (24%)		11.9	16.1	4.3 (36%)		11.8	14.1	2.3 (20%)		13.9	12.5	-1.4 (-10%)		12.3	12.0	-0.3 (-3%)
75%	12.8	16.6	3.8 (30%)		17.0	17.8	0.8 (5%)		16.2	17.4	1.1 (7%)		15.4	13.8	-1.6 (-10%)		14.4	15.1	0.7 (5%)
95%	16.9	17.5	0.6 (3%)		18.0	19.9	1.9 (10%)		18.7	18.5	-0.2 (-1%)		18.6	17.0	-1.7 (-9%)		18.1	18.0	-0.1 (-1%)

Table 6.6-20. Summary Statistics of Residence Time (Days) in the Rock Slough and Discovery Bay Subregion from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	4.8	7.4	2.6 (54%)		3.9	8.5	4.6 (119%)		4.7	11.0	6.3 (135%)		5.4	8.4	3.0 (55%)		5.0	6.9	1.9 (37%)
25%	5.6	8.8	3.3 (59%)		5.3	9.7	4.4 (84%)		5.6	14.6	8.9 (159%)		7.3	10.0	2.8 (38%)		5.9	8.2	2.3 (39%)
50% (median)	6.4	10.0	3.7 (57%)		5.7	11.9	6.2 (109%)		6.8	17.5	10.7 (158%)		8.8	15.2	6.4 (72%)		7.5	9.8	2.2 (29%)
75%	7.3	11.4	4.1 (56%)		10.1	15.9	5.9 (58%)		16.6	19.3	2.7 (17%)		12.1	17.1	5.0 (42%)		10.8	12.1	1.3 (12%)
95%	10.7	13.9	3.1 (29%)		19.2	22.3	3.1 (16%)		19.8	25.2	5.4 (27%)		20.6	19.2	-1.4 (-7%)		12.2	13.6	1.5 (12%)

Table 6.6-21. Summary Statistics of Residence Time (Days) in the Old River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.5	1.5	1.0 (212%)	0.4	1.4	1.0 (275%)	0.6	1.7	1.1 (199%)	0.6	2.5	1.9 (304%)	0.7	1.3	0.6 (82%)
25%	0.7	1.8	1.1 (164%)	0.6	1.6	1.1 (189%)	0.8	2.5	1.7 (208%)	1.0	3.4	2.3 (228%)	0.9	1.7	0.8 (89%)
50% (median)	1.0	2.3	1.3 (131%)	1.0	2.0	1.0 (102%)	1.1	3.5	2.5 (231%)	1.3	5.9	4.6 (363%)	1.1	1.9	0.7 (64%)
75%	1.4	2.8	1.4 (101%)	2.0	2.5	0.5 (23%)	1.9	6.4	4.5 (243%)	1.7	8.0	6.4 (382%)	1.8	7.2	5.4 (299%)
95%	4.2	3.8	-0.3 (-8%)	4.1	4.8	0.7 (17%)	2.7	12.0	9.3 (347%)	2.4	12.0	9.6 (393%)	2.8	8.6	5.8 (205%)

Table 6.6-22. Summary Statistics of Residence Time (Days) in the Middle River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.5	0.8	0.3 (62%)	0.4	0.7	0.3 (78%)	0.4	1.1	0.7 (180%)	0.5	1.5	1.0 (196%)	0.4	0.7	0.3 (58%)
25%	0.6	1.1	0.6 (101%)	0.4	0.9	0.5 (114%)	0.4	1.2	0.7 (177%)	0.6	2.0	1.4 (228%)	0.6	0.9	0.3 (51%)
50% (median)	0.7	1.3	0.6 (93%)	0.5	1.0	0.5 (99%)	0.5	1.4	0.8 (155%)	0.7	2.8	2.1 (292%)	0.7	1.1	0.4 (63%)
75%	0.8	1.6	0.8 (100%)	0.9	1.1	0.3 (29%)	0.8	1.6	0.8 (95%)	1.0	7.9	7.0 (727%)	0.8	10.9	10.1 (1,218%)
95%	2.4	4.5	2.1 (88%)	1.9	1.7	-0.2 (-13%)	1.3	2.4	1.1 (84%)	1.2	18.0	16.8 (1351%)	1.1	11.8	10.7 (979%)

Table 6.6-23. Summary Statistics of Residence Time (Days) in the Victoria Canal Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	0.3	2.5	2.2 (713%)	0.2	0.5	0.3 (116%)	0.3	0.7	0.4 (170%)	0.3	3.7	3.4 (1082%)	0.3	0.5	0.2 (51%)
25%	0.3	7.4	7.0 (2074%)	0.3	2.2	2.0 (731%)	0.3	4.1	3.8 (1339%)	0.4	5.4	5.1 (1353%)	0.4	0.6	0.2 (57%)
50% (median)	1.3	13.0	11.7 (939%)	4.6	7.6	3.0 (64%)	1.2	7.2	5.9 (480%)	0.6	10.5	9.9 (1734%)	0.6	7.1	6.5 (1052%)
75%	10.0	19.9	9.9 (99%)	14.5	14.2	-0.3 (-2%)	10.6	11.6	1.0 (10%)	3.9	14.7	10.8 (278%)	4.9	11.1	6.2 (126%)
95%	16.8	25.4	8.7 (52%)	26.4	21.1	-5.3 (-20%)	20.4	19.9	-0.5 (-3%)	15.7	17.8	2.1 (13%)	12.3	14.1	1.8 (15%)

Table 6.6-24. Summary Statistics of Residence Time (Days) in the Grant Line Canal and Old River Subregion from DSM2-PTM.

Percentile	July			August			September			October			November		
	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA	NAA	PA	PA vs. NAA
5%	2.2	3.0	0.8 (35%)	9.3	9.3	-0.1 (-1%)	2.7	6.2	3.4 (125%)	3.6	3.1	-0.5 (-14%)	4.4	5.4	1.0 (23%)
25%	29.3	29.6	0.3 (1%)	20.2	23.5	3.2 (16%)	8.5	10.0	1.5 (18%)	6.7	4.3	-2.4 (-36%)	8.2	8.1	-0.1 (-1%)
50% (median)	38.7	40.0	1.4 (4%)	27.3	29.1	1.8 (6%)	16.9	23.3	6.4 (38%)	13.6	10.1	-3.4 (-25%)	11.8	9.2	-2.7 (-22%)
75%	40.4	41.0	0.6 (1%)	36.2	35.5	-0.7 (-2%)	32.9	35.8	3.0 (9%)	19.5	14.7	-4.8 (-24%)	14.4	11.2	-3.3 (-23%)
95%	42.8	42.0	-0.9 (-2%)	40.8	37.0	-3.8 (-9%)	38.1	38.0	-0.1 (0%)	24.2	24.8	0.6 (3%)	21.2	13.1	-8.0 (-38%)

Table 6.6-25. Summary Statistics of Residence Time (Days) in the Upper San Joaquin River Subregion from DSM2-PTM.

Percentile	July				August				September				October				November		
	NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA		NAA	PA	PA vs. NAA
5%	0.2	0.2	0.0 (0%)		0.2	0.2	0.0 (-1%)		0.4	0.4	0.0 (-2%)		0.3	0.3	0.0 (16%)		0.3	0.3	0.0 (-8%)
25%	0.8	0.7	-0.1 (-11%)		0.9	0.8	-0.1 (-16%)		0.7	0.7	-0.1 (-10%)		0.5	0.6	0.1 (23%)		0.4	0.3	0.0 (-6%)
50% (median)	2.0	1.4	-0.7 (-33%)		1.5	1.2	-0.3 (-18%)		1.0	0.8	-0.1 (-13%)		0.6	0.7	0.1 (25%)		0.5	0.5	0.0 (-8%)
75%	3.3	1.8	-1.5 (-46%)		1.9	1.6	-0.3 (-15%)		1.2	1.1	-0.2 (-14%)		0.7	0.8	0.2 (27%)		0.6	0.6	0.0 (-7%)
95%	13.5	6.7	-6.8 (-50%)		2.8	2.4	-0.4 (-15%)		1.5	1.3	-0.2 (-16%)		0.8	0.9	0.1 (18%)		0.6	0.6	0.0 (-1%)

The extent to which giant garter snakes occur within the Delta is unknown, though population concentrations are known to occur along the periphery of the delta in the Yolo Basin-Willow Slough, Yolo Basin Liberty Farms, and Caldoni Marsh-White Slough regions (Figure 6.6-1; Appendix 4.A *Status of the Species and Critical Habitat Accounts*; U.S. Fish and Wildlife Service 1999). The giant garter snake diet consists primarily of frogs (chiefly American bullfrog [*Rana catesbeiana]*) and western chorus frog [*Pseudacris triseriata*]) and fish, with preference given to frogs (Halsted and Ersan pers. comm). American bullfrog tadpoles eat algae, aquatic plant matter, and some insects. Adult bullfrogs are opportunistic predators, consuming a wide-range of terrestrial and aquatic prey including invertebrates, mammals, birds, fish, reptiles, and amphibians, including other bullfrogs. The western chorus frog has a primarily land-sourced diet of slugs, spiders, isopods, centipedes, earthworms, and insects (Morey 2008), and thus has low potential exposure to microcystin. Bullfrogs forage within the terrestrial and aquatic foodwebs, and may ingest microcystins through the consumption of fish and other aquatic organisms, or through consumption of other bullfrogs.

The streamflow and temperature modeling results suggest there is potential for increased frequency of *Microcystis* blooms during the summer and fall months where giant garter snakes occur in portions of the Sacramento River system in the Delta. *Microcystis* toxicity has been shown to cause deleterious effects on fish and bird species (Butler et al. 2009), but sensitivity to microcystins varies by species and life stage (Table 6.6-3; Butler et al. 2009). The effects of *Microcystis* blooms on giant garter snakes or the prey of giant garter snakes are unknown. Small fish and bullfrogs consumed by giant garter snakes during or after *Microcystis* blooms could be sources of microcystins for giant garter snakes. In the northern portion of the Delta, *Microcystis* blooms are currently not common; if water in this region remains turbid in the future, current conditions are expected to continue.

In the south and central Delta, residence time would be increase under the PA relative to the NAA, which would increase the potential of giant garter snakes exposure to microcystin through the consumption of fish and bullfrogs. This would give greater potential for adverse effects of *Microcystis* under the PA relative to the NAA; however, under the NAA, lower residence time would reflect zooplankton and other food web materials being more susceptible to entrainment because of greater south Delta export pumping, so the overall effect is uncertain; and, as stated previously, the potential effect of *Microcystis* blooms on giant garter snakes is unknown, especially given their preference for American bullfrogs and western chorus frogs.

There is potential for increased occurrence of *Microcystis* blooms in the Sacramento and San Joaquin Delta and therefore increased potential for giant garter snake exposure to microcystins. However, because giant garter snakes preferentially prey upon frogs, which forage in both the terrestrial and aquatic foodweb, and because the effects of current *Microcystis* blooms on giant garter snake are not well understood, the effects of potential increased occurrence of *Microcystis* blooms on giant garter snakes is also unknown.

6.6.3.3.2.2 Selenium

The giant garter snake inhabits marshes, sloughs, ponds, small lakes, low gradient streams, and other waterways and agricultural wetlands, such as irrigation and drainage canals, rice fields and the adjacent uplands (U.S. Fish and Wildlife Service 1999). The extent to which Giant Garter Snakes occur within the Delta is unknown, but it occurs at sites along the San Joaquin River from Vernalis to Sherman Island. The population status of giant garter snake in the Delta is unknown because there is no established monitoring program; current information on their distribution is limited to sporadic sightings.

6.6.3.3.2.2.1 Baseline Exposure

A current mass balance of selenium, as a function of source and conveyance, is not available for the San Francisco Estuary (Presser and Luoma 2010). Annual and seasonal variations of selenium concentrations in the Delta and estuary are influenced by discharges in rivers and anthropogenic sources (Presser and Luoma 2006). Water inflow to the Delta comes primarily from the Sacramento and San Joaquin rivers of which the Sacramento River provides the largest water volume contribution and dilution of selenium inputs from other sources. Factors affecting selenium contribution and dilution include the total river inflow, water diversions and/or exports, the proportion of the San Joaquin River that is diverted south before entering the Estuary, and total outflow of the Estuary to the Pacific Ocean (Presser and Luoma 2010).

Selenium contamination in soils and water of the Sacramento Valley is not high and thus not considered a threat in this part of the giant garter snake's range (Seiler *et al.* 2003). In the San Joaquin River basin implementation of both regulatory controls and the Grassland Bypass Project, which manages agricultural drainage south and west of the Grassland Ecological Area, have significantly improved water quality in the San Joaquin River and adjacent channels. However, irrigation drainage into Mud Slough and the San Joaquin River results in non-compliance with the selenium water quality objective. Achieving water quality compliance for this segment of the river is not anticipated until 2019 or later. Continued inputs from precipitation runoff from selenium-laden soils, irrigation drainage, and existing riverbed loads still provide inputs of selenium to the Delta where GGS are potentially exposed to selenium through their diet consisting principally of amphibians and small fish.

Modification of Delta inflow via construction of the North Delta diversions and water operations changes for the SWP and CVP may interact with selenium fate and transport. Conceptually, exports of San Joaquin River selenium-laden water out of the Delta and into Delta Mendota Canal and California Aquaduct will be reduced under the PA. In addition, less Sacramento River water will be available for dilution of San Joaquin River. Meseck and Cutter (2006) developed a biogeochemical modeling of the estuary to simulate salinity, total suspended material, phytoplankton biomass, and dissolved and particulate selenium concentrations. They modeled an increase in discharge from the San Joaquin River and varying sources of refinery inputs to investigate how it would affect the dissolved and particulate selenium in the San Francisco Bay. They found that when river flow was low (i.e., November, 70-day residence time) total particulate selenium (the bioavailable form) concentrations could increase. These results suggest that bioavailable selenium and associated food web accumulation could increase because of increased San Joaquin River flow and reduced south Delta exports (Meseck and Cutter 2006).

6.6.3.3.2.2.2 Known Effects of Selenium on Snakes and Reptiles

Dietary uptake is the principal route of toxic exposure to selenium in wildlife, including giant garter snake (Beckon et al. 2003). Our current understanding is that selenium does not biomagnify and the majority of food web enrichment occurs at the lowest trophic levels. Scaled reptiles, such as giant garter snake generally do not secrete an albumin layer, as do birds, crocodilians, and turtles (Unrine *et al.* 2006). As a result, selenium may be transported through serum to the egg from the liver as vitellogenin, whereas in birds, crocodilians, and turtles, additional oviductal contributions of selenium occur post-ovulation (Unrine *et al.* 2006, Janz *et al.* 2010). Therefore, a dietary selenium toxicity threshold, rather than an egg concentration threshold, appears appropriate for assessing selenium effects to GGS.

Elevated selenium through diet or maternal transfer to offspring can affect vertebrates when selenium is substituted for sulfur during protein synthesis. Improperly folded proteins and dysfunctional enzymes can result, with consequences including oxidative stress and embryo toxicity. Toxicity thresholds are established by identifying concentrations of selenium that result in an observable effect on an organism (e.g. altered metabolism, mortality, deformity, reproductive failure). No information is available on the toxicity thresholds or indirect effects of selenium for giant garter snake or other snakes. However, information on the risk of selenium exposure on other species may be useful in predicting general effects on giant garter snakes. Laboratory and field study on giant garter snake and terrestrial snakes have documented selenium bioaccumulation from through prey consumption.

A single laboratory study dosed female terrestrial brown house snakes (*Lamprophis falginosus*) with selenium, as selanomethonine, injected into their food items at ~1 (control), 10, and 20 µg/g (dry weight) doses. The investigators selected these dosages because they represented the range of exposures used in prior avian and mammalian studies. No significant effects on survival or reproduction were observed at any dose (Hopkins *et al.* 2004). However, in the two treatment groups selenium was transferred to eggs in concentrations that exceeded all suggested reproduction thresholds for birds and fish (24.25 ±0.49 µg/g dry weight in the 20 µg/g treatment group) (Hopkins *et al.* 2004). No information was available on the consequences of the egg selenium burdens for post-hatch survival.

Wylie et al. (2009) measured selenium and other trace elements in 23 dead giant garter snakes collected from 1995 to 2004 at sites in Colusa National Wildlife Refuge, the Natomas Basin, and other sites in northern California. Giant garter snake liver selenium concentrations ranged from 1.24 to 6.98 µg/g (dry weight) with a geometric mean of 3.06 µg/g. Current science does not provide information about the consequences of these selenium body burdens to the health or survival of individuals or populations of GGS.

6.6.3.3.2.2.3 Effects of the PA

There are currently no predictive modeling tools, nor is there an understanding of effects thresholds, that would enable predicting direct effects of dietary selenium exposure on giant garter snakes. However, inferences about the effects of selenium exposure are possible using Delta Smelt as a surrogate for giant garter snakes' prey.

In the Delta Smelt effects analysis (Section 6.1, *Effects on Delta Smelt*) DSM2 volumetric fingerprinting was used to estimate the source water contribution of the Delta water sources including the San Joaquin River that are the primary source of selenium loading to the Delta. Aqueous and Delta Smelt selenium tissue concentrations were modeled at five sites: San Joaquin River at Prisoners Point, Cache Slough at Ryer Island, Sacramento River at Emmaton, San Joaquin River at Antioch, and Suisun Bay at Mallard Island. Modeling results indicated that, of these five sites, the highest proportion of San Joaquin River water and its selenium load (and thus resulting fish tissue selenium) occurred at Prisoners Point. Thus, of the Delta sites modeled for Delta Smelt, Prisoners Point represents the worst-case scenario for selenium exposure.

Results for the PA selenium bioaccumulation modeling for Delta Smelt at Prisoners Point showed increases of as much as twice the modeled tissue concentration, in Delta Smelt foraging at that location. Despite the predicted increases, all but 0.7% of modeled tissue concentrations were below the effects threshold for fish deformities. Based on these modeling results, the PA is unlikely to increase tissue concentrations significantly enough to result in detrimental effects to Delta Smelt. The PA would be expected to have similar effects on fishes with diets and habitat preferences similar to Delta Smelt (e.g., silversides). However, this assumption would not apply to young sunfishes or Sacramento Splittail whose parental diet may include other fish or bivalves that bioaccumulate selenium at substantially higher rate than crustaceans. Our surrogate Delta Smelt tissue modeling also does not represent the risk to giant garter snake foraging in locations upstream of Prisoners Point that have higher San Joaquin River water and selenium contributions.

Residence times could provide an additional line of evidence in evaluating the risk of selenium effects from the PA. A significant factor in the bioavailability of selenium is water residence time. Biogeochemical modeling suggests that increasing the San Joaquin River discharge could result in increased bioavailable selenium during “low flow” conditions (Meseck and Cutter 2006). Low flow conditions modeled were 70-day residence times.

For the PA, residence times were estimated using DSM2-PTM to evaluate the effects of water operations on water quality. Residence time changes under for the PA varied greatly by model site. The highest residence times for the both the NAA and the PA occurred at Grant Line Canal and Old River sites. The modeling predicted for the PA a 95% percentile, July water residence time of 42.8 days, a reduction of 0.8 days compared to the NAA. Residence time estimates did not meet or exceed the 70-day residence times used in the Meseck and Cutter (2006) biogeochemical modeling that predicted increased selenium bioavailability. This would suggest that the PA and would not result in the same increase of bioavailable, particulate selenium predicted by their hydrologic conditions modeling of Meseck and Cutter (2006).

6.6.3.3.2.2.4 All Life Stages

6.6.3.3.2.2.4.1 Individual-Level

Two modeling efforts suggest the potential for increases in San Joaquin River water and its associated selenium load to the Delta. We lack information about effects thresholds or exposure risk directly to giant garter snake. Using Delta Smelt as a surrogate for giant garter snake fish prey, selenium bioaccumulation modeling suggests that reductions in fish prey for fish feeding at the same tropic level as Delta Smelt are unlikely to result from the PA. Prey fishes that feed on bivalves or at a higher trophic level may represent an increased risk. Project effects on giant garter snake, either directly to the snake via increased dietary selenium, indirectly through reduced fish prey availability are currently unquantifiable. If risk were increased because of the PA, it would most likely occur for giant garter snakes residing and feeding in the South Delta and the San Joaquin River upstream from Prisoners Point to Vernalis or from snakes that consumed Sacramento Splittail or piscivorous fish species.

6.6.3.3.2.2.4.2 Population-Level

There is inadequate information available to assess this risk to giant garter snake individuals or populations from selenium. If giant garter snakes were affected by a selenium increase caused by the PA it would be most likely to occur in the South Delta and the San Joaquin River upstream from Prisoners Point to Vernalis. Giant garter snakes reside in areas of the Delta and lower San Joaquin River (Kesterson and Grasslands Bypass) where selenium has been historically elevated. Population effects were not documented as a result of those historic exposures.

6.6.3.3.2.2.4.3 Effects on Critical Habitat and Habitat

Critical habitat has not been designated for giant garter snake. Based on the result of biogeochemical and particle tracking modeling, increased San Joaquin River inflow increased the potential availability of selenium to the Delta. The magnitude of change in selenium and its bioavailability is highly uncertain.

6.6.4 Tunneled Conveyance Facilities

The water conveyance facilities that overlap with giant garter snake habitat include a tunnel work area, the intermediate forebay and spillway, a road interchange, vent shafts, barge unloading facilities, and access roads.

6.6.4.1 Habitat Loss and Fragmentation

The mapped water conveyance facilities overlap with 220 acres of giant garter snake modeled habitat (0.15% of modeled habitat in action area), including 127 acres of upland habitat (0.2% of modeled upland habitat in action area) and 93 acres of aquatic habitat (0.3% of modeled aquatic habitat in the Delta).

The 220 acres of giant garter snake habitat to be removed because of conveyance facility construction consists of multiple small areas spread out across the action area, and this loss is not expected to appreciably fragment or isolate patches of giant garter snake habitat in the action area.

Table 6.6-2 provides the compensation acreage to offset giant garter snake habitat loss resulting from water conveyance facility construction. As described in Section 3.4.7.6.1.1 *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities.

6.6.4.2 Construction Related Effects

Construction activities associated with the conveyance facilities will include short-term segment storage, fan line storage, crane use, dry houses, settling ponds, daily spoils piles, use of power supplies, air, and water treatment. There will also be slurry wall construction at some sites, and associated slurry ponds. RTM handling and permanent spoils disposal will be necessary, as discussed in Section 3.2.10.6 *Dispose Spoils*. Access routes and new permanent access roads will be constructed for each shaft site. SR 160 provides access to the intermediate forebay and their associated shafts, but for all other shafts, access roads will be constructed (within the existing impact footprint).

Construction of the intermediate forebay first entails excavating the embankment areas down to suitable material, then constructing the embankment, and then building the inlet and outlet shafts (which also serve as TBM launch shafts). Then the interior basin is excavated to design depth (-20 feet), and the spillway is constructed.

To allow time for soil consolidation and pad curing at the tunnel work areas and the intermediate forebay, fill pad construction significantly precedes other work at the shaft site; at the intermediate forebay, for instance, earthwork begins 2.5 years prior to ground improvement, and is then followed by a 9-month period of ground improvement, before the site is ready for construction. The result is that the entire footprint will be cleared very early in the construction schedule. The duration of active tunnel construction is expected to be approximately 8 years. The duration of construction activity at the intermediate forebay is expected to be approximately 5 years. See Section 3.2.3 *Tunnel Conveyance* and Appendix 3.D *Construction Schedule for the Proposed Action*, for complete construction activity and timing details.

The construction related effects and measures to minimize them are similar to those described above for construction of the intake facilities under Section 6.6.3.2 *Construction Related Effects.*

6.6.4.3 Operations and Maintenance

Permanent water conveyance facilities, including the pumping plant and the intermediate forebay, will require operation and maintenance. Routine maintenance of the tunnel facility will likely include some weed control around the structure which may result in injury or mortality of giant garter snakes. There is also a potential for giant garter snakes to be injured or killed if, for example, vehicles traveling to or from the facilities must travel greater than 10 miles per hour and are unable to avoid giant garter snakes. These effects will be minimized by restricting vegetation control to the active season and confining the use of heavy equipment to outside suitable garter snake habitat unless it is needed for travel to the site as described in Section 3.4.7.6.1.2 *Activities with Flexible Locations.* With these measures in place, operations and maintenance activities are expected to avoid take of giant garter snake.

6.6.5 Clifton Court Forebay Modification

6.6.5.1 Habitat Loss and Fragmentation

An estimated 235 acres of giant garter snake modeled habitat overlaps with the mapped Clifton Court Forebay modifications (Figures 6.6-29 through 6.6-32), where land will be cleared for permanent facilities and temporary work areas. The 235 acres of modeled habitat (0.3% of modeled habitat in the action area) includes 16 acres of aquatic habitat (>0.1% of modeled aquatic habitat in the action area) and 219 acres of upland habitat (0.3% of modeled upland habitat in action area).

Construction related activities near Clifton Court Forebay will remove upland and aquatic habitat for giant garter snake. These activities include construction of a barge unloading facility, fuel station, and shaft location, which will result in loss of natural wetlands providing aquatic habitat and adjacent upland habitat at the northern end of Clifton Court Forebay. Also, construction of the tunnel conveyor facility and a shaft will remove upland habitat in this area, and construction of the new forebay will remove upland habitat at the southern end of the Clifton Court Forebay.

Construction of access roads, a control structure with associated work area, forebay embankment, and canal work areas will result in loss of aquatic and upland habitat on the west side of Clifton Court Forebay. The forebay dredging area and construction of the new forebay, forebay embankment area, and control structure work area will remove upland habitat around Clifton Court Forebay, Old River, and Delta-Mendota Canal.

Table 6.6-2 provides the compensation acreage to offset giant garter snake habitat loss resulting from Clifton Court Forebay modifications. As described in Section 3.4.7.6.1.1 *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities.

6.6.5.2 Construction Related Effects

Construction activities at Clifton Court Forebay include vegetation clearing, pile driving, excavation, dredging, and coffer dam and embankment construction. Construction at Clifton Court Forebay will be phased by location and the duration of construction will be approximately 6 years. For complete details on construction activities and phasing, see Section 3.2.5 *Clifton Court Forebay*, for more details on schedule, see Appendix 3.D *Construction Schedule for the Proposed Action*.

The construction related effects and measures to minimize them are the same as described above for construction of the intake facilities under Section 6.6.1.2, *Construction Related Effects.*

6.6.5.3 Operations and Maintenance

The operational components of the modified Clifton Court Forebay include the pumping plant, control structures, and siphons. The features will are not located in giant garter snake habitat and are not expected to affect the species.

The forebay and the canals will require erosion control. Giant garter snake could potentially become entangled, trapped, or injured as a result of erosion control measures that use plastic or synthetic monofilament netting in construction areas. This effect will be avoided as described in Appendix 3.F *General Avoidance and Minimization Measures*, AMM2 *Construction Best Management Practices and Monitoring*, by requiring the use of silt fencing. With these measures in place, the potential for giant garter snakes to be affected in this manner is minimal.

The forebay and canals will also require control of vegetation and rodents, and embankment repairs. Maintenance of control structures could include removal or installation of 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. Use of heavy equipment for maintenance may injure or kill giant garter snakes: these effects and associated minimization measures are as described in Section 6.6.1.2, *Construction Related Effects.* Additionally, removal of vegetation, embankment repairs, and rodent control measures may result in injury or mortality of giant garter snakes, or may degrade habitat by removing cover. These effects will be minimized by restricting vegetation control to the active season, avoiding the use of poison bait, and confining the use of heavy equipment to outside suitable garter snake habitat as described in Section 3.4.7.6.1.2 *Activities with Flexible Locations.*

Maintenance dredging is not expected to be necessary to remove sediments in the forebays.

6.6.6 Power Supply and Grid Connections

6.6.6.1 Habitat Loss and Fragmentation

To conservatively asses temporary impacts from transmission line placement due to the flexibility of the final alignment, a 50-foot wide permanent disturbance area along the transmission line corridor was assumed (see Appendix 6.B *Terrestrial Effects Analysis Methods*, for additional details about the impact assessment method). Based on this method, an estimated 67 acres (>0.1% of modeled habitat in the action area) of giant garter snake upland habitat may be temporarily impacted as a result of the construction of both temporary and permanent transmission lines (Table 6.6-1). Temporary impacts are incurred from activities that will not last more than 1 year and include access routes (vehicles driving over ground to access the site), temporary staging areas for poles or placement, and reconductoring areas. Permanent habitat loss will result from pole and tower placement, and will affect less than 1 acre of habitat. Ongoing vegetation management around the poles and under the lines will be minimal in giant garter snake habitat because aquatic and grassland areas typically do not need to be cleared to maintain transmission line corridors.

Because this disturbance is primarily from short-term, temporary effects, specific compensation for the 67 acres of giant garter snake habitat disturbance will be offset by returning these areas to pre-project conditions. The permanent loss of up to 1 acre of upland habitat will be compensated at a 2:1 or 3:1 ratio (Table 6.6-2). As detailed in Section 3.4.5 *Spatial Extent, Location, and Design of Restoration for Terrestrial Species*, these conservation lands will be sited in locations that provide high habitat values for the species, consisting of large, contiguous blocks of habitat suitable for giant garter snake. As detailed in Section 3.4.1 *Restoration and Protection Site Management Plans,* these conservation lands will be protected and managed for the species.

6.6.6.2 Construction Related Effects

New temporary power 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 power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, 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, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Construction of new transmission lines will require 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-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at 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 will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than 1 year at any one location.

The construction related effects and measures to minimize them are the same as described above for construction of the intake facilities under Section 6.6.1.2, *Construction Related Effects.*

6.6.6.3 Operations and Maintenance

The temporary transmission lines will be in place for the duration of conveyance facility construction (approximately 10 years); the permanent transmission lines will remain to supply power to the pumping plant. Maintenance activities at the transmission lines will include vegetation management and overland travel for some emergency repairs. Vegetation control along the transmission line alignment is not expected to adversely affect the giant garter snake because this species typically occurs in open upland areas such as grasslands, and grassland removal is not typically done for transmission line maintenance. Maintenance vehicles could injure or kill giant garter snakes as they travel to and from maintenance sites.

6.6.7 Head of Old River Gate

6.6.7.1 Habitat Loss and Fragmentation

Construction of the HOR gate will result in loss of an estimated 3 acres (<0.01% of modeled habitat in the action area) of giant garter snake habitat, including 1 acre of aquatic habitat (<0.1% of modeled aquatic habitat in the action area) and 2 acres of associated uplands (<0.1% of modeled upland habitat in the action area) (Figure 6.6-28). Table 6.6-2 provides the compensation acreage to offset giant garter snake habitat loss resulting from construction of HOR gate. As described in Section 3.4.7.6.1.1 *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. Suitable habitat for giant garter snake is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts,* Section 4.A.12.6 *Suitable Habitat Definition.*

6.6.7.2 Construction Related Effects

HOR gate construction has two major components: dredging and construction. 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. Dredging will 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*. Dredging equipment will be operated from a barge in the channel. Giant garter snakes could be injured or killed by dredging equipment during this activity. As described in Section 3.4.7.6.1.1 *Activities with Fixed*

Locations, this effect will be minimized by dewatering of habitat prior to construction to encourage giant garter snakes to move out of aquatic habitat, and by installation of construction fencing and monitoring to exclude giant garter snakes from the work area. There is still a chance that giant garter snakes occur in the work areas and be missed by monitors, therefore the potential remains for injury or killing of giant garter snakes in this area.

During HOR gate construction, a cofferdam will be erected to 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 duration is estimated to be up to 32 months. 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. 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*. Sheet piles will be installed starting with a vibratory hammer, then switching to an impact hammer if refusal is encountered before target depths. Installing 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 will be set per day with up to 1,050 strikes per pile over an estimated 7-day period.

The operable barrier construction site has for many years been used for seasonal construction and removal of a temporary rock barrier, and this disturbance at the site renders it less likely that giant garter snakes occur in the area to be affected. If giant garter snakes are present during construction, however, they may potentially be killed or injured by construction equipment or vehicles. These effects and measures to minimize them are as described in Section 6.6.1.2 *Construction Related Effects.* With these measures in place, there is still potential for giant garter snakes to be injured or killed if, for example, if vehicles must travel greater than 10 miles per hour and are unable to avoid giant garter snakes or if a snake is able to get through the construction fencing and is undetected by the biological monitor.

Giant garter snakes may potentially be affected by vibrations from the pile drivers. This could cause giant garter snakes to move out of suitable habitat near construction.

6.6.7.3 Operations and Maintenance

Maintenance of the motors, compressors, and control systems will occur annually and require a service truck. 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 will occur every 3 to 5 years, removing no more than 25% of the original dredged amount. This dredging will have similar effects and be subject to the same minimization measures as those described for dredging in Section 6.6.3.2 *Construction Related Effects.*

6.6.8 Reusable Tunnel Material

6.6.8.1 Habitat Loss and Fragmentation

An estimated 242 acres (0.2% of modeled habitat in the action area) of giant garter snake modeled habitat overlaps with the mapped RTM sites, where reusable tunnel material will be placed. The 242 acres of modeled habitat includes 83 acres (0.3% of modeled aquatic habitat in the action area) of aquatic habitat and 159 acres (0.02 acres of modeled upland habitat in the action area) of upland habitat. Table 6.6-1 quantifies the loss of habitat for each habitat value category.

The habitat to be removed at several RTM sites, and the extent to which RTM placement at each site may fragment the remaining habitat, is described below.

6.6.8.1.1 RTM Site Near Intake 2 (Figure 6.6.2)

The RTM site near Intake 2 overlaps with a strip of giant garter snake upland habitat along Morrison Creek that consists of riparian vegetation. Giant garter snakes tend to use open areas rather than shaded riparian areas for upland habitat. It is therefore unlikely that giant garter snakes use this area frequently if at all. The RTM site will only remove a sliver of the upland habitat in this area and the remaining upland and aquatic habitat along Morrison Creek will remain intact, therefore the RTM placement and storage will not result in fragmentation or isolation of giant garter snake habitat.

6.6.8.1.2 RTM Site South of Lambert Road (Figures 6.6-5, 6.6-14)

The RTM site just south of Lambert Road overlaps with two narrow stretches of drainage ditch providing aquatic giant garter snake habitat, however they are bordered by cultivated lands that are regularly disked and therefore do not provide upland habitat for giant garter snake. Furthermore, the RTM site is south of a large, contiguous block of habitat in the Stone Lakes area and does not fragment this habitat or isolate it from contiguous habitat to the east and south of the RTM site. It may, however, contribute to fragmentation by diminishing the existing string of small habitat patches between the larger Mokelumne and the Stone Lakes habitat blocks.

6.6.8.1.3 RTM Site on Zacharias Island (Figure 6.6-14)

The RTM site on Zacharias Island overlaps with giant garter snake modeled high value upland habitat along the western edge of the island, adjacent to Snodgrass Slough.

The RTM site is located between giant garter snake habitat along Snodgrass Slough, to the west, and giant garter snake habitat along a tributary to Snodgrass Slough, to the east. Placement of the RTM may impede overland travel of giant garter snakes between these two tributaries, although except during the period of active use of the RTM site, the impediment would not be greater than that imposed by cultivated land, which is not classified as dispersal habitat under the Draft *Recovery Plan for Giant Garter Snake* (U.S. Fish and Wildlife Service 2015c). The RTM site currently consists of cultivated lands that are regularly disked. Connectivity will remain via aquatic habitat, which is connected at the southern tip of Zacharias Island.

6.6.8.1.4 RTM Site, Northernmost Triangular RTM Site (Figures 6.6-14, 6.6-15)

This RTM site overlaps with giant garter snake modeled aquatic habitat and adjacent modeled upland habitat. The aquatic habitat consists of an open borrow pit and the surrounding uplands are sparsely vegetated with riparian species. Removal of this habitat will reduce the size of a fairly isolated habitat block in this area. The remaining habitat within this block will consist of narrow drainage ditches and associated uplands. The RTM placement will not create any barriers to movement from the remaining habitat, as there is no habitat present immediately to the east of the RTM site. It may, however, contribute to fragmentation by diminishing the existing string of small habitat patches between the larger Mokelumne and the Stone Lakes habitat blocks.

6.6.8.1.5 RTM Site, Second Triangular RTM Site from the North (Figures 6.6-15, 6.6-16)

This RTM site overlaps with giant garter snake modeled aquatic habitat and associated modeled upland habitat. The aquatic habitat consists of an open borrow pit and the surrounding uplands are open and sparsely vegetated. Removal of this habitat may contribute to fragmentation by diminishing the existing string of small habitat blocks between the larger Mokelumne and the Stone Lakes habitat blocks.

6.6.8.1.6 RTM Site North and South of Twin Cities Road (Figure 6.6-16)

This RTM site overlaps with giant garter snake modeled aquatic habitat and associated modeled upland habitat. The aquatic habitat consists of two open borrow pits (one north and one south of Twin Cities Road) and the surrounding uplands are open and sparsely vegetated. As described above, the RTM placement may contribute to fragmentation by diminishing the existing string of small habitat patches between the larger Mokelumne and the Stone Lakes habitat blocks.

6.6.8.1.7 RTM Site on Bouldin Island (Figure 6.6-21, 6.6-22)

This RTM site overlaps with giant garter snake modeled aquatic habitat consisting of shallow ponded areas surrounded by regularly disked cultivated lands. The RTM placement will remove several isolated patches of giant garter snake habitat, including aquatic habitat associated with regularly disked lands that do not provide suitable upland habitat. The RTM placement in this location will not further isolate the remaining giant garter snake habitat in this area, or block species dispersal.

6.6.8.1.8 RTM West of Clifton Court Forebay (Figure 6.6-30)

This RTM site will result in the removal of a small amount of upland habitat associated with a small, isolated aquatic feature west of Clifton Court Forebay. Most of the upland habitat associated with this aquatic feature will remain.

6.6.8.1.9 Summary of Habitat Loss Resulting from RTM Storage

RTM storage will result in the loss of an estimated 159 acres of upland habitat and 83 acres of aquatic habitat for giant garter snake. There are no known giant garter snake occurrences within the habitat that will be removed, although these areas have not been thoroughly surveyed. Table 6.6-2 provides the compensation acreage to offset giant garter snake habitat loss resulting from RTM placement. As described in Section 3.4.7.6.1.1 *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. Suitable habitat for giant garter snake is described in Appendix 4.A, *Status of the Species and Critical Habitat Accounts,* Section 4.A.12.6 *Suitable Habitat Definition.*

6.6.8.2 Construction Related Effects

Each RTM storage area will take 5 to 8 years to construct and fill. RTM areas will be constructed, as needed, depending on location. The RTM storage site at Clifton Court (reach 7) will be the first to be constructed and filled (Appendix 3.D *Construction Schedule for the Proposed Action*) with all other RTM storage sites beginning construction within 2 years. The RTM storage site at Bouldin Island will be the last to begin construction. RTM storage area construction and placement will occur almost continuously during tunnel excavation, approximately 10 years.

Construction activities at each RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed. The movement of the material to another site is not an activity covered in the assessment. For more details about the activities associated with RTM placement see Section 3.2.10.6 *Dispose Soils*.

Vehicles and heavy equipment used to clear the RTM sites and transport equipment and material could injure or kill giant garter snakes if individuals are present within the RTM footprint. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for giant garter snake to enter the work area. Other effects related to placement of RTM may include entanglement in erosion control materials, contamination as a result of toxic substances such as fuels, degradation of aquatic habitat from run-off and siltation, and behavioral changes as a result of noise, lighting, or vibration. These effects and measures to minimize them are similar to those described above for construction of the intake facilities under Section 6.6.1.2 *Construction-Related Effects.*

6.6.8.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM sites and therefore no effects to giant garter snake. While reuse of the RTM is possible, future uses for the 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 use is identified, and any such use or disturbance of the site that could result in take of giant garter snake 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.

6.6.9 Habitat Restoration/Mitigation

Habitat restoration to mitigate effects of the PA could affect giant garter snake, as described below. However, take of giant garter snake resulting from habitat restoration will not be authorized through the biological opionion for this project, and will require separate consultation. Therefore, these acreages are not included in Tables 6.6-1 or 6.6-2.

6.6.9.1 Habitat Conversion

Tidal, nontidal, and riparian restoration and channel margin enhancement to offset the effects on species habitat and wetlands will result in conversion of giant garter snake habitat to other habitat types. All restoration sites will be selected by DWR, subject to approval by the jurisdictional fish and wildlife agencies (CDFW, NMFS, USFWS). The acres to be lost as a result of restoration were estimated as described in Appendix 6.B *Terrestrial Impact Assessment Methods*.

6.6.9.1.1.1 Tidal Restoration

DWR will restore 305 acres of tidal wetlands to benefit delta smelt and other aquatic species to meet habitat restoration requirements. Tidal wetland restoration will include restoration for the loss of wetland types such as emergent wetland and tidal channels. This tidal restoration is likely to occur in the east, north, or west Delta. Potential locations of tidal and wetland restoration include Grizzly Slough, Lower Yolo Ranch, Zacharias Island, and Sherman Island. In the Delta, wetland and riparian habitats are typically restored by the conversion of currently leveed, cultivated land. Such wetland restoration typically involves grading and contouring of the previously cultivated land within the levees, and breaching of the levees in one or more places.

Permanent effects on giant garter snake aquatic habitat are likely to occur when agricultural ditches are modified and flooded as part of the restoration process. The conversion of rice to tidal habitat would be a permanent loss, however, rice is not common the portions of north slough, Cache Slough, or Sherman Island where tidal restoration would likely be placed. Other aquatic features that have potential to occur on cultivated lands converted to wetlands include natural channels and topographic depressions. Tidal aquatic edge habitat where open water meets the levee edge will also be permanently lost in those reaches where the levee is breached. Temporary effects on aquatic edge habitat are also likely to occur during the time of construction, though these effects would not be expected to last more than 2 years. Permanent effects on upland habitat will primarily occur where upland basking habitat (levees) are removed to create tidal connectivity. If small, interior levees exist on the property, these features could be graded to achieve topographical or elevational design requirements, though in many cases, these features are allowed to persist as they foster the formation of mixed plant communities and high-tide refugial habitat for wetland species.

Tidal restoration will result in the loss of an estimated 154 acres of giant garter snake habitat, including an estimated 118 acres of upland habitat and 36 acres of aquatic habitat. Table 6.6-1 provides a breakdown of estimated loss by habitat value category. See Appendix 6.B *Terrestrial Effects Analysis Methods*, for details about the method used to calculate the effects of tidal restoration to giant garter snake.

6.6.9.1.1.2 Nontidal Restoration

DWR will restore 625 acres of nontidal wetlands to benefit giant garter snake and other species that rely upon nontidal wetlands (e.g., greater sandhill crane). Nontidal restoration for these species may also contribute to mitigation required as compliance with Section 404 of the Clean Water Act. Of the 625 acres that will be restored, 521 acres will be restored to benefit giant garter snake as described in Section 3.4.7.6.2 *Compensation for Effects*, and Section 3.4.7.6.3 *Siting Criteria for Compensation for Effects*; see Table 6.B-6 for a summary of restoration activity by type. The remaining 104 acres of nontidal restoration will benefit the greater and lesser sandhill crane. Nontidal wetland restoration projects for giant garter snake, when constructed, will increase the available, high quality, aquatic and upland habitat for giant garter snake. Habitat loss associated with nontidal wetland restoration projects for giant garter snake is assumed to be temporary and result in a net benefit to the species. Temporary effects will be related to the use and staging of construction equipment on the tops of levees where giant garter snakes are known to bask. There is also potential for canal and ditch aquatic habitat for giant garter snake will be converted to nontidal wetland. These effects on giant garter snakes from nontidal wetland restoration to benefit giant garter snake are expected to be negligible. Adverse effects on giant garter snake from wetland restoration will be avoided to greatest extent practicable as detailed in Section 3.4.7.6.1 *Avoidance and Minimization Measures.*

6.6.9.1.1.3 Riparian Restoration

DWR will restore 79 acres of riparian natural community to benefit the valley elderberry longhorn beetle and Swainson’s hawk. Riparian restoration is likely to occur in the north Delta, Cache Slough, Cosumnes-Mokelumne, or along the Sacramento River. Riparian restoration in this region will likely be accomplished in one of two ways. One way is to reconnect subsided, cultivated lands to flood flows and allow the upland areas (often around the edges of levees) within the parcel to recruit riparian vegetation types, riparian planting will also likely be used to enhance recruitment. Grading could be used in this scenario to increase the amount of area that is at the proper elevations for riparian habitats. Riparian restoration could also be accomplished through levee setbacks. This kind of restoration will require building a new levee behind the existing levee, grading and contouring the existing levee to create the desired habitat types which will likely be a mix of wetland, vegetated edge, and riparian. This kind of riparian restoration will likely occur in a matrix of channel margin enhancement and/or floodplain restoration.

Riparian restoration projects will likely occur on lands that are currently in cultivation. Giant garter snake aquatic habitat in the cultivated regions of Cache Slough, north Delta, Cosumnes-Mokelumne, or the Sacramento River is primarily vegetated edge of tidal habitat or irrigation canals or ditches. Upland habitat in these regions is primarily the tops of levees. For riparian projects where parcels of land are flooded, the primary giant garter snake habitat type that will be lost is the aquatic habitat provided by irrigation canals and ditches. Vegetated tidal edge will be permanently lost wherever levee sections are removed. Canals and ditches will be flooded, at least during some times of the year, and may be graded to increase topographic diversity. Additional vegetated edge could be created on the internal sides of the levees however, these are the regions where riparian restoration will be targeted. Riparian restoration through levee setback may have greater potential to benefit giant garter snake because these types of projects will likely also include channel margin enhancement components that could benefit giant garter snake by restoring sections of vegetated edge habitat.

6.6.9.1.1.4 Channel Margin Enhancement

DWR will enhance approximately 5 miles of channel margins between open water and upland areas to provide improved habitat for migrating salmonids. Channel margin enhancement activities are likely to occur near the intake construction area on the mainstem of the Sacramento River or on one of the nearby connected tidal sloughs (e.g., Steamboat Slough, Elk Slough, or Snodgrass Slough). Channel margin enhancement has the potential to be combined with riparian restoration to meet multiple goals on one restoration site.

Channel margin enhancement will target degraded aquatic edge habitat to improve habitat conditions for migrating salmon and other aquatic species such as delta smelt. Enhanced channel margin sections will seek to replace “hardened”, riprap edge habitat with more emergent wetland

and riparian habitat. This can be achieved by creating a "bench" of sediment (or other material) at the aquatic edge onto which vegetation can be planted or naturally recruited. This approach to channel margin enhancement is likely to be used to create emergent wetland habitat. More complex channel margin enhancement, where riparian restoration is likely to be a component, will be achieved using levee setbacks.

6.6.9.2 Construction Related Effects

The construction related effects and measures to minimize them are the same as described above for construction of the intake facilities under Section 6.6.1.2 *Construction Related Effects*.

6.6.9.3 Operations and Maintenance

Management activities in restored giant garter snake habitat may affect the species. Management activities may include invasive species control or hydrologic modifications. These management activities would have minimal effect on the species with the implementation of measures defined in Section 3.4.7.6.1.1 *Activities with Fixed Locations*, which would avoid and minimize effects on the species.

6.6.10 Effectiveness Monitoring

On lands protected to benefit giant garter snakes, monitoring to detect the presence of individuals will be performed to determine the effectiveness of conservation. Monitoring for giant garter snakes will consist of trapping surveys to detect presence of individuals. For additional details about monitoring see Section 3.4.9.2.3 *Effectiveness Monitoring for Wildlife Species*. The presence of biologists and trapping activities have potential to alter typical behavior of giant garter snake. As such, effectiveness monitoring for giant garter snake monitoring will be performed by a USFWS approved biologist and any take associated with the monitoring will be authorized through the biologist's recovery permit.

6.6.11 Effects on Critical Habitat

Critical habitat has not been designated for giant garter snake.

6.6.12 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Potential cumulative effects on giant garter snake in the action area include habitat loss and fragmentation, changes in agricultural and land management practices, predation from introduced and native species, and water pollution. Both habitat loss and fragmentation, and changes in land management practices, could result from conversion of agricultural land to more developed land uses, which is not likely to be extensive due to existing constraints upon land use changes; or from conversion of agricultural land to different crop types having lower habitat suitability, which is not foreseeble. Habitat loss or degradation from agricultural practices is not expected to increase in the forseeable future as agriculture in the Delta is assumed to be fully developed.

Predation by an existing introduced native species is likely to be maintained at levels comparable to current conditions; the introduction of new predators or parasites is possible, but not foreseeable; nor are the consequences of such an introduction.

Water pollution effects on the physiology of giant garter snakes or giant garter snake prey could result from a variety of causes, including agricultural practices, increased urbanization, and wastewater treatment plants. The input of pesticides and herbicides associated with agricultural practices are likely to be maintained, because the action area is already fully developed with regard to agricultural land uses, and regulations in place constrain the associated water quality effects. Water quality effects of urbanization include point and nonpoint-source water quality impairments such as oil, gasoline, herbicides, pesticides, heavy metals, etc., and there is a potential for those effects to further degrade water quality as further urbanization occurs in the action area. Wastewater treatment plants also contribute to impaired water quality, but significant improvements in discharge water quality and reductions in discharge water volume have occurred in recent years, primarily in response to regulatory and economic factors increasing the value of reusable water; thus this stressor is likely to diminish over time. Some of these effects will improve, and others will impair habitat quality for giant garter snake in the action area; their net effect is to approximately maintain current conditions for the foreseeable future.

These cumulative effects have little potential to impair the effectiveness of avoidance and minimization measures described in the PA, nor are they expected to alter the efficacy of offsetting measures in the PA such as habitat creation and restoration.

6.7 Effects on California Red-Legged Frog

Appendix 6.B *Terrestrial Effects Analysis Methods* describes the methods and assumptions used to analyze the effects of the proposed action (PA) on wildlife species. Appendix 4.A *Status of the Species and Critical Habitat Accounts,* Section 4.A.10.7 *Species Habitat Suitability Model* provides a description of the suitable habitat model for California red-legged frog.

Activities associated with geotechnical exploration, Clifton Court Forebay modifications, power supply and grid connections, reusable tunnel material, and habitat restoration may affect California red-legged frog, as described below. Figure 6.7-1 provides an overview of the locations of surface impacts relative to California red-legged frog modeled habitat, occurrences, and critical habitat. See Section 3.4.7.6.1 *Habitat Definition* for the definition of suitable California red-legged frog habitat. There are 3,616 acres of modeled California red-legged frog habitat in the action area, including 118 acres of aquatic and 3,498 acres of modeled upland cover and dispersal habitat. An estimated 52 acres (<2% of total modeled habitat in action area) of California red-legged frog modeled habitat will be lost as a result of project implementation, which includes 1 acres of aquatic habitat (2% of modeled aquatic habitat in the action area) and 51 acres of modeled upland cover and dispersal habitat (<2% of modeled upland cover and dispersal habitat in the action area). Four of the 51 acres of upland habitat is outside the construction footprint but is assumed to be affected by vibrations associated with construction equipment within 75 feet of habitat. Table 6.7-1 and Table 6.7-2 summarize the total loss of California red-legged frog modeled habitat under the PA and the amount to be conserved.

Table 6.7-1. Maximum Habitat Loss on Modeled Habitat for California Red-Legged Frog by Activity Type (Acres)

California Red-Legged Frog Modeled Habitat	Total Modeled Habitat in Action Area	Permanent Habitat Loss								Temporary Habitat Disturbance	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Power Supply and Connection	Total Permanent Habitat Loss	Geotechnical Exploration	Power Supply and Connection
Aquatic	118	0	0	0	1	0	0	0	1	0	0
Upland Cover and Dispersal	3,498	0	0	0	50[1]	0	0.1	1	51	6	11
Total	**3,616**	**0**	**0**	**0**	**51**	**0**	**0.1**	**1**	**52**	**6**	**11**

Notes
1. This includes 46 acres within the project footprint and 4 acres within 75 feet of activities that would generate vibrations.

Table 6.7-2. Loss and Conservation of Modeled Habitat for California Red-Legged Frog

California Red-Legged Frog Modeled Habitat	Permanent Habit Loss	Compensation Ratios		Total Compensation (Acres)	
	Total Maximum Habitat Loss (Acres)	Protection	Restoration	Protection	Restoration
Aquatic	1	3:1		3	
Upland Cover and Dispersal Habitat	51	3:1		153	
Total	**52**			**156**	

6.7.1 Geotechnical Exploration

6.7.1.1 Habitat Loss and Fragmentation

The only permanent loss of California red-legged frog habitat resulting from geotechnical exploration will be boreholes, which will be grouted upon completion. These holes are very small (approximately 8 inches in diameter) and would have no or negligible effects on the California red-legged frog. Geotechnical exploration will avoid loss of California red-legged frog aquatic habitat as described in 3.4.7.7.1.2, *Activities with Flexible Locations*. Temporary habitat disturbance expected to occur during the geotechnical exploration is described in section 6.7.1.2, *Construction Related Effects.*

6.7.1.2 Construction Related Effects

Geotechnical exploration will avoid effects on California red-legged frog aquatic habitat but may temporarily affect up to 6 acres of modeled upland cover and dispersal habitat (6 acres or ~0.1% of all modeled upland habitat in the action area). This effect will consist of driving overland to access the boring sites, and storing equipment for short time periods (several hours to 12 days). Given the low likelihood of California red-legged frog being present in the areas to be affected, effects on California red-legged frog from geotechnical exploration will be minimal. Construction related actions could injure or kill California red-legged frog if individuals are present, but the potential for this effect will be minimized by limited activities to the dry season and other measures described in Section 3.4.5.6.2.2.1 *Geotechnical Activities*.

6.7.1.3 Operations and Maintenance

There will be no ongoing operations and maintenance associated with the geotechnical exploration activities, therefore no effect on California red-legged frog.

6.7.2 Safe Haven Work Areas

Safe haven work areas are not expected to occur in California red-legged frog habitat, therefore this activity is not expected to affect California red-legged frog.

6.7.3 North Delta Intake Construction

The north Delta intake construction area does not overlap with California red-legged frog modeled habitat and this activity will not have an adverse effect on the species (Figure 6.7-1).

6.7.4 Tunneled Conveyance Facilities

Tunneled conveyance facilities construction does not overlap with California red-legged frog modeled habitat and will not have an adverse effect on the species (Figure 6.7-1).

6.7.5 Clifton Court Forebay Modification

6.7.5.1 Habitat Loss and Fragmentation

An estimated 48 acres of California red-legged frog modeled habitat overlaps with the mapped Clifton Court Forebay modifications (Figures 6.7-2 and 6.7-3), where land will be cleared for permanent facilities and temporary work areas. The 48 acres of modeled upland cover and dispersal habitat includes 1 acre of aquatic habitat (<1% of modeled aquatic habitat in the action area) and 47 acres of modeled upland cover and dispersal habitat (1% of modeled upland cover and dispersal habitat in the action area) (Table 6.7-1). Another 4 acres of upland habitat may be affected by construction related vibrations, as described in Section 6.7.5.2, *Construction Related Effects.*

Construction of the new forebay will remove aquatic habitat at the southern end of the Clifton Court Forebay. As shown on Figures 6.7-2 and 6.7-3, the forebay dredging area and construction of the new forebay, forebay embankment area, and control structure work area will remove modeled upland cover and dispersal habitat around Clifton Court Forebay and the Delta-Mendota Canal. Nearly all of the affected modeled upland and dispersal habitat would be considered dispersal habitat as it is not located in close proximity to aquatic habitat or known occurrences; modeled aquatic habitat is contiguous to modeled upland cover and dispersal habitat only at a transmission line corridor east of Byron Highway, as shown on Figure 6.7-4.

As described in Section 3.4.7.6.2.1 *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. Loss of California red-legged frog habitat will be offset through habitat protection at a 3:1 ratio (Table 6.7-2).

6.7.5.2 Construction Related Effects

Construction activities are those effects that result from construction activities, and only occur during construction. These effects on California red-legged frog may occur at Clifton Court Forebay include vegetation clearing, pile driving, excavation, dredging, and coffer dam and embankment construction. Construction at Clifton Court Forebay will be phased by location and the duration of construction will be approximately 6 years. For complete details on construction activities and phasing, see Section 3.2.5 *Clifton Court Forebay*; for more details on schedule, see Appendix 3.D *Construction Schedule for the Proposed Action*. Vehicles and heavy equipment used at the construction site could injure or kill California red-legged frog if individuals are present within the construction footprint. California red-legged from mortality from vehicles and heavy equipment are more likely 24 hours proceeding a rain event and during nighttime construction. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for California red-legged frog to enter the work area. Other effects related to construction may include entanglement in erosion control materials, contamination because of toxic substances such as fuels, degradation of aquatic habitat from run-off and siltation, and behavioral changes as a result of lighting or vibration. Although measures will be applied to minimize the risk of injuring or killing California red-legged frogs during construction, and to minimize the risk of disrupting behavioral patterns, some potential remains for these effects to occur with all the minimization measures in effect.

Construction activities could generate light and vibrations, which could cause California red-legged frog to emerge from burrows or other cover at night and make them vulnerable to predation. One study found that spadefoot toads relied primarily on vibration from rain falling on the ground at their burrows, rather than increased moisture in the soil from rain, as the signal to emerge from burrows. They were able to induce emergence by setting an off-balance test tube spinner within 1 meter of the burrow, which vibrated the soil in close proximity to the animals, and observed almost 100% emergence. Additionally, the researchers noted that sound-induced vibration from violent, rainless thunder storms, would also produce the emergence response. Spadefoot toads also emerge from their burrows without any inducement to feed. This research has been assumed relevant to California red-legged frog, though no similar study has been applied to those species. Based on data regarding the distance vibration travels for the project-related activities, it is assumed that vibrations will affect areas within 75 feet of activities related to Clifton Court Forebay modifications. Therefore, 3 acres of California red-legged upland habitat could be affected by vibrations.

6.7.5.3 Operations and Maintenance

The operational components of the modified Clifton Court Forebay include the pumping plant, control structures and siphons. The features will not be operated in or near California red-legged frog habitat and are not expected to affect the species.

The forebay and canals will require control of vegetation and rodents, and embankment repairs. Maintenance of control structures could include removal or installation of roller gates, radial gates, and stop logs. Maintenance requirements for the spillway would include the removal and disposal of any debris blocking the outlet culverts. Use of heavy equipment for maintenance may injure or kill California red-legged frog: these effects and associated minimization measures are as described in Section 6.7.5.2, *Construction Related Effects.* Additionally, removal of vegetation, embankment repairs, and rodent control measures may result in injury or mortality of California red-legged frog. These effects will be minimized through observance of speed limits where possible, and other measures described in Section 3.4.7.6.2.1 *Activities with Fixed Locations.*

6.7.6 Power Supply and Grid Connections

6.7.6.1 Habitat Loss and Fragmentation

To conservatively asses impacts from transmission line placement due to the flexibility of the final alignment, a 50-foot wide permanent disturbance area along the transmission line corridor was assumed (see Appendix 6.B *Terrestrial Effects Analysis Methods* for additional details about the impact assessment method). Based on this method, an estimated 12 acres (0.3% of all modeled upland habitat in the action area) of California red-legged frog modeled upland cover and dispersal habitat may be temporarily lost as a result of the construction of both temporary and permanent transmission lines (Figures 6.7-2 through 6.7-6 and Table 6.7-1). Temporary impacts are incurred from activities that will not last more than 1 year and include access routes (vehicles driving over ground to access the site), temporary staging areas for poles or placement, and reconductoring areas. Temporary habitat loss will result from pole and tower placement. Ongoing vegetation management around the poles and under the lines will be minimal in California red-legged frog habitat because grassland areas typically do not need to be cleared to maintain transmission line corridors. Transmission line construction will avoid loss of California red-legged frog aquatic habitat as described in 3.4.7.7.1.2, *Activities with Flexible Locations*.

Because this disturbance is primarily from short-term, temporary effects, specific compensation for the 12 acres of California red-legged frog upland habitat disturbance will be offset by returning these areas to pre-project conditions.

6.7.6.2 Construction Related Effects

New temporary power 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 power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, 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, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Construction of new transmission lines will require 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-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at 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 will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than 1 year at any one location. See Section 3.2.7.2 *Construction*, for a full description of the construction activities.

The operation of equipment during construction of the transmission lines could injure or kill California red-legged frog if individuals are present. The construction related effects and measures to minimize them are similar to those described above for reusable tunnel material sites under Section 6.7.5.2 *Construction Related Effects*. Although measures will be applied to minimize the risk of injuring or California red-legged frog during construction, some potential remains for these effects to occur.

6.7.6.3 Operations and Maintenance

Ongoing vegetation management around the poles and under the lines is expected to be minimal (small scale mechanical mowing and trimming around poles) in California red-legged frog habitat because grassland areas seldom if ever need to be cleared to maintain transmission line corridors.

6.7.7 Head of Old River Gate

The HOR gate construction area does not overlap with California red-legged frog modeled habitat and activities in that area will not have an adverse effect on the species (Figure 6.7-1).

6.7.8 Reusable Tunnel Material

6.7.8.1 Habitat Loss and Fragmentation

An estimated 0.1 acres (>0.1% of modeled upland cover and dispersal habitat in the action area) of California red-legged frog modeled upland cover and dispersal habitat overlaps with the mapped RTM access road where Western Farms Ranch Road meets Byron Highway (Figure 6.7-4, Table 6.7-1). The habitat to be removed is adjacent to cultivated lands and on the east side of Byron Highway, disconnected from the contiguous grassland habitat to the west. As shown in Figure 6.7-1, the RTM site is at the easternmost edge of California red-legged frog modeled habitat in the action area, and therefore will not result in habitat fragmentation or isolation.

The loss of 0.1 acres of modeled upland cover and dispersal habitat will be compensated through protection and management of California red-legged frog habitat at a 3:1 ratio in an area that connects to over 620 acres of existing habitat protected under the *East Contra Costa County HCP/NCCP*. The compensation for the PA will complement the conservation goals of the *East Contra Costa County HCP/NCCP.* See Section 3.4.7.6.3 *Compensation to Offset Impacts,* for a full description of how protected lands will be sited to provide valuable habitat for this species.

6.7.8.2 Construction Related Effects

The RTM storage area will take 5 to 8 years to construct and fill. All RTM areas will be constructed, as needed, depending on location. RTM storage area construction and placement will occur almost continuously through tunnel excavation, approximately 10 years.

Construction activities at the RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed. For more details about the activities associated with RTM placement see Section 3.2.10.6 *Dispose Soils*.

Vehicles and heavy equipment used to clear the RTM sites and transport equipment and material could injure or kill California red-legged frogs if individuals are present within the RTM footprint. California red-legged from mortality from vehicles and heavy equipment are more likely 24 hours proceeding a rain event and during nighttime construction. This effect would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for California red-legged frog to enter the work area. To help minimize the effects to the greatest extent practicable, no construction activities will occur during rain events or within 24-hours following a rain event or during nighttime hours. Other effects related to placement of RTM may include entanglement in erosion control materials, contamination as a result of toxic substances such as fuels, and degradation of aquatic habitat from run-off and siltation, dust, individuals trapped in pipes or other equipment, and falling in trenches or pits 1 foot or deeper. Additional measures to minimize construction related impacts are discussed in Section 3.4.7.6.2 *Avoidance and Minimization Measures,* and include using an open-top trailer to elevate materials for onsite storage above ground such as pipes, conduits and other materials that could provide shelter for California red-legged frogs, eliminating the use of plastic monofilament netting (erosion control matting), loosely woven netting, or similar material, implementing dust control measures, and covering trenches and/or pits with wooden planks.

6.7.8.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM sites and therefore no effects to California red-legged frog.

6.7.9 Restoration/Mitigation

6.7.9.1 Habitat Loss and Fragmentation

Restoration activities are expected to avoid effects on California red-legged frog and its habitat. Effects resulting from restoration associated with mitigation, if any, will be addressed through a separate section 7 consultation process. Individuals involved in monitoring on mitigation lands will hold a USFWS recovery permit for this species if such actions may result in take of California red-legged frog.

6.7.10 Critical Habitat

California red-legged frog critical habitat occurs in the action area to the west of CCF approximately 0.5 miles from the nearest construction activity area (Figure 6.7-1). Because there is no overlap between the construction footprint and California red-legged frog habitat, no effects on California red-legged frog critical habitat will occur. Future restoration for the project will not result in the adverse modification of California red-legged frog critical habitat.

6.7.11 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of California red-legged frog will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect California red-legged frog in the action area when habitat loss and degradation occurs without USFWS authorization. The most likely activity of this type is conversion of rangeland to urban uses. Unauthorized take as a result of urbanization is unlikely where most of the habitat occurs west of CCF because urbanization within the cities of Brentwood, Pittsburg, Oakley, and Clayton is covered by the East Contra Costa County HCP/NCCP. Urban development outside these incorporated cities (i.e., in the jurisdiction of Contra Costa County) is not covered by the East Contra Costa County HCP/NCCP. Although unlikely to occur due to land use controls, if urban development was proposed in or near the community of Byron it could contribute to a cumulative adverse effect on California red-legged frog in the action area.

Climate change also threatens to modify annual weather patterns. Climate change may result in a loss of California red-legged frog and/or prey, and/or increased numbers of their predators, parasites, and disease. Since the habitat in the action area with the highest likelihood of supporting California red-legged frog is within the East Contra Costa County HCP/NCCP, where large scale conservation efforts will be implemented, cumulative effects in the action area are not expected to appreciably diminish the likelihood of the species' long-term survival and recovery.

6.8 Effects on California Tiger Salamander

Appendix 6.B *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the proposed action (PA) on wildlife species. Appendix 4.A *Status of the Species and Critical Habitat Accounts,* Section 4.A.11.6 *Suitable Habitat Definition* and Section 4.A.11.7 *Species Habitat Suitability Model* define suitable habitat and describe the habitat model for California tiger salamander.

Activities associated with geotechnical exploration, Clifton Court Forebay modification, power supply and grid connections, and habitat restoration may affect California tiger salamander, as described below. Figure 6.8-1 provides an overview of the locations of surface impacts relative to California tiger salamander modeled habitat, occurrences, and critical habitat. There are 12,724 acres of modeled California tiger salamander habitat in the Delta. An estimated 50 acres (<1% of total modeled habitat in the Delta) of California tiger salamander modeled habitat will be lost as a result of project implementation, including 47 acres within the project footprint and 3 acres that may be affected by activities generating vibrations. Table 6.8-1 and Table 6.8-2 summarize the total estimated habitat loss of California tiger salamander modeled habitat. Only terrestrial cover and aestivation habitat loss is expected to occur; the PA would not entail loss of any aquatic breeding habitat.

Table 6.8-1. Maximum Habitat Loss on Modeled Habitat for California Tiger Salamander by Activity Type (Acres)

California Tiger Salamander Modeled Habitat	Total Modeled Terrestrial Cover and Aestivation Habitat in the Action Area	Permanent Habitat Loss								Temporary Habitat Loss	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Power Supply and Connection	Total Maximum Habitat Loss	Geotechnical Exploration	Power Supply and Connection
Terrestrial Cover and Aestivation	12,724	0	0	0	49	0	0	1	50	2	6

Table 6.8-2. Maximum Direct Effects on and Conservation of Modeled Habitat for California Tiger Salamander

California Tiger Salamander Modeled Habitat	Permanent Habit Loss	Compensation Ratios		Total Compensation (Acres)	
	Total Maximum Habitat Loss (Acres)	Protection	Restoration	Protection	Restoration
Terrestrial Cover and Aestivation	50[1]	3:1		150	

Notes

[1] This includes 47 acres within the construction footprint and 3 acres within 75 feet of project activities that may generate vibrations affecting California tiger salamander.

6.8.1 Geotechnical Exploration

6.8.1.1 Habitat Loss and Fragmentation

The only permanent loss of California tiger salamander habitat resulting from geotechnical exploration will be boreholes, which will be grouted upon completion. These holes are very small (approximately 8 inches in diameter) and their filling would have no or negligible effects on the California tiger salamander. Additional habitat disturbance during construction is described in Section 6.8.1.2, *Construction Related Effects.*

6.8.1.2 Construction Related Effects

Geotechnical exploration activities will temporarily affect up to 2 acres (<0.1% of modeled terrestrial cover and aestivation habitat in the action area) of modeled California tiger salamander terrestrial cover and aestivation habitat. This effect will consist of driving overland to access the boring sites, and storing equipment for short time periods (2 to 21 days). Given the low likelihood of California tiger salamander being present in the areas to be affected, effects on California tiger salamander from geotechnical exploration will be minimal. Construction related actions could injure or kill California tiger salamander if individuals are present within the 2 acres to be disturbed, but the potential for this effect will be minimized as described in Section 3.4.7.7.2.3, *Activities with Flexible Locations.*

6.8.1.3 Operations and Maintenance

There will be no ongoing operations and maintenance associated with the geotechnical activities, resulting in no effect on California tiger salamander.

6.8.2 Safe Haven Work Areas

Safe haven work areas are not expected to occur in California tiger salamander habitat. Activities in these areas will not affect the species.

6.8.3 North Delta Intake Construction

The north Delta intake construction area does not overlap with California tiger salamander modeled habitat. Activities in this area will not affect the species (Figure 6.8-1).

6.8.4 Tunneled Conveyance Facilities

Tunneled conveyance facilities construction does not overlap with California tiger salamander modeled habitat. Activities in this area will not affect the species (Figure 6.8-1).

6.8.5 Clifton Court Forebay Modification

6.8.5.1 Habitat Loss and Fragmentation

An estimated 46 acres (>0.1% of modeled terrestrial cover and aestivation habitat in the action area) of California tiger salamander modeled terrestrial cover and aestivation habitat overlaps with the mapped canal modifications at Clifton Court Forebay (Figure 6.8-2), where land will be cleared for permanent facilities and temporary work areas. The activities that will result in habitat loss include canal construction that will remove terrestrial cover and aestivation habitat at the southern end of the Clifton Court Forebay. Another 3 acres of upland habitat may be affected by construction related vibrations, as described in Section 6.8.5.2, *Construction Related Effects.*

The loss of California tiger salamander terrestrial cover and aestivation habitat will be offset through protection at a 3:1 ratio (Table 6.8-2). As described in Section 3.4.7.7.2.2, *Activities with Fixed Locations*, workers will confine ground disturbance and habitat removal to the minimal area necessary to facilitate construction activities. As detailed in Section 3.4.7.7.4, *Siting Criteria for Compensation for Effects*, these conservation lands will be sited in locations that provide high habitat values for the species, consisting of large, contiguous blocks of habitat suitable for California tiger salamander. As detailed in Section 3.4.7.7.5, *Management and Enhancement*, these conservation lands will be protected and managed for the species in perpetuity.

6.8.5.2 Construction Related Effects

Construction activities at the canal work area south of Clifton Court Forebay include vegetation clearing, excavation, pile driving, dredging, and cofferdam and embankment construction. The duration of construction in this area will be approximately 6 years. For complete details on construction activities and phasing, see Section 3.2.6 *Connections to Banks and Jones Pumping Plants;* for more details on schedule, see Appendix 3.D *Construction Schedule for the Proposed Action*.

Vehicles and heavy equipment used at the construction site could injure or kill California tiger salamanders if individuals are present within the construction footprint. Other effects related to construction within the construction footprint may include entanglement in erosion control materials or contamination because of toxic substances such as fuels. Effects within the construction footprint would be most likely to occur during site clearing (up to several days at each location) because thereafter, exclusion fencing will be installed, and these areas will be monitored to minimize the potential for California tiger salamanders to enter the work area.

DWR will implement measures to minimize effects on California tiger salamander that could result from initial ground clearing activities, as described in Section 3.4.6.7.2.2 *Activities with Fixed Locations,* under *Site Preparation* and *Initial Clearance/Ground Disturbance.* To minimize effects on California tiger salamander during the initial clearing, a USFWS-approved biologist will conduct preconstruction surveys within the construction footprint (after installing amphibian exclusion fencing along the perimeter) and will relocate any California tiger salamanders found in accordance with a USFWS-approved relocation plan. The initial ground disturbance and clearing within suitable California tiger salamander habitat will be then be confined to the dry season, and all such activities will be limited to periods of no or low rainfall. Ground disturbing activities in suitable California tiger salamander terrestrial cover and aestivation habitat will cease on days with a 40% or greater forecast of rain from the closest National Weather Service (NWS) weather station, however, ground disturbing work may continue if a USFWS-approved biologist surveys the worksite before construction begins each day rain is forecast and is present during ground disturbing work. Ground disturbing activities may continue after the rain ceases and the work areas is surveyed by the USFWS-approved biologist. 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 as described in Section 3.4.7.7.2, *Avoidance and Minimization Measures*. With these measures in place, the potential for injury or mortality of California tiger salamander will be minimized but there will still be potential for mortality of any individuals not detected during preconstruction surveys within the 46 acres of habitat in the construction footprint. There is also the potential for California tiger salamanders found within the construction footprint to be harassed through the relocation process. Potential for injury, mortality, or harassment is low because the likelihood of California tiger salamander occurrence in this area is low.

During initial site clearing and ongoing construction, DWR will implement measures to prevent injury, mortality, or harassment of individuals that could otherwise result from degradation of adjacent habitat from run-off and siltation. This will include implementation of a Stormwater Pollution Prevention Plan (AMM3) and an Erosion and Sediment Control Plan (AMM4). With implementation of these measures, take associated with run-off or siltation will be avoided.

During initial site clearing and ongoing construction, DWR will implement measures to prevent injury or mortality of individuals that could otherwise result from erosion control materials. 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 and the perimeter of construction sites will be fenced with amphibian exclusion fencing. With this measure in place, take associated with erosion control measures will be avoided.

During initial site clearing and ongoing construction, DWR will implement measures to prevent injury or mortality of individuals that could otherwise result from toxic substances such as fuels. With implementation of AMM5, *Spill Prevention, Containment, and Countermeasure Plan,* take associated with toxic substances will be avoided.

Because dusk and dawn are often the times when the California tiger salamander 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 30 minutes after sunrise within suitable California tiger salamander habitat. 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 within California tiger salamander aquatic habitat or as determined in coordination with the US Fish and Wildlife Service. If night working and lighting is necessary, all lighting will be directed away and shielded from California tiger salamander habitat outside the construction area to minimize light spillover to the greatest extent possible. If light spillover into adjacent California tiger salamander habitat occurs, a USFWS-approved biologist will be present during night work to survey for burrows and emerging California tiger salamanders in areas illuminated by construction lighting. If California tiger salamander is found above-ground the USFWS-approved biologist has the authority to terminate the project activities until the light is directed away from the burrows, the California tiger salamander moves out of the illuminated area, or the California tiger salamander is relocated out of the illuminated area by the USFWS-approved biologist. Although measures will be applied to minimize the risk of harassing or displacing California tiger salamanders outside the construction footprint during construction, some individuals may be harassed or displaced from habitat with these measures in place, as described below.

Construction activities could generate light and vibrations, which could cause California tiger salamander to emerge from burrows or other cover at night and make them vulnerable to predation. One study found that spadefoot toads relied primarily on vibration from rain falling on the ground at their burrows, rather than increased moisture in the soil from rain, as the signal to emerge from burrows. They were able to induce emergence by setting an off-balance test tube spinner within 1 meter of the burrow, which vibrated the soil in close proximity to the animals, and observed almost 100% emergence. Additionally, the researchers noted that sound-induced vibration from violent, rainless thunder storms, would also produce the emergence response. Spadefoot toads also emerge from their burrows without any inducement to feed. This research has been assumed relevant to California tiger salamander, though no similar study has been applied to those species. Based on data regarding the distance vibration travels for the project-related activities, it is assumed that vibrations will affect areas within 75 feet of activities related to Clifton Court Forebay modifications. Therefore, 3 acres of California tiger salamander upland habitat could be affected by vibrations.

6.8.5.3 Operations and Maintenance

The operational components of the modified Clifton Court Forebay include the pumping plant, control structures, and siphons. These features will not be operated in or near California tiger salamander habitat and are not expected to affect the species.

The forebay and canals will need control of vegetation and rodents, and perhaps embankment repairs. Maintenance of control structures could include removal or installation of 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. After construction, however, these areas will no longer consist of suitable California tiger salamander habitat, therefore this species is not expected to be affected by these activities.

6.8.6 Power Supply and Grid Connections

6.8.6.1 Habitat Loss and Fragmentation

To conservatively assess impacts from transmission line placement, a 50-foot wide permanent disturbance area along the transmission line corridor was assumed (see Appendix 6.B *Terrestrial Effects Analysis Methods* for additional details about the impact assessment method). Based on this method, an estimated 9 acres (>0.1% of modeled terrestrial cover and aestivation habitat in the action area) of California tiger salamander aestivation and cover habitat may be temporarily lost as a result of the construction of temporary transmission lines (Table 6.8-1). Temporary impacts are incurred from activities that will not last more than 1 year and include access routes (vehicles driving over ground to access the site), temporary staging areas for poles or placement, and reconductoring areas. Ongoing vegetation management around the poles and under the lines will be minimal (small scale mechanical mowing and trimming) in California tiger salamander habitat because aquatic and grassland areas typically do not need to be cleared to maintain transmission line corridors.

Because transmission line effects are primarily short-term and temporary, specific compensation for the 7 acres of California tiger salamander habitat (>0.1% of modeled terrestrial and cover habitat in the action area) disturbance will be offset by returning these areas to pre-project conditions.

6.8.6.2 Construction Related Effects

New temporary power 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.

Construction of new transmission lines will require 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-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at 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 will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than 1 year at any one location. See Section 3.2.7.2, *Construction*, for a full description of the construction activities.

The operation of equipment during construction of the transmission lines could injure or kill California tiger salamander if individuals within the 7 acres of habitat if individuals are present. The construction related effects and measures to minimize them are similar to those described above for construction at the canal work area near Clifton Court Forebay in Section 6.8.5.2, *Construction Related Effects,* with the exception that activities will be restricted to the daytime so that no artificial lighting is necessary. Additionally, because noise and vibrations from the transmission line activities are not expected to reach the levels they would under Clifton Court Forebay construction, harassment or displacement of individuals beyond the 7-acre disturbance footprint is not anticipated.

6.8.6.3 Operations and Maintenance

Ongoing vegetation management around the poles and under the lines is expected to be minimal in California tiger salamander habitat because aquatic and grassland areas seldom if ever need to be cleared to maintain transmission line corridors. Effects on California tiger salamander from transmission line operations and maintenance, if any, are expected to be negligible, and are not expected to result in take of California tiger salamander.

6.8.7 Head of Old River Gate

The HOR gate construction area does not overlap with California tiger salamander modeled habitat. Activities in this area will not affect the species (Figure 6.8-1).

6.8.8 Reusable Tunnel Material

The RTM sites do not overlap with California tiger salamander modeled habitat. Activities in this area will not affect the species (Figure 6.8-1).

6.8.9 Restoration

6.8.9.1 Habitat Loss and Fragmentation

Restoration activities will avoid effects on California tiger salamander and its habitat with the exception of vernal pool complex restoration, which may result in loss of 11 acres of California tiger salamander terrestrial cover and aestivation habitat. While the exact location of vernal pool restoration is not known, it is likely that it will be in the region directly west, north, or south of CCF where California tiger salamander modeled habitat exists. Although vernal pool restoration in grasslands will result in some loss of California tiger salamander habitat, protection and management of surrounding grasslands associated with the vernal pools is expected to benefit California tiger salamander.

6.8.9.2 Construction Related Effects

Vernal pool restoration will involve use of heavy equipment to excavate areas within grasslands to create topographic depressions. California tiger salamanders could be injured or killed by heavy equipment or struck by vehicles associated with vernal pool construction. The types of effects and measures to minimize these effects are as described in Section 6.8.5.2, *Construction Related Effects*. Although measures will be applied to minimize the risk of injuring or California tiger salamander during construction, and to minimize the risk of disrupting behavior through noise or lighting, some potential remains for these effects to occur with all the minimization measures in effect.

6.8.9.3 Operations and Maintenance

A variety of management actions to be implemented within restored vernal pool complex may result in localized ground disturbances within California tiger salamander habitat. Ground-disturbing activities such as removal of nonnative vegetation and road and other infrastructure maintenance activities are expected to have minor effects on available California tiger salamander. Management activities could result in the injury or mortality of California tiger salamanders if individuals are present in work sites or if dens occur near habitat management work sites. Noise and visual disturbances could also affect California tiger salamanders use of the surrounding habitat. These effects are expected to be minor, and will be minimized with implementation of the worker awareness training, monitoring, and best management practices described in Section 3.4.7.7.2, *Avoidance and Minimization Measures*. Furthermore, the management and enhancement of vernal pool complexes are expected to benefit the species.

6.8.10 Effectiveness Monitoring

On lands protected to benefit California tiger salamander, monitoring to detect the presence of California tiger salamanders will be performed to determine the effectiveness of conservation. Monitoring will include dip net surveying for the presence of individuals. The presence of the biologist and dip netting may temporarily alter behavior. As such, effectiveness monitoring for California tiger salamander will be performed by a USFWS approved biologist.

6.8.11 Effects on Critical Habitat

Critical habitat for California tiger salamander occurs in the Jepson Prairie area and overlaps with the action area near to the terminus of Lindsey Slough, west of Rio Dixon Road. There are no water conveyence facility construction activities in this region, however, tidal resotration could occur in the Cache Slough and Lindsey Slough area. Avoidance and minimization measures described in Section 3.4.7.7.2.3.3.2, *Tidal Restoration*, require tidal restoration projects be designed to avoid areas within 250 feet of any of the physical and biological features (PBFs) 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 PBFs.

6.8.12 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of California tiger salamander will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect California tiger salamander in the action area when habitat loss and degradation occurs without USFWS authorization. The most likely activity of this type is conversion of rangeland to urban uses. Unauthorized take as a result of urbanization is unlikely where most of the habitat occurs west of CCF because urbanization within the cities of Brentwood, Pittsburg, Oakley, and Clayton is covered by the East Contra Costa County HCP/NCCP. Urban development outside these incorporated cities (i.e., in the jurisdiction of Contra Costa County) is not covered by the East Contra Costa County HCP/NCCP. Although unlikely to occur due to land use controls, if urban development was proposed in or near the community of Byron it could contribute to a cumulative adverse effect on California tiger salamander in the action area.

Climate change also threatens to modify annual weather patterns. Climate change may result in a loss of California tiger salamander and/or prey, and/or increased numbers of their predators, parasites, and disease. Since the habitat in the action area with the highest likelihood of supporting California tiger salamander is within the East Contra Costa County HCP/NCCP, where large scale conservation efforts will be implemented, cumulative effects in the action area are not expected to appreciably diminish the likelihood of the species' long-term survival and recovery.

6.9 Effects on Valley Elderberry Longhorn Beetle

Appendix 6.B *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the PA on terrestrial species. Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.14.7 *Species Habitat Suitability Model*, provides a description of the suitable habitat model for valley elderberry longhorn beetle.

Activities associated with safe haven work areas, north delta intakes, tunneled conveyance facilities, Clifton Court Forebay modification, power supply and grid connections, head of Old River gate (HOR gate), reusable tunnel material, and restoration may affect valley elderberry longhorn beetle, as described below. Figure 6.9-1 provides an overview of the locations of surface impacts relative to valley elderberry longhorn beetle modeled habitat and occurrences. See Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.14.6 *Suitable Habitat Definition*, for the definition of suitable valley elderberry longhorn beetle habitat. There are 31,495 acres (15,195 acres of grassland habitat and 16,300 acres of riparian habitat) of modeled valley elderberry longhorn beetle habitat in the action area. An estimated 276 acres (1% of total modeled habitat in action area) of valley elderberry longhorn beetle modeled habitat, which includes 227 acres of grassland habitat and 49 acres of riparian habitat, will be lost as a result of project implementation. Table 6.9-1 and Table 6.9-2 summarize the maximum loss of valley elderberry longhorn beetle habitat and present compensation, respectively.

6.9.1 Geotechnical Exploration

The exact locations of geotechnical exploration activities are not known at this time. As noted in Section 3.4.7.8.2.2 *Activities with Flexible Locations*, preconstruction surveys for elderberry shrubs will be conducted in potential work areas during the planning phase for geotechnical exploration. Geotechnical activities will be planned to fully avoid elderberry shrubs and effects on the species.

6.9.2 Safe Haven Work Areas

6.9.2.1 Habitat Loss and Fragmentation

An estimated 2 acres (>0.1% of modeled habitat in action area) of valley elderberry longhorn beetle modeled habitat will be affected at safe haven work areas. The 2 acres of modeled habitat includes 1 acre of riparian habitat (>0.1% of modeled riparian habitat in action area) and 1 acre of non-riparian habitat (>0.1% of modeled grassland habitat in action area). Because the exact locations of safe haven work areas are not known at this time, it is unknown whether these locations will result in fragmentation of valley elderberry longhorn beetle habitat.

As described in Appendix 6.B *Terrestrial Effects Analysis Methods*, Table 6.B-10, *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made of the number of shrubs and associated stems that could be affected by construction. As seen in Table 6.9-1, the construction of the safe haven interventions is estimated to result in direct effects on approximately 7 elderberry shrubs with an estimated total of 140 stems. The actual number of shrubs and stems that will be affected will be determined during preconstruction surveys in suitable habitat as outlined in Section 3.4.7.8.2.1 *Activities with Fixed Locations*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6 *Suitable Habitat Definition.*

Table 6.9-1. Loss of Valley Elderberry Longhorn Beetle Habitat (Elderberry Bushes) by Activity Type (Acres)

Valley Elderberry Longhorn Beetle Habitat	Total Modeled Habitat in the Action Area	Permanent Habitat Loss								Temporary Habitat Loss	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Restoration	Total	Geotechnical Exploration	Power Supply and Connection
Grassland within 200ft	15,195	1	31	57	72	1	65	0	227	52	35
Riparian Habitat	16,300	1	14	19	1	0	14	0	49	11	8
Total Acres Modeled Habitat	**31,495**	**2**	**45**	**77**	**73**	**1**	**79**	**0**	**276**	**63**	**43**
Shrubs	n/a	2	15	23	7	1	19	29	107	0	11[a]
Stems	n/a	20	300	460	140	20	380	581	2,121	0	220[a]

[a] Impacts to shrubs and stems are direct and require transplanting and mitigation. See Section 3.4.7.8.3, *Compensation to Offset Impacts*, for full details on shrubs and stem compensation.

Table 6.9-2. Maximum Shrub and Stem Loss of Valley Elderberry Longhorn Beetle Habitat (Elderberry Bush) and Proposed Compensation (See Section 3.4.7.8.3 *Compensation to Offset Effects*, for compensation by activity type).

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	No	413	2:1	1:1	826	826	
			Yes	378	4:1	2:1	1,512	3,024	
	From 3 to 5 inches	300	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	No	90	4:1	1:1	361	361	
			Yes	88	8:1	2:1	701	1,600	
						Total	**5,569**	**9,433**	**15,002**

Notes

[1] Presence or absence of exit holes indicating presence of valley elderberry longhorn beetle. All stems measuring 1 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 (1 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 6.9-2 shows the compensation for the estimated direct effects to elderberry shrubs from safe haven construction. Table 3.4.-14 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Section 3.4.7.8.2, *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.2.2 Construction Related Effects

Construction of safe haven interventions will include the use of heavy equipment for ground clearing, grading, excavation, and drilling. Construction related actions could injure or kill valley elderberry longhorn beetles if individuals are present in shrubs to be transplanted, but the potential for this effect will be minimized as described in Section 3.4.7.8.2, *Avoidance and Minimization Measures*, which includes having a USFWS-approved biologist present to prevent unauthorized take and to ensure that transplanting measures adhere to the USFWS's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*. These guidelines include transplanting shrubs during their dormant season (generally between November and the first 2 weeks of February), which is when they have lost most of their leaves.

Construction related actions could injure or kill valley elderberry longhorn beetles if individuals are present in shrubs to be transplanted, but the potential for this effect will be minimized as described in Section 3.4.7.8.2, *Avoidance and Minimization Measures*, which includes having a USFWS-approved biologist present to prevent unauthorized take and to ensure that transplanting measures adhere to the USFWS's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*. These guidelines include transplanting shrubs during their dormant season (generally between November and the first 2 weeks of February), which is when they have lost most of their leaves.

The operation of equipment during construction in the vicinity of occupied elderberry shrubs could also result in injury or mortality of valley elderberry longhorn beetles if they are actively dispersing between shrubs, which is generally between March 15th to June 15th; or if occupied shrubs are inadvertently damaged by construction activities. These effects will be avoided and minimized as described in Section 3.4.7.8.2, *Avoidance and Minimization Measures* by surveying all areas within 100 feet of construction work areas, setting up barrier fencing and signs around shrubs, training crews on the sensitivity of the habitat and ramifications of violating the Endangered Species Act, and avoiding application of pesticides, herbicides, fertilizers, or other chemicals that could be hazardous to elderberry shrubs within 100 feet of the shrubs.

Temporary construction-related ground disturbances could generate dust that could adversely affect adjacent valley elderberry longhorn beetle habitat. Dust is listed in the valley elderberry longhorn beetle recovery plan as a threat to the species (U.S. Fish and Wildlife Service 1984). However, one study indicated that dust deposition was not correlated with valley elderberry longhorn beetle presence (Talley et al. 2006), although dust was weakly correlated with elderberry stress symptoms (water stress, dead stems, smaller leaves). During times of drought, when elderberry shrubs are under stress, dust deposition could further stress the shrubs, potentially leading to their death. Such a loss of shrubs could adversely affect valley elderberry longhorn beetle (Talley and Hollyoak 2009). The potential effects of dust on valley elderberry longhorn beetle will be minimized by applying water during construction activities or by presoaking work areas that will occur within 100 feet of any potential elderberry shrub habitat.

Exhaust from construction and maintenance vehicles may result in deposition of particulates, heavy metals, and mineral nutrients that could influence the quality and quantity of elderberry shrubs and thereby affect beetle presence and abundance. The results of a study by Talley and Hollyoak (2009) showed no relationship, however, between the distance of the shrubs from highways and the presence or abundance of the beetle. Potential effects from vehicle exhaust will be minimized by implementing measures in Section 3.4.7.8.2, *Avoidance and Minimization Measures*, which include establishing buffers between the shrubs and work areas.

Temporary lighting from construction activities could adversely affect valley elderberry longhorn beetle. The effects of lighting on valley elderberry longhorn beetle are unknown, although insects are known to be subject to heavy predation when they are attracted to night lighting (Eisenbeis 2006). As identified in Section 3.4.7.8.2, *Avoidance and Minimization Measures*, 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. 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. There may, however, be residual effects on the species when it is not practicable to prohibit artificial lighting. Since lighting has not been found to have an adverse effect on this species and is not recognized as a threat to the species (U.S. Fish and Wildlife Service 2014), these effects are not expected to be appreciable.

6.9.2.3 Operations and Maintenance

Operation and maintenance in safe havens is not anticipated to result in any effects on valley elderberry longhorn beetle. In addition, as noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Section 3.4.7.8, *Valley Elderberry Longhorn Beetle*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species during construction.

6.9.3 North Delta Intake Construction

6.9.3.1 Habitat Loss and Fragmentation

An estimated 45 acres (0.13% of modeled habitat in the action area) of valley elderberry longhorn beetle modeled habitat overlaps with the mapped north delta intakes 2, 3, and 5 along the Sacramento River (Figures 6.9-2 through 6.9-4), where land will be cleared for permanent facilities and temporary work areas. The 45 acres of modeled habitat includes 13 acres of riparian habitat (>0.1% of modeled riparian habitat in action area) and 31 acres of grassland habitat (>0.1% of modeled grassland habitat in action area). Of the estimated 45 acres of habitat to be removed, 34 acres (7 acres of riparian and 27 acres of non-riparian) will result from construction of permanent facilities such as intake structures and associated electrical buildings and facilities, and permanent access roads. The remaining 11 acres (6 acres of riparian and 5 acres of non-riparian) of loss will result from use of work areas, which will last for approximately 5 years at each intake: because the duration of this effect is greater than 1 year, this effect will be compensated as if it were a permanent effect.

As described in Appendix 6.B *Terrestrial Effects Analysis Methods*, Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made on the number of shrubs and associated stems that could be affected by construction. As shown in Table 6.9-1, construction of the intakes is anticipated to result in direct effects (permanent and temporary impacts) on approximately 15 elderberry shrubs with an estimated 300 stems. The actual number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as described in Section 3.4.7.8.2 *Avoidance and Minimization Measures*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6 *Suitable Habitat Definition.*

As seen in Figures 6.9-2, 6.9-3, and 6.9-4, the habitat to be lost as a result of intake construction is along the east shore of the Sacramento River as well as along waterways (ditches, canals, and streams) that drain into the river. Though the impacted areas are relatively narrow (approximately 45 feet wide) they provide continuous modeled habitat along the eastern bank of the Sacramento River and intake construction of them would fragment this habitat. Construction of Intakes 2, 3, and 5 would remove approximately 1.5 miles, 1.4 miles, and 0.8 mile of modeled habitat, respectively along the eastern bank of the river. Considering that valley elderberry longhorn beetle is known to have poor dispersal abilities (Talley et al. 2006), the intakes would create dispersal barriers along the eastern bank of the Sacramento River. There are currently no known records of the species along the Sacramento River south of West Sacramento (California Department of Fish and Wildlife 2015), but surveys for the species in this area may be limited.

Table 6.9-2 shows the compensation for the estimated direct effects to elderberry shrubs from north Delta intakes. Table 3.4-8 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Section 3.4.7.8.2 *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable consistent with USFWS's 1999 *Conservation Guidelines for the Valley Elderberry Longhorn Beetle*. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.3.2 Construction Related Effects

The effects from construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Section 6.9.2.2 *Construction Related Effects*.

The duration of construction at each intake will be approximately 5 years. Implementation of intake construction at each location will be staggered by approximately 6 months. Intake 3, the middle intake, will begin construction first; approximately 6 months later, construction will begin at intake 5, the southernmost intake. Construction at intake 2, the northernmost intake, will begin approximately 1 year after having begun at intake 5. The result is that construction will overlap at all three sites for approximately 4 years.

6.9.3.3 Operations and Maintenance

Operation of the intakes is not anticipated to result in any effects on valley elderberry longhorn beetle. Maintenance of the intakes as described in Section 3.3.6.1 *North Delta Intakes,* would not likely result in effects on valley elderberry longhorn beetle. In addition, as noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Section 3.4.7.8.2.1 *Activities with Fixed Locations*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species.

6.9.4 Tunneled Conveyance Facilities

6.9.4.1 Habitat Loss and Fragmentation

An estimated 76 acres (0.2% of modeled habitat in action area) of valley elderberry longhorn beetle modeled habitat overlaps with the tunnel conveyance facilities (Figures 6.9-5 through 6.9-11), where land will be cleared for permanent facilities and temporary work areas. The 76 acres of modeled habitat includes 19 acres (0.1% of modeled riparian habitat) of riparian habitat and 57 acres (0.3% of modeled grassland habitat) of non-riparian habitat. Of the estimated 76 acres of habitat to be removed, 62 acres (17 acres of riparian and 45 acres of non-riparian) will result from construction of permanent facilities. The remaining estimated 14 acres (2 acres of riparian and 12 acres of non-riparian) of loss will result from use of tunnel work areas, which will be in use for several years: because the duration of this effect is greater than 1 year, this effect will be compensated as if it were a permanent effect. Most of the modeled non-riparian habitat affected by access roads consists of areas along existing levee roads that are vegetated in grasses and do not appear to support trees and shrubs.

As described in Appendix 6.B *Terrestrial Effects Analysis Methods*, Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made of the number of shrubs and associated stems that could be affected by construction. As seen in Table 6.9-1, the construction of the water conveyance facilities is anticipated to result in direct effects (permanent and temporary impacts) on approximately 23 elderberry shrubs with an estimated total of 460 stems. The actual number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as outlined in Section 3.4.7.8.2 *Avoidance and Minimization Measures.* Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6 *Suitable Habitat Definition.*

Tunneled conveyance facility construction will result in the fragmentation of modeled habitat in some areas. Some of the conveyance facilities (e.g., access roads) result in slivers of adjacent modeled habitat affected that would fragment habitat and others would only affect non-riparian habitat that if occupied shrubs are present in adjacent areas they will already have been somewhat isolated. Some facilities would result in the removal of large areas of habitat or create barriers along stretches of riparian habitat that will result in the fragmentation of habitat and the creation of barriers to dispersal. These areas would include: *Barge Unloading Facility on Zacharias Island* (Figure 6.9-6), which create a small barrier in the riparian habitat along Snodgrass Slough and *Tunnel Conveyor Facility, Fuel Station, and Shaft Locations adjacent to*

Clifton Court Forebay, which would fragment modeled riparian habitat along the north end of Clifton Court Forebay (Figure 6.9-9).

Table 6.9-2 shows the compensation for the estimated direct effects to elderberry shrubs from tunneled conveyance facilities. Table 3.4-11 provides details of how the number of elderberry seedlings and associated native plants were determined. As described in Section 3.4.7.8.2 *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.4.2 Construction Related Effects

Tunnel conveyance facility construction activities detailed in Section 3.2 *Conveyance Facility Construction*, include the use of heavy equipment for ground clearing and grading. The effects from water conveyance facility construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Section 6.9.2.2 *Construction Related Effects.*

6.9.4.3 Operations and Maintenance

Operation and maintenance of the conveyance facilities is not anticipated to result in any effects on valley elderberry longhorn beetle. In addition, as noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Section 3.4.7.8.2.1 *Activities with Fixed Locations*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species.

6.9.5 Clifton Court Forebay Modification

6.9.5.1 Habitat Loss and Fragmentation

An estimated 73 acres (0.2% of all modeled habitat in action area) of valley elderberry longhorn beetle modeled habitat overlaps with the Clifton Court Forebay facilities (Figures 6.9-12 to 6.9-15) where land will be cleared for permanent facilities and temporary work areas. The 73 acres of modeled habitat includes 1 acre of riparian habitat (>0.1%) and 72 acres (0.3%) of non-riparian habitat, all of which would be permanent impacts. The areas affected are around Clifton Court Forebay and are mostly non-riparian habitat that is mostly vegetated in grasses (Figures 6.9-12 to 6.9-15). Clifton Court Forebay was completely surveyed during the DHCCP surveys between 2009 and 2011. During these surveys, no elderberry shrubs were identified around Clifton Court Forebay.

As described in Appendix 6.B *Terrestrial Effects Analysis Methods*, Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made on the number of shrubs and associated stems that could be affected by construction. As seen in Table 6.9-1, the construction of Clifton Court Forebay modifications is anticipated to result in direct effects (permanent and temporary impacts) on approximately 7 elderberry shrubs with an estimated total of 140 stems. The actual number of shrubs and stems that will be affected will be determined during preconstruction surveys in suitable habitat as outlined in Section 3.4.7.8.2 *Avoidance and Minimization Measures.* Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6 *Suitable Habitat Definition.* Although no shrubs were mapped around Clifton Court Forebay during the DHCCP surveys, due to the time between these surveys and project construction there is potential that shrubs could have become established, so for this analysis the modeled habitat there is considered to potentially support elderberry shrubs.

The expansion of Clifton Court Forebay will not fragment any riparian habitat but will fragment some areas of non-riparian habitat along the California Aqueduct. These nonriparian areas, however, appear to only be vegetated with grass.

Table 6.9-2 provides the compensation for the estimated direct effects to elderberry shrubs from Clifton Court Forebay modifications. Table 3.4-12 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Section 3.4.7.8.2 *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.5.2 Construction Related Effects

Clifton Court Forebay construction activities detailed in Section 3.2.5.2 *Construction*, include the use of heavy equipment for ground clearing, excavation, and grading and riprap placement. The effects from construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Section 6.9.2.2 *Construction Related Effects.*

6.9.5.3 Operations and Maintenance

Operation of the conveyance facilities is not anticipated to result in any effects on valley elderberry longhorn beetle. Maintenance of Clifton Court Forebay and associated facilities as described in Section 3.3.6.3 *Intermediate Forebay,* and Section 3.3.6.5 *Connections to Banks and Jones Pumping Plants* could result in effects on valley elderberry longhorn beetle. Vegetation maintenance of the forebays and connections to Banks and Jones Pumping Plants could affect valley elderberry longhorn beetle if elderberry shrubs become established in these areas and/or if these activities affect adjacent habitat (e.g., herbicide drift, spills, dust). These potential effects will be avoided and minimized with the implementation of measures identified in Appendix 3.F *General Avoidance and Minimization Measures*, which includes: AMM1 *Worker Awareness Training*, which requires that maintenance staff be trained on the types of sensitive resources located in the project area and the measures required to avoid and minimize effects on these resources; AMM2 *Construction Best Management Practices and Monitoring*, which includes guidance on the use of herbicides; and AMM14 *Hazardous Materials Management*, which requires the development of a hazardous materials management plan and will include appropriate practices to reduce the likelihood of a spill of toxic chemicals and other hazardous materials during maintenance activities.

In addition, as noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Section 3.4.7.8.2.1 *Activities with Fixed Locations*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species.

6.9.6 Power Supply and Grid Connections

6.9.6.1 Habitat Loss and Fragmentation

An estimated 43 acres (0.15% of all modeled habitat in the action area) of valley elderberry longhorn beetle modeled habitat overlaps with the transmission lines (Figures 6.9-1 through 6.9-4 and 6.9-6 through 6.9-19), where transmission line construction could remove habitat. The temporary loss of 43 acres of modeled habitat includes 8 acres of riparian habitat (0.1%) and 35 acres (0.1%) of non-riparian habitat.

As described in Appendix 6.B *Terrestrial Effects Analysis Methods*, Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made of the number of shrubs and associated stems that could be affected by construction. As seen in Table 3.4-13, the construction of transmission line is anticipated to result in direct effects (permanent and temporary impacts) on approximately 11 elderberry shrubs with an estimated total of 220 stems. The actual number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as outlined in Section 3.4.7.8.2.1 *Activities with Fixed Locations*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6 *Suitable Habitat Definition.*

Construction of the transmission lines will most often span areas of modeled habitat, which primarily occur adjacent to waterways; however, for this analysis it is assumed that transmission line construction would result in habitat removal. The corridors used for the GIS analysis were 50 feet wide. Habitat removal along these corridors would cut through areas of modeled riparian habitat throughout the project area, which would create barriers to valley elderberry longhorn beetle dispersal.

Table 6.9-2shows the compensation for the estimated direct effects to elderberry shrubs from transmission line construction. Table 3.4-13 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Section 3.4.7.8.2.2 *Activities with Flexible Locations,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.6.2 Construction Related Effects

New temporary power 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 power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, 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, existing distribution lines will be used to power gate operations, lighting, and auxiliary equipment at these facilities.

Construction of new transmission lines will require 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-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at 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 will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. The duration of transmission line construction activities will not be more than 1 year at any one location. See Section 3.2.7.2 *Construction*, for a full description of the construction activities.

Transmission line construction activities detailed in Section 3.2.7.2 *Construction*, would result in ground disturbance and potential vegetation clearing. The effects from construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Section 6.9.2.2 *Construction Related Effects.*

6.9.6.3 Operations and Maintenance

Operation of the transmission lines would not affect valley elderberry longhorn beetle. Maintenance activities for transmission lines would require the maintenance of vegetation around transmission facilities, which is typically comprised of removal of trees and large shrubs underneath lines and around poles. These activities could result in take of valley elderberry longhorn beetle. As noted in Section 3.3.6.6 *Power Supply and Grid Connections*, the power providers (PG&E, SMUD, and Western) are responsible for the maintenance of these facilities. As noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Section 3.4.7.8.2.1 *Activities with Fixed Locations*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species where feasible. The effects analysis, however, assumes all vegetation along the transmission lines will be permanently removed.

6.9.7 Head of Old River Gate

6.9.7.1 Habitat Loss and Fragmentation

Construction of the HOR Gate will result in loss of an estimated 1 acre (>0.1% of modeled habitat in the action area) of valley elderberry longhorn beetle habitat, which consists of non-riparian habitat (see Figure 6.9-20).

As described in Appendix 6.B *Terrestrial Effects Analysis Methods*, Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made on the number of shrubs and associated stems that could be affected by construction. As seen in Table 6.9-1, the construction of the HOR Gate is anticipated to result in direct effects (permanent and temporary impacts) on approximately 1 elderberry shrub with an estimated total of 20 stems. The actual number of shrubs and stems that will be affected will be determined during preconstruction surveys in suitable habitat as outlined in Section 3.4.7.8.2 *Avoidance and Minimization Measures*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6 *Suitable Habitat Definition.*

Table 6.9-2 provides the compensation for the estimated direct effects to elderberry shrubs from HOR Gate construction. Table 3.4-10 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Section 3.4.7.8.2 *Avoidance and Minimization Measures*, effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.7.2 Construction Related Effects

HOR Gate construction activities detailed in Section 3.2 *Conveyance Facility Construction*, include the use of heavy equipment for ground clearing and grading. The effects from these construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Section 6.9.2.2 *Construction Related Effects.*

6.9.7.3 Operations and Maintenance

The operations and maintenance activities for the HOR gate described in Section 3.3.6.7 *Head of Old River Gate,* would not result in direct or indirect effects to valley elderberry longhorn beetle because these activities are all within the footprint of the gate and in the wetted portion of the channel where elderberry shrubs would not be found and would not require the use of nighttime lighting, the generation of dust, use of herbicides and other chemicals that could affect adjacent habitat. In addition, as noted in the avoidance and minimization measures for valley elderberry longhorn beetle in Section 3.4.7.8.2.1 *Activities with Fixed Locations*, buffer areas around elderberry shrubs identified during preconstruction surveys will be maintained for the continued protection of the species.

6.9.8 Reusable Tunnel Material

6.9.8.1 Habitat Loss and Fragmentation

RTM storage area construction footprints overlap with modeled valley elderberry longhorn beetle habitat at several RTM storage areas (6.9-5, 6.9-12, 6.9-15, and 6.9-20 through 6.9-24). These impacts will be minimized with AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*, which calls for the avoidance of riparian and grassland habitats to the extent practicable. The RTM storage areas near Intake 2, on Zacharias Island, on Bouldin Island, and west of Clifton Court Forebay all have some areas where only slivers of habitat are shown to be affected. Some of these areas likely could be avoided if minor changes were made to the RTM storage footprints. However, for the purposes of this analysis it is assumed that all of these areas would be impacted.

An estimated 79 acres (0.3% of the 26,333 acres of modeled habitat in the action area) of valley elderberry longhorn beetle modeled habitat overlaps with the RTM storage areas. The 79 acres of modeled habitat includes 14 acres of riparian habitat (0.1% of modeled riparian habitat) and 65 acres (0.4% of modeled grassland habitat in the action area) of non-riparian habitat. Based on a review of aerial photos, all of the modeled riparian habitat appears to be suitable for the species and some of the non-riparian habitat appears suitable. The RTM storage area north of Dierssen Road will remove a large patch of modeled habitat for valley elderberry longhorn beetle that is mostly non-riparian habitat. This patch of habitat is relatively isolated from other modeled habitat and thus is not likely to be occupied and is less than optimum for the long-term conservation of the species. The non-riparian habitat in the RTM storage areas on Bouldin Island and west of Clifton Court Forebay appears to be vegetated in grasses with no shrubs, and thus to not be suitable.

As described in Appendix 6.B *Terrestrial Effects Analysis Methods*, Table 6.B-10 *Method for Estimating Effects on Valley Elderberry Longhorn Beetle Habitat*, estimates were made on the number of shrubs and associated stems that could be affected by construction. As seen in Table 6.9-1, the RTM storage areas are anticipated to result in direct effects (permanent and temporary impacts) on approximately 19 elderberry shrubs with an estimated total of 380 stems. The actual number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as outlined in Section 3.4.7.8.2 *Avoidance and Minimization Measures*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6 *Suitable Habitat Definition.*

The use of RTM storage areas will fragment modeled habitat in some areas. Some of the RTM storage areas affect slivers of adjacent modeled habitat and some remove large areas of habitat to cause habitat fragmentation. These areas include:

- the *Second Triangular RTM Storage Area from the North* (Figure 6.9-5), where the removal of a large patch of habitat the remaining habitat immediately west and south of this RTM storage area would become fragmented and more isolated;
- *RTM Storage Area North and South of Twin Cities Road* (Figure 6.9-21), where the loss of modeled habitat will create a barrier between modeled habitat northeast and south of the RTM storage area, making the habitat to the northeast isolated; also a small patch of non-riparian habitat would become isolated along the western boundary of the RTM storage area;
- *RTM Storage Area on Bouldin Island* (Figure 6.9-22 through 6.9-24), where construction of a barge landing will create a gap between modeled habitat to the west and east; and
- *RTM Storage Area West of Clifton Court Forebay* (Figures 6.9-12 and 6.9-15), where the loss of modeled habitat will create a barrier between habitat to the north and south of the

RTM storage area; however this habitat consists of grassy levee banks with rip-rap, and thus is not suitable.

Some of these effects could be reduced with the implementation of AMM6 *Disposal and Reuse of Spoils, Reusable Tunnel Material, and Dredged Material*, which commits to avoid effects to riparian and grassland habitat to the extent practicable.

Table 6.9-2 provides the compensation for the estimated direct effects to elderberry shrubs from RTM storage areas. Table 3.4-9 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Section 3.4.7.8.2 *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.8.2 Construction Related Effects

Construction activities at each RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed.

Each RTM storage area will take 5 to 8 years to construct and fill. RTM areas will be constructed, as needed, depending on location. The RTM storage site at Clifton Court (reach 7) will be the first to be constructed and filled (see Appendix 3.D *Construction Schedule for the Proposed Action*) with all other RTM storage sites beginning construction within 2 years. The RTM storage site at Bouldin Island will be the last to begin construction. RTM storage area construction and placement will occur almost continuously through tunnel excavation, approximately 10 years.

The effects from RTM construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Section 6.9.2.2 *Construction Related Effects.*

6.9.8.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM sites and therefore no effects to valley elderberry longhorn beetle. While reuse of the RTM is possible, end uses for the 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.

6.9.9 Restoration

6.9.9.1 Habitat Loss and Fragmentation

Tidal restoration and channel margin enhancement to offset effects on species habitat and wetlands may result in conversion of valley elderberry longhorn beetle habitat to other habitat types. The acres potentially lost as a result of this restoration were estimated as described in Appendix 6.B *Terrestrial Effects Assessment Methods*.

6.9.9.1.1 Tidal Restoration

Tidal restoration implemented to offset effects on Delta Smelt and to provide compensation under Section 404 of the Clean Water Act will result in conversion of valley elderberry longhorn beetle habitat to other habitat types. The number of lost stems as a result of this restoration were estimated as described in Appendix 6.B *Terrestrial Effects Analysis Methods,* Section 6.B.4.3.1.5 *Restoration*. As seen in Table 6.9-1, restoration is anticipated to result in direct effects (permanent and temporary impacts) 29 elderberry shrubs with an estimated total of on 581 stems. The actual number of shrubs and stems that would be affected would be determined during preconstruction surveys in suitable habitat as outlined in Section 3.4.7.8.2 *Avoidance and Minimization Measures*. Suitable habitat for valley elderberry longhorn beetle is described in Appendix 4.A *Status of the Species and Critical Habitat Accounts*, in Section 4.A.14.6 *Suitable Habitat Definition.*

Because the exact locations of tidal restoration areas are not known at this time, it is unknown whether these locations will result in the fragmentation of valley elderberry longhorn beetle habitat.

Table 6.9-2 provides the compensation for the estimated direct effects to elderberry shrubs from restoration. Table 3.4-15 provides details on how the number of elderberry seedlings and associated native plants were determined. As described in Section 3.4.7.8.2 *Avoidance and Minimization Measures,* effects to shrubs will be avoided and minimized to the maximum extent practicable. Shrubs that cannot be avoided will be transplanted to a USFWS approved conservation area.

6.9.9.1.2 Channel Margin Enhancement

DWR will enhance 4.6 miles of channel margins between open water and upland areas to provide improved habitat for migrating salmonids. Channel margin enhancement activities are likely to occur near the intake construction area on the mainstem of the Sacramento River or on one of the nearby connected tidal sloughs (e.g., Steamboat Slough, Elk Slough, or Snodgrass Slough). Channel margin enhancement has potential to be combined with riparian restoration to meet multiple goals on one site.

Channel margin enhancement will target degraded aquatic edge habitat to improve habitat conditions for migrating salmon. Enhanced channel margin sections will seek to replace “hardened” riprap edge habitat with more emergent wetland and riparian habitat. This can be achieved by creating a “bench” of sediment (or other material) at the aquatic edge onto which vegetation can be planted or naturally recruited. This approach to channel margin enhancement is likely to be used to create emergent wetland habitat. More complex channel margin enhancement, where riparian restoration is likely to be a component, will be achieved using levee setbacks.

These activities have the potential to affect valley elderberry longhorn beetle habitat but would increase the availability of riparian habitat and improve habitat connectivity along the Sacramento River and nearby connected sloughs.

6.9.9.2 Construction Related Effects

Restoration activities will in some instances include the use of heavy equipment for ground clearing, grading, and excavation. The effects from construction activities on valley elderberry longhorn beetle and the measures to avoid and minimize them are similar to those described above for construction of the safe haven work areas under Section 6.9.2.2 *Construction Related Effects*.

6.9.9.3 Operations and Maintenance

Operational requirements for tidal restoration are not expected. Maintenance activities will include non-native plant control which might include mowing and herbicide application. Vegetation control measures will avoid impacts to valley elderberry longhorn beetle as described in Section 3.4.7.8.5.1 *Levee Maintenance*, and Section 3.4.7.8.5.2 *Weed Control*.

6.9.10 Effectiveness Monitoring

On lands protected to benefit valley elderberry long-horned beetle, monitoring will be performed to determine the effectiveness of conservation. Monitoring for valley elderberry long-horned beetle will consist of shrub and stem surveys. Surveys will include counting the number of exit holes in stems and overall health of the shrub. The presence of biologists may alter typical behavior of individual valley elderberry long-horn beetle. As such, effectiveness monitoring for will be performed by a USFWS approved biologist.

6.9.11 Effects on Critical Habitat

Critical habitat has not been designated for the valley elderberry longhorn beetle.

6.9.12 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of valley elderberry longhorn beetle will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect valley elderberry longhorn beetle in the action area when habitat loss and degradation occurs without USFWS authorization. The most likely activity of this type is agricultural conversion. Since climate change threatens to modify annual weather patterns, it may result in a loss of valley elderberry longhorn beetle habitat and/or increased numbers of their predators, parasites, and disease.

6.10 Effects on Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

Appendix 6.B *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the PA on terrestrial species. Appendix 4.A *Status of the Species and*

Critical Habitat Accounts, Sections 4.A.13.7 and 4.A.14.7 provide descriptions of the suitable habitat model for vernal pool fairy shrimp and vernal pool tadpole shrimp, respectively.

Activities associated with Clifton Court Forebay modifications and reusable tunnel material may affect vernal pool fairy shrimp and vernal pool tadpole shrimp, as described below.

Figure 6.10-1 provides an overview of the locations of surface impacts relative to vernal pool crustacean habitat, occurrences, and critical habitat. See Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Sections 4.A.13.6 and 4.A.14.6 for the definitions of suitable vernal pool fairy shrimp habitat and vernal pool tadpole shrimp habitat, respectively. There are 89 acres of modeled vernal pool fairy shrimp and vernal pool tadpole shrimp habitat in the action area. An estimated 6 acres (7% of total modeled habitat in action area) of vernal pool fairy shrimp and vernal pool tadpole shrimp modeled habitat will be affected as a result of project implementation. Affected habitat and offsetting measures are summarized in Table 6.10-1 and Table 6.10-2 below.

6.10.1 Geotechnical Exploration

There is no vernal pool fairy shrimp or vernal pool tadpole shrimp habitat within or near geotechnical exploration areas, therefore geotechnical exploration activities will not affect vernal pool fairy shrimp or vernal pool tadpole shrimp.

6.10.2 Safe Haven Work Areas

6.10.2.1 Habitat Loss and Fragmentation

There is no habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp within the tunnel alignment, therefore safe haven work areas will not affect vernal pool fairy shrimp or vernal pool tadpole shrimp habitat.

6.10.3 North Delta Diversion Construction

The construction footprint for the NDDs does not overlap with any suitable or potentially suitable habitat and there is no suitable or potentially suitable vernal pool fairy shrimp or vernal pool tadpole shrimp habitat in or within 250 feet of NDD construction, so NDD construction will not affect vernal pool fairy shrimp and vernal pool tadpole shrimp habitat.

Table 6.10-1. Maximum Modeled Habitat Affected for Vernal Pool Crustaceans by Activity Type (Acres)

Total Modeled Habitat in Action Area	Type of Effect	Permanent Habitat Affected								Temporary Habitat Affected	
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Restoration	Total Maximum Habitat Affected	Geotechnical Exploration	Power Supply and Connection
89	Direct	0	0	0	6	0	0	0	6	0	0
	Indirect	0	0	0	0	0	0	0.2	0.2	0	0

Table 6.10-2. Maximum Affected Habitat for Vernal Pool Crustacean Habitat and Proposed Offsetting Measures

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]
Protection (direct and indirect effects)	6	0.2	2:1	3:1	12.4	18.6
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.

6.10.4 Tunneled Conveyance Facilities

The construction footprint for the tunneled conveyance facilities does not overlap with any suitable or potentially suitable habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp, therefore tunneled conveyance facility construction will not affect vernal pool fairy shrimp or vernal pool tadpole shrimp habitat.

6.10.5 Clifton Court Forebay Modification

6.10.5.1 Habitat Loss and Fragmentation

Modifications of Clifton Court Forebay will affect 6 acres (7% of modeled of vernal pool habitat in the action area) of vernal pool fairy shrimp or vernal pool tadpole shrimp habitat. These effects will occur from the construction of the new forebay, which will affect 5.38 acres of habitat consisting of 0.24 acre of vernal pools and 5.14 acres of alkali seasonal wetlands (Figures 6.10-2 and 6.10-3). The affected vernal pools occur in a cluster of seven pools situated to the south and between the forebay and agricultural fields. There is a CNDDB record of vernal pool fairy shrimp associated with these pools. The affected alkali seasonal wetlands consists of three wetlands, the largest of which is located between the forebay and the aforementioned vernal pools; the other two are located in a narrow strip of land between the forebay and the California Aqueduct.

Table 6.10-2 shows the compensation for direct effects on vernal pool fairy shrimp and vernal pool tadpole shrimp habitat. As seen in this table, directly affected vernal pool crustacean habitat will be mitigated by either purchasing restoration/creation credits at conservation bank (at 1:1) or by restoring/creating habitat at non-bank site approved by the USFWS (at 2:1), and by protecting habitat at either a conservation bank (at 2:1) or at a non-bank site approved by the USFWS (at 3:1). As noted in Section 3.4.7.9.4.2 *Restoration*, if compensation is not provided at a USFWS-approved conservation bank it shall meet several criteria, in particular showing evidence of historical vernal pools, having suitable soils, and sufficient land to provide supporting uplands. As noted in Section 3.4.7.9.4 *Siting Criteria for Compensation for Effects*, if protection occurs at a non-bank site, the priority is to protect habitat in the Livermore recovery unit, which is identified as one of the core recovery areas in the *Vernal Pool Recovery Plan* (U.S. Fish and Wildlife Service 2005).

Despite the loss in habitat, the Clifton Court Forebay modifications will not result in the fragmentation of remaining habitat for vernal pool fairy shrimp and vernal pool tadpole shrimp because all the remaining habitat is to the west of Clifton Court Forebay.

6.10.5.2 Construction Related Effects

Construction activities for the Clifton Court Forebay modifications will occur within 250 feet of vernal pool crustacean habitat. As seen in Figure 6.10-2 and 6.10-3, a control structure and the associated temporary work area west of Clifton Court Forebay and a permanent access road, which is the existing Clifton Court Road, occur within 250 feet of vernal pool crustacean habitat. Construction activities occurring within 250 feet of vernal pool crustacean habitat have the potential to result in indirect effects to the habitat through changes in hydrology and changes in water quality. Construction of the control structure[34] will be in the existing canal, which when originally constructed likely disrupted subsurface soils and thus potentially the surrounding hydrology. The construction of the control structure is therefore not likely to alter the supporting hydrology of these wetlands. Construction activities in the adjacent work area will provide access to the area and will include staging materials and equipment. The approximately 100-foot wide work area currently consists of the levee adjacent to the canal, a road on top of the levee road, and work and storage areas. Construction activities have the potential to affect water quality in these wetlands if sediment is transported from the work area during storm events or if there are chemical spills in the work area that could affect groundwater or surface waters during storm events. As noted in Section 3.4.7.9.2 *Avoidance and Minimization Measures*, staging areas will be designed to be more than 250 feet from vernal pool crustacean habitat; however, access to construction areas and activities that don't have a potential to result in changes to water quality will not be prohibited. Furthermore, potential indirect effects in this area will be further be avoided and minimized with the implementation of measures identified in Appendix 3.F *General Avoidance and Minimization Measures*, which include AMM1, *Worker Awareness Training;* AMM2, *Construction Best Management Practices and Monitoring;* AMM3, *Stormwater Pollution Prevention Plan;* AMM5, *Spill Prevention, Containment, and Countermeasure Plan;* AMM14, *Hazardous Materials Management;* and AMM16, *Fugitive Dust Control.* Other measures specific to the listed vernal pool crustaceans (Section 3.4.7.9.2 *Avoidance and Minimization Measures*) will also help to minimize indirect effects on these species. These include monitoring by a USFWS-approved biologist to ensure protection of the avoided habitat, fencing around the avoided areas during construction, and training construction personnel on the sensitivity of the species and the importance of avoiding impacts on their habitat

Though Clifton Court Road has been identified as permanent access road, it is an existing paved road the construction of which affected the hydrology of the adjacent alkali seasonal wetland. Repaving this road will not alter the hydrology of the adjacent wetlands; however, repaving could affect water quality in the wetland. These potential effects will be avoided and minimized through the AMMs listed above.

Considering the existing development and land use (existing canal, levee road, and paved access road), the commitment to design final work areas and staging areas to be more than 250 feet from vernal pool crustacean habitat, and the aforementioned AMMs, offsetting measures in the form of habitat protection or restoration are not proposed.

6.10.5.3 Operations and Maintenance

No facilities operations or maintenance activities are expected to occur in habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp. Vernal pool fairy shrimp or vernal pool tadpole

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[34] 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. Control structures will be constructed in the Middle River/Jones PP canal, NCCF/Jones PP canal, NCCF/Banks PP canal, and SCCF/Bank canal.

shrimp and their habitat could potentially be indirectly affected by maintenance of Clifton Court Road, but this potential indirect effect will be avoided by implementation of the measures described in Appendix 3.F *General Avoidance and Minimization Measures*.

6.10.6 Power Supply and Grid Connections

As seen in Figures 6.10-2 and 6.10-3, vernal pool fairy shrimp and vernal pool tadpole shrimp habitat occurs in the areas of proposed permanent transmission lines to the west of Clifton Court Forebay. This habitat consists of alkali seasonal wetlands and vernal pools. As stated in Section 3.4.7.9.2.2 *Activities with Uncertain Locations*, transmission lines will be designed to fully avoid effects on vernal pool fairy shrimp or vernal pool tadpole shrimp, which includes a minimum 250-foot no disturbance buffer around all vernal pool fairy shrimp and vernal pool tadpole shrimp habitat. Thus, there are no impacts to vernal pool fairy shrimp or vernal pool tadpole shrimp from power supply and grid connections.

6.10.7 Head of Old River Gate

The construction footprint for the HOR gate does not overlap with any suitable or potentially suitable habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp, therefore will not result in impacts to vernal pool fairy shrimp or vernal pool tadpole shrimp habitat.

6.10.8 Reusable Tunnel Material

No habitat for vernal pool fairy shrimp or vernal pool tadpole shrimp occurs within the footprint of RTM storage. Therefore no habitat will be lost due to construction or use of RTM storage areas.

6.10.8.1 Construction Related Effects

Habitat for vernal pool fairy shrimp and vernal pool tadpole shrimp falls within 250 feet of the RTM storage area that is located to the west of Clifton Court Forebay and just east of Byron Highway. This habitat consists of two vernal pools to the south of the RTM storage areas.

Construction activities at each RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt and on-site, long-term storage is assumed. The RTM storage area will take approximately 5 to 8 years to construct and fill. RTM storage area construction and placement will occur almost continuously through tunnel excavation, approximately 10 years.

The widening of Western Farms Ranch Road immediately south of the RTM storage area will indirectly affect (ground disturbance and construction activities within 250 feet) 0.2 acre of vernal pool fairy shrimp and vernal pool tadpole shrimp habitat. This habitat consists of two vernal pools that are 25 to 30 feet south of the proposed widening of the Western Farms Ranch Road and as close as 150 feet southeast of the RTM storage area (Figure 6.10-3). Indirect effects on these pools may include changes in water quality, which could include sediment, dust, and construction related chemicals such as fuel, oil, and lubricants entering these pools, and changes to hydrology that support these pools by altering the watershed that supports the pools and/or affecting subsurface soils (i.e., breaking through restrictive soil layers that support pool ponding). Also, the introduction of invasive species could displace native vernal pool vegetation. These effects will be minimized through general avoidance and minimization measures (AMMs) in Appendix 3.F *General Avoidance and Minimization Measures*, including *AMM1 Worker Awareness Training; AMM2 Construction Best Management Practices and Monitoring; AMM3 Stormwater Pollution Prevention Plan; AMM5 Spill Prevention, Containment, and Countermeasure Plan; AMM14 Hazardous Materials Management;* and *AMM16 Fugitive Dust Control.* Other measures specific to the listed vernal pool crustaceans (Section 3.4.7.9.2 *Avoidance and Minimization Measures*) will also help to minimize indirect effects on these species. These include monitoring by a USFWS-approved biologist to ensure protection of the avoided habitat, fencing around the avoided areas during construction, and training construction personnel on the sensitivity of the species and the importance of avoiding impacts on their habitat.

Table 6.10-2 shows the compensation for indirect effects on vernal pool fairy shrimp and vernal pool tadpole shrimp habitat. As seen in this table, indirectly affected vernal pool crustacean habitat will be mitigated by protecting habitat at either a conservation bank (at 2:1) or at a nonbank site approved by the USFWS (at 3:1). As noted in Section 3.4.7.9.4 *Siting Criteria for Compensation for Effects*, if protection occurs at a non-bank site, the priority is to protect habitat in the Livermore recovery unit, which is identified as one of the core recovery areas in the *Vernal Pool Recovery Plan* (U.S. Fish and Wildlife Service 2005).

6.10.8.2 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM sites and therefore no effects to vernal pool fairy shrimp or vernal pool tadpole shrimp, or their habitat.

6.10.9 Restoration

As stated in Section 3.4.7.9.2.2 *Activities with Uncertain Locations*, restoration sites will be designed to fully avoid effects on vernal pool fairy shrimp and vernal pool tadpole shrimp, including observance of a minimum 250-foot no disturbance buffer around all vernal pool fairy shrimp or vernal pool tadpole shrimp habitat. No habitat will be lost or fragmented by restoration activities.

6.10.10 Effectiveness Monitoring

On lands protected to benefit vernal pool fairy shrimp and vernal pool tadpole shrimp, monitoring to detect the presence of these will be performed to determine the effectiveness of conservation. Effectiveness monitoring for these species will be performed by a USFWS approved biologist.

6.10.11 Effects on Critical Habitat

A designated critical habitat unit for vernal pool fairy shrimp overlaps with a portion of the action area (Figures 6.10-1 through 6.10-3).

The PBFs for vernal pool fairy shrimp are defined as follows (70 Federal Register 46924–46998).

1. Topographic features characterized by mounds and swales and depressions within a matrix of surrounding uplands that result in complexes of continuously, or intermittently, flowing surface water in the swales connecting the pools described below, providing for dispersal and promoting hydroperiods of adequate length in the pools.

2. Depressional features including isolated vernal pools with underlying restrictive soil layers that become inundated during winter rains and that continuously hold water for a minimum of 18 days, in all but the driest years, thereby providing adequate water for incubation, maturation, and reproduction. As these features are inundated on a seasonal basis, they do not promote the development of obligate wetland vegetation habitats typical of permanently flooded emergent wetlands.

3. Sources of food, expected to be detritus occurring in the pools, contributed by overland flow from the pools' watershed, or the results of biological processes within the pools themselves, such as single-celled bacteria, algae, and dead organic matter, to provide for feeding.

4. Structure within the pools described above, consisting of organic and inorganic materials, such as living and dead plants from plant species adapted to seasonally inundated environments, rocks, and other inorganic debris that may be washed, blown, or otherwise transported into the pools, that provide shelter.

The footprints for a proposed transmission line, the RTM site west of Clifton Court Forebay and just east of Byron Highway, and the associated access road (an existing road) overlap with the critical habitat unit for vernal pool fairy shrimp. Only those portions of the designated critical habitat unit that support the PBFs listed above constitute critical habitat for vernal pool fairy shrimp. Areas supporting the PBFsinclude the depressional wetlands (vernal pool type wetlands) and the surrounding watershed (i.e., 250 feet around the vernal pools). As described in Section 6.10.6, *Power Supply and Grid Connections*, the transmission lines will be designed to avoid vernal pool crustacean habitat, including the vernal pool type wetlands and uplands within 250 feet of the wetlands, thereby avoiding vernal pool fairy shrimp critical habitat. The footprint for the RTM site west of Clifton Court Forebay and just east of Byron Highway will encroach within 250 feet of 0.2 acres of vernal pool type wetlands within the designated critical habitat unit for vernal pool fairy shrimp (Figure 6.10-3). This potentially affects the matrix of surrounding uplands described in PBFs#1, above, as well as potentially affecting overland flow described in PBFs#3, above. Encroachment within 250 feet of vernal pool type wetlands may also affect the transport of materials contributing to vernal pool structure as described in PBF 4, above.

Although the Clifton Court Forebay construction will bisect the vernal pool fairy shrimp designated critical habitat unit (Figure 6.10-3), there are no PBFsin the southern portion of this unit, therefore the project would not fragment critical habitat for vernal pool fairy shrimp.

Effects on critical habitat within 250 feet of vernal pool type wetlands will be offset through protection at a 2:1 ratio if protection occurs in a USFWS-approved conservation bank, and a 3:1 ratio if protection occurs outside a USFWS-approved conservation bank. 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. For the 0.2 acres of effects within a critical habitat unit, the California Department of Water Resources (DWR) will prioritize protection within designated critical habitat for this species, such as at the Mountain House Conservation Bank.

The PA will not appreciably reduce the conservation value of critical habitat for vernal pool fairy shrimp because no vernal pool type wetlands will be directly lost within critical habitat; effects within 250 feet of the depressional wetlands will be avoided and minimized through measures listed in Section 3.4.7.9.2 *Avoidance and Minimization Measures* (applicable measures are named in Section 6.10.8.1 *Construction Related Effects*); the vernal pool type wetlands to be indirectly affected through encroachment into the surrounding watershed are in a disturbed area surrounded by roads, ditches, and agricultural lands; and DWR will fully offset adverse effects.

6.10.12 Cumulative Effects

Cumulative effects are defined under Section 7 of the Endangered Species Act as the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions are not addressed in a Section 7 cumulative effects analysis because they require separate consultation pursuant to Section 7 of the Endangered Species Act. Projects that result in take of vernal pool fairy shrimp or vernal pool tadpole shrimp will require incidental take authorization pursuant to the Endangered Species Act and therefore are not addressed in this cumulative effects analysis because they require a Federal action.

Non-Federal activities could affect vernal pool fairy shrimp or vernal pool tadpole shrimp in the action area when habitat loss and degradation occurs without USFWS authorization. The most likely activity of this type is agricultural conversion. Unauthorized take as a result of urbanization is unlikely where most of the habitat occurs west of Clifton Court Forebay because urbanization in this area is covered by the *East Contra Costa County Habitat Conservation Plan/Natural Communities Conservation Plan (HCP/NCCP).* Since climate change threatens to modify annual weather patterns, it may result in a loss of vernal pool crustacean habitat.

6.11 Least Bell's Vireo

Appendix 6.B *Terrestrial Effects Analysis Methods*, describes the methods and assumptions used to analyze the effects of the proposed action (PA) on wildlife species. Field surveys of the entire action area were not possible because many of the properties are in private ownership. For this reason, GIS-based habitat models were used to identify areas of potential effect. Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.11.11 *Species Habitat Suitability Model*, provides a description of the habitat suitability model for least Bell's vireo.

Activities associated with geotechnical exploration, safe haven work areas, north Delta intakes, tunneled conveyance facilities, and power supply and grid connection activities may affect least Bell's vireo, as described below. Figure 6.11-1 provides an overview of the locations of surface impacts relative to least Bell's vireo habitat. An estimated 32 acres of least Bell's vireo habitat will be lost as a result of project implementation. There is a total of approximately 11,224 acres of least Bell's vireo habitat in the action area. Therefore, the loss of 33 acres would result an impact on 0.3% of the migratory habitat in the action area (Table 6.11-1). As described in

Section 3.4.7.5.3, *Compensation to Offset Impacts*, the loss will be offset through riparian creation or restoration at a 2:1 ratio for a total of 64 acres of riparian creation or restoration.

Table 6.11-1. Maximum Habitat Loss on Habitat for Least Bell's Vireo by Activity Type (Acres)

Least Bell's Vireo Habitat	Total Habitat in Action Area	Permanent Habitat Loss								
		Safe Haven Work Areas	North Delta Intakes	Tunneled Conveyance Facilities	Clifton Court Forebay Modifications	Head of Old River Gate	Reusable Tunnel Material	Power Supply and Connection	Geotechnical Exploration	Total Habitat Loss
Total Habitat	11,224	0	5	11	0	0	12	4	0	32

6.11.1 Geotechnical Exploration

Geotechnical exploration sites are currently undetermined but will occur along the tunnel alignment. A USFWS approved biologist will work with the geotechnical exploration team to identify and avoid adverse effects on least Bell's vireo habitat as described in Section 3.4.10.4.2.2.1, *Geotechnical Exploration*. Therefore, geotechnical exploration will not affect least Bell's vireo.

6.11.2 Safe Haven Work Areas

The placement of safe haven work areas is currently unknown because they are constructed "as needed" along the alignment. As described in Section 3.4.10.4.2.2.2, *Save Haven Work Areas,* safe havens will avoid least Bell's vireo habitat. Therefore, safe havens will not affect least Bell's vireo.

6.11.3 North Delta Intake Construction

6.11.3.1 Habitat Loss and Fragmentation

The north delta intakes will result in the loss of an estimated 5 acres of least Bell's vireo habitat (Table 6.11-1; Figures 6.11-2, 6.11-3, and 6.11-4). As described in Section 3.4.10.5.3, *Compensation to Offset Impacts*, the loss of this habitat will be offset through riparian creation or restoration at a 2:1 ratio.

6.11.3.2 Construction Related Effects

Construction activities at each intake are described in Section 3.3.10.1, *North Delta Intakes*. Intake construction will require the use of loud, heavy equipment within the construction site as well as along the access roads to the site. Pile driving will create noise and vibration effects.

Construction activities will create noise up to 60 dBA at no more than 1,200 feet from the edge of the noise generating activity unless pile driving is required, in which case noise up to 60 dBA could reach up to 2,000 feet from the edge of the noise generating activity. While 60 dBA is the standard noise threshold for birds (Dooling and Popper 2007), this standard is generally applied during the nesting season, when birds are more vulnerable to behavioral modifications that can cause nest failure. There is evidence, however, that migrating birds will avoid noisy areas during migration (McClure et al. 2013). To minimize this effect, DWR will reduce noise in the vicinity of least Bell's vireo habitat as described in Section 3.4.10.5.1, *Avoidance and Minimization Measures*. This will include surveying for least Bell's vireos within the 60 dBA noise contour around the construction footprint, and if a least Bell's vireo is found, limiting noise to less than 60 dBA where the bird occurs until it has left the area. DWR will also limit pile driving to daytime hours within 1,200 feet of least Bell's vireo habitat. With these measures in place, least Bell's vireo is not expected to be affected by noise.

Night lighting may also have the potential to affect least Bell's vireos. While there is no data on effects of night lighting on this species, studies show that birds of other species are attracted to artificial lights and this may disrupt their behavioral patterns or cause collision-related fatalities (Gauthreaux and Belser 2006). To minimize this effect, DWR will screen all lights and direct them away from habitat as described in Section 3.4.7.5.1, *Avoidance and Minimization Measures*. With this measure in effect, and given that least Bell's vireos are expected to occur in the vicinity of project activities seldom if at all, residual lighting effects on the species are expected to be negligible and is not expected to result in take of the species.

6.11.3.3 Operations and Maintenance

Ongoing maintenance activities at the intakes include intake dewatering, sediment removal, debris removal, and biofouling and corrosion removal. These activities will occur from water-based equipment approximately annually. Noise and lighting effects from maintenance activities and permanent facility lighting could adversely affect least Bell's vireos if they use habitat in the vicinity. Permanent and maintenance-related lighting in least Bell's vireo habitat will be avoided as described in Section 3.4.10.5.1 *Avoidance and Minimization Measures.*

Because the intakes are gravity fed, with all pumping being done at the pumping plant at Clifton Court Forebay, no effects from noise will occur as a result of intake operation.

6.11.4 Tunneled Conveyance Facilities

Tunneled conveyance facilities include tunnel work areas, vent shafts, the pumping plant and shaft location, a new forebay and spillway, tunnel conveyors, barge unloading facilities, fuel stations, and concrete batch plants (Figures 6.11-1, 6.11-2, 6.11-5, 6.11-8, and 6.11-9).

6.11.4.1 Habitat Loss and Fragmentation

An estimated 11 acres of least Bell's vireo habitat (0.1% of migratory habitat in the action area) will be removed for tunneled conveyance facility construction (Table 6.11-1). As described in Section 3.4.10.5.3, *Compensation to Offset Impacts*, the loss will be offset through riparian creation or restoration at a 2:1 ratio.

6.11.4.2 Construction Related Effects

Construction activities associated with conveyance facility activities are described in Section 3.2, *Conveyance Facility Construction.* Least Bell's vireo habitat occurs in the vicinity of the forebay and spillway and may be affected by construction noise and light. Construction noise up to 60 dBA will occur at up to 2,000 feet from the forebay and spillway construction footprint. Light effects from nighttime activities are also possible. Noise and lighting associated with conveyance facility construction may affect least Bell's vireos as described in Section 6.11.3.2, *Construction Related Effects*. With the avoidance and minimization measures in place, noise effects on the species will be avoided and lighting effects, if any, will be negligible and are not expected to result in take of the species.

6.11.4.3 Operations and Maintenance

The intermediate forebay and spillway will require operations and maintenance. Intermediate forebay maintenance includes dredging, control of vegetation and rodents, embankment repairs, and monitoring of seepage flows. As described in Section 6.5.4.1 *Habitat Loss and Fragmentation*, least Bell's vireo habitat occurs in the vicinity of construction. However, this habitat is greater than 4,000 feet south of the forebay and spillway. Therefore, adverse effects on least Bell's vireo from operations and maintenance activity noise are not expected.

6.11.5 Clifton Court Forebay Modification

Clifton Court Forebay (CCF) modification includes dredging, the expansion of the forebay through the creation of a new embankment, and creating a new canal and siphon. The CCF modification footprint does not overlap with least Bell's vireo habitat. Furthermore, there is no habitat for this species in the vicinity of the CCF modification footprint. Therefore, activities associated with CCF modification will not affect least Bell's vireos.

6.11.6 Power Supply and Grid Connections

6.11.6.1 Habitat Loss and Fragmentation

Mapped construction footprints for the transmission lines will result in loss of up to 4 acres of least Bell's vireo habitat (Figures 6.11-1 through 6.11-4 and 6.11-6 through 6.11-9). As described in Section 3.4.10.5.3, *Compensation to Offset Impacts*, the loss will be offset through riparian creation or restoration at a 2:1 ratio.

6.11.6.2 Construction Related Effects

New temporary power 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 power lines. An existing 500kV line, which crosses the area proposed for expansion of the Clifton Court Forebay, 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.

Construction of new transmission lines will require 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-related activities will be largely concentrated in a 100- by 50-foot area around pole or tower placement areas, and, in the case of conductor pulling locations, in a 350-foot corridor (measured from the base of the tower or pole); conductor pulling locations will occur at 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 will use existing routes to the greatest extent practicable, but some overland travel will likely be necessary. Section 3.2.7.2, *Construction*, provides a full description of the construction activities related to transmission line installation. The duration of transmission line construction activities will not be more than 1 year at any one location.

Least Bell's vireo habitat occurs in the vicinity of the transmission lines, and may be affected by construction noise and light. Light effects from nighttime activities are also possible. Noise and lighting associated with transmission line construction may affect least Bell's vireo as described in Section 6.5.3.2 *Construction Related Effects*. For details on the avoidance and minimization measures, see Section 3.4.7.5.1.1 *Activities with Fixed Locations*. With the avoidance and minimization measures in place, noise related effects will be avoided and lighting effects on the species, if any, will be negligible and are not expected to result in take of the species.

6.11.6.3 Operations and Maintenance

The temporary transmission lines will be in place for the duration of conveyance facility construction (approximately 10 years); the permanent transmission lines will remain to supply power to the pumping plant. Maintenance activities at the transmission lines will include vegetation management and overland travel for some emergency repairs. Loss of habitat associated with the transmission line is counted under permanent habitat loss, therefore vegetation control is not likely to result in any additional effects on least Bell's vireo.

Least Bell's vireos may be subject to bird strikes at the transmission lines. However, 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, as described in Section 3.4.7.4.1 *Avoidance and Minimization Measures*. With the avoidance and minimization measures in place, and in view of the rarity of least Bell's vireos in the action area, it is highly unlikely that this species will experience bird strikes at project transmission lines.

6.11.7 Head of Old River Gate

The HOR gate construction footprint does not overlap with least Bell's vireo habitat. Furthermore, there is no habitat for this species in the vicinity of the HOR gate. Therefore, activities associated with the HOR gate will not affect least Bell's vireo.

6.11.8 Reusable Tunnel Material

6.11.8.1 Habitat Loss and Fragmentation

An estimated 12 acres of least Bell's vireo habitat (0.1% of migratory habitat in the action area) will be removed for reusable tunnel material placement (Table 6.11-1; Figures 6.11-2, 6.11-5, 6.11-6, and 6.11-10). As described in Section 3.4.7.5.3, *Compensation to Offset Impacts*, the habitat loss will be offset through riparian creation or restoration at a 2:1 ratio.

6.11.8.2 Construction Related Effects

Each RTM storage area will take 5 to 8 years to construct and fill. Construction activities at each RTM site will include the use of heavy equipment for ground clearing and grading and soil tilling and rotation. Material will be moved to the site using a conveyor belt for long-term on-site storage. The movement of the material to another site is not an activity covered in the assessment. For more details about the activities associated with RTM placement see Section 3.2.10.6, *Dispose Soils*.

Least Bell's vireo habitat occurs in the vicinity of several RTM sites. Noise and lighting associated with RTM construction may affect least Bell's vireos as described in Section 6.5.3.2, *Construction Related Effects*. With the avoidance and minimization measures in place, noise related effects will be avoided and lighting effects on the species, if any, will be negligible and are not expected to result in take of the species.

6.11.8.3 Operations and Maintenance

There are no operations and maintenance activities associated with the RTM storage areas and therefore no effects to least Bell's vireo. While reuse of the RTM is possible, end uses for the 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.

6.11.9 Habitat Restoration/Mitigation

A USFWS approved biologist will work with DWR and BOR to avoid the loss of suitable habitat. As such, no least Bell's vireo habitat will be removed to construct restoration sites. Take of least Bell's vireo that could result from habitat restoration, if any, will not be authorized through the biological opinion.

6.11.9.1 Effects on Critical Habitat

There is no critical habitat for least Bell's vireo in the action area.

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6.12.1 Personal Communications

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7 Effects Determination

7.1 Introduction

The Biological Assessment's (BA) determination of effects for listed species and their designated critical habitat considers direct and indirect effects of the proposed action (PA) together with the effect of other activities that are interrelated or dependent on the PA. The BA also considers effects associated with actions identified in the environmental baseline and effects anticipated to result from future state or private activities that are reasonably certain to occur (cumulative effects). This Chapter presents a summary of the effects for listed species and their designated critical habitat discussed in detail in Chapters 4 to 6 of the BA. The effects determinations for terrestrial species in Suisun Marsh are provided in Appendix 6.C, *Suisun Marsh Species*.

7.2 Chinook Salmon, Sacramento River Winter-run ESU

7.2.1 Sacramento River Upstream of Delta

Upstream quantitative analyses of temperature and flow effects are based on CalSim II modeling. The uncertainties associated with using CalSim II outputs must be considered in interpreting biological analyses (Appendix 5.A, *CALSIM Methods and Results*). CalSim II is a long-term planning model that allows for quantitative simulation of the CVP and SWP operations on a monthly time-step across a wide range of hydrologic, regulatory and operations instances. CalSim II uses a set of pre-defined generalized rules, which represent the assumed regulations, to specify operations of the CVP/SWP. These rules are often specified as a function of year type or a prior month's simulated storage or flow condition. As described above, the model has no capability of adjusting these rules to respond to specific events that may have occurred historically, e.g., fish presence, levee failures, fluctuations in barometric pressure that may have affected Delta tides and salinities, facility outages, etc. These generalized rules have been developed based on historical operational trends and on limited CVP/SWP operator input and only provide a coarse representation of the project operations over the inputted hydrologic conditions. Thus, results do not exactly match what operators might do in a specific month or year within the simulation period since the latter will be informed by numerous real-time considerations that cannot be input to CalSim II. Rather, results are intended to be a reasonable representation of long-term operational trends of CVP and SWP, providing the ability to compare and contrast the effect of current and assumed future operational conditions.

Analysis of potential effects of the PA on Sacramento River winter-run Chinook salmon in the Sacramento River upstream of the Delta found differences between the NAA and PA that include

- Increased frequency of water temperature threshold exceedances during August through October coinciding with the winter-run Chinook salmon spawning and rearing period;
- Increased risk of redd dewatering for egg cohorts spawned in June and August; and
- Reduced flows in above normal, below normal, and dry water years during September and in wet and above normal water years during November that could affect juvenile migration.

The reduced Shasta releases associated with the PA's operational modeling result in the modeled increased frequency of the water temperature threshold exceedances during September. However, modeling of the cold-water pool volume, which is more indicative of temperature management, suggests PA end-of-September storage similar to that of the NAA (Appendix 5.C, *Upstream Water Temperature Methods and Results*). Based on the proposed decision making approaches and criteria for real-time cold-water pool management efforts described in Section 3.1.5, *Real-Time Operations Upstream of the Delta,* and 3.3.3, *Real-Time Operational Decision-Making Process*, releases from Shasta Lake under the PA will be at similar levels as the NAA during September. Thus, the PA will not result in higher September water temperatures. Considering these results, the frequency and magnitude of differences in effects between NAA and the PA are so small as to be biologically insignificant to the species. The PA will provide flows and water temperatures for spawning, rearing, and migration consistent with those required by NMFS (2009, 2011). As such, there will be no take of winter-run Chinook salmon in areas upstream of the Delta, other than the take previously authorized by NMFS (2009).

The effects described above will be further minimized, in a manner that cannot be demonstrated within the limitations of the CalSim II modeling environment, by day-to-day decision-making on the part of the CVP/SWP operators. These decisions consider the recommendations from many of the decision-making/advisory teams, such as the Sacramento River Temperature Technical Group (SRTTG), Water Operations Management Team (WOMT), b2 interagency team (B2IT) and American River Operations Group. The current decision-making processes and the advisory groups will continue and will be improved under the PA (Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3, *Operations and Maintenance for the New and Existing Facilities*). A separate real time operations coordination team (RTOCT) will meet to assist DWR and Reclamation in fulfilling their responsibility to inform the SWP and CVP participants regarding available information and real-time decisions. This coordination effort may 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. This revised process and RTOCT will allow for alternative criteria to be developed, based on the results of coordinated monitoring and research under real-time operations (RTO) and the Adaptive Management Program, that will continue to address effects to listed species under future operations of the PA consistent with the applicable requirements of the ESA, while maximizing water supplies.

In addition, Reclamation will work with NMFS and other state and Federal agencies to adjust the RPA Action Suite 1.2, as described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*. This process is anticipated to conclude in the fall of 2016, and may include refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. The adjusted RPA Action Suite I.2 will apply to Reclamation's Shasta operations. This RPA revision process is intended to improve egg-to-fry survival of winter-run Chinook salmon to Red Bluff, but would likely improve survival of other races of Chinook salmon, steelhead, and green sturgeon, depending on the timing of refinements that will be made.

7.2.2 Sacramento-San Joaquin Delta

The PA is expected to result in incidental take of Sacramento River winter-run Chinook salmon associated with construction effects of the PA by mechanisms including underwater noise from pile driving, in-water use of construction equipment, fish rescue efforts, and possibly the accidental discharge of contaminants (Section 5.2, *Effects of Water Facility Construction on Fish*). The effects of construction activities will be minimized through avoidance and minimization measures. Temporary and permanent habitat losses will be offset by 4.3 miles of channel margin enhancement and 154.8 acres of tidal perennial habitat restoration (Table 3.4-1).

The PA has the potential to result in incidental take of Sacramento River winter-run Chinook salmon through operational effects that include entrainment (Sections 5.4.1.3.1.1.1.1 *Entrainment* and 5.4.1.3.1.1.2.1 *Entrainment*), impingement (Section 5.4.1.3.1.1.1.2 *Impingement and Screen Contact*), and predation (Sections 5.4.1.3.1.1.1.3 *Predation* and 5.4.1.3.1.1.2.2 *Predation*) at the NDD (see also Section 5.4.1.4.1.1.1 *Risk to Salmonids from North Delta Exports*) and south Delta facilities (see also Section 5.4.1.4.1.1.2 *Risk to Salmonids from South Delta Exports*), and changes in flows that may affect migratory success (Section 5.4.1.3.1.2.1 *Indirect Mortality Within the Delta;* Section 5.4.1.4.1.2.1 *Risk to Salmonids from Indirect Mortality Within the Delta*) and availability of inundated riparian bench habitat (Section 5.4.1.3.1.2.2.1.1 *Operational Effects;* Section 5.4.1.4.1.2.2 *Risk to Salmonids from Changes in Habitat Suitability*). PA operations in compliance with NMFS (2009) BiOp conditions together with the additional PA proposed operational criteria for south Delta, NDD, and DCC provide protection during the winter and spring, thereby reducing the impact of CVP/SWP Delta operations on Chinook salmon. The RTO and adaptive management and monitoring provisions included in the PA provide additional opportunities to refine the operating criteria and make adjustments to the CVP/SWP Delta operations to minimize the risk of incidental take while maximizing water supply. Adverse operational effects will be offset by restoring channel margin habitat (Section 5.4.1.3.1.2.2.1.2 *Channel Margin Enhancement*) and installing a nonphysical barrier at the Sacramento River-Georgiana Slough divergence (Section 5.4.1.3.1.2.1.2.2 *Nonphysical Fish Barrier at Georgiana Slough*). Projected operation of other Delta facilities (for example, the North Bay Aqueduct, Rock Slough Diversion, and the Suisun Marsh Salinity Control Gates [SMSCG]) is expected to result in a discountable risk of incidental take of Sacramento River winter-run Chinook salmon (Sections 5.4.1.3.1.1.5 through 5.4.1.3.1.1.7, *Suisun Marsh Facilities, North bay Aqueduct,* and *Other Facilities*, respectively; Sections 5.4.1.4.1.1.5 through 5.4.1.4.1.1.7 *Risk to Salmonids from Suisun Marsh Facilities*, *Risk to Salmonids from North Bay Aqueduct*, and *Risk to Salmonids from Other Facilities*, respectively).

7.2.3 Cumulative Effects and the Changing Baseline

Cumulative effects on Sacramento River winter-run Chinook salmon include effects associated with water diversions, agricultural practices, increased urbanization, and wastewater treatment plants. These effects will accrue over the duration of the PA. Non-federal water diversions are potentially a cause of mortality via entrainment, but ongoing projects such as the CVPIA fish screen program are reducing the number of such diversions and their mortality risk, so this effect is likely to diminish over time. Potentially adverse agricultural practices primarily entail water quality impairments; the action area is already fully developed with regard to agricultural land uses, and regulations in place constrain the associated water quality effects, so this effect is likely to be maintained in the future. Adverse effects of urbanization include point and nonpoint-source water quality impairments, and increased vessel traffic in waterways. These activities are likely to further degrade Chinook salmon habitat over time. Wastewater treatment plants also contribute to impaired water quality, but significant improvements in discharge water quality and reductions in discharge water volume have occurred in recent years, primarily in response to regulatory and economic factors increasing the value of reusable water; thus this stressor is likely to diminish over time. Some of these effects will improve, and others will impair habitat quality for Chinook salmon in the action area; their net effect is to approximately maintain current conditions for the foreseeable future because improvements are generally implemented to compensate for adverse project effects through the ESA consultation and other environmental review processes. These cumulative effects have little potential to impair the effectiveness of avoidance and minimization measures described in the PA, nor are they expected to alter the efficacy of offsetting measures in the PA such as habitat creation and restoration.

The environmental baseline for Sacramento River winter-run Chinook salmon is described in Chapter 4. Due to the span of time until the beginning of water operations under the proposed action, and over the course of the proposed operations, the baseline is expected to change. The principal such changes concern climate change, and certain federal actions that are reasonably certain to occur but have not yet been implemented.

Foreseeable climate change effects, described in Section 4.3.2.1 *Climate Conditions*, include sea level rise, reduced Sierra Nevada winter snowpack, warmer water temperatures, and increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for Chinook salmon, and also to increase year-to-year fluctuations in population sizes. There will also be changes in the marine environment where Chinook salmon spend most of their life cycle. Marine changes, and their likely effects upon Chinook salmon, are difficult to forecast, and may include both beneficial and adverse consequences.

Federal actions that are reasonably certain to occur but have not yet been implemented primarily include habitat protection and restoration requirements and passage above dams on the Sacramento River, included in the NMFS (2009) BiOp. These actions are expected to have beneficial consequences for adult and juvenile passage, and for juvenile migration and rearing, within the action area.

7.2.4 Determination of Effects to Sacramento River Winter-run Chinook Salmon ESU

The PA is likely to adversely affect the Sacramento River winter-run Chinook salmon ESU due to incidental take associated with facility construction and operation.

7.2.5 Determination of Effects to Sacramento River Winter-run Chinook Salmon ESU Designated Critical Habitat

Due to the implementation of avoidance and minimization measures and the construction of habitat restoration measures, the PA will minimize effects on the physical and biological features of the Sacramento River winter-run Chinook salmon designated critical habitat. Restoration measures proposed under the PA include 154.8 acres of tidal perennial aquatic habitat and 4.3 miles of channel margin habitat, as described in Section 3.4 *Conservation Measures*.

The physical and biological features (PBFs)[1] of critical habitat for winter-run Chinook salmon include: (1) access to spawning areas in the upper Sacramento River; (2) the availability of clean gravel for spawning substrate; (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles; (4) water temperatures for successful spawning, egg incubation, and fry development; (5) habitat areas and adequate prey that are not contaminated; (6) riparian habitat that provides for successful juvenile development and survival; and (7) access downstream so that juveniles can migrate from spawning grounds to San Francisco Bay and the Pacific Ocean.

As discussed in Chapter 5, *Effects Analysis for Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.4.2.1.5.1, *Winter-Run Chinook Salmon*, upstream of the Delta, these PBFs could only be affected by the PA through changes in instream flows and water temperatures. Because any effects of the project on flow and water temperature upstream of the Delta will be insignificant and consistent with the requirements of NMFS (2009), the PA will have insignificant effects on these PBFs. These insignificant effects will be further minimized, in a manner that cannot be demonstrated within the limitations of the CalSim II modeling environment, by real-time operations as described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which will be used to avoid and minimize the modeled effects found in this effects analysis.

As described in Section 5.4.1.5, *Effects of the Action on Designated Critical Habitat,* within the Delta, operational criteria (bypass flows) will minimize the potential for adverse effects to PBF 7, downstream access, for juvenile winter-run Chinook salmon (e.g., from reduced Sacramento River flows downstream of the NDD influencing probability of survival because reduced transit speed), and the Georgiana Slough NPB will minimize near-field and far-field effects of the NDD on PBF 7 by keeping a greater proportion of juvenile winter-run Chinook salmon migrating down the Sacramento River out of the low-survival interior Delta. Channel margin enhancement of poor habitat will compensate for potential reduction in PBF 6, riparian habitat, at inundated bench areas caused by reductions in Sacramento River water level by the NDD.

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[1] The designations of critical habitat for listed species have generally used the term primary constituent elements (PCEs). NMFS and USFWS' recently issued a final rule amending the regulations for designating critical habitat (81 FR 7414; February 11, 2016), which replaced the term PCEs with physical or biological features (PBFs). In addition, NMFS and USFWS' recently issued a final rule revising the regulatory definition of "destruction or adverse modification" of critical habitat (81 FR 7214; February 11, 2016), which refers to PBFs, not PCEs. The shift in terminology does not change the approach used in conducting an analysis of the effects of the proposed action on critical habitat, which is the same regardless of whether the original designation identified PCEs or PBFs. In this biological assessment, we use the term PBFs to include PCEs, as appropriate for the specific critical habitat, for NMFS species.

In summary, the PA is likely to adversely affect the physical and biological features of designated critical habitat for Sacramento River winter-run Chinook salmon because the temporary impairment of critical habitat functions associated with in-water construction activities, permanent impairment associated with permanent placement of in-water structures, and potential impairment associated with flow diversion at the NDDs. However, these effects will be avoided, minimized, and/or compensated. The impairment associated with in-water construction activities will be minimized through avoidance and minimization measures. The impairment associated with permanent placement of in-water structures will be offset by habitat restoration in the form of tidal perennial aquatic habitat restoration and channel margin enhancement. The impairment associated with flow diversion will be minimized through real-time operations that use transitional flow criteria based on fish presence, installing a nonphysical barrier at the Sacramento River-Georgiana Slough divergence, and restoring channel margin habitat.

7.3 Chinook Salmon, Central Valley Spring–run ESU

7.3.1 Sacramento River Upstream of Delta

Upstream quantitative analyses of temperature and flow effects are based on CalSim II modeling. The uncertainties associated with using CalSim II outputs must be considered in interpreting biological analyses (Appendix 5.A, *CALSIM Methods and Results*). CalSim II is a long-term planning model that allows for quantitative simulation of the CVP and SWP operations on a monthly time-step across a wide range of hydrologic, regulatory and operations instances. CalSim II uses a set of pre-defined generalized rules, which represent the assumed regulations, to specify operations of the CVP/SWP. These rules are often specified as a function of year type or a prior month’s simulated storage or flow condition. As described above, the model has no capability of adjusting these rules to respond to specific events that may have occurred historically, e.g., fish presence, levee failures, fluctuations in barometric pressure that may have affected Delta tides and salinities, facility outages, etc. These generalized rules have been developed based on historical operational trends and on limited CVP/SWP operator input and only provide a coarse representation of the project operations over the inputted hydrologic conditions. Thus, results do not exactly match what operators might do in a specific month or year within the simulation period since the latter will be informed by numerous real-time considerations that cannot be input to CalSim II. Rather, results are intended to be a reasonable representation of long-term operational trends of CVP and SWP, providing the ability to compare and contrast the effect of current and assumed future operational conditions.

Analysis of potential effects of the PA on Central Valley spring-run Chinook salmon in the Sacramento River upstream of the Delta found differences between the NAA and PA that include

- Increased frequency of water temperature threshold exceedances during August through October coinciding with the spring-run Chinook salmon spawning and rearing period;
- Increased risk of redd dewatering for egg cohorts spawned in August;

- Decreased rearing WUA during June in some portions of the Sacramento River, if population numbers were high enough that habitat could be limiting[2];
- Reduced flows in above normal, below normal, and dry water years during September that could affect adult migration and in wet and above normal water years during November that could affect juvenile migration.

The reduced Shasta releases associated with the PA's operational modeling result in the modeled increased frequency of water temperature threshold exceedances during September. However, modeling of the cold-water pool volume, which is more indicative of temperature management, suggests PA end-of-September storage similar to that of the NAA (Appendix 5.C, *Upstream Water Temperature Methods and Results*). Based on the proposed decision making approaches and criteria for real-time cold-water pool management efforts described in Section 3.1.5, *Real-Time Operations Upstream of the Delta,* and 3.3.3, *Real-Time Operational Decision-Making Process*, releases from Shasta Lake under the PA will be at similar levels as the NAA during September. Thus, the PA will not result in higher September water temperatures. Considering these results, the frequency and magnitude of differences in effects between NAA and the PA are so small as to be biologically insignificant to the species. The PA will provide flows and water temperatures for spawning, rearing, and migration consistent with those required by NMFS (2009). As such, there will be no take of spring-run Chinook salmon in areas upstream of the Delta, other than the take previously authorized by NMFS (2009).

The effects described above will be further minimized in a manner that cannot be demonstrated within the limitations of the CalSim II modeling environment, by day-to-day decision-making on the part of the CVP/SWP operators. These decisions consider the recommendations from many of the decision-making/advisory teams, such as the Sacramento River Temperature Technical Group (SRTTG), Water Operations Management Team (WOMT), b2 interagency team (B2IT) and American River Operations Group. The current decision-making processes and the advisory groups will continue and will be improved under the PA (Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3, *Operations and Maintenance for the New and Existing Facilities*). A separate real time operations coordination team (RTOCT) will meet to assist DWR and Reclamation in fulfilling their responsibility to inform the SWP and CVP participants regarding available information and real-time decisions. This coordination effort may 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. This revised process and RTOCT will allow for alternative operating criteria to be developed, based on the results of the coordinated monitoring and research under real-time operations (RTO) and the Adaptive Management Program, that will continue to address effects to listed species under future operations of the PA consistent with the applicable requirements of the ESA, while maximizing water supplies.

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[2] Habitat limitation has not been a concern in recent years due to low population size, but it could be in the future if population size was to increase or there was a strong year class. Awareness of the effects to be managed in the best interest of the species is necessary, regardless of variability in population size.

In addition, Reclamation will work with NMFS and other state and Federal agencies to adjust the RPA Action Suite 1.2, as described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*. This process is anticipated to conclude in the fall of 2016, and may include refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. The adjusted RPA Action Suite I.2 will apply to Reclamation's Shasta operations. This RPA revision process is intended to improve egg-to-fry survival of winter-run Chinook salmon to Red Bluff, but would likely improve survival of spring-run Chinook salmon as well, depending on the timing of refinements that will be made.

7.3.2 Sacramento-San Joaquin Delta

The PA is expected to result in incidental take of Central Valley spring-run Chinook salmon associated with construction effects of the PA by mechanisms including underwater noise from pile driving, in-water use of construction equipment, fish rescue efforts, and possibly the accidental discharge of contaminants (Section 5.2, *Effects of Water Facility Construction on Fish*). The effects of construction activities will be minimized through avoidance and minimization measures. Temporary and permanent habitat losses will be offset by 4.3 miles of channel margin enhancement and 154.8 acres of tidal perennial habitat restoration (Table 3.4-1).

The PA has the potential to result in incidental take to Central Valley spring-run Chinook salmon through operational effects that include entrainment (Sections 5.4.1.3.1.1.1.1, *Entrainment* and 5.4.1.3.1.1.2.1, *Entrainment*), impingement (Section 5.4.1.3.1.1.1.2, *Impingement and Screen Contact*), and predation (Sections 5.4.1.3.1.1.1.3, *Predation*, and 5.4.1.3.1.1.2.2, *Predation*) at the NDD (see also Section 5.4.1.4.1.1.1 *Risk to Salmonids from North Delta Exports*) and south Delta facilities (see also Section 5.4.1.4.1.1.2 *Risk to Salmonids from South Delta Exports*), and changes in flows that may affect migratory success (Section 5.4.1.3.1.2.1, *Indirect Mortality Within the Delta;* Section 5.4.1.4.1.2.1 *Risk to Salmonids from Indirect Mortality Within the Delta*) and availability of inundated riparian bench habitat (Section 5.4.1.3.1.2.2.1.1, *Operational Effects;* Section 5.4.1.4.1.2.2 *Risk to Salmonids from Changes in Habitat Suitability*), although San Joaquin River basin spring-run Chinook would not be affected by NDD construction or operations. PA operations in compliance with NMFS (2009) BiOp conditions together with the additional PA proposed operational criteria for south Delta, NDD, and DCC provide protection during the winter and spring, thereby reducing the impact of CVP/SWP Delta operations on Chinook salmon. The RTO and adaptive management and monitoring provisions included in the PA provide additional opportunities to refine the operating criteria and adjust the CVP/SWP Delta operations to minimize the risk of incidental take while maximizing water supply. Adverse operational effects will be offset by restoring channel margin habitat (Section 5.4.1.3.1.2.2.1.2, *Channel Margin Enhancement*) and installing a nonphysical barrier at the Sacramento River-Georgiana Slough divergence (Section 5.4.1.3.1.2.1.2.2, *Nonphysical Fish Barrier to Georgiana Slough*). Projected operation of other Delta facilities (for example, the North Bay Aqueduct, Rock Slough Diversion, and the Suisun Marsh Salinity Control Gates [SMSCG]) is expected to result in a discountable risk of incidental take of Central Valley spring-run Chinook salmon(Sections 5.4.1.3.1.1.5 through 5.4.1.3.1.1.7, *Suisun Marsh Facilities, North Bay Aqueduct, and Other Facilities*, respectively; Sections 5.4.1.4.1.1.5

through 5.4.1.4.1.1.7 *Risk to Salmonids from Suisun Marsh Facilities*, *Risk to Salmonids from North Bay Aqueduct*, and *Risk to Salmonids from Other Facilities*, respectively; Sections 5.4.1.4.1.1.5 through 5.4.1.4.1.1.7 *Risk to Salmonids from Suisun Marsh Facilities*, *Risk to Salmonids from North Bay Aqueduct*, and *Risk to Salmonids from Other Facilities*, respectively). Additionally, the PA would result in benefits to San Joaquin River basin spring-run Chinook due to the reduced use of the south Delta facilities (*Section 5.4.1.4.1.1.2 Risk to Salmonids from South Delta Exports).*

7.3.3 Cumulative Effects and the Changing Baseline

Cumulative effects on Central Valley spring-run Chinook salmon are the same as those effects on the Sacramento River winter-run Chinook salmon and include effects associated with water diversions, agricultural practices, increased urbanization, and wastewater treatment plants. These effects will accrue over the duration of the PA. Non-federal water diversions are potentially a cause of mortality via entrainment, but ongoing projects such as the CVPIA fish screen program are reducing the number of such diversions and their mortality risk, so this effect is likely to diminish over time. Potentially adverse agricultural practices primarily entail water quality impairments; the action area is already fully developed with regard to agricultural land uses, and regulations in place constrain the associated water quality effects, so this effect is likely to be maintained in the future. Adverse effects of urbanization include point and nonpoint-source water quality impairments, and increased vessel traffic in waterways. These activities are likely to further degrade Chinook salmon habitat over time. Wastewater treatment plants also contribute to impaired water quality, but significant improvements in discharge water quality and reductions in discharge water volume have occurred in recent years, primarily in response to regulatory and economic factors increasing the value of reusable water; thus this stressor is likely to diminish over time. Some of these effects will improve, and others will impair habitat quality for Chinook salmon in the action area; their net effect is to approximately maintain current conditions for the foreseeable future because improvements are generally implemented to compensate for adverse project effects through the ESA consultation and other environmental review processes. These cumulative effects have little potential to impair the effectiveness of avoidance and minimization measures described in the PA, nor are they expected to alter the efficacy of offsetting measures in the PA such as habitat creation and restoration.

The environmental baseline for Central Valley spring-run Chinook salmon is described in Chapter 4. Due to the span of time until the beginning of water operations under the proposed action, and over the course of the proposed operations, the baseline is expected to change. The principal such change concern climate change, and certain federal actions that are reasonably certain to occur but have not yet been implemented.

Foreseeable climate change effects, described in Section 4.3.2.1 *Climate Conditions*, include sea level rise, reduced Sierra Nevada winter snowpack, warmer water temperatures, and increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for Chinook salmon, and also to increase year-to-year fluctuations in population sizes. There will also be changes in the marine environment where Chinook salmon spend most of their life cycle. Marine changes, and their likely effects upon Chinook salmon, are difficult to forecast, and may include both beneficial and adverse consequences.

Federal actions that are reasonably certain to occur but have not yet been implemented primarily include habitat protection and restoration requirements and passage above dams on the Sacramento and American Rivers, included in the NMFS (2009) BiOp. These actions are expected to have beneficial consequences for adult and juvenile passage, and for juvenile migration and rearing, within the action area.

7.3.4 Determination of Effects to Central Valley Spring-run Chinook Salmon ESU

The PA is likely to adversely affect the Central Valley spring-run Chinook salmon ESU due to incidental take associated with facility construction and operation.

7.3.5 Determination of Effects to Central Valley Spring-run Chinook Salmon ESU Designated Critical Habitat

Due to the implementation of avoidance and minimization measures and the construction of habitat restoration measures, the PA will minimize effects on the physical and biological features of the Central Valley spring-run Chinook salmon designated critical habitat. Restoration measures proposed under the PA include 154.8 acres of tidal perennial aquatic habitat and 4.3 miles of channel margin habitat, as described in Section 3.4 *Conservation Measures.*

The physical and biological features (PBFs)[3] of critical habitat for Central Valley spring-run Chinook salmon include: (1) spawning habitat with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) freshwater rearing habitat with water quantity and quality, floodplain connectivity, forage, and natural cover supporting juvenile development, growth, mobility, and survival; (3) freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover supporting juvenile and adult mobility and survival; and (4) estuarine areas free of obstruction and excessive predation supporting mobility and survival, with water quantity, water quality, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater, and natural cover and forage supporting growth, maturation and survival.

As discussed in Chapter 5, *Effects Analysis for Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.4.2.1.5.2, *Spring-Run Chinook Salmon*, upstream of the Delta, these PBFss could only be affected by the PA through changes in instream flows and water temperatures. Because any effects of the project on flow and water temperature upstream of the Delta will be insignificant and consistent with the requirements of NMFS (2009), the PA will have insignificant effects on these PBFs. These insignificant effects will be

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[3] The designations of critical habitat for listed species have generally used the term primary constituent elements (PCEs). NMFS and USFWS' recently issued a final rule amending the regulations for designating critical habitat (81 FR 7414; February 11, 2016), which replaced the term PCEs with physical or biological features (PBFs). In addition, NMFS and USFWS' recently issued a final rule revising the regulatory definition of "destruction or adverse modification" of critical habitat (81 FR 7214; February 11, 2016), which refers to PBFs, not PCEs. The shift in terminology does not change the approach used in conducting an analysis of the effects of the proposed action on critical habitat, which is the same regardless of whether the original designation identified PCEs or PBFs. In this biological assessment, we use the term PBFs to include PCEs, as appropriate for the specific critical habitat, for NMFS species.

further minimized, in a manner that cannot be demonstrated within the limitations of the CalSim II modeling environment, by real-time operations as described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which will be used to avoid and minimize the modeled effects found in this effects analysis.

As described in Section 5.4.1.5, *Effects of the Action on Designated Critical Habitat*, and above for winter-run Chinook salmon, within the Delta, operational criteria (bypass flows) will minimize the potential for adverse effects to PBF 7, downstream access, for juvenile spring-run Chinook salmon (e.g., from reduced Sacramento River flows downstream of the NDD influencing probability of survival because of reduced transit speed), and the Georgiana Slough NPB will minimize near-field and far-field effects of the NDD on PBF 7 by keeping a greater proportion of juvenile spring-run Chinook salmon migrating down the Sacramento River out of the low-survival interior Delta.. Channel margin enhancement of poor habitat will compensate for potential reduction in PBF 6, riparian habitat at inundated bench areas caused by reductions in Sacramento River water level by the NDD..

In summary, the PA is likely to adversely affect the physical and biological features of designated critical habitat for Central Valley spring-run Chinook salmon because the temporary impairment of critical habitat functions associated with in-water construction activities, permanent impairment associated with permanent placement of in-water structures, and potential impairment associated with flow diversion at the NDDs. However, these effects will be avoided, minimized, and/or compensated. The impairment associated with in-water construction activities will be minimized through avoidance and minimization measures. The impairment associated with permanent placement of in-water structures will be offset by habitat restoration in the form of tidal perennial aquatic habitat restoration and channel margin enhancement. The impairment associated with flow diversion will be minimized through real-time operations that use transitional flow criteria based on fish presence.

7.4 Steelhead, California Central Valley DPS

7.4.1 Upstream (Sacramento and American Rivers)

Upstream quantitative analyses of temperature and flow effects are based on CalSim II modeling. The uncertainties associated with using CalSim II outputs must be considered in interpreting biological analyses (Appendix 5.A, *CALSIM Methods and Results*). CalSim II is a long-term planning model that allows for quantitative simulation of the CVP and SWP operations on a monthly time-step across a wide range of hydrologic, regulatory and operations instances. CalSim II uses a set of pre-defined generalized rules, which represent the assumed regulations, to specify operations of the CVP/SWP. These rules are often specified as a function of year type or a prior month's simulated storage or flow condition. As described above, the model has no capability of adjusting these rules to respond to specific events that may have occurred historically, e.g., fish presence, levee failures, fluctuations in barometric pressure that may have affected Delta tides and salinities, facility outages, etc. These generalized rules have been developed based on historical operational trends and on limited CVP/SWP operator input and only provide a coarse representation of the project operations over the inputted hydrologic conditions. Thus, results do not exactly match what operators might do in a specific month or year within the simulation period since the latter will be informed by numerous real-time considerations that cannot be input to CalSim II. Rather, results are intended to be a reasonable representation of long-term operational trends of CVP and SWP, providing the ability to compare and contrast the effect of current and assumed future operational conditions.

Analysis of potential effects of the PA on California Central Valley steelhead in the Sacramento River upstream of the Delta and the American River found differences between the NAA and PA that include:

- Decreased rearing WUA during June in some portions of the Sacramento River, if population numbers were high enough that habitat could be limiting[4];
- Reduced flows in above normal, below normal, and dry water years during September that could affect adult migration in the Sacramento River and in wet and above normal water years during November that could affect juvenile and adult migration in the Sacramento River and adult migration in the American River.

The reduced Shasta releases associated with the PA's operational modeling result in the modeled reduced migratory flows during September. Based on the proposed decision making approaches and criteria for real-time reservoir operations described in Section 3.1.5, *Real-Time Operations Upstream of the Delta,* and 3.3.3, *Real-Time Operational Decision-Making Process*, releases from Shasta Lake under the PA will be at similar levels as the NAA during September. Thus, the PA will not result in adult California Central Valley steelhead experiencing reduced flows during September. Considering these results, the frequency and magnitude of differences in effects between NAA and the PA are so small as to be biologically insignificant to the species. The PA will provide flows and water temperatures for spawning, rearing, and migration consistent with those required by NMFS (2009). As such, there will be no take of steelhead in areas upstream of the Delta, other than the take previously authorized by NMFS (2009).

The effects described above will be further minimized, in a manner that cannot be demonstrated within the limitations of the CalSim II modeling environment, by day-to-day decision-making on the part of the CVP/SWP operators. These decisions consider the recommendations from many of the decision-making/advisory teams, such as the Sacramento River Temperature Technical Group (SRTTG), Water Operations Management Team (WOMT), b2 interagency team (B2IT) and American River Operations Group. The current decision-making processes and the advisory groups will continue and will be improved under the PA (Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3, *Operations and Maintenance for the New and Existing Facilities*). A separate real time operations coordination team (RTOCT) will meet to assist DWR and Reclamation in fulfilling their responsibility to inform the SWP and CVP participants regarding available information and real-time decisions. This coordination effort may 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.

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[4] Habitat limitation has not been a concern in recent years due to low population size, but it could be in the future if population size was to increase or there was a strong year class. Awareness of the effects to be managed in the best interest of the species is necessary, regardless of variability in population size.

This revised process and RTOCT will allow for alternative operating criteria to be developed, based on the results of coordinated monitoring and research under the RTO and Adaptive Management Program, that will continue to address effects to listed species under future operations of the PA consistent with the applicable requirements of the ESA, while maximizing water supplies.

In addition, Reclamation will work with NMFS and other state and Federal agencies to adjust the RPA Action Suite 1.2, as described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*. This process is anticipated to conclude in the fall of 2016, and may include refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. The adjusted RPA Action Suite I.2 will apply to Reclamation’s Shasta operations. This RPA revision process is intended to improve egg-to-fry survival of winter-run Chinook salmon to Red Bluff, but would likely improve survival of steelhead as well, depending on the timing of refinements that will be made.

7.4.2 Sacramento-San Joaquin Delta

The PA is expected to result in incidental take of California Central Valley steelhead associated with construction effects of the PA by mechanisms including underwater noise from pile driving, in-water use of construction equipment, fish rescue efforts, and possibly the accidental discharge of contaminants (Section 5.2, *Effects of Water Facility Construction on Fish*). The effects of construction activities will be minimized through avoidance and minimization measures. Temporary and permanent habitat losses will be offset by 4.3 miles of channel margin enhancement and 154.8 acres of tidal perennial habitat restoration (Table 3.4-1).

The PA has the potential to result in incidental take to California Central Valley steelhead through entrainment (Sections 5.4.1.3.1.1.1.1 *Entrainment* and 5.4.1.3.1.1.2.1 *Entrainment*), impingement (Section 5.4.1.3.2.1.1.2 *Impingement and Screen Contact*), and predation (Sections 5.4.1.3.1.1.1.3 *Predation* and 5.4.1.3.1.1.2.2 *Predation*) at the NDD (see also Section 5.4.1.4.1.1.1 *Risk to Salmonids from North Delta Exports*) and south Delta facilities (see also Section 5.4.1.4.1.1.2 *Risk to Salmonids from South Delta Exports*), and changes in flows that may affect migratory success (Section 5.4.1.3.1.2.1 *Indirect Mortality Within the Delta*; Section 5.4.1.4.1.2.1 *Risk to Salmonids from Indirect Mortality Within the Delta*) and availability of inundated riparian bench habitat (Section 5.4.1.3.1.2.2.1.1, *Operational Effects;* Section 5.4.1.4.1.2.2 *Risk to Salmonids from Changes in Habitat Suitability*). PA operations in compliance with NMFS (2009) BiOp conditions together with the additional PA proposed operational criteria for south Delta, NDD, and DCC provide protection during the winter and spring, thereby reducing the impact of CVP/SWP Delta operations on steelhead. The RTO and adaptive management and monitoring provisions included in the PA provide additional opportunities to refine the operating criteria and make adjustments to CVP/SWP Delta operations to minimize the risks of incidental take while maximizing water supply. Adverse operational effects will be offset by restoring channel margin habitat (Section 5.4.1.3.1.2.2.1.2 *Channel Margin Enhancement*) and installing a nonphysical barrier at the Sacramento River-Georgiana Slough divergence (Section 5.4.1.3.1.2.1.2.2, *Nonphysical Fish Barrier at Georgiana Slough*). Projected operation of other Delta facilities (for example, the North Bay

Aqueduct, Rock Slough Diversion, and the Suisun Marsh Salinity Control Gates [SMSCG]) is expected to result in a discountable risk of take of California Central Valley steelhead (Sections 5.4.1.3.1.1.5 through 5.4.1.3.1.1.7, *Suisun Marsh Facilities, North Bay Aqueduct, and Other Facilities*, respectively; Sections 5.4.1.4.1.1.5 through 5.4.1.4.1.1.7 *Risk to Salmonids from Suisun Marsh Facilities*, *Risk to Salmonids from North Bay Aqueduct*, and *Risk to Salmonids from Other Facilities*, respectively).

7.4.3 Cumulative Effects and the Changing Baseline

Cumulative effects on California Central Valley steelhead are similar to those for both Sacramento River winter-run and Central Valley spring-run Chinook Salmon, and include effects associated with water diversions, agricultural practices, increased urbanization, and wastewater treatment plants. These effects will accrue over the duration of the PA. Non-federal water diversions are potentially a cause of mortality via entrainment, but ongoing projects such as the CVPIA fish screen program are reducing the number of such diversions and their mortality risk, so this effect is likely to diminish over time. Potentially adverse agricultural practices primarily entail water quality impairments; the action area is already fully developed with regard to agricultural land uses, and regulations in place constrain the associated water quality effects, so this effect is likely to be maintained in the future. Adverse effects of urbanization include point and nonpoint-source water quality impairments, and increased vessel traffic in waterways. These activities are likely to further degrade steelhead habitat over time. Wastewater treatment plants also contribute to impaired water quality, but significant improvements in discharge water quality and reductions in discharge water volume have occurred in recent years, primarily in response to regulatory and economic factors increasing the value of reusable water; thus this stressor is likely to diminish over time. Some of these effects will improve, and others will impair habitat quality for steelhead in the action area; their net effect is to approximately maintain current conditions for the foreseeable future because improvements are generally implemented to compensate for adverse project effects through the ESA consultation and other environmental review processes. These cumulative effects have little potential to impair the effectiveness of avoidance and minimization measures described in the PA, nor are they expected to alter the efficacy of offsetting measures in the PA such as habitat creation and restoration.

The environmental baseline for California Central Valley steelhead is described in Chapter 4. Due to the span of time until the beginning of water operations under the proposed action, and over the course of the proposed operations, the baseline is expected to change.. The principal such changes concern climate change, and certain federal actions that are reasonably certain to occur but have not yet been implemented.

Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include sea level rise, reduced Sierra Nevada winter snowpack, warmer water temperatures, and increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for steelhead, and also to increase year-to-year fluctuations in population sizes. There will also be changes in the marine environment where steelhead spend most of their life cycle. Marine changes, and their likely effects upon steelhead, are difficult to forecast, and may include both beneficial and adverse consequences.

Federal actions that are reasonably certain to occur but have not yet been implemented primarily include habitat protection and restoration requirements and passage above dams on the Sacramento and American Rivers, included in the NMFS (2009) BiOp. These actions are expected to have beneficial consequences for adult and juvenile passage, and for juvenile migration and rearing, within the action area.

7.4.4 Determination of Effects to California Central Valley Steelhead DPS

The PA is likely to adversely affect the California Central Valley steelhead DPS due to incidental take associated with facility construction and operation.

7.4.5 Determination of Effects to California Central Valley Steelhead DPS Designated Critical Habitat

Due to the implementation of avoidance and minimization measures and the construction of habitat restoration measures, the PA will minimize effects on the physical and biological features of the California Central Valley steelhead designated critical habitat. Restoration measures proposed under the PA include 154.8 acres of tidal perennial aquatic habitat and 4.3 miles of channel margin habitat, as described in Section 3.4 *Conservation Measures*..

The physical and biological features PBFs of critical habitat for California Central Valley steelhead include: (1) spawning habitat with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) freshwater rearing habitat with water quantity and quality, floodplain connectivity, forage, and natural cover supporting juvenile development, growth, mobility, and survival; (3) freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover supporting juvenile and adult mobility and survival; and (4) estuarine areas free of obstruction and excessive predation supporting mobility and survival, with water quantity, water quality, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater, and natural cover and forage supporting growth, maturation and survival.

As discussed in Chapter 5, *Effects Analysis for Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.4.2.1.5.3, *California Central Valley Steelhead*, upstream of the Delta these PBFs could only be affected by the PA through changes in instream flows and water temperatures. Because any effects of the project on flow and water temperature upstream of the Delta will be insignificant and consistent with the requirements of NMFS (2009), the PA will have insignificant effects on these PBFs. These insignificant effects will be further minimized, in a manner that cannot be demonstrated within the limitations of the CalSim II modeling environment, by real-time operations as described in Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which will be used to avoid and minimize the modeled effects found in this effects analysis.

As described in Section 5.4.1.5, *Effects of the Action on Designated Critical Habitat,* and above for winter-run and spring-run Chinook salmon, within the Delta, operational criteria (bypass flows) will minimize the potential for adverse effects to PBF 7, downstream access, for juvenile steelhead (e.g., from reduced Sacramento River flows downstream of the NDD influencing probability of survival because of reduced transit speed), and the Georgiana Slough NPB will minimize near-field and far-field effects of the NDD on PBF 7 by keeping a greater proportion of juvenile steelhead migrating down the Sacramento River out of the low-survival interior Delta. Channel margin enhancement of poor habitat will compensate for potential reduction in PBF 6, riparian habitat, at inundated bench areas caused by reductions in Sacramento River water level by the NDD.

In summary, the PA is likely to adversely affect the physical and biological features of designated critical habitat for California Central Valley steelhead because the temporary impairment of critical habitat functions associated with in-water construction activities, permanent impairment associated with permanent placement of in-water structures, and potential impairment associated with flow diversion at the NDDs. However, these effects will be avoided, minimized, and/or compensated. The impairment associated with in-water construction activities will be minimized through avoidance and minimization measures. The impairment associated with permanent placement of in-water structures will be offset by habitat restoration in the form of tidal perennial aquatic habitat restoration and channel margin enhancement. The impairment associated with flow diversion will be minimized through real-time operations that use transitional flow criteria based on fish presence.

7.5 Green Sturgeon, Southern DPS

7.5.1 Sacramento River Upstream of Delta

Upstream quantitative analyses of temperature and flow effects are based on CalSim II modeling. The uncertainties associated with using CalSim II outputs must be considered in interpreting biological analyses (Appendix 5.A, *CALSIM Methods and Results*). CalSim II is a long-term planning model that allows for quantitative simulation of the CVP and SWP operations on a monthly time-step across a wide range of hydrologic, regulatory and operations instances. CalSim II uses a set of pre-defined generalized rules, which represent the assumed regulations, to specify operations of the CVP/SWP. These rules are often specified as a function of year type or a prior month's simulated storage or flow condition. As described above, the model has no capability of adjusting these rules to respond to specific events that may have occurred historically, e.g., fish presence, levee failures, fluctuations in barometric pressure that may have affected Delta tides and salinities, facility outages, etc. These generalized rules have been developed based on historical operational trends and on limited CVP/SWP operator input and only provide a coarse representation of the project operations over the inputted hydrologic conditions. Thus, results do not exactly match what operators might do in a specific month or year within the simulation period since the latter will be informed by numerous real-time considerations that cannot be input to CalSim II. Rather, results are intended to be a reasonable representation of long-term operational trends of CVP and SWP, providing the ability to compare and contrast the effect of current and assumed future operational conditions.

Analysis of potential effects of the PA on Southern DPS green sturgeon in the Sacramento River upstream of the Delta found insignificant differences between the NAA and PA in flows and water temperatures for spawning, rearing, and migration. The PA will provide flows and water temperatures consistent with those required by NMFS (2009). As such, there will be no take of green sturgeon in areas upstream of the Delta, other than the take previously authorized by NMFS (2009).

These insignificant effects will be further minimized, in a manner that cannot be demonstrated within the limitations of the CalSim II modeling environment, by day-to-day decision-making on the part of the CVP/SWP operators. These decisions consider the recommendations from many of the decision-making/advisory teams, such as the Sacramento River Temperature Technical Group (SRTTG), Water Operations Management Team (WOMT), b2 interagency team (B2IT) and American River Operations Group. The current decision-making processes and the advisory groups will continue and will be improved under the PA (Section 3.1.5, *Real-Time Operations Upstream of the Delta*, and Section 3.3, *Operations and Maintenance for the New and Existing Facilities*). A separate real time operations coordination team (RTOCT) will meet to assist DWR and Reclamation in fulfilling their responsibility to inform the SWP and CVP participants regarding available information and real-time decisions. This coordination effort may 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. This revised process and RTOCT will allow for alternative criteria to be developed, based on the results of coordinated monitoring and research under the RTO and Adaptive Management Program, that will continue to address effects to listed species under future operations of the PA consistent with the applicable requirements of the ESA, while maximizing water supplies.

In addition, Reclamation will work with NMFS and other state and Federal agencies to adjust the RPA Action Suite 1.2, as described in Section 3.1.4.5, *Annual/Seasonal Temperature Management Upstream of the Delta*. This process is anticipated to conclude in the fall of 2016, and may include refinements and additions to the existing annual/seasonal temperature management processes, including spring storage targets, revised temperature compliance criteria and a range in summertime Keswick release rates. The adjusted RPA Action Suite I.2 will apply to Reclamation’s Shasta operations. This RPA revision process is intended to improve egg-to-fry survival of winter-run Chinook salmon to Red Bluff, but would likely improve survival of green sturgeon as well, depending on the timing of refinements that will be made.

7.5.2 Sacramento-San Joaquin Delta

The PA is expected to result in incidental take of Southern DPS green sturgeon associated with construction effects of the PA by mechanisms including underwater noise from pile driving, in-water use of construction equipment, fish rescue efforts, and possibly the accidental discharge of contaminants (Section 5.2, *Effects of Water Facility Construction on Fish*). The effects of construction activities will be minimized through avoidance and minimization measures. Temporary and permanent habitat losses will be offset by 154.8 acres of tidal perennial habitat restoration (Table 3.4-1).

The PA has the potential to result in incidental take to Southern DPS green sturgeon through entrainment, impingement, and predation at the NDD (Section 5.4.1.3.2.1.1 *North Delta Exports;* Section 5.4.1.4.2.1.1 *Risk to Green Sturgeon from North Delta Exports)* and south Delta facilities (Section 5.4.1.3.2.1.2 *South Delta Exports;* 5.4.1.4.2.1.2 *Risk to Green Sturgeon from South Delta Exports*), and changes in flows that may affect migratory success (Section 5.4.1.3.2.2.1 *Indirect Mortality Within the Delta;* 5.4.1.4.2.2.1 *Risk to Green*

Sturgeon from Indirect Mortality Within the Delta). PA operations in compliance with NMFS (2009) BiOp conditions together with the additional PA proposed operational criteria for south Delta, NDD, and DCC provide protection during the winter and spring, thereby reducing the impact of CVP/SWP Delta operations on green sturgeon. The RTO and adaptive management and monitoring provisions included in the PA provide additional opportunities to better define the operating criteria and make adjustments to CVP/SWP Delta operations to minimize the risks of incidental take while maximizing water supply. Projected operation of other Delta facilities (for example, the North Bay Aqueduct, Rock Slough Diversion, and the Suisun Marsh Salinity Control Gates [SMSCG]) is expected to result in a discountable risk of take of green sturgeon (Sections 5.4.1.3.1.1.5 through 5.4.1.3.1.1.7 *Suisun Marsh Facilities, North Bay Aqueduct, and Other Facilities*, respectively; Sections 5.4.1.4.2.1.5 through 5.4.1.4.2.1.7 *Risk to Green Sturgeon from Suisun Marsh Facilities*, *Risk to Green Sturgeon from North Bay Aqueduct*, and *Risk to Green Sturgeon from Other Facilities*, respectively).

7.5.3 Cumulative Effects and the Changing Baseline

As with the salmonids, cumulative effects on Southern DPS green sturgeon include effects associated with water diversions, agricultural practices, increased urbanization, and wastewater treatment plants. These effects will accrue over the duration of the PA. Non-federal water diversions are potentially a cause of mortality via entrainment, but ongoing projects such as the CVPIA fish screen program are reducing the number of such diversions and their mortality risk, so this effect is likely to diminish over time. Potentially adverse agricultural practices primarily entail water quality impairments; the action area is already fully developed with regard to agricultural land uses, and regulations in place constrain the associated water quality effects, so this effect is likely to be maintained in the future. Adverse effects of urbanization include point and nonpoint-source water quality impairments, and increased vessel traffic in waterways. These activities are likely to further degrade green sturgeon habitat over time. Wastewater treatment plants also contribute to impaired water quality, but significant improvements in discharge water quality and reductions in discharge water volume have occurred in recent years, primarily in response to regulatory and economic factors increasing the value of reusable water; thus this stressor is likely to diminish over time. Some of these effects will improve, and others will impair habitat quality for green sturgeon in the action area; their net effect is to approximately maintain current conditions for the foreseeable future because improvements are generally implemented to compensate for adverse project effects through the ESA consultation and other environmental review processes. These cumulative effects have little potential to impair the effectiveness of avoidance and minimization measures described in the PA, nor are they expected to alter the efficacy of offsetting measures in the PA such as habitat creation and restoration.

The environmental baseline for Southern DPS green sturgeon is described in Chapter 4. Due to the span of time until the beginning of water operations under the proposed action, and over the course of the proposed operations, the baseline is expected to change. The principal such changes concern climate change, and certain federal actions that are reasonably certain to occur but have not yet been implemented.

Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include sea level rise, reduced Sierra Nevada winter snowpack, warmer water temperatures, and increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for green sturgeon, and also to increase year-to-year fluctuations in population sizes. There will also be changes in the marine environment where green sturgeon spend much of their life cycle. Marine changes, and their likely effects upon green sturgeon, are difficult to forecast, and may include both beneficial and adverse consequences.

Federal actions that are reasonably certain to occur but have not yet been implemented primarily include habitat protection and restoration requirements of the NMFS (2009) BiOp. These actions are expected to have beneficial consequences for adult and juvenile passage, and for juvenile migration and rearing, within the action area.

7.5.4 Determination of Effects to Southern DPS Green Sturgeon

The PA is likely to adversely affect Southern DPS green sturgeon because of incidental take associated with facility construction and operation.

7.5.5 Determination of Effects to Southern DPS Green Sturgeon Designated Critical Habitat

Due to the implementation of avoidance and minimization measures and the construction of habitat restoration measures, the PA will minimize effects on the physical and biological features of the Southern DPS green sturgeon designated critical habitat. Restoration measures proposed under the PA include 154.8 acres of tidal perennial aquatic habitat, as described in Section 3.4 *Conservation Measures*.

The PBFs for Southern DPS green sturgeon include: (1) food resources for larval, juvenile, subadult, and adult life stages; (2) water flow regime with flow magnitude, duration, seasonality, and rate-of-change supporting growth, survival, and migration of all life stages; (3) water quality including temperature, salinity, oxygen content, and other chemical characteristics supporting growth and viability of all life stages; (4) migratory corridor free of obstruction and excessive predation with water quantity and quality conditions supporting safe and timely passage of juveniles and adults within and between riverine, estuarine and marine habitats; (5) water depth sufficient (>5 m) for holding pools supporting adults and subadults; (6) substrate type or size (for freshwater riverine systems but not estuarine habitat) supporting egg deposition, egg and larval development, subadult and adult holding, and adult spawning; and (7) sediment quality (*i.e*, chemical characteristics) supporting growth and viability of all life stages. .

As discussed in Chapter 5, *Effects Analysis for Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*, Section 5.4.2.1.5.4, *Green Sturgeon*, upstream of the Delta, these PBFs could only be affected by the PA through changes in instream flows and water temperatures. Because any effects of the project on flow and water temperature upstream of the Delta will be insignificant and consistent with the requirements of NMFS (2009), the PA will have insignificant effects on these PBFs. These insignificant effects will be further minimized, in a manner that cannot be demonstrated within the limitations of the CalSim II modeling environment, by real-time operations as described in Section 3.1.5, *Real-Time*

Operations Upstream of the Delta, and Section 3.3.3, *Real-Time Operational Decision-Making Process,* which will be used to avoid and minimize any of the modeled effects found in this effects analysis.

As described in Section 5.4.1.5.1, *Effects of the Action on Designated Critical Habitat,* the potential adverse effects to the PBFs of critical habitat in the Delta will be limited.

In summary, the PA is not likely to adversely affect the physical and biological features of designated critical habitat for Southern DPS green sturgeon because the temporary impairment of critical habitat functions associated with in-water construction activities, permanent impairment associated with permanent placement of in-water structures, and potential impairment associated with flow diversion at the NDDs. However, these effects will be avoided, minimized, and/or compensated. The impairment associated with in-water construction activities will be minimized through avoidance and minimization measures. The impairment associated with permanent placement of in-water structures will be offset by habitat restoration in the form of tidal perennial aquatic habitat restoration. The impairment associated with flow diversion will be minimized through real-time operations that use transitional flow criteria based on fish presence.

7.6 Killer Whale, Southern Resident DPS

The PA has insignificant potential to alter the Southern Resident killer whale prey base. Project operations have the potential to affect Southern Resident killer whales by altering salmonid populations, thereby altering prey availability for Southern Resident killer whales. Reductions in prey availability could force the whales to spend more time foraging, and could lead to reduced reproductive rates and higher mortality. However, the effects analysis for salmonids, including the EFH assessment including fall-run Chinook salmon, does not find evidence that the PA will lead to any measurable reduction in abundance of Central Valley salmonid populations that will affect the Southern Resident killer whale prey base.

Based on the effects analysis, the PA may affect, but is not likely to adversely affect the Southern Resident DPS of killer whales, due to an insignificant potential for the PA to affect the Southern Resident killer whale prey base.

Based on the effects analysis, the PA is not likely to adversely affect designated critical habitat for the Southern Resident killer whale due to the PA's insignificant potential to affect the Southern Resident killer whale prey base, compounded by the small percentage of Central Valley salmon potentially present in the Washington waters designated as critical habitat.

7.7 Delta Smelt

7.7.1 Determination of Effects to Delta Smelt

The central component of the PA is to move the point of diversion of water for CVP and SWP export to the north Delta, outside the main range of Delta Smelt, and to minimize and avoid entrainment effects through further reduced reliance on the south Delta export facilities. As a result, the overall effects of the PA on Delta Smelt will be minor and the PA will not affect flows and water temperatures for spawning and rearing. The PA has the potential to result in incidental take of Delta Smelt associated with construction effects of the PA including underwater noise from pile driving, in-water use of construction equipment, fish rescue efforts, and accidental discharge of contaminants (Section 6.1.1, *Effects of Water Facility Construction on Delta Smelt*). The effects of construction activities will be minimized through avoidance and minimization measures and all habitat losses will be offset by tidal perennial habitat and shallow water habitat restoration. Additionally, the in-water construction activities will occur in areas and/or during periods when Delta Smelt are likely not present but could be present in very low densities.

The PA has the potential to result in incidental take of Delta Smelt through entrainment (Sections 6.1.3.2.1, *Entrainment*, and 6.1.3.3.1, *Entrainment*), impingement (Section 6.1.3.2.2, *Impingement and Screen Contact*), and predation (6.1.3.3.2, *Predation at the South Delta Export Facilities*, and 6.1.3.3.2, *Predation at the South Delta Export Facilities*), at the north Delta intakes and south Delta export facilities. The shifting of exports to the NDD, which is outside the main range of Delta Smelt, allows water exports to occur where the potential to affect most Delta Smelt is substantially reduced or avoided, and the screen design and operations (0.2-ft/s approach velocity) will minimize the potential for entrainment and impingement of Delta Smelt that do occur near the NDD. Actions taken in compliance with USFWS (2008) and the proposed operational criteria for south Delta provide additional protection during the winter and spring, and shifting of pumping to the screened NDD provides further protection, thereby substantially reducing the potential impact of CVP/SWP Delta operations on Delta Smelt. Delta operations and outflows have been designed to minimize effects on Delta Smelt habitat based on assessment of current science. The RTOs and Adaptive Management Program included in the PA provide additional opportunities to better define the operating criteria and make adjustments to CVP/SWP Delta operations to minimize the risks of incidental take while maximizing water supply. Projected operations of other Delta facilities (for example, the North Bay Aqueduct, Rock Slough Diversion, and the Suisun Marsh Salinity Control Gates [SMSCG]) are expected to result in minimal take of Delta Smelt (Sections 6.1.3.7 through 6.1.3.9, *Suisun Marsh Facilities, North Bay Aqueduct,* and *Other Facilities,* respectively).

Accordingly, the PA is likely to adversely affect Delta Smelt in the action area.

7.7.2 Cumulative Effects and the Changing Baseline

Cumulative effects on Delta Smelt include effects associated with water diversions, agricultural practices, increased urbanization, and wastewater treatment plants. These effects will accrue over the duration of the PA. Non-federal water diversions are likely a minor cause of mortality via entrainment (Nobriga et al. 2004), and this effect is likely to be maintained for the foreseeable future. Potentially adverse agricultural practices primarily entail water quality impairments; the action area is already fully developed with regard to agricultural land uses, and regulations in place constrain the associated water quality effects, so this effect is also likely to be maintained in the future. Adverse effects of urbanization include point and nonpoint-source water quality impairments, and increased vessel traffic in waterways. These activities are likely to further degrade Delta Smelt habitat over time. Wastewater treatment plants also contribute to impaired water quality, but significant improvements in discharge water quality and reductions in discharge water volume have occurred in recent years, primarily in response to regulatory and economic factors increasing the value of reusable water; thus this stressor is likely to diminish over time. Overall, these effects will variously improve, maintain, or impair habitat quality for Delta Smelt in the action area; their net effect is to approximately maintain current conditions for the foreseeable future. These cumulative effects have little potential to impair the effectiveness of avoidance and minimization measures described in the PA, nor are they expected to alter the efficacy of offsetting measures in the PA such as habitat creation and restoration.

The environmental baseline for Delta Smelt is described in Chapter 4. Due to the span of time until the beginning of water operations under the proposed action, and over the course of the proposed operations, the baseline is expected to change. The principal such effects concern climate change, and certain federal actions that are reasonably certain to occur but have not yet been implemented.

Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include sea level rise, reduced Sierra Nevada winter snowpack, warmer water temperatures, and increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for Delta Smelt, and also to increase year-to-year fluctuations in population sizes.

Federal actions that are reasonably certain to occur but have not yet been implemented primarily include habitat protection and restoration requirements of the USFWS (2008) BiOp. These actions are expected to have beneficial consequences for the abundance and quality of Delta Smelt habitat within the action area.

7.7.3 Determination of Effects to Delta Smelt Designated Critical Habitat

Due to the implementation of avoidance and minimization measures and the construction of habitat restoration measures, the PA will minimize effects on the primary constituent elements of Delta Smelt designated critical habitat. Restoration measures proposed under the PA include 74.7 acres of tidal perennial aquatic habitat and 273 acres of shallow water habitat, of which 108 acres of the shallow water habitat will be sandy beach spawning habitat, as described in Section 3.4 *Conservation Measures*.

The PA is likely to adversely affect the primary constituent elements of designated critical habitat for Delta Smelt because of temporary impairment of critical habitat functions associated with in-water construction activities and permanent impairment associated with permanent placement of in-water structures. Additionally, there is a potential for impairment associated with flow diversion at the NDDs. However, these effects will be minimized, avoided, and/or compensated. Water diversion at the NDDs occur through screens meeting agency criteria, including approach velocity of 0.2 ft/s to minimize potential effects on Delta Smelt. The impairment associated with in-water construction activities will be minimized through avoidance and minimization measures. The impairment associated with permanent placement of in-water structures at the NDD will be offset with shallow water habitat at a 5:1 ratio for the intakes and their wing walls, plus the acreage associated with the in-water construction disturbance and a 1,000-foot-downstream suspended sediment effect (28 acres in total). In addition, the potential for reduced access to critical habitat upstream of the NDD because of conversion of low-velocity habitat to high-velocity screen face will be mitigated with restoration of 245 acres of shallow water habitat, of which 108 acres will be sandy beach habitat (representing a 3:1 mitigation ratio for the potential loss of access to 36 acres of existing shallow water sandy beach habitat). In-water effects from construction and facility footprints at the HOR gate and barge landings will be offset by habitat restoration in the form of tidal perennial habitat restoration (74.7 acres in total, representing a 3:1 mitigation ratio).

Continued operation of the south Delta export facilities will be at a lower rate than exists under the NAA, generally resulting in less potential for effects to PCE 3 (river flow); management of Old and Middle River flows in similar ways to those currently in place under the USFWS (2008) BiOp would minimize the potential for adverse effects on PCE 3. Inclusion of the fall X2 criteria from the USFWS (2008) BiOp in the PA would minimize the potential for adverse effects to PCE 4 (low salinity zone) during the important juvenile rearing period, and the general similarity of low salinity zone conditions throughout the year between NAA and PA would minimize effects on PCE 4 for the other life stages.

7.8 Riparian Brush Rabbit

There is minimal potential for the PA to affect riparian brush rabbit. There is no potentially suitable habitat for riparian brush rabbit within the PA construction footprint, and there is not likely to be suitable habitat within 1,260 feet of the HOR gate construction site.

Avoidance and minimization measures require that construction activity be confined to existing disturbed areas. These avoidance and minimization measures will avoid harm or harassment of riparian brush rabbit. Suitable riparian brush rabbit habitat is not expected to be present within 1,260 feet from the HOR gate construction site. At this distance, noise and light associated with construction activity may be perceived by the brush rabbit, but will only slightly exceed background levels and thus is not expected to alter essential behaviors that affect foraging, reproduction, predation risk, etc. Avoidance and minimization measures require that the area within 1,260 feet of riparian brush rabbit habitat be surveyed to confirm there is no suitable habitat in the vicinity of HOR gate related activities – if habitat exists in this area, measures will be implemented to reduce noise and light to the extent that it will not be expected to alter essential behaviors that affect foraging, reproduction, predation risk. Thus the PA may affect, is not likely to adversely affect riparian brush rabbit.

Critical habitat has not been designated for riparian brush rabbit.

7.9 San Joaquin Kit Fox

7.9.1 Determination of Effects to San Joaquin Kit Fox

Overall effects of the PA on San Joaquin kit fox breeding, foraging, and dispersal habitat are less than 50 acres, and will be offset with protection and restoration of habitat. The PA may affect San Joaquin kit fox based on the following.

- Project related activities will occur within and adjacent to San Joaquin kit fox modeled habitat.

- San Joaquin kit fox presence has been detected in the vicinity of the PA, within grassland landscape south of Brentwood, with the most recent sighting in the late 1990s. The species has not been detected, nor is it expected to occur, elsewhere within the action area.

- Protection of San Joaquin kit fox habitat will beneficially affect the species.

The PA is likely to adversely affect the San Joaquin kit fox as follows.

- Harm could result from the permanent loss of 47 acres of San Joaquin kit fox modeled habitat potentially occupied by the species.

- Harm could occur as a result of use of land clearing and construction equipment, vehicular transportation, storage of equipment onsite, and other construction, operations, and maintenance related activities.

- Harassment could result from noise, lighting, or other human disturbances, which could affect San Joaquin kit fox during construction, operations, and maintenance.

These adverse effects will be minimized through implementation of minimization and avoidance measures to reduce the risk of injury, mortality, and harassment of individuals, and offset by the protection or restoration of up to 141 acres of habitat based on current project impact estimates.

Thus the PA may affect, is likely to adversely affect the San Joaquin kit fox.

7.9.2 Cumulative Effects and Changing Baseline

Potential cumulative effects on San Joaquin kit fox in the action area include habitat loss and impairment, primarily through conversion of rangeland to more developed land uses. This is not likely to be extensive, due to existing constraints upon land use changes, e.g. via existing or developing habitat conservation plans that cover much of the range of San Joaquin kit fox in the action area. In particular the habitat in the action area with the highest likelihood of supporting San Joaquin kit fox is within the plan area of the East Contra Costa County HCP/NCCP, where large scale conservation efforts are being implemented that will benefit the species.

Changing baseline effects are also likely to alter habitat conditions for San Joaquin kit fox between now and the conclusion of the PA. The principal such effects concern climate change. Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for San Joaquin kit fox, with potential adverse effects upon species status in the action area.

7.9.3 Determination of Effects to San Joaquin Kit Fox Designated Critical Habitat

Critical habitat has not been designated for the San Joaquin kit fox.

7.10 California Least Tern

There is minimal potential for the PA to affect California least tern. The PA will result in permanent loss of 269 acres of open water that constitutes modeled California least tern foraging habitat, but a Clifton Court Forebay modifications will result in a gain of 677 acres of foraging habitat, for a net gain of 408 acres of habitat. Dredging will temporarily disturb another 1,930 acres. The proposed construction activities are located at least 20 miles from the nearest known or recently active California least tern nesting locations. Typically, foraging habitat for California least tern is located within 2 miles of their colonies (Atwood and Minsky 1983), so the foraging habitat that will be lost to construction is rarely or never used. Furthermore, foraging habitat in the region (San Francisco Bay and the action area) is abundant and is not considered limiting for California least tern (e.g., there are 61,751 acres of modeled foraging habitat in the action area). Therefore, in consideration of the amount of available foraging habitat in the action area and its distance from known nesting sites, the total permanent and temporary foraging habitat loss due to the PA is insignificant. For these reasons, the PA is may affect, is not likely to adversely affect California least tern.

Critical habitat has not been designated for California least tern.

7.11 Western Yellow-Billed Cuckoo

7.11.1 Determination of Effects to Western Yellow-Billed Cuckoo

Overall effects of the PA on western yellow-billed cuckoo include loss of 32 acres of habitat, and will be offset with restoration of its habitat. The PA may affect western yellow-billed cuckoo based on the following.

- Project related activities will occur within and adjacent to western yellow-billed cuckoo modeled habitat.
- Migratory western yellow-billed cuckoos have been detected in the action area in recent years.
- Restoration of western yellow-billed cuckoo habitat will beneficially affect the species.

The PA is likely to adversely affect the western yellow-billed cuckoo as follows.

- Harm could result from the permanent loss of 32 acres of modeled western yellow-billed cuckoo migratory habitat.

These adverse effects will be minimized through implementation of minimization and avoidance measures to reduce the risk of injury, mortality, and harassment of individuals, and offset by the protection or restoration of up to 64 acres of suitable habitat based on current project impact estimates.

Thus the PA may affect, is likely to adversely affect the western yellow-billed cuckoo.

7.11.2 Cumulative Effects and the Changing Baseline

Potential cumulative effects on western yellow-billed cuckoo in the action area include habitat loss and fragmentation, and predation from introduced and native species. Habitat loss and fragmentation could result from conversion of riparian habitat to alternative cover types, which is not likely to be extensive due to existing constraints emplaced to protect riparian natural communities. Predation by existing introduced and native species is likely to be maintained at levels comparable to current conditions; the introduction of new predators or parasites is possible, but not foreseeable; nor are the consequences of such an introduction. These effects will tend to slightly impair habitat quality for western yellow-billed cuckoo in the action area, but their net effect is to approximately maintain current conditions for the foreseeable future. These cumulative effects have little potential to impair the effectiveness of avoidance and minimization measures described in the PA, nor are they expected to alter the efficacy of offsetting measures in the PA such as habitat creation and restoration.

Changing baseline effects are also likely to alter habitat conditions for western yellow-billed cuckoo between now and the conclusion of the PA. The principal such effects concern climate change. Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include sea level rise, reduced Sierra Nevada winter snowpack, warmer water temperatures, and increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for western yellow-billed cuckoo, e.g. by increasing the frequency of flood disturbance in riparian habitat and thus scouring and clearing areas of habitat temporarily, and potentially increasing the fragmentation of that habitat.

7.11.3 Determination of Effects to Western Yellow-Billed Cuckoo Designated Critical Habitat

There is no designated western yellow-billed cuckoo critical habitat in the action area.

7.12 Giant Garter Snake

7.12.1 Determination of Effects to Giant Garter Snake

Overall effects of the PA on giant garter snake and its habitat are minor and temporary, and will be offset with protection and restoration of its habitat. The PA may affect the giant garter snake based on the following.

- Project related activities will occur within and adjacent to giant garter snake modeled habitat.
- Giant garter snake presence has been recorded in the vicinity of areas proposed for clearing and construction.
- Protection and restoration of giant garter snake habitat will beneficially affect the species.

The PA is likely to adversely affect the giant garter snake as follows.

- Harm could result from the loss of 205 acres of aquatic habitat and 570 acres of upland habitat potentially occupied by the species.
- Harm could occur as a result of use of land clearing and construction equipment, vehicular transportation, and other construction, operations, and maintenance related activities.
- Harassment could result from noise, lighting, and vibrations, or other human disturbance adjacent to occupied giant garter snake habitat during construction, operations, and maintenance.

These adverse effects will be minimized and offset through implementation of minimization and avoidance measures to reduce the risk of harm or harassment of individuals, and by the protection or restoration of aquatic and upland habitat in the amounts and according to the mitigation ratios detailed in Table 3.4-4, *Compensation for Direct Effects on Giant Garter Snake Habitat*.

Thus the PA may affect, is likely to adversely affect the giant garter snake.

7.12.2 Cumulative Effects and the Changing Baseline

Potential cumulative effects on giant garter snake in the action area include habitat loss and fragmentation, changes in agricultural and land management practices, predation from introduced and native species, and water pollution. Both habitat loss and fragmentation, and changes in land management practices, could result from conversion of agricultural land to more developed land uses, which is not likely to be extensive due to existing constraints upon land use changes; or from conversion of agricultural land to different crop types having lower habitat suitability, which is not foreseeable. Predation by existing introduced and native species is likely to be maintained at levels comparable to current conditions; the introduction of new predators or parasites is possible, but not foreseeable; nor are the consequences of such an introduction. Water pollution effects could result from a variety of causes, including agricultural practices, increased urbanization, and wastewater treatment plants. Effects associated with agricultural practices are likely to be maintained, because the action area is already fully developed with regard to agricultural land uses, and regulations in place constrain the associated water quality effects. Water quality effects of urbanization include point and nonpoint-source water quality impairments, and there is a potential for those effects to further degrade water quality as further urbanization occurs in the action area. Wastewater treatment plants also contribute to impaired water quality, but significant improvements in discharge water quality and reductions in discharge water volume have occurred in recent years, primarily in response to regulatory and economic factors increasing the value of reusable water; thus this stressor is likely to diminish over time. Some of these effects will improve, and others will impair habitat quality for giant garter snake in the action area; their net effect is to approximately maintain current conditions for the foreseeable future. These cumulative effects have little potential to impair the effectiveness of avoidance and minimization measures described in the PA, nor are they expected to alter the efficacy of offsetting measures in the PA such as habitat creation and restoration.

Changing baseline effects are also likely to alter habitat conditions for giant garter snake between now and the conclusion of the PA. The principal such effects concern climate change. Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include sea level rise, reduced Sierra Nevada winter snowpack, warmer water temperatures, and increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for giant garter snake, and also to increase the potential for year-to-year fluctuations in population sizes, with potential adverse effects upon species status in the action area.

7.12.3 Determination of Effects to Giant Garter Snake Designated Critical Habitat

Critical habitat has not been designated for the giant garter snake.

7.13 California Red-Legged Frog

7.13.1 Determination of Effects to California Red-Legged Frog

Overall effects of the PA on California red-legged frog and its habitat are minor and temporary, and will be offset with protection and restoration of its habitat. The PA may affect the California red-legged frog based on the following.

- Project related activities will occur within and adjacent to California red-legged frog modeled habitat.
- California red-legged frog presence has been recorded in the vicinity of areas proposed for clearing and construction.
- Protection and restoration of California red-legged frog habitat will beneficially affect the species.

The PA is likely to adversely affect the California red-legged frog as follows.

- Harm could result from the permanent loss of 51 acres of modeled upland cover and dispersal habitat (four of which would be outside the construction footprint but subject to vibrations within 75 feet of project activity) and 1 acre of modeled aquatic habitat potentially occupied by the species.
- Harm could occur as a result of use of land clearing and construction equipment, vehicular transportation, and other construction, operations, and maintenance related activities.
- Harassment could result from noise, lighting, and vibrations, and other human disturbance adjacent to occupied California red-legged frog habitat during construction, operations, and maintenance.

These adverse effects will be minimized and offset through implementation of minimization and avoidance measures to reduce the risk of harm or harassment of individuals, and by the protection or restoration of up to 153 acres of upland habitat and 3 acres of aquatic habitat based on current project impact estimates.

Thus the PA may affect, is likely to adversely affect the California red-legged frog.

7.13.2 Cumulative Effects and the Changing Baseline

Potential cumulative effects on California red-legged frog in the action area include habitat loss and impairment, primarily through conversion of rangeland to more developed land uses. This is not likely to be extensive, due to existing constraints upon land use changes, e.g. via existing or developing habitat conservation plans that cover much of the range of California red-legged frog in the action area. In particular the habitat in the action area with the highest likelihood of supporting California red-legged frog is within the plan area of the East Contra Costa County HCP/NCCP, where large scale conservation efforts are being implemented that will benefit the species.

Changing baseline effects are also likely to alter habitat conditions for California red-legged frog between now and the conclusion of the PA. The principal such effects concern climate change. Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for California red-legged frog, with potential adverse effects upon species status in the action area.

7.13.3 Determination of Effects to California Red-Legged Frog Designated Critical Habitat

No California red-legged frog critical habitat occurs in the action area. The closest occurrence of critical habitat is approximately 0.5 miles from the nearest construction activity area. Because there is no California red-legged frog critical habitat in the action area, the PA will have no effect on California red-legged frog critical habitat.

7.14 California Tiger Salamander

7.14.1 Determination of Effects to California Tiger Salamander

Overall effects of the PA on California tiger salamander and its habitat are minor and temporary, and will be offset with protection and restoration of its habitat. The PA may affect the California tiger salamander based on the following.

- Project related activities will occur within and adjacent to California tiger salamander modeled habitat.
- California tiger salamander presence has been recorded in the vicinity of areas proposed for clearing and construction.
- Protection and restoration of California tiger salamander upland cover and aestivation habitat will beneficially affect the species.

The PA is likely to adversely affect the California tiger salamander as follows.

- Harm could result from the permanent loss of 50 acres of terrestrial cover and aestivation habitat (three acres of which would be outside the construction footprint but subject to vibrations resulting from construction activities within 75 feet) potentially occupied by the species.
- Harm could occur as a result of use of land clearing and construction equipment, vehicular transportation, and other construction, operations, and maintenance related activities.
- Harassment could result from noise, lighting, vibrations, and other human disturbance adjacent to occupied California tiger salamander upland cover and aestivation habitat during construction, operations, and maintenance.

These adverse effects will be minimized and offset through implementation of minimization and avoidance measures to reduce the risk of harm or harassment of individuals, and by the protection or restoration of up to 150 acres of upland cover and aestivation habitat based on current project impact estimates.

Thus the PA may affect, is likely to adversely affect the California tiger salamander.

7.14.2 Cumulative Effects and the Changing Baseline

Potential cumulative effects on California tiger salamander in the action area include habitat loss and impairment, primarily through conversion of rangeland to more developed land uses. Unauthorized take as a result of urbanization is unlikely where most of the habitat occurs west of CCF because urbanization within the cities of Brentwood, Pittsburg, Oakley, and Clayton is covered by the East Contra Costa County HCP/NCCP. Urban development outside these incorporated cities (i.e., in the jurisdiction of Contra Costa County) is not covered by the East Contra Costa County HCP/NCCP. Although unlikely to occur due to land use controls, if urban development was proposed in or near the community of Byron it could have an adverse effect on California tiger salamander in the action area.

Changing baseline effects are also likely to alter habitat conditions for California tiger salamander between now and the conclusion of the PA. The principal such effects concern climate change. Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for California tiger salamander, with potential adverse effects upon species status in the action area.

7.14.3 Determination of Effects to California Tiger Salamander Designated Critical Habitat

Critical habitat for California tiger salamander occurs in the Jepson Prairie area and overlaps with the action area near the terminus of Lindsey Slough, west of Rio Dixon Road. There are no water conveyence facility construction activities proposed in this region, however, tidal restoration could occur in the Cache Slough and Lindsey Slough area. Avoidance and minimization measures require tidal restoration projects be designed to avoid areas within 250 feet of any of the 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 affect these PCEs.

In conclusion, the PA is not likely to adversely affect California tiger salamander critical habitat for the following reasons.

- No water conveyance facilities will be constructed in any designated critical habitat unit.
- Tidal restoration associated with mitigation for impacts to other species or habitats will be designed to avoid areas within 250 feet of California tiger salamander PCEs in the critical habitat unit, or a lesser distance with concurrence from USFWS that the restoration will not adversely affect any PCEs for this species.
- No other restoration, management, or enhancement activities will occur in the critical habitat unit without prior concurrence from USFWS that such activity will not adversely affect any PCEs for this species.

7.15 Valley Elderberry Longhorn Beetle

7.15.1 Determination of Effects to Valley Elderberry Longhorn Beetle

Overall effects of the PA on valley elderberry longhorn beetle and its habitat are minor and temporary, and will be offset with restoration of its habitat. The PA may affect the valley elderberry longhorn beetle based on the following.

- Project related activities will occur within and adjacent to valley elderberry longhorn beetle modeled habitat.
- Protection of riparian habitat suitable and managed for elderberry shrubs and planting of elderberry seedlings and associated natives in conservations areas will beneficially affect the species.

The PA is likely to adversely affect the valley elderberry longhorn beetle as follows.

- Harm could result from the removal of an estimated 107 elderberry shrubs with an estimated 2,121 stems that are greater than 1 inch in diameter. The PA will result in the permanent loss of 276 acres of modeled valley elderberry longhorn beetle habitat including 227 acres of modeled grassland habitat and 49 acres of modeled riparian habitat.
- Harm could also result from the deposition of dust and other airborne construction related particulate matter on elderberry shrubs, which could stress and damage shrubs resulting in effects on valley elderberry longhorn beetle.

- Harm could occur as a result of transplanting shrubs that are occupied and the operation of equipment in the vicinity of occupied shrubs if adults are actively dispersing between shrubs.
- Harassment could result from lighting, dust, and other disturbances adjacent to occupied valley elderberry longhorn beetle habitat during construction, operations, and maintenance.

These adverse effects will be minimized and offset through implementation of minimization and avoidance measures to reduce the risk of injury, mortality, and harassment of individuals, and by the restoration of up to an estimated 79 acres of habitat dedicated to the planting of elderberry seedlings and associated natives, as well as the transplanting of an estimated up to 83 shrubs based on current project impact estimates.

Thus the PA may affect, is likely to adversely affect the valley elderberry longhorn beetle.

7.15.2 Cumulative Effects and the Changing Baseline

Potential cumulative effects on valley elderberry longhorn beetle in the action area include habitat loss and impairment, primarily through conversion of rangeland to more developed land uses. Although unlikely to occur due to land use controls, such development could have an adverse effect on valley elderberry longhorn beetle in the action area.

Changing baseline effects are also likely to alter habitat conditions for valley elderberry longhorn beetle between now and the conclusion of the PA. The principal such effects concern climate change. Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for valley elderberry longhorn beetle, with potential adverse effects upon species status in the action area. The environmental baseline for valley elderberry longhorn beetle may also be affected by future habitat protection and restoration efforts in the Delta that may protect existing habitat or create new habitat, e.g. by restoration of riparian corridors along Delta waterways.

7.15.3 Determination of Effects to Valley Elderberry Longhorn Beetle Designated Critical Habitat

Critical habitat has been designated for valley elderberry longhorn beetle, but does not occur within the action area. The proposed action will have no effect on designated critical habitat for valley elderberry longhorn beetle.

7.16 Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

7.16.1 Determination of Effects to Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp

Overall effects of the PA on vernal pool fairy shrimp and vernal pool tadpole shrimp, and their habitat, are minor and temporary, and will be offset with protection and restoration of their habitat. The PA may affect the vernal pool fairy shrimp and vernal pool tadpole shrimp based on the following.

- Project related activities will occur within and adjacent to vernal pool fairy shrimp and vernal pool tadpole shrimp modeled habitat.
- Protection and restoration of vernal pool fairy shrimp and vernal pool tadpole shrimp will benefit the species.

The PA is likely to adversely affect the vernal pool fairy shrimp and vernal pool tadpole shrimp as follows.

- Harm could result from the permanent loss of 6 acres of modeled habitat for the species.
- Harm could result from altering the hydrology of vernal pool fairy shrimp and vernal pool tadpole shrimp habitat within 250 feet of construction areas, which could reduce the hydroperiod of affected habitat, making it less suitable for the species.
- Harm could occur as a result of changes to water quality in watersheds that support vernal pool fairy shrimp and vernal pool tadpole shrimp habitat.

These adverse effects will be minimized and offset through implementation of minimization and avoidance measures to reduce the risk of injury, mortality, and the conversion of habitat, and by the protection or restoration of habitat. If an existing mitigation bank were used to offset effects, up to 12 acres of habitat restoration credits would be provided. If DWR were to select a non-bank site, habitat losses would be offset by protection of up to 18 acres of existing habitat, based on current project impact estimates.

Thus the PA may affect, is likely to adversely affect the vernal pool fairy shrimp and vernal pool tadpole shrimp.

7.16.2 Cumulative Effects and the Changing Baseline

Potential cumulative effects on vernal pool fairy shrimp and vernal pool tadpole shrimp in the action area include habitat loss and impairment, primarily through conversion of vernal pool or degraded vernal pool natural communities to more developed land uses. This is unlikely to occur due to regulatory prohibitions on such activity. If it were to occur, for example via unauthorized actions, such development could have an adverse effect on vernal pool fairy shrimp and vernal pool tadpole shrimp in the action area.

Changing baseline effects are also likely to alter habitat conditions for vernal pool fairy shrimp and vernal pool tadpole shrimp between now and the conclusion of the PA. The principal such effects concern climate change. Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for vernal pool fairy shrimp and vernal pool tadpole shrimp, with potential adverse effects upon species status in the action area. The environmental baseline for vernal pool fairy shrimp and vernal pool tadpole shrimp may also be affected by future habitat protection and restoration efforts in the Delta that may protect existing habitat or create new habitat.

7.16.3 Determination of Effects to Vernal Pool Fairy Shrimp and Vernal Pool Tadpole Shrimp Designated Critical Habitat

A critical habitat unit for vernal pool fairy shrimp occurs to the west of Clifton Court Forebay and overlaps with two RTM storage areas. As discussed in Section 6.10.11, *Effects on Critical Habitat*, the wetland delineation prepared by DWR did not identify any modeled vernal pools or alkali seasonal wetland within these RTM footprints. However, two vernal pools occurring in the critical habitat unit may be indirectly affected by one of the RTM storage areas areas and therefore the PA is likely to adversely affect critical habitat for the vernal pool fairy shrimp. However, the PA will not appreciably diminish the value of the designated critical habitat to conservation due to the implementation of avoidance and minimization measures. In addition, to further address effects associated with facilities construction, operation, and maintenance within designated critical habitat, the PA includes implementation of restoration measures.

There is no designated critical habitat for vernal pool tadpole shrimp in the action area. Because there is no vernal pool tadpole shrimp critical habitat in the action area, the PA will have no effect on vernal pool tadpole shrimp critical habitat.

7.17 Least Bell's Vireo

7.17.1 Determination of Effects to Least Bell's Vireo

Overall effects of the PA on least Bell's vireo will include removal of 32 acres of habitat, and will be offset with restoration of 64 acres of its habitat. The PA may affect least Bell's vireo based on the following.

- Project related activities will occur within and adjacent to least Bell's vireo habitat.
- Least Bell's vireos have been detected near the action area in recent years.
- Restoration of least Bell's vireo habitat will beneficially affect the species.

The PA is likely to adversely affect the least Bell's vireo as follows.

- Harm could result from the permanent loss of 32 acres of least Bell's vireo habitat.

These adverse effects will be minimized through implementation of minimization and avoidance measures to reduce the risk of injury, mortality, and harassment of individuals, and offset by the protection or restoration of 64 acres of suitable habitat based on current project impact estimates.

Thus the PA may affect, is likely to adversely affect the least Bell's vireo.

7.17.2 Cumulative Effects and the Changing Baseline

Potential cumulative effects on least Bell's vireo in the action area include habitat loss and fragmentation, and predation from introduced and native species. Habitat loss and fragmentation could result from conversion of riparian habitat to alternative cover types, which is not likely to be extensive due to existing constraints emplaced to protect riparian natural communities. Predation by existing introduced and native species is likely to be maintained at levels comparable to current conditions; the introduction of new predators or parasites is possible, but not foreseeable; nor are the consequences of such an introduction. These effects will tend to slightly impair habitat quality for least Bell's vireo in the action area, but their net effect is to approximately maintain current conditions for the foreseeable future. These cumulative effects have little potential to impair the effectiveness of avoidance and minimization measures described in the PA, nor are they expected to alter the efficacy of offsetting measures in the PA such as habitat creation and restoration.

Changing baseline effects are also likely to alter habitat conditions for least Bell's vireo between now and the conclusion of the PA. The principal such effects concern climate change. Foreseeable climate change effects, described in Section 4.3.2.1, *Climate Conditions*, include sea level rise, reduced Sierra Nevada winter snowpack, warmer water temperatures, and increased climate variability as seen in changes such as more severe winter storms, more intense droughts, larger floods, etc. These effects will tend to impair habitat quality and quantity for least Bell's vireo, e.g. by increasing the frequency of flood disturbance in riparian habitat, and potentially increasing the fragmentation of that habitat.

7.17.3 Determination of Effects to Least Bell's Vireo Designated Critical Habitat

There is no designated least Bell's vireo critical habitat in the action area.

7.18 Conclusion

Reclamation has analyzed the effects of the Proposed Action using the best available science and has made the following effects determinations (Table 7-1).

Table 7-1. Determination of Effects for Species Addressed in This BA

Common and Scientific Names	Scientific Name	Jurisdiction	Status	Effect Determination
Chinook salmon, Sacramento River winter-run ESU	*Oncorhynchus tshawytscha*	NMFS	Endangered	Species: May affect, likely to adversely affect Critical Habitat: Likely to adversely affect
Chinook salmon, Central Valley spring-run ESU	*Oncorhynchus tshawytscha*	NMFS	Threatened	Species: May affect, likely to adversely affect Critical Habitat: Likely to adversely affect
Steelhead, California Central Valley DPS	*Oncorhynchus mykiss*	NMFS	Threatened	Species: May affect, likely to adversely affect Critical Habitat: Likely to adversely affect
Green sturgeon, southern DPS	*Acipenser medirostris*	NMFS	Threatened	Species: May affect, likely to adversely affect Critical Habitat: Likely to adversely affect
Killer whale, Southern Resident DPS	*Orcinus orca*	NMFS	Endangered	Species: May affect, not likely to adversely affect Critical Habitat: Not likely to adversely affect
Delta Smelt	*Hypomesus transpacificus*	USFWS	Threatened	Species: May affect, likely to adversely affect Critical Habitat: Likely to adversely affect
Riparian brush rabbit	*Sylvilagus bachmani riparius*	USFWS	Endangered	Species: May affect, not likely to adversely affect Critical Habitat: Not designated
San Joaquin kit fox	*Vulpes macrotis mutica*	USFWS	Endangered	Species: May affect, likely to adversely affect Critical Habitat: Not designated
California least tern	*Sternula antillarum browni*	USFWS	Endangered	Species: May affect, not likely to adversely affect Critical Habitat: Not designated
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	USFWS	Threatened	Species: May affect, likely to adversely affect Critical Habitat: Not in action area
Giant garter snake	*Thamnophis gigas*	USFWS	Threatened	Species: May affect, likely to adversely affect Critical Habitat: Not designated
California red-legged frog	*Rana draytonii*	USFWS	Threatened	Species: May affect, likely to adversely affect Critical Habitat: Not in action area
California tiger salamander	*Ambystoma californiense*	USFWS	Threatened	Species: May affect, likely to adversely affect Critical Habitat: Not likely to adversely affect
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	USFWS	Threatened	Species: May affect, likely to adversely affect Critical Habitat: Not in action area
Vernal pool fairy shrimp	*Branchinecta lynchi*	USFWS	Threatened	Species: May affect, likely to adversely affect Critical Habitat: Likely to adversely affect
Vernal pool tadpole shrimp	*Lepidurus packardi*	USFWS	Endangered	Species: May affect, likely to adversely affect Critical Habitat: Not in action area
Least Bell's vireo	*Vireo pusillus*	USFWS	Endangered	Species: May affect, likely to adversely affect Critical Habitat: Not in action area
Salt Marsh harvest mouse[a]	*Reithrodontomys raviventris*	USFWS	Endangered	Species: May affect, not likely to adversely affect Critical Habitat: not designated

Common and Scientific Names	Scientific Name	Jurisdiction	Status	Effect Determination
California clapper rail[a]	*Rallus longirostris obsoletus*	USFWS	Endangered	Species: May affect, not likely to adversely affect Critical Habitat: not designated
Soft bird's beak[a]	*Chloropyron molle* ssp. *molle*	USFWS	Endangered	Species: May affect, not likely to adversely affect Critical Habitat: Not likely to adversely affect
Suisun thistle[a]	*Cirsium hydrophilum* var. *hydrophilum*	USFWS	Endangered	Species: May affect, not likely to adversely affect Critical Habitat: Not likely to adversely affect

DPS = distinct population segment
ESU = evolutionarily significant unit

[a] The effects determinations for these species are described in Appendix 6.C, *Suisun Marsh Species.*

7.18.1 References

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