Part III

Revisions to the DEIR

PART III REVISIONS TO THE DEIR

Part III contains revisions to the DEIR following the public review process. The DEIR is presented in its entirety, with revisions to text shown in Microsoft Word tracked changes, which is presented as a strikethrough or underline. Text shown with a ~~strikethrough~~ (~~strikethrough~~) has been deleted from the DEIR. Text that has been added is presented as single underlined (underlined).

There are no revisions to DEIR Chapters 4.1, 4.2, 4.3, or 7. Updates to DEIR Chapters 1, "Summary," 2, "Introduction," and 3, "Project Description," include editorial and consistency revisions. Updates to DEIR Chapter 4.4, "Aquatic Resources," include similar editorial and consistency revisions, as well as additional analytical discussion of operations-related effects on Chinook Salmon rearing, effects of water transfers on all special status fish species evaluated in the DEIR, Delta Smelt Summer-Fall habitat, Longfin Smelt Outflow-Abundance, and Longfin Smelt larval entrainment. Updates to Chapter 5 include more detailed impact analysis conducted for Refined Alternative 2b to match the level of analyses completed for the DEIR's Proposed Project. Chapter 6, "References," was modified in response to the updates previously described. Updated and supplemental technical studies are also included in Appendices C, E, F, H, J, and K.

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Draft Environmental Impact Report
for
Long-Term Operation of the California State Water Project

State Clearinghouse No. 2019049121

State of California
Department of Water Resources

November 22, 2019

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for
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Acronyms and Other Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
AB 52	Assembly Bill 52
ACID	Anderson–Cottonwood Irrigation District
AF	acre-feet
AFSP	Anadromous Fish Screen Program
AFY	acre-feet per year
Ag	agriculture
AMP	Adaptive Management Plan
ANN	artificial neural network
ARB	Air Resources Board
ARIS	Adaptive Resolution Imaging Sonar
AT	acoustic tag
B.P.	Before Present
BAFF	bio-acoustic fish fence
Banks Pumping Plant	Harvey O. Banks Pumping Plant
Bay Study	San Francisco Bay Study
Bay-Delta	San Francisco Bay/Sacramento–San Joaquin Delta
BDCP	Bay Delta Conservation Plan
BiOp	Biological Opinion
BMP	best management practice
BSPP	Barker Slough Pumping Plant
CAEP	Classroom Aquarium Education Project
CAISMP	California Aquatic Invasive Species Management Plan
CAL/OSHA	California Occupational Safety and Health Administration
CalEPA	California Environmental Protection Agency
CalRecycle	California Department of Resources Recycling and Recovery
Caltrans	California Department of Transportation
CAMT	Collaborative Adaptive Management Team
CAP	Climate Action Plan
CARB	California Air Resources Board
CCF	Clifton Court Forebay
CCR	California Code of Regulations
CCSB	Cache Creek Settling Basin
CCTAG	Climate Change Technical Advisory Group
CCWD	Contra Costa Water District
CDE	California Department of Education
CDFG	California Department of Fish and Game

CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CGS	California Geological Survey
CH_4	methane
CHP	California Highway Patrol
cm	centimeter(s)
cm TL	centimeters total length
CMIP5	Coupled Model Intercomparison Project 5
CNPS	California Native Plant Society
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
COA	Coordinated Operation Agreement
Council	Delta Stewardship Council
CRHR	California Register of Historical Resources
CRPR	California Rare Plant Ranks
CSAMP	Collaborative Science and Adaptive Management Program
CTC	California Transportation Commission
CTR	California Toxics Rule
CV RWQCB	Central Valley Regional Water Quality Control Board
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWA	Clean Water Act
CWT	coded-wire tag
D-1485	SWRCB Water Rights Decision 1485
D-1641	SWRCB Water Rights Decision 1641
D-893	SWRCB Water Rights Decision 893
dB	decibel(s)
dBA	A-weighted decibels
DBP	disinfection by-product
DBW	California Department of Boating and Waterways
DCC	Delta Cross Channel
DDT	dichlorodiphenyltrichloroethane
Delta	Sacramento–San Joaquin Delta
Delta Methylmercury TMDL	Sacramento–San Joaquin Delta Estuary Total Maximum Daily Load for Methylmercury
Delta Reform Act	Sacramento–San Joaquin Delta Reform Act of 2009

DMC	Delta–Mendota Canal
DO	dissolved oxygen
DOI	U.S. Department of the Interior
DPC	Delta Protection Commission
DPM	Delta Passage Model
DPR-DBW	Department of Parks and Recreation-Division of Boating and Waterways
DPS	Distinct Population Segment
DRS	Delta Research Station
DSC	Delta Stewardship Council
DSLCM	Delta Smelt Life Cycle Model
DSM2	Delta Simulation Model II
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
E/I	export/import
EBMUD	East Bay Municipal Utility District
EC	electrical conductivity
EchoWater	Sacramento Regional Wastewater Treatment Plant Facility Upgrade Project
EDCP	The Egeria Densa Control Program
EDSM	Enhanced Delta Smelt Monitoring Program
EFH	essential fish habitat
EID	El Dorado Irrigation District
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERP	Ecosystem Restoration Program
ERS	Estuarine Research Station
ESA	federal Endangered Species Act
ESU	Evolutionary Significant Unit
FBD	Fish Barrier Dam
FCCL	Fish Conservation and Culture Laboratory
FERC	Federal Energy Regulatory Commission
FESA	Federal Endangered Species Act
F-gases	fluorinated gases
FFGS	Floating Fish Guidance Structure
FHWA	Federal Highway Administration
FMS	Flow Management Standard
FMWT	Fall Midwater Trawl
FRPA	Fish Restoration Program Agreement

FRSA	Feather River Service Allocation
ft/sec	foot (or feet) per second
FTC	Fish Technology Center
GCID	Glenn Colusa Irrigation District
GHG	greenhouse gas
GSPs	Groundwater Sustainability Plans
GWP	Global warming potential
HAB	harmful algal bloom
HCP	habitat conservation plan
HFC	hydrofluorocarbon
HOR	Head of Old River
HORB	Head of Old River Barrier
HSC	Habitat Suitability Criteria
Hz	hertz
I	Interstate
IBU	in-basin use
ID	Irrigation District
IEP	Interagency Ecological Program
IPCC	Intergovernmental Panel on Climate Change
IS	initial study
ITP	Incidental Take Permit
ITS	incidental take statements
JPE	juvenile production estimate
JPOD	Joint Point of Diversion
km	kilometer
kWh	kilowatt-hour(s)
L_{eq}	equivalent sound level
LFC	Low Flow Channel
LFS	Longfin Smelt
L_{max}	maximum sound level
LMP	Land Management Plan
LSIWA	The Lower Sherman Island Wildlife Area
LSZ	low salinity zone
LTO	long-term operation
M&I	municipal and industrial
MAF	million acre-feet
MAST	Management Analysis and Synthesis Team
MCVD	mosquito and vector control district
MERP	Mercury Exposure Reduction Program
MFR	minimum flow requirements

mg/L	milligrams per liter
mgd	million gallons per day
MID	Modesto Irrigation District
MIDS	Morrow Island Distribution System
mm	millimeter(s)
mm TL	millimeters total length
mmhos/cm	millimhos per centimeter
MND	mitigated negative declaration
mS/cm	microsiemens per centimeter
MRV	junction of Middle River and the San Joaquin River
MWD	Metropolitan Water District
NAAQS	National Ambient Air Quality Standards
Natomas Mutual	Natomas Central Mutual Water Company
NBA	North Bay Aqueduct
NCCP	natural community conservation plan
Ne	effective population size
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
NPB	non-physical barrier
NO_2	nitrogen dioxide
NOD	Notice of Determination
NOP	Notice of Preparation
NO_X	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRA	National Recreation Area
NRHP	National Register of Historic Places
NSJCGBA	Northeastern San Joaquin County Groundwater Banking Authority
NTU	nephelometric turbidity units
O&M	operations and maintenance
OBI	Old River at Bacon Island
OCAP	Operations Criteria and Plan
OMR	Old and Middle River
ORV	junction of Old River and the San Joaquin River
PCB	polychlorinated biphenyl
PFC	perfluorinated chemicals
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas and Electric Company
PM	particulate matter
PM_{10}	PM equal to or less than 10 micrometers in diameter
$PM_{2.5}$	PM equal to or less than 2.5 micrometers in diameter

POD	Pelagic Organism Decline
Porter-Cologne Act	Porter-Cologne Water Quality Control Act
ppt	parts per thousand
PRC	Public Resources Code
Proposed Project	Long-Term Operation of the Central Valley Project and State Water Project
PSL	pre-screen loss
psu	practical salinity units
PTM	Particle Tracking Model
PWA	Public Water Agencies
QWEST	Net flow on the San-Joaquin River at Jersey Point
RBDD	Red Bluff Diversion Dam
RCRA	Resource Conservation and Recovery Act
Reclamation	U.S. Bureau of Reclamation
RHJV	Riparian Habitat Joint Venture
RM	River Mile
ROC on LTO	Reinitiation of Consultation on the Coordinated Long-Term Operation
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
RPS	Renewables Portfolio Standard
RRDS	Roaring River Distribution System
RWQCB	Regional Water Quality Control Board
Sacramento County RSD	Sacramento County Regional Sanitation District
SAIL	Salmon and Sturgeon Assessment of Indicators by Life Stage
SB	Senate Bill
SBA	South Bay Aqueduct
SCHISM	Semi-implicit Cross-scale Hydroscience Integrated System Model
SCWA	Solano County Water Agency
SDM	Structured Decision Model
SF_6	sulfur hexafluoride
SFCWA	State and Federal Contractor’s Water Agency
SFE	San Francisco Estuary
SFPF	Skinner Fish Protective Facility
SGM	Sustainable Groundwater Management
SGMA	Sustainable Groundwater Management Act
SJRRP	San Joaquin River Restoration Program
SLCP	short-lived climate pollutant
SLDMWA	San Luis and Delta–Mendota Water Authority
SLS	Smelt Larva Survey
SMARA	Surface Mining and Reclamation Act

SMGB	State Mining and Geology Board
SMPA	Suisun Marsh Preservation Agreement
SMSCG	Suisun Marsh Salinity Control Gates
SNP	single-nucleotide polymorphism
SO_2	sulfur dioxide
SR	State Route
SRA	State Recreation Area
SJRGA	San Joaquin River Group Authority
SRWTP	Sacramento Regional Wastewater Treatment Plant
SSC	species of special concern
SSQP	Sacramento Stormwater Quality Partnership
SST	Salmonid Scoping Team
STARS	Survival, Travel Time, and Routing Simulation
State	State of California
SVP	Society of Vertebrate Paleontology
SWC	State Water Contractors
SWG	Smelt Working Group
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAF	thousand acre-feet
TBP	DWR South Delta Temporary Barrier Project
TCCA	Tehama-Colusa Canal Authority
TCD	temperature control device
TCR	tribal cultural resource(s)
TFCF	Tracy Fish Collection Facility
TID	Turlock Irrigation District
TL	total length
TMDL	Total Maximum Daily Load
TOC	total organic carbon
Trinity River ROD	Trinity River Mainstem Fishery Restoration Record of Decision
UC Davis	University of California, Davis
UCMP	University of California, Berkeley Museum of Paleontology
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UV	ultraviolet
UWFE	unstored water for export
WNV	West Nile Virus
WOMT	Water Operations Management Team

WQCP	Water Quality Control Plan
WSPP	Western Systems Power Pool
YBHR	Yolo Bypass Habitat Restoration
YBSHRFPP	Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
YOY	young-of-the-year

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1 SUMMARY

The California State Water Project (SWP) is a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants extending more than 700 miles—two-thirds the length of California. Planned, constructed, and operated by the Department of Water Resources (DWR), the SWP is the nation's largest state-built, multi-purpose, user-financed water project. It supplies water to more than 27 million people in Northern California, the Bay Area, the San Joaquin Valley, the Central Coast, and Southern California. SWP water also irrigates about 750,000 acres of farmland, mainly in the San Joaquin Valley. In addition to water supply, the SWP was designed to provide multiple benefits, including:

- Flood control – The flood of 1955, which submerged Yuba City, was the impetus for the construction of Lake Oroville.
- Power generation – The SWP produces hydroelectric power to operate pumping facilities required to move water from Northern to Southern California. The SWP sells power when it generates a surplus of electricity.
- Recreation – SWP lakes and reservoirs provide opportunities to swim, picnic, waterski, boat, fish, hike, bicycle, camp, and ride horses. Visitors are also welcome at three visitor centers located at Lake Oroville, San Luis Reservoir, and Pyramid Lake.
- Fish and wildlife habitat – The SWP is operated to protect fish and wildlife with fish hatcheries, fish screens and passages, mitigation agreements, fish surveys and monitoring, a fish salvage facility, habitat restoration, and restricted pumping schedules.

The SWP operates to balance the needs of water delivery and environmental protection. In cooperation with the federal Central Valley Project (CVP), DWR operates the SWP to limit salinity intrusion into the Sacramento-San Joaquin Delta and Suisun Marsh by supplementing freshwater outflows to the ocean and limiting water exports from the Delta during certain times of the year. The sustainability of California's water resources depends on the environmental health of the Sacramento-San Joaquin Delta.

The SWP is subject to multiple layers of State and federal regulation. The State of California regulates the SWP directly through the California Department of Fish and Wildlife (CDFW) under the California Endangered Species Act (CESA), and through the State Water Resources Control Board under California's Porter-Cologne Water Quality Control Act and California's implementation of the federal Clean Water Act. The State of California also has influence over various aspects of DWR's activities in managing the SWP through its boards and councils, including, but not limited to, the Delta Stewardship Council and Fish and Wildlife Commission. The federal government also regulates the SWP through implementation of the federal Endangered Species Act (ESA) by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service and through the authority of the U.S. Army Corps of Engineers over navigable waterways.

DWR works cooperatively with regulatory agencies to develop interim and long-term operations solutions that are responsive to state and federal law. DWR implements habitat restoration projects that preserve and protect special-status species affected by SWP operations. DWR also assesses, evaluates, and proposes solutions to improve system water management performance through improved operational agreements, economic analyses, and other methods.

Over the last decade, scientific knowledge about the Delta ecosystem and its relationship to water operations has grown, largely due to new science that has been developed through collaborative processes since the issuance of the existing ESA and CESA authorizations for current SWP operations. The Long-Term Operation of the ~~Central Valley Project and~~ State Water Project (~~Proposed P~~project)~~, which is the preferred alternative in this Draft Environmental Impact Report (DEIR),~~ incorporates this new science, as well as information about the current status of listed species, to develop updates to the long-term SWP operations. The operational updates are designed to minimize adverse environmental effects, particularly with respect to listed species and water quality, on accounting for operational restrictions based on species as well as on environmental conditions such as salinity and turbidity. For example, the Proposed Project would provide for pumping restrictions for the protection of listed species to be triggered in most water year types, which would be more often than under current project operations. The Proposed Project also would allow operational flexibility where appropriate, but would incorporate specific bounds providing for regulatory oversight, such as CDFW's ability to object to and stop operational adjustments related to entrainment when it determines that such operations would violate CESA. In addition, a State-organized adaptive management plan would evaluate the long-term SWP operations and identify a process to ensure continued operations are consistent with applicable legal requirements. The end result is a Proposed Project that is better tailored than the existing operational scenario to continue long-term SWP operations to provide environmental protection and meet water delivery needs.

This DEIR is intended to support DWR's decision regarding ongoing SWP operations and CDFW's issuance of a CESA Incidental Take Permit (ITP) under Section 2081 of the Fish and Game Code. It includes a robust analysis of the Proposed Project and considers actions that potentially could minimize environmental effects on long-term SWP operations. The DEIR also identifies other actions that are occurring in or affecting the Delta, such as ecosystem restoration projects and efforts under the Sacramento Valley Salmon Resiliency Strategy (SRS), to consider a broad perspective of cumulative impacts. Specifically, with respect to the SRS as identified in the cumulative impacts section, DWR reaffirms its commitment to participate in the SRS and to take multiple actions that are subject to separate full CEQA review before any project approvals. The DEIR evaluates the applicable resource areas and determines that, with respect to each resource area, the Proposed Project has either no impact or a less-than-significant impact on the environment. Because the Proposed Project would not result in any significant impacts, no mitigation is required under the California Environmental Quality Act (CEQA). Even though CEQA does not require mitigation, the EIR explains that DWR will propose mitigation to meet the legal standard under CESA to minimize and fully mitigate the take of listed species and discusses the mitigation measures that will be identified in DWR's application for an ITP. The DEIR also analyzes four project alternatives in addition to the "no project" alternative. Pursuant to CEQA, the DEIR includes sufficient information about each alternative to allow meaningful evaluation, analysis, and comparison with the Proposed Project.

1.1 PURPOSE OF THIS ENVIRONMENTAL IMPACT REPORT

This DEIR has been prepared to comply with the requirements of CEQA and the State CEQA Guidelines (Chapter 3 of Title 14, California Code of Regulations). As described in Section 15121(a) of the State CEQA Guidelines, an Environmental Impact Report (EIR) is a public information document that objectively assesses and discloses potential environmental impacts of a proposed project and identifies mitigation measures and alternatives to the proposed project that would reduce or avoid identified significant adverse environmental impacts. CEQA requires that lead, responsible, or trustee agencies consider the environmental consequences of projects over which they have discretionary authority.

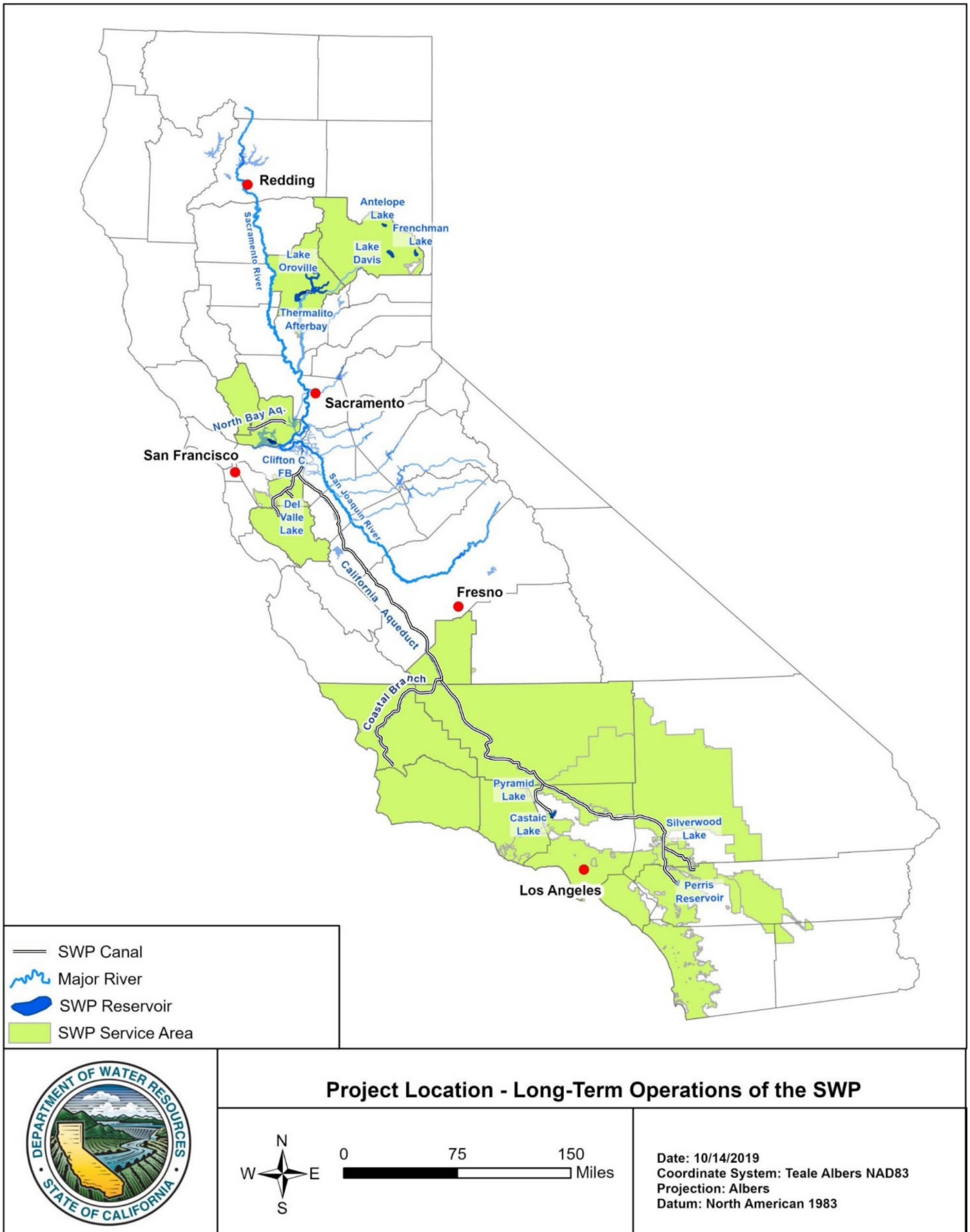
As the lead agency for the Proposed Project, DWR will use the information in this DEIR to evaluate the Proposed Project's potential environmental impacts; determine whether any feasible mitigation measures and alternatives are necessary and available to reduce potentially significant environmental impacts; and approve, modify, or deny approval of the Proposed Project. This document also may be used by CDFW, as a responsible agency as defined by CEQA, in its discretionary approval process and consideration to issue an ITP for the Proposed Project.

1.2 PROJECT BACKGROUND

The Proposed Project would continue DWR's ongoing, long-term SWP operations consistent with applicable laws, contractual obligations, and agreements. DWR proposes long-term operation of the SWP that will allow DWR to continue to store, divert, and convey water, in accordance with its existing water rights, to deliver water pursuant to water contracts and agreements up to full contract quantities. DWR is seeking to optimize water supply and improve operational flexibility while protecting fish and wildlife.

The project area includes existing SWP service areas and storage and export facilities located within the Sacramento-San Joaquin Delta (Delta) and vicinity. Figure 1-1 shows the project area in the context of SWP water facilities, service areas, and associated waterways.

DWR operates the SWP in coordination with the CVP, under the Coordinated Operation Agreement (COA) between the federal government and the State of California (authorized by Public Law 99–546). The CVP and SWP operate pursuant to water rights permits and licenses that are issued by the State Water Resources Control Board (SWRCB). The CVP and SWP water rights allow appropriation of water by directly using and/or diverting water to storage for later withdrawal and use or use and re-diversion to storage further downstream for later consumptive use. Among the conditions of those water rights are requirements for projects either to bypass or withdraw water from storage and to help satisfy specific water quality, quantity, and operations criteria in source rivers and within the Delta.



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Source: Data compiled by DWR in 2019

Figure 1-1. Long-Term SWP Operations Project Area

1.3 SUMMARY OF PROPOSED PROJECT

The Proposed Project would consist of multiple elements that are expected to characterize future operations of SWP facilities, would modify ongoing programs being implemented as part of SWP operations, would improve specific activities to enhance protection of special-status fish species, and would support ongoing studies and research on these special-status species to improve the basis of knowledge and management of these species. Implementation of these elements is intended to continue operation of the SWP and deliver up to the full contracted water amounts while minimizing and fully mitigating the take of listed species, in compliance with CESA requirements.

For discussion purposes in this DEIR, these elements are divided into four categories: (1) proposed SWP operations that can be described in detail and assessed on a project-level basis; (2) proposed SWP operations that can only be described generally and assessed on a program-level basis; (3) proposed environmental commitments or protective measures that would offset, reduce, or otherwise mitigate potential environmental impacts on special-status species, and (4) adaptive management actions that would include establishing a governance framework, a compliance and reporting program, and specific drought- and dry-year actions; establishing independent review panels; and conducting Four-Year Reviews of management measures.

Table 1-1 shows the Proposed Project's operations and actions.

Table 1-1. Proposed Project Elements – Table 1-1 a – Table 1-1 d

Table 1-1 a. Proposed Project Elements for Proposed Project-Level SWP Operations and Facilities

Facility or Action	Proposed Project Actions	Action Goal or Objective
Existing Regulatory Requirements	Comply with D-1641 and USACE Permit 2100.	Continue to comply with existing limits and permit requirements to protect water quality for the beneficial uses of fish and wildlife, agriculture and urban uses.
Minimum Export Rate	The combined CVP and SWP export rates at Jones Pumping Plant and Banks Pumping Plant will not be required to drop below 1,500 cfs.	Establish minimum export rate to protect human health and safety.
Old and Middle River Flow Requirements	Manage OMR reverse flows based on species distribution, modeling, and risk analysis, with provisions for capturing storm flows.	Implement real-time OMR management to minimize entrainment and aquatic species loss during water operations at Bank Pumping Plant.
Barker Slough Pumping Plant (BSPP)	Continue operating the BSPP to minimize effects on Delta Smelt and Longfin Smelt and continue implementing sediment removal and aquatic weed management actions as part of normal operations at Barker Slough Pumping Plant.	Implement actions as components of facility maintenance for continued water supply deliveries.
South Delta Temporary Barriers	Continue operation of three South Delta Temporary Barriers according to existing terms and conditions.	Maintain ongoing annual installation of three South Delta Temporary Barriers with goal of maintaining surface water levels and circulation) in the South Delta.

Facility or Action	Proposed Project Actions	Action Goal or Objective
Suisun Marsh Operations	Operate the Suisun Marsh Salinity Control Gates, Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall in compliance with D-1641.	Operate the Suisun Marsh Salinity Control Gate to improve habitat conditions for the benefit of Delta Smelt.
Delta Smelt Summer-Fall Habitat Action	Operate the Suisun Marsh Salinity Control Gate for up to 60 days (not necessarily consecutive) in June through October of below-normal, above-normal, and wet years. Project operations are to maintain a monthly average 2 ppt isohaline at 80 kilometers (km) from the Golden Gate Bridge in above normal and wet water years in September and October. Food enhancement actions similar to the North Delta Food Subsidies and Colusa Basin Drain project, and Suisun Marsh Food Subsidies (Roaring River distribution system reoperation).	Operate the Suisun Marsh Salinity Control Gate to improve Delta Smelt food supply and habitat.
North Delta Food Subsidies and Colusa Basin Drain Project	Facilitate downstream transport of phytoplankton and zooplankton to areas inhabited by Delta Smelt.	Implement actions to transport productivity downstream to where it can be utilized by Delta Smelt.

Table 1-1 b. Proposed Project Elements for Proposed Program-Level Changes to SWP Operations and Facilities

Facility or Action	Proposed Project Actions	Action Goal or Objective
Water Transfers	Water transfers would occur during an expanded water transfer window, between July through November, with volumes up to 600 TAF.	Increase SWP operational flexibility.

Table 1-1 c. Proposed Project Elements for Proposed Environmental Protective Measures

Facility or Action	Proposed Project Actions	Action Goal or Objective
Clifton Court Forebay	Continue implementing actions to reduce mortality of listed fish species at the Clifton Court Forebay; these measures would include: (a) continued evaluation of predator relocation methods; and (b) controlling aquatic weeds.	Increase species survival and control weeds to reduce impacts on the SWP's physical facilities (clogging screens) and predation reduction.
Skinner Fish Facility	Continue implementing studies to better understand and continuously improve the performance of the Skinner Fish Facility including: (a) changes to release site scheduling and rotation of release site locations to reduce post-salvage predation, and (b) continued refinement and improvement of the fish sampling and hauling procedures and infrastructure to improve the accuracy and reliability of data and fish survival.	Continue ongoing salvage fish at the Skinner Fish Facility and implement actions to reduce post-salvage predation and improve the accuracy and reliability of data and fish survival.
Longfin Smelt Science Program	DWR proposes to continue implementing studies to better understand LFS population distribution and abundance in San Francisco Bay and the Delta.	Implement study of environmental factors affecting LFS distribution and reproduction.

Facility or Action	Proposed Project Actions	Action Goal or Objective
Studies to support Establishment of a Delta Fish Hatchery	Conduct further studies to locate, design, construct, and operate a hatchery facility that would be capable of producing a substantial number of Delta Smelt and other Delta fish species for reintroduction to the Delta and recovery of the species populations.	Protect the species and provide resiliency.
Conduct Further Studies to Prepare for Delta Smelt Reintroduction from Stock Raised at the University of California, Davis Fish Conservation and Cultural Laboratory (FCCL)	Continue to support facilities and research to establish a Delta Smelt conservation population that is as genetically close as possible to the wild population and to provide a safeguard against extinction.	Protect the species and provide resiliency.
Additional elements related to real-time operation of the SWP	DWR proposes a governance structure for real-time operation of the SWP that includes compliance and performance reporting, monitoring, convening independent panels, drought and dry year actions, and Four-Year Reviews.	Advancements in science and minimization of effects of project operations.

Table 1-1 d. Proposed Project Elements for Adaptive Management Actions

Facility or Action	Proposed Project Actions	Action Goal or Objective
Adaptive Management Plan	The Adaptive Management Plan (AMP) will be carried out to evaluate the efficacy of the operations and activities stated below. An Adaptive Management Team (AMT) will be established to carry out this AMP. The AMT will oversee efforts to monitor and evaluate the operations and related activities. In addition, the AMT will use structured decision-making to assess the relative costs and benefits of those operations and activities. The AMT will also identify proposed adaptive management changes to those operations and activities. The AMP will be developed before issuance of, and could be incorporated into, the ITP DWR is seeking for CESA coverage for the Proposed Project.	The objectives of the AMP are to (1) continue the long-term operation of the SWP consistent with applicable laws, contractual obligations, and agreements and (2) ensure that the long-term operation of the SWP is consistent with CESA.

Notes:

AMP = Adaptive Management Plan
AMT = Adaptive Management Team
D-1641 = State Water Resources Control Board’s Water Rights Decision 1641
DWR = California Department of Water Resources
FCCL = Fish Conservation and Cultural Laboratory
km = kilometers
LFS = Longfin Smelt
OMR = Old and Middle River
ppt = parts per thousand
SWP = State Water Project
TAF = thousand acre-feet
USACE = U.S. Army Corps of Engineers

1.4 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

This DEIR presents an analysis of potential environmental impacts that would result from implementation of the Proposed Project. This analysis focuses on the following four environmental resource categories:

- Hydrology
- Surface Water Quality
- Aquatic Biological Resources
- Tribal Cultural Resources

The Initial Study, provided in Appendix A of this DEIR, concluded that the Proposed Project would not result in significant impacts on hydrology or surface water resources. However, because implementation of the Proposed Project would alter existing hydrology, such changes could result in impacts on resources dependent upon existing hydrologic conditions. These resources include water quality and aquatic biological resources.

To provide the reader with an understanding of the potential project impacts on water quality and aquatic biological resources, this DEIR presents a description of the existing hydrologic setting and compares it with the estimated hydrology associated with the Proposed Project in the following discussion.

This DEIR also addresses the potential for the Proposed Project to result in growth-inducing impacts that may result in secondary environmental impacts. Furthermore, this DEIR considers whether the Proposed Project would result in or contribute to significant, cumulative environmental impacts when combined with other past, present, and reasonably foreseeable future projects.

1.5 SUMMARY OF FINDINGS

Table 1-2 presents a summary of the environmental impact analysis findings for the Proposed Project presented in this DEIR. A detailed discussion of these findings, corresponding to each environmental resource topic, is presented in Section 4.2 Hydrology, Section 4.3 Surface Water Quality, Section 4.4 Aquatic Biological Resources, and Section 4.5 Tribal Cultural Resources.

Table 1-2. Summary of Impacts of the Proposed Project

Resource Topic	Impact Category	Significance of Impact	Mitigation Measures	Significance of Impact After Mitigation
Surface Water Hydrology	Changes to **surface water hydrology**. Changes in surface water hydrology, by themselves, are not considered significant environmental impacts based on California Environmental Quality Act (CEQA) Guidelines. However, changes to surface water hydrology may result in impacts on other secondary environmental resources evaluated in this DEIR.	No Impact	None Required	No Impact

Resource Topic	Impact Category	Significance of Impact	Mitigation Measures	Significance of Impact After Mitigation
Surface Water Quality	Changes to **salinity** in the Delta that exceed an established limit and results in an exceedance of any water quality standard or waste discharge requirement, or otherwise substantially degrade water quality	Less Than Significant Impact	None Required	Less Than Significant Impact
Aquatic Biological Resources	**Delta Smelt**	Less Than Significant Impact	None Required	Less Than Significant Impact
Aquatic Biological Resources	**Longfin Smelt**	Less Than Significant Impact	None Required	Less Than Significant Impact
Aquatic Biological Resources	**Winter-run Chinook Salmon**	Less Than Significant Impact	None Required	Less Than Significant Impact
Aquatic Biological Resources	**Spring-run Chinook Salmon**	Less Than Significant Impact	None Required	Less Than Significant Impact
Aquatic Biological Resources	Adverse effect on other aquatic federal- or state-listed species, recreationally or commercially important species, or other special-status species, including **Central Valley Steelhead, Green Sturgeon, White Sturgeon, Pacific Lamprey and River Lamprey, Native Minnows, Striped Bass, American Shad, Non-Native Freshwater Bass, or Killer Whales**	Less Than Significant Impact	None Required	Less Than Significant Impact
Tribal Cultural Resources	Cause a substantial adverse change in the significance of an identified **Tribal cultural resource** as defined in Public Resources Code 21074	No Impact	None Required	No Impact

Notes:
CEQA = California Environmental Quality Act
DEIR = Draft Environmental Impact Report

The summary of findings presented in Table 1-2 addresses aquatic biological resources based on the detailed evaluation of specific life stages for each species being assessed. These detailed life-stage evaluations, discussed in Section 4.4 of this DEIR, make up the basis for the species-level impact findings shown in Table 1-2.

The DEIR addresses the incremental contribution of the Proposed Project in combination with other related past, present, and future plans and projects. As discussed in Section 4.6.1, the DEIR finds that while ecological conditions in the Delta have been degraded because of past actions and activities, the Proposed Project's contribution to this cumulative impact is not cumulatively considerable, and the Proposed Project would not contribute to cumulatively significant impacts when viewed in combination with other reasonably foreseeable plans or projects.

The DEIR addresses the potential growth-inducing impacts of the proposed long-term SWP operations. As discussed in Section 4.6.2, while the Proposed Project has the potential to increase average annual water supply yields, any potential additional water supply would be within the historic range of water supply deliveries. In addition, any increase in water would be allocated between the 24 SWP water agencies south of the Delta and would not significantly increase water deliveries within areas serviced by these agencies. Thus, the Proposed Project would not remove a water-related obstacle to growth and would not induce growth in the areas served by SWP water agencies beyond what is already planned by the various local jurisdictions.

Because no significant impacts associated with implementation of the Proposed Project were identified, no CEQA mitigation measures are required.

1.6 AREAS OF CONTROVERSY

This section is included in this Summary as required by CEQA Guidelines 15123(b)(2). Numerous comments were received in response to the Notice of Preparation (NOP) that was issued at the onset of this DEIR preparation. Many of these comments identified various issues, including technical questions, procedural inquiries, and some matters that were found to be outside the scope of this analysis. Comments identified that were received in response to the NOP were considered in the preparation of this DEIR.

Issues raised by the public and other agencies include:

- Alternatives that incorporate actions to reduce demand for water from the Delta
- Alternatives that incorporate actions to reduce impacts on fish species
- Water quality modeling and water quality standards
- Climate change effects, floods, and drought
- Long-term effects, future water needs, and population growth

1.7 ISSUES TO BE RESOLVED

This section is included in this Summary as required by CEQA Guidelines 15123(b)(3). No issues requiring resolution have been identified.

2 INTRODUCTION

The California Department of Water Resources (DWR) is proposing to implement ongoing, long-term operation of the State Water Project (SWP) consistent with the protection and conservation of designated species, in compliance with the California Endangered Species Act (CESA) as authorized by the California Department of Fish and Wildlife (CDFW) through the issuance of a permit for incidental take under Section 2081 of CESA (California Fish and Game Code Section 2081).

The SWP includes water, power, and conveyance systems, moving an annual average of 2.9 million acre-feet of water. The principal facilities of the SWP are the Oroville Reservoir and related facilities, San Luis Dam and related facilities, facilities in the Sacramento–San Joaquin Delta (Delta), the Suisun Marsh Salinity Control Gates, the California Aqueduct (including its terminal reservoirs), and the North and South Bay Aqueducts. DWR holds contracts with 29 public agencies in northern, central, and southern California for the SWP water supplies.

The SWP operations provide flood control and water for agricultural, municipal, industrial, recreational, and environmental purposes. The SWP operates pursuant to the water rights permits and licenses issued by the State Water Resources Control Board (SWRCB), which allow appropriation of water by storing, releasing, and conveying from storage throughout the year. DWR and the U.S. Bureau of Reclamation (Reclamation) operate the SWP and federal Central Valley Project (CVP) under the terms of the Coordinated Operation Agreement (COA) between the federal government and the State of California (authorized by Public Law 99-546). DWR and Reclamation executed a COA Addendum on December 12, 2018, updating the agreement that reflected changed conditions since its original execution in 1986.

The SWP and CVP currently are operated in accordance with the 2008 United States Fish and Wildlife Service (USFWS) Biological Opinion and the 2009 National Marine Fisheries Service (NMFS) Biological Opinion issued pursuant to Section 7 of the federal Endangered Species Act (ESA) of 1973. Both the 2008 USFWS and 2009 NMFS Biological Opinions determined that the coordinated long-term operation of the SWP and CVP, as proposed in the Reclamation 2008 Biological Assessment (Reclamation 2008), was likely to jeopardize the continued existence of listed species and destroy or adversely modify designated critical habitat of listed species. Both Biological Opinions included Reasonable and Prudent Alternatives (RPAs) that were designed to allow the SWP and CVP to continue operating without causing jeopardy to listed species or adverse modification to designated critical habitat, provided the RPAs were implemented.

On August 2, 2016, Reclamation and DWR jointly requested the Reinitiation of Consultation on the Coordinated Long-Term Operation of the CVP and SWP. USFWS accepted the reinitiation request on August 3, 2016, and NMFS accepted the reinitiation request on August 17, 2016. Reclamation completed a biological assessment (Reclamation 2019) to support the consultation. This biological assessment also fulfills consultation requirements for the Magnuson-Stevens Fishery Conservation and Management Act of 1976 for Essential Fish Habitat (EFH). USFWS and NMFS issued new Biological Opinions on October 21, 2019.

DWR also operates the SWP in compliance with the CESA. DWR has obtained consistency determinations from CDFW, pursuant to Section 2080.1 of the California Fish and Game Code, that the 2008 USFWS and 2009 NMFS Biological Opinions are consistent with the requirements of the CESA for aquatic species listed under both the ESA and CESA (i.e., Delta Smelt, Winter-run Chinook Salmon, and Spring-run Chinook Salmon). CDFW's consistency determinations represent that no further authorizations are necessary under the CESA to take those dual listed species in accordance with the 2008 USFWS and 2009 NMFS Biological Opinions. DWR also holds an Incidental Take Permit (ITP) from CDFW pursuant to Section 2081 of the California Fish and Game Code covering Longfin Smelt (LFS), which is listed only under the CESA. The ITP for Longfin Smelt expires on December 31, 2019.

DWR intends to seek a new ITP from CDFW pursuant to Section 2081 of the California Fish and Game Code, which will cover species that are listed under the CESA and are subject to incidental take from long-term operation of the SWP (Delta Smelt, Longfin Smelt, Winter-run Chinook Salmon, and Spring-run Chinook Salmon). CDFW is expected to rely on this Draft Environmental Impact Report (DEIR) when issuing a decision on DWR's ITP application.

DWR is the lead agency for compliance with the California Environmental Quality Act (CEQA) and has prepared an Initial Study (provided in Appendix A), pursuant to CEQA, California Public Resources Code Section 21000 et seq., and the State CEQA Guidelines (Title 14, Section 15000 et. seq. of the California Code of Regulations).

2.1 PURPOSE OF THE DEIR

This DEIR has been prepared to conform with the requirements of CEQA and the State CEQA Guidelines. As described in Section 15121(a) of the State CEQA Guidelines, an Environmental Impact Report (EIR) is a public informational document that discloses significant environmental impacts of a proposed project and identifies mitigation measures and alternatives to the proposed project that would reduce or avoid identified significant adverse environmental impacts.

As the lead agency for the Long-Term Operation of the ~~Central Valley Project and~~ State Water Project (~~Proposed P~~project), DWR will use the information in this DEIR to evaluate the Proposed Project's potential environmental impacts; determine whether any feasible mitigation measures and alternatives are necessary and available to reduce potentially significant environmental impacts; and approve, modify, or deny approval of the Proposed Project. This document also may be used by CDFW, as a responsible agency as defined by CEQA, in its discretionary approval process and consideration to issue an ITP for the proposed long-term SWP operations.

The preparation of an EIR involves multiple steps in which the public is provided the opportunity to review and comment on the scope of the analysis, the content of the EIR, the results and conclusions presented, and the overall adequacy of the document to comply with the requirements of CEQA. The following discussion describes the steps in the environmental review process for the Proposed Project.

2.2 DEIR PREPARATION PROCESS

The following discussion describes the EIR preparation process, including those activities completed to date and those to be performed that will lead to EIR certification.

2.2.1 Notice of Preparation

DWR prepared and distributed a Notice of Preparation (NOP) for this DEIR on April 19, 2019. DWR provided copies of the NOP to (1) local, State, and federal agencies; (2) City and County Clerk offices; and (3) other interested parties. A public notice was placed in seven newspapers with regional circulation throughout the state to announce the availability of the NOP and the opportunity to submit comments. The NOP was circulated for comment for 36 days, ending on May 28, 2019. The NOP included a description of the project background, project objectives, a description of the Proposed Project, and a summary of environmental topics to be considered in the DEIR.

Public scoping meetings were held in Los Angeles on May 6, 2019, and in Sacramento on May 13, 2019. The purpose of the public scoping meetings was to provide a forum for the public to learn about the Proposed Project and make verbal and written comments on the proposed scope and content of the DEIR.

2.2.2 Initial Study

DWR prepared an Initial Study (provided in Appendix A), consistent with the requirements of Section 15063(c)(3) of the State CEQA Guidelines. The purpose of the Initial Study is to assist with the preparation of the DEIR by focusing the analysis on the impacts determined to be potentially significant, identifying resources that would be affected but determined not to be significant, and explaining the reasons for determining that potentially significant impacts would not be significant.

Based on the information and analyses developed, the Initial Study concluded that the proposed long-term operation of the SWP would not have a significant impact on the following resource topics:

- Aesthetics
- Agriculture and Forestry Resources
- Air Quality
- Biological Resources (Terrestrial)
- Cultural Resources
- Energy
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards and Hazardous Materials
- Surface Water Hydrology
- Land Use and Planning
- Mineral Resources
- Noise
- Population and Housing
- Public Services

- Recreation
- Transportation/Traffic

The Initial Study, provided in Appendix A, concluded that the Proposed Project would not result in significant impacts on hydrology or surface water resources. However, because implementation of the Proposed Project would alter existing hydrology, such changes could result in impacts on resources dependent upon existing hydrologic conditions. These resources include water quality and aquatic biological resources.

To provide the reader with an understanding of the potential project impacts on water quality and aquatic biological resources, this DEIR presents a description of the existing hydrologic setting and compares it with the estimated hydrology associated with the Proposed Project in the following discussion.

2.2.3 DEIR

This DEIR is being circulated for public review and comment for a period of 45 days, from **November 21, 2019 to January 6, 2020**. The DEIR and associated Notice of Completion were filed with the California Office of Planning and Research State Clearinghouse on November 21, 2019.

DWR provided public notice of availability of the DEIR as required by Section 15087 of the CEQA Guidelines. Written notice was provided to the last known name and address of all individuals and organizations who previously have requested such notice, including the 19 parties who submitted comments in response to the NOP. A public notice of availability was placed in seven newspapers with regional circulation throughout the state, announcing the availability of the EIR and opportunity to submit comments. The public notice was also distributed to 48 County Clerk offices; and 19 State, federal, and local agencies.

A public meeting will be held on December 12, 2019, to receive input from agencies and the public on the DEIR.

During the public comment period, written comments from organizations, agencies, and the public on the DEIR may be submitted to DWR. Written comments (including those sent via e-mail) must be received by 5 p.m. on **January 6, 2020**. Written comments should be addressed to:

> **You Chen Chou**
> **California Department of Water Resources**
> **P.O. Box 942836**
> **Sacramento, CA 94236-0001**

E-mail comments and questions may be addressed to LTO@water.ca.gov.

Digital copies of the DEIR are available on the DWR website at https://water.ca.gov/News/Public-Notices. A hard copy is available at DWR's office at 3500 Industrial Boulevard, West Sacramento, California 95691. Digital copies are also available for public review at the following locations:

- Alameda County Library, 2450 Stevenson Boulevard, Fremont CA, 94538
- Beale Memorial Library, 701 Truxtun Avenue, Bakersfield, CA, 93301
- Central Library, 40 East Anapamu Street, Santa Barbara CA, 93101
- Cesar Chavez Central Library, 605 N. El Dorado Street, Stockton CA, 95202
- Colusa County Library, 738 Market Street, Colusa CA, 95932
- Contra Costa Library, Martinez Branch, 740 Court Street, Martinez CA, 94533
- Dr. Martin Luther King, Jr. Library, 150 East San Fernando Street, San Jose CA, 95112
- E.P. Foster Library, 651 East Main Street, Ventura CA, 93001
- East San Jose Carnegie Branch Library, 1102 E Santa Clara Street, San Jose CA, 95116
- El Centro Public Library, Community Center, 375 South 1st Street, El Centro CA, 92243
- Fairfield Civic Center Library, 1150 Kentucky Street, Fairfield, CA, 94533
- Fremont Library, 2400 Stevenson Boulevard, Fremont CA, 94538
- Hanford Branch Library, 401 North Douty Street, Hanford CA, 93230
- Los Angeles Public Library, 630 West 5th Street, Los Angeles CA 90071
- Marin County Library, 3501 Civic Center Drive #427, San Rafael, CA, 94903
- Mary L. Stephans Davis Branch library, 315 E. 14th Street, Davis, CA, 95616
- Merced County Library, Merced Branch, 2100 O Street, Merced CA, 95340
- Modesto Public Library, 1500 I Street, Modesto CA, 95354
- Napa Main Library, 580 Coombs Street, Napa CA 94559
- Norman F. Feldheym Central Library, 555 West 6th Street, San Bernardino CA, 92410
- Oroville Branch Library, 1820 Mitchell Avenue, Oroville CA, 95966
- Pleasant Hill Library, 1750 Oak Park Boulevard, Pleasant Hill CA, 94523
- Quincy Public Library, 445 Jackson Street, Quincy CA, 95971
- Red Bluff Library, 645 Madison Street, Red Bluff CA, 96080
- Redding Library, 1100 Parkview Avenue, Redding CA, 96001
- Riverside Public Library, 3581 Mission Inn Avenue, Riverside CA, 92501
- Sacramento County Library, 828 I Street, Sacramento CA, 95202
- San Diego Public Library, Central Library, 820 E Street, San Diego CA, 92101
- San Francisco Public Library, 100 Larkin Street, San Francisco CA, 94102
- San Luis Obispo Library, 995 Palm Street, San Luis Obispo, CA, 93401
- San Mateo Public Library, 55 West 3rd Avenue, San Mateo CA, 94402
- Santa Clara City, Central Park Library, 2635 Homestead Road, Santa Clara CA, 95051
- Sonoma County Central Library, 211 East Street, Santa Rosa CA, 95404
- Sutter County Library, Main Branch, 750 Forbes Avenue, Yuba City CA, 95991

- Visalia Branch Library, 200 West Oak Avenue, Visalia CA, 93291
- Willows Public Library, 201 North Lassen Street, Willows CA, 95988

2.2.4 Final EIR and EIR Certification

Following the public comment period, responses to comments that have been received on environmental issues will be prepared. Consistent with State CEQA Guidelines Section 15088(b) of the CCR, commenting agencies will be provided a minimum of 10 days to review the proposed responses to their comments before any action is taken on the Final EIR or Proposed Project. The Final EIR will be considered for certification and approval by DWR.

This DEIR is organized as follows.

Chapter 1, "Summary": This chapter introduces the Proposed Project, discusses impacts found not to be significant and key environmental issues, and describes the results of the technical analysis presented in Chapter 4, "Environmental Setting, Impacts, and Mitigation Measures," of the DEIR.

Chapter 2, "Introduction": This chapter describes the legal authority and purpose of the DEIR, the scope of the environmental analysis, agency roles and responsibilities, the CEQA public review process, and the organization of this document.

Chapter 3, "Project Description": This chapter describes the project background, objectives, and location, and provides a detailed description of the characteristics associated with the Proposed Project.

Chapter 4, "Environmental Setting, Impacts, and Mitigation Measures": The resource sections in this chapter evaluate the potential environmental impacts that would result from implementation of the Proposed Project. In each section of Chapter 4, the regulatory setting, environmental setting, methods and assumptions, and the thresholds of significance are described. The anticipated changes to the existing environmental conditions after project implementation are evaluated for each resource. For any significant or potentially significant impact that would result from project implementation, mitigation measures are presented, followed by the remaining level of significance.

In addition, this chapter includes information regarding the potential cumulative impacts that would result from project implementation together with other past, present, and probable future projects. This chapter also presents discussions of other CEQA-required topics, including growth-inducing impact.

Chapter 5, "Alternatives to the Proposed Project": This chapter discusses four alternatives to the Proposed Project, including the No Project Alternative.

Chapter 6, "References": This chapter lists the documents and other sources of information that are cited in the DEIR.

Chapter 7, "List of Preparers": This chapter identifies the individuals who contributed to preparation of the DEIR.

Appendices: The DEIR includes appendices that provide technical studies, calculations, computer modeling output, and other information supporting the findings and conclusions of specific technical analyses.

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3 PROJECT DESCRIPTION

3.1 INTRODUCTION

The SWP includes water, power, and conveyance systems, conveying an annual average of 2.9 million acre-feet (AF) of water. The principal facilities of the SWP are Oroville Reservoir and related facilities, and San Luis Dam and related facilities, facilities in the Sacramento-San Joaquin Delta (Delta), the Suisun Marsh Salinity Control Gates, the California Aqueduct including its terminal reservoirs, and the North and South Bay Aqueducts. 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.

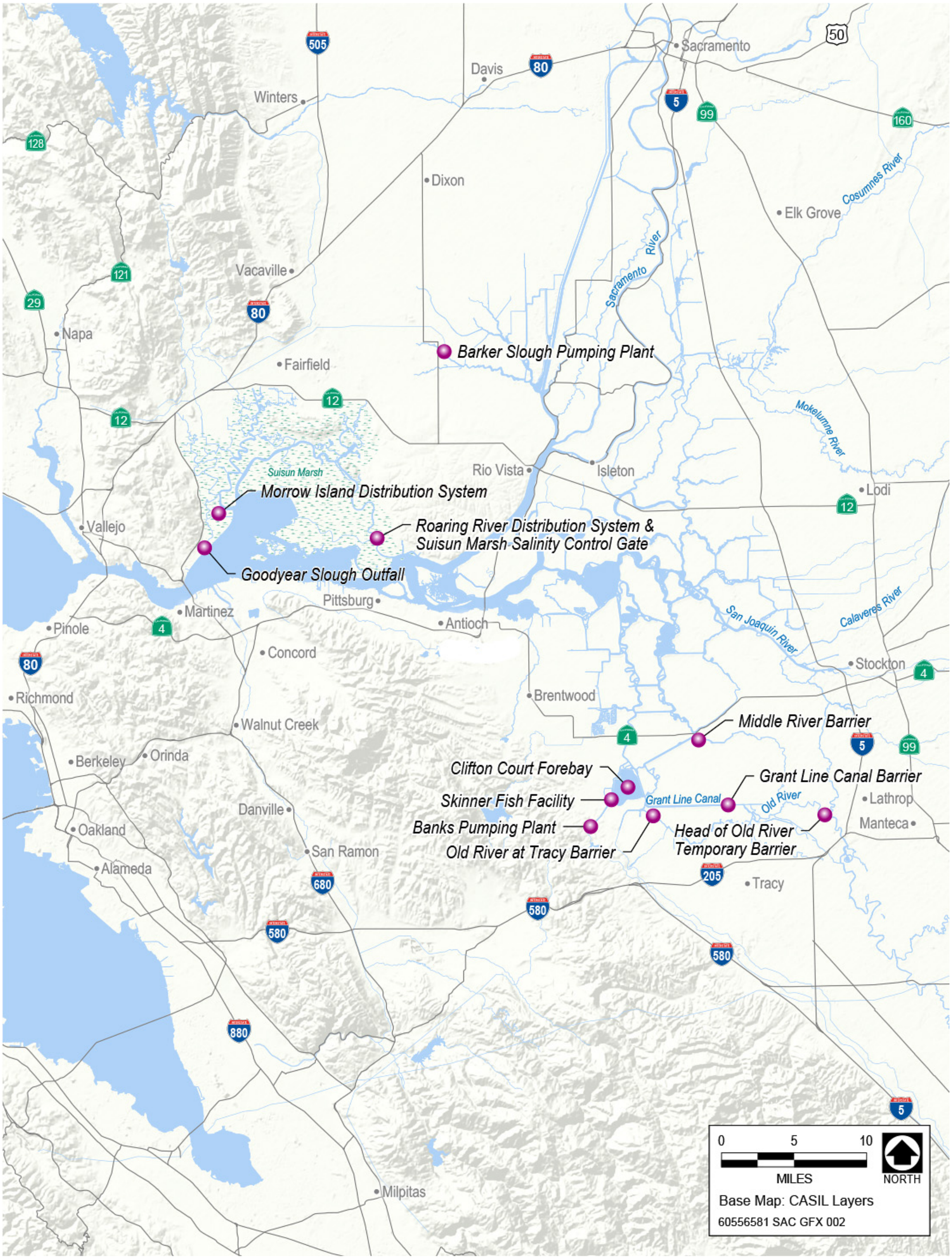
3.1.1 PROJECT PURPOSE AND OBJECTIVES

The underlying purpose~~objective~~ of the Proposed Project is to obtain incidental take authorization from the California Department of Fish and Wildlife pursuant to the California Endangered Species Act to allow DWR to continue the long-term operation of the SWP consistent with applicable laws, contractual obligations, and agreements. Consistent with this underlying purpose, DWR's ~~proposes~~ project objectives are to store, divert, and convey water in accordance with DWR's existing water rights to deliver water pursuant to water contracts and agreements up to full contract quantities and~~.~~ ~~DWR seeks~~ to optimize water supply and improve operational flexibility while protecting fish and wildlife based on the best available scientific information.

3.1.2 PROJECT LOCATION

The project area includes the SWP Service Areas and existing SWP storage and export facilities located within the Delta and vicinity. Figure 1-1 shows the entire project area, including the SWP Service areas, while Figure 3-1 shows those SWP facilities located in the Delta and vicinity.

The DWR operates the SWP in coordination with the Central Valley Project (CVP), under the COA between the federal government and the State of California (authorized by Pub. L. 99 546). The CVP and SWP operate pursuant to water rights permits and licenses issued by the State Water Resources Control Board. The CVP and SWP water rights allow appropriation of water by directly using ~~and/or diverting~~the water, diverting water to storage for later withdrawal~~ and use~~, ~~or use~~ and rediverting water~~ diversion~~ to storage further downstream for later consumptive use. ~~Among the conditions of their water rights, are r~~Requirements of the SWP and CVP to either bypass or withdraw water from storage and to help satisfy specific water quality, quantity, and operations criteria in source rivers and within the Delta are ~~.~~among the conditions of their water rights.



Source: Data compiled by AECOM in 2017

Figure 3-1. Locations of State Water Project Facilities in the Delta, Suisun Marsh, and Suisun Bay

3.1.3 DESCRIPTION OF EXISTING SWP FACILITIES

The SWP facilities in the Delta provide for delivery of water supply to areas within and immediately adjacent to the Delta, and to regions south of the Delta. The main SWP Delta features are Suisun Marsh and Bay facilities, the Harvey O. Banks Pumping Plant (Banks Pumping Plant), the Clifton Court Forebay (CCF), the Skinner Fish Facility, and the Barker Slough Pumping Plant (BSPP).

3.1.3.1 HARVEY O. BANKS PUMPING PLANT

The Banks Pumping Plant, located about 8 miles northwest of Tracy, marks the upstream end of the California Aqueduct. The plant discharges into five pipelines that convey water into a roughly 1-mile-long canal, which in turn conveys water to Bethany Reservoir (DWR and Reclamation 2015). The Banks Pumping Plant consists of 11 pumps—two rated at 375 cfs capacity, five at 1,130 cfs capacity, and four at 1,067 cfs capacity—that provide the initial lift of water 244 feet from the CCF into the California Aqueduct. The rated capacity of the Banks Pumping Plant is 10,300 cfs. The plant maximum daily pumping rate is controlled by a combination of the State Water Resources Control Board's (SWRCB's) D-1641 and permits issued by the U.S. Army Corps of Engineers (USACE) that regulate the rate of diversion of water into the CCF. The diversion rate is normally restricted to 6,680 cfs as a 3-day average inflow and 6,993 cfs as a 1-day average inflow to the CCF in accordance with the existing USACE Section 10 permit issued in pursuant to the Rivers and Harbors Act (SWRCB 2017). The diversions may be greater in the winter and spring, depending on San Joaquin River flows at Vernalis (DWR and Reclamation 2015). As part of the adaptive management process, the SWP is permitted to pump an additional 500 cfs between July 1 and September 30 to offset water costs associated with fisheries actions, making the summer limit effectively 7,180 cfs (Reclamation 2008).

3.1.3.2 JOHN E. SKINNER DELTA FISH PROTECTIVE FACILITY

The Skinner Fish Facility is west of the CCF, about 2 miles upstream from the Banks Pumping Plant. The Skinner Fish Facility guides fish away from entering the pumps that convey 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. These smaller fish pass through a secondary system of screens, louvers, and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish are then returned to the Delta in oxygenated tank trucks.

3.1.3.3 CLIFTON COURT FOREBAY

The CCF is located near the city of Byron in the South Delta. The Banks Pumping Plant pumps water diverted from the CCF via the intake channel past Skinner Fish Protective Facility (SFPF). A set of five radial gates are located at the CCF inlet near the confluence of the Grant Line and West Canal. They are operated so that they can be closed during critical periods of the ebb/flood tidal cycle to protect water levels experienced by local agricultural water users in the South Delta. The gates are operated on the tidal cycle to reduce approach velocities, prevent scour in adjacent channels, and minimize fluctuations in water elevation in the South Delta by taking water in through the gates at times other than low tide.

Banks Pumping Plant pumping rates are constrained operationally by limits on CCF diversions from the Delta. The maximum daily diversion limit from the Delta into the CCF is 13,870 AF per day (6,990 cfs/day) and the maximum averaged diversion limit over any 3 days is 13,250 AF per day (6,680 cfs/day). In addition to these requirements, DWR may increase diversions from the Delta into the CCF by one-third of the San Joaquin River flow at Vernalis from mid-December through mid-March when flows at Vernalis exceed 1,000 cfs. These limits are listed in USACE Public Notice 5820A Amended (Oct. 13, 1981).

From July through September, the maximum daily diversion limit from the Delta into the CCF is increased from 13,870 AF per day (6,990 cfs/day) to 14,860 AF per day (7,490 cfs/day), and the maximum averaged diversion limit over any 3 days is increased from 13,250 AF per day (6,680 cfs/day) to 14,240 AF per day (7,180 cfs/day). These increases are for the purpose of recovering water supply losses incurred earlier in the same year to protect ESA-listed fish species. Those increases are a separate action permitted for short-term time periods.

3.1.3.4 Barker Slough Pumping Plant

The Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct (NBA) for delivery to Napa and Solano counties. The NBA intake is located approximately 10 miles from the mainstem Sacramento River at the end of Barker Slough. In accordance with salmon screening criteria, each of the aqueduct’s 10 pump bays are 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 and prevent the entrainment of fish measuring approximately 1 inch or larger. The bays tied to the two smaller units have an approach velocity of about 0.2 foot per second (ft/sec). The larger units were designed for a 0.5 ft/sec approach velocity, but actual approach velocity is about 0.44 ft/sec. The screens are routinely cleaned to prevent excessive head loss, thereby minimizing increases in localized approach velocities.

3.1.3.5 Suisun Marsh Operations

The Suisun Marsh Preservation Agreement (SMPA) among DWR, Reclamation, CDFW, and Suisun Resource Conservation District (SRCD) contains provisions for DWR and Reclamation to mitigate the impacts on Suisun Marsh channel water salinity from SWP and CVP operations and other upstream diversions. The SMPA requires DWR and Reclamation to meet salinity standards in accordance with D-1641, sets a timeline for implementing the Plan of Protection, and delineates monitoring and mitigation requirements.

There are two primary physical mechanisms for meeting salinity standards set forth in D-1641 and the SMPA: (1) the implementation and operation of physical facilities in the Marsh and (2) management of Delta outflow (i.e., facility operations are driven largely by salinity levels upstream of Montezuma Slough, and salinity levels are highly sensitive to Delta outflow). Physical facilities (described below) have been operating since the 1980s and have proven to be a highly reliable method for meeting standards.

Physical facilities in the Suisun Marsh and Bay include the Suisun Marsh Salinity Control Gates (SMSCG), the Roaring River Distribution System (RRDS), the Morrow Island Distribution System (MIDS) and the Goodyear Slough Outfall (GYSO). The location and operation of these facilities is described below.

The SMSCG are located on Montezuma Slough about 2 miles downstream from the confluence of the Sacramento and San Joaquin rivers, near Collinsville. The objective of Suisun Marsh Salinity Control Gate operation is to decrease the salinity of the water in Montezuma Slough. 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 through Suisun Marsh.

The SMSCG are operated during the salinity control season, which spans from October to May. Operational frequency is affected by salinity at D-1641 compliance stations, hydrologic conditions, weather, Delta outflow, tide, fishery considerations, and other factors. The boat lock portion of the gate is now held partially open during SMSCG operation to allow an opportunity for continuous salmon passage. ~~After~~ At a future date when an engineering solution is implemented to prevent boaters from entering the boat lock ~~prior to~~without approval from the operator ~~closing it, the gate~~, the boat lock gate will be held open at all times. However, the boat lock gates may be closed temporarily to stabilize flows to facilitate safe passage of watercraft through the facility.

Assuming no significant long-term changes in the drivers mentioned above, it is expected that gate operations will remain at current levels or as needed to implement the summer action to benefit Delta Smelt.

The RRDS was constructed to provide lower salinity water to 5,000 acres of private and 3,000 acres of CDFW 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. 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 the RRDS above the adjacent managed wetlands. The intake to the RRDS is screened to prevent entrainment of fish larger than approximately 25 mm. After the listing of Delta Smelt, RRDS diversion rates have been controlled to maintain a maximum average approach velocity of 0.2 ft/sec at the intake fish screen except during the period from September 14 through October 20, when RRDS diversion rates are controlled to maintain a maximum average approach velocity of 0.7 ft/sec for fall flood up operations.

The MIDS allows Reclamation and DWR to provide fresher water to the landowners for managed wetland activities ~~so that lands may be managed according to~~ approved in 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.

The GYSO connects the south end of Goodyear Slough to Suisun Bay. Prior to construction of the outfall, Goodyear Slough was a dead-end slough. The GYSO was designed to increase circulation and reduce salinity in Goodyear Slough to provide higher water quality to the wetland managers who flood their ponds with Goodyear Slough water. GYSO has a series of four passive intakes that drain to Suisun Bay. The outfall is equipped with slide gates on the interior of the outfall structure to allow DWR to close the system as needed for maintenance or repairs. The intakes and outfall of GYSO are unscreened but are equipped with trash racks to prevent damage. Any fish that entered the system would be able to leave via the intake or the outfall, as GYSO is an open system.

3.1.3.6 South Delta Temporary Barrier Project

DWR's South Delta Temporary Barrier Project (TBP) was initiated in 1991. The objectives of the TBP are to increase water levels, circulation patterns, and water quality in the southern Delta area for local agricultural diversions. The existing SWP consists of installation and removal of temporary rock barriers at the following locations:

- Middle River near the Victoria Canal, about 0.5 mile south of the confluence of Middle River, Trapper Slough, and the North Canal
- Old River near Tracy, approximately 0.5 mile east of the Delta-Mendota Canal intake
- Grant Line Canal, approximately 400 feet east of the Tracy Boulevard Bridge

These rock barriers are designed to act as flow control structures, trapping tidal waters behind them after a high tide. These barriers improve water levels and circulation for local South Delta farmers and are collectively referred to as agricultural barriers.

Rock barriers at Old River near Tracy, Middle River, and the Grant Line Canal are in place ~~from~~between ~~April 15~~May 1 ~~to~~and ~~September~~November 30 each year when the HORB is not installed – but the barriers may be installed as early as March 1 when HORB is installed. These barriers are installed annually based on local conditions (e.g., when San Joaquin River flows are below 5,000 cfs) and are not necessarily installed on May 1 every year. The barriers are notched to allow adult salmon passage by September 15 but are completely removed by November 30 each year. The Old River barrier near Tracy has been installed since 1991 and the Middle River barrier has been installed since 1987. A rock barrier was first installed in the Grant Line Canal in spring 1996, and since then the barrier has been installed in every year except 1998.

This document is focused on the operation of the barriers within the South Delta and does not analyze or address the construction or removal of the barriers, which is covered by a separate Biological Opinion (BiOp) and associated permits.

3.1.3.7 Head of Old River Barrier

The Head of Old River Barrier (HORB) is a temporary structure at the divergence from the San Joaquin River. The fall HORB is intended to keep water in the San Joaquin River, which may improve downstream dissolved-oxygen conditions. The spring barrier is intended to prevent downstream-migrating salmonid smolts in the San Joaquin River from entering Old River.

The HORB has been installed seasonally, between September 15 and November 30, in most years since 1963. Since 1992, the rock barrier has also been installed frequently in the spring, between April 15 and May 30. ~~High flows in the San Joaquin River prevented~~For various reasons, installation of the HORB did not occur in 1993, 1995, 1998, 1999, 2005, 2006, 2008, 2009, 2010, 2011, 2013, 2017, and 2019~~1~~. The spring installation of the HORB is currently required as part of the 2009 NMFS Biological Opinion but is not included in the 2019 NMFS Biological Opinion.

~~The construction and removal of the HORB is covered by a separate BiOp and associated permits.~~

3.1.3.8 San Luis Reservoir

San Luis Reservoir is an off-stream storage facility located along the California Aqueduct downstream of the Jones and Banks pumping plants. The CVP and SWP share San Luis Reservoir storage roughly 50/50 (CVP has 966 thousand acre-feet [TAF] of storage, and SWP has 1062 TAF of storage). San Luis Reservoir is used by both the SWP and CVP to meet deliveries to their contractors during periods when Delta pumping is insufficient to meet demands. San Luis Reservoir is also operated to supply water to the CVP San Felipe Division in San Benito and Santa Clara counties.

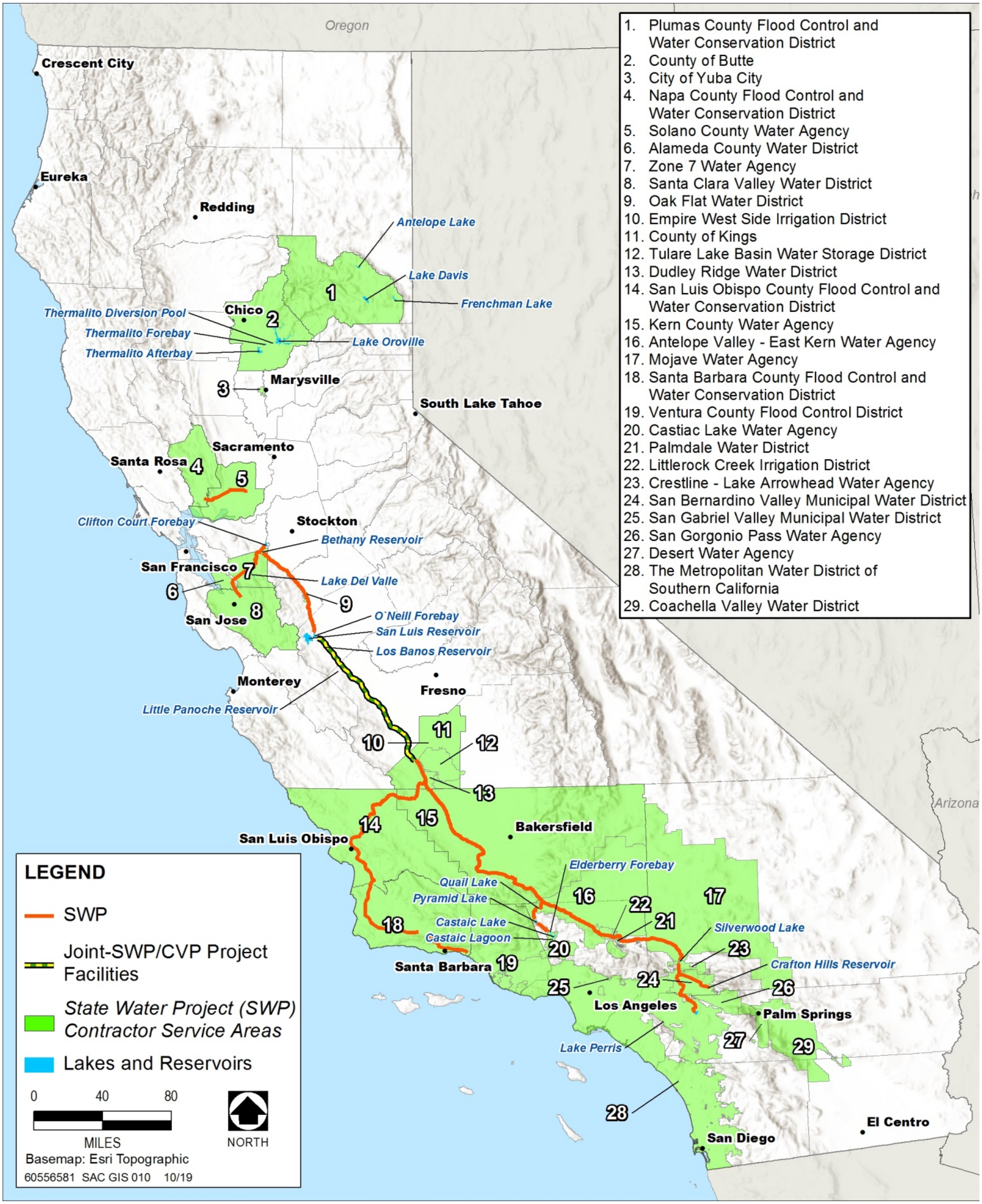
San Luis Reservoir operates as a regulator on the CVP/SWP system, accepting any water pumped from the Banks and Jones pumping plants that exceeds contractor demands, then releasing that water back to the aqueduct system when the pumping at the Jones and Banks pumping plants is insufficient to meet demands. The reservoir allows the CVP/SWP to meet peak-season demands that are seldom balanced by Jones and Banks pumping.

As San Luis Reservoir is drawn down to meet contractor demands, it usually reaches its low point in late August or early September. From September through early October, demand for deliveries declines until it is less than the rate of diversions from the Delta at the Jones and Banks pumping plants. At this point, the additional diverted water is added to San Luis Reservoir, reversing its spring and summer decline and eventually filling the San Luis Reservoir—typically before April of the following year.

Operations of the San Luis Reservoir are not discussed further in this document, as there will be no changes to the operations of this reservoir, and it is an off-stream facility.

3.1.4 Description of Existing SWP Water Service Contracts

DWR has signed long-term contracts with 29 water agencies statewide to deliver water supplies developed from the SWP system (Figure 3-2). These contracts are with both municipal and industrial (M&I) water users and agricultural water users. The contracts specify the charges that will be made by the water agency for both (1) water conservation and (2) conveyance of water. The foundation allocation of water to each contractor is based on their respective “Table A” entitlement, which is the maximum amount of water delivered to them by the SWP on an annual basis.



Source: California Spatial Information Library, DWR 2019

Figure 3-2. The 29 Water Purveyors Under Contract to Receive SWP Water Deliveries

~~DWR proposes to operate the SWP in accordance with contracts with senior water rights holders in the Feather River Service Area (approximately 983 TAF). Furthermore, u~~Under statewide contracts, DWR allocates Table A water as an annual supply made available for scheduled delivery throughout the year. Table A contracts total 4,173 TAF, with more than 3 million acre-feet (MAF) for San Joaquin Valley and Southern California water users.

Article 21 of the long-term SWP water supply contracts provides an interruptible water supply made available only when certain conditions exist: (1) The SWP share of San Luis Reservoir is physically full or is projected to be physically full; (2) other SWP reservoirs south of the Delta are at their storage targets or the conveyance capacity to fill these reservoirs is maximized; (3) the Delta is in excess conditions; (4) current Table A demand is being fully met; and (5) Banks Pumping Plant has export capacity beyond that which is needed to meet current Table A and other SWP operational demands.

Table 3-1 shows the maximum contracted annual water supply per water purveyor per DWR's most recent water supply reliability report.

Table 3-1. State Water Contractors

State Water Contractors	Table A Contracted Water Supply (acre-feet)	Purpose of Use
Butte County	27,500	M&I
Plumas County	2,700	M&I
Yuba City	9,600	M&I
Napa County Flood Control and Water Conservation District	29,025	M&I
Solano County Water Agency	47,756	M&I
Alameda County—Zone 7	80,619	M&I
Alameda County Water District	42,000	M&I
Santa Clara Valley Water District	100,000	M&I
Oak Flat Water District	5,700	Agriculture
Kings County	9,305	Agriculture
Dudley Ridge Water District	45,350	Agriculture
Empire West Side Irrigation District	3,000	Agriculture
Kern County Water Agency	982,730	Agriculture/M&I[1]
Tulare Lake Water Storage District	87,471	Agriculture
San Luis Obispo County	25,000	M&I
Santa Barbara County	45,486	M&I
Antelope Valley-East Kern Water Agency	144,844	Agriculture/M&I[2]
Santa Clarita Valley Water Agency	95,200	M&I
Coachella Valley Water District	138,350	M&I
Crestline-Lake Arrowhead Water Agency	5,800	M&I
Desert Water Agency	55,750	M&I
Littlerock Creek Irrigation District	2,300	M&I
Metropolitan Water District of Southern California	1,911,500	M&I
Mojave Water Agency	85,800	M&I
Palmdale Water District	21,300	M&I
San Bernardino Valley Municipal Water District	102,600	M&I
San Gabriel Valley Municipal Water District	28,800	M&I
San Gorgonio Pass Water Agency	17,300	M&I
Ventura County Watershed Protection District	20,000	M&I

Notes:

[1] Approximately 15% of the Kern County Water Agency Table A Amount is classified as municipal and industrial (M&I) supply.

[2] Approximately 25% of the Antelope Valley-East Kern Water Agency Table A amount is used for agricultural purposes.

Source: DWR 2016

M&I = municipal and industrial

~~3.1.5 SWP Allocation and Forecasting~~

~~At the beginning of each new water year, there is significant uncertainty as to the hydrologic conditions that will exist in the future several months, and hence the water supplies that will be allocated by the SWP to its water contractors. In recognition of this, DWR uses a forecasting water supply allocation process that is updated monthly, incorporates known conditions in the Central Valley watershed to date, and forecasts future hydrologic conditions in a conservative manner to provide an accurate estimate of SWP water supplies that can be delivered to SWP contractors as the water year progresses.~~

~~There are many factors considered in the forecast-supply process. Some of these factors are the following:~~

- ~~Water storage in Lake Oroville (both updated and end-of-water-year (September 30)~~
- ~~Water storage in San Luis Reservoir (both updated and end-of-calendar-year)~~
- ~~Flood operations constraints at Lake Oroville~~
- ~~Snowpack surveys (updated monthly from February through May)~~
- ~~Forecasted runoff in the Central Valley (reflects both snowpack and precipitation)~~
- ~~Feather River settlement agreement obligations~~
- ~~Feather River fishery flows and temperature obligations~~
- ~~Anticipated depletions in the Sacramento and Delta basins~~
- ~~Anticipated Delta standards and conditions~~
- ~~Anticipated CVP operations for joint responsibilities~~
- ~~Contractor supply requests and delivery patterns~~

~~Staff from both the Operations Control Office (OCO) and the State Water Project Analysis Office (SWPAO) coordinate their efforts to determine the current water supply allocations. OCO primarily focuses on runoff/operations models to determine allocations. SWPAO requests updated information from the contractors on supply requests and delivery patterns to determine allocations. Both OCO and SWPAO staff meet at least once a month with the Director of DWR to make final decisions on staff's proposed allocations.~~

~~The Initial Allocation for SWP Deliveries is made by December 1 of each year with a conservative assumption of future precipitation to avoid overallocating water before the hydrologic conditions are well defined for the year. As the water year unfolds, Central Valley hydrology and water supply delivery estimates are updated using measured and known information and conservative forecasts of future hydrology. Monthly briefings are held with the Director of DWR to determine formal approvals of delivery commitments announced by DWR.~~

~~Another water supply consideration is the contractual ability of SWP contractors to "carry over" allocated (but undelivered) Table A supplies from the previous year to the next if space is available in San Luis Reservoir. The carryover storage is often used to supplement an individual contractor's current year Table A allocations if conditions are dry. Carryover supplies left in San Luis Reservoir by~~

~~SWP contractors can result in higher storage levels in San Luis Reservoir. As SWP pumping fills San Luis Reservoir, the contractors are notified to take, or lose, their carryover supplies. Carryover water not taken, after notice is given to remove it, then becomes water available for reallocation to all contractors in a given year.~~

~~Article 21 (surplus to Table A) water, which is delivered early in the calendar year, may be reclassified as Table A water later in the year depending on final allocations, hydrology, and contractor requests.~~

~~Reclassification does not affect the amount of water carried over in San Luis Reservoir, nor does it alter pumping volumes or schedules.~~

~~3.1.6~~3.1.5 SWP Settlement Agreements

DWR has water rights settlement agreements to provide water supplies with entities north (upstream) of Oroville, along the Feather River and Bear River and in the Delta. These agreements provide ~~users~~ diverters with SWP water supplies. The agreements are premised upon the idea that these diverters ~~that they~~ were entitled to water prior to the construction of the SWP's Oroville Complex. Collectively, these agreements are between DWR and ~~with~~ more than 60 riparian diverters along the Feather and Bear rivers provide water for diversion. Table 3-2 summarizes the volume under the water rights settlement agreements. In addition to Table 3-2, additional water may be diverted by the Feather River Settlement Contractors agreement, which allows for diversion of SWP water in the fall and winter months, consistent with their settlement contracts. DWR proposes to operate the SWP in accordance with these agreements with senior water rights holders in the Feather River Service Area (approximately 983 TAF) and in the Delta.

Table 3-2. SWP Settlement Agreements

Location	Entity	Amount (Acre-Feet)
North of Oroville	Andrew Valberde	135
North of Oroville	Jane Ramelli	800
North of Oroville	Last Chance Creek WD	12,000
Feather River	Garden Highway Mutual Water	18,000
Feather River	Joint Water Districts Board	620,000
Feather River	South Feather Water & Power	17,555
Feather River	Oswald WD	3,000
Feather River	Plumas Mutual Water	14,000
Feather River	Thermalito Irrigation District	8,200
Feather River	Tudor Mutual Water	5,000
Feather River	Western Canal/PG&E	295,000
Bear River	South Sutter/Camp Far West	4,400
Delta	Byron-Bethany ID	50,000
Delta	East Contra Costa ID	50,000
Delta	Solano Co./Fairfield, Vacaville and Benicia	31,620

Notes:
ID = Irrigation District
PG&E = Pacific Gas & Electric Company
WD = water district

3.1.6 SWP Allocation and Forecasting

At the beginning of each new water year, there is significant uncertainty as to the hydrologic conditions that will exist in the future several months, and hence the water supplies that will be allocated by the SWP to its water contractors. In recognition of this uncertainty, DWR uses a forecasting water supply allocation process that is updated monthly, incorporates known conditions in the Central Valley watershed to date, and forecasts future hydrologic conditions in a conservative manner to provide an accurate estimate of SWP water supplies that can be delivered to SWP contractors as the water year progresses.

There are many factors considered in the forecast-supply process. Some of these factors are the following:

- Water storage in Lake Oroville (both updated and end-of-water-year (September 30)
- Water storage in San Luis Reservoir (both updated and end-of-calendar-year)
- Flood operations constraints at Lake Oroville
- Snowpack surveys (updated monthly from February through May)
- Forecasted runoff in the Central Valley (reflects both snowpack and precipitation)
- Feather River settlement agreement obligations
- Feather River fishery flows and temperature obligations
- Anticipated depletions in the Sacramento and Delta basins
- Anticipated Delta standards and conditions
- Anticipated CVP operations for joint responsibilities
- Contractor supply requests and delivery patterns

Staff from both the Operations Control Office (OCO) and the State Water Project Analysis Office (SWPAO) coordinate their efforts to determine the current water supply allocations. OCO primarily focuses on runoff/operations models to determine allocations. SWPAO requests updated information from the contractors on supply requests and delivery patterns to determine allocations. Both OCO and SWPAO staff meet at least once a month with the Director of DWR to make final decisions on staff's proposed allocations.

The Initial Allocation for SWP Deliveries is made by December 1 of each year with a conservative assumption of future precipitation to avoid overallocating water before the hydrologic conditions are well defined for the year. As the water year unfolds, Central Valley hydrology and water supply delivery estimates are updated using measured and known information and conservative forecasts of future hydrology. Monthly briefings are held with the Director of DWR to determine formal approvals of delivery commitments announced by DWR.

Another water supply consideration is the contractual ability of SWP contractors to "carry over" allocated (but undelivered) Table A supplies from the previous year to the next if space is available in San Luis Reservoir. The carryover storage is often used to supplement an individual contractor's current year Table A allocations if conditions are dry. Carryover supplies left in San Luis Reservoir by

SWP contractors can result in higher storage levels in San Luis Reservoir. As SWP pumping fills San Luis Reservoir, the contractors are notified to take, or lose, their carryover supplies. Carryover water not taken, after notice is given to remove it, then becomes water available for reallocation to all contractors in a given year.

Article 21 (surplus to Table A) water, which is delivered early in the calendar year, may be reclassified as Table A water later in the year depending on final allocations, hydrology, and contractor requests.

Reclassification does not affect the amount of water carried over in San Luis Reservoir, nor does it alter pumping volumes or schedules.

3.1.7 Daily Operations

After the allocations and forecasting process, Reclamation and DWR coordinate their operations on a daily basis. Some factors Reclamation and DWR consider when coordinating their joint operations include required in-Delta flows, Delta outflow, water quality, schedules for the joint use facilities, pumping and wheeling arrangements, and any facility limitations. Both the SWP and CVP must meet the flood obligations of individual reservoirs. CVP operations must also consider flows at Wilkins Slough and associated pump intake elevations.

During balanced water conditions, Reclamation and DWR maintain a daily water accounting of CVP and SWP obligations. This accounting allows for flexible operations and avoids the need to change reservoir releases made several days in advance (due to travel time from the Delta). Therefore, adjustments can be made “after the fact,” using actual observed data rather than by prediction for the variables of reservoir inflow, storage withdrawals, and in-basin uses. This iterative process of observation and adjustment results in a continuous trueing up of the running COA account. If either the SWP or CVP is “owed” water (i.e., the project that provided more or exported less than its COA-defined share), each may request the other to adjust its operations to reduce or eliminate the accumulated account within a reasonable time.

The COA provides the mechanism for determining SWP and CVP responsibility for meeting in-basin use, but real-time conditions dictate real-time actions. Conditions in the Delta can change rapidly. For example, weather conditions combined with tidal action can quickly affect Delta salinity conditions and therefore the Delta outflow required to maintain joint salinity standards under D-1641.

Increasing or decreasing SWP or CVP exports can achieve changes to Delta outflow immediately. Imbalances in meeting each other’s initial shared obligations are captured by the COA accounting and balanced out later.

When more reaction time is available, reservoir release changes are used to adjust to changing in-basin conditions. If Reclamation decides the reasonable course of action is to increase upstream reservoir releases, the response may be to increase Folsom Reservoir releases first because the released water will reach the Delta before flows released from other CVP and SWP reservoirs. DWR’s Lake Oroville water releases require about 3 days to reach the Delta, while water released from Reclamation’s Shasta Reservoir requires 5 days to travel from Keswick Reservoir to the Delta. As water from another reservoir arrives in the Delta, Reclamation can adjust Folsom Reservoir releases downward.

Alternatively, if sufficient time exists for water to reach the Delta, Reclamation may choose to make initial releases from Shasta Reservoir. Each occurrence is evaluated on an individual basis, and appropriate action is taken based on multiple factors. Again, the COA accounting captures imbalances in meeting each other's initial shared obligation.

The duration of balanced water conditions varies from year to year. Balanced conditions never occur in some very wet years, while very dry years may have long continuous periods of balanced conditions, and still other years may have had several periods of balanced conditions interspersed with excess water conditions. Account balances continue from one balanced water condition through the excess water condition and into the next balanced water condition. When either the SWP or CVP enters into flood control operations, the accounting is zeroed out for that project.

Reclamation and DWR staff meet daily to discuss and coordinate CVP and SWP system operations. Several items are discussed at this daily meeting, including:

- Current reservoir conditions
- Pumping status and current outages (for both the CVP and the SWP and how they are affecting combined operations)
- Upcoming planned outages (CVP and SWP) and what that means for future operations
- Current reservoir releases and what changes may be planned
- Current regulatory requirements and compliance status
- Delta conditions to determine if CVP and SWP pumping make use of all available water

Reclamation and DWR also coordinate with Hydrosystem Controllers and Area Offices to ensure that, if necessary, personnel are available to make the desired changes. Once Reclamation and DWR each decide on a plan for that day and complete all coordination, the respective agencies issue change orders to implement the decisions, if necessary.

Reclamation and DWR are co-located in the Joint Operations Center. In addition, the California Data Exchange Center, California-Nevada River Forecast Center, and the DWR Flood Management Group are also co-located in the Joint Operations Center. This enables efficient and timely communication, particularly during flood events.

3.2 EXISTING REGULATIONS

3.2.1 U.S. ARMY CORPS OF ENGINEERS PERMITS

In Public Notice 5820A (October 1981), USACE limited the volume of daily SWP diversions from the Delta into Clifton Court Forebay, stating that such diversions may not exceed 13,870 AF and 3-day average diversions into the CCF may not exceed 13,250 AF. In addition, the SWP can increase diversions into the CCF by one-third of the San Joaquin River flow at Vernalis from mid-December to mid-March when the river's flow at Vernalis exceeds 1,000 cfs (USACE 1981).

In August 2013, USACE issued Permit SPK-1999-0715 and raised the daily diversion from 13,870 AF to 14,860 AF and the 3-day average diversion from 13,250 AF to 14,240 for calendar years 2013 through

2016 (USACE 2013). These increased diversions also required compliance with applicable terms and conditions in the existing BiOps and installation of the South Delta temporary barriers.

In 2017, USACE issued a revised Permit SPK-1999-0715 and raised the daily diversion from 13,870 AF to 14,860 AF and the 3-day average diversion from 13,250 AF to 14,240 AF. The conditions in this permit apply to SWP operations from 2017 through 2020 (USACE 2016). The permit also required compliance with applicable terms and conditions in the existing BiOps and installation of the South Delta temporary barriers.

3.2.2 State Water Resources Control Board Water Rights and D-1641

Reclamation and DWR operate the CVP and the SWP in accordance with the joint obligations under D-1641, which provides protection for fish and wildlife, M&I water quality, agricultural water quality, and Suisun Marsh salinity. D-1641 granted Reclamation and DWR the ability to use or exchange either SWP or CVP diversion capacity capabilities to maximize the beneficial uses of the CVP and SWP. The SWRCB conditioned the use of Joint Point of Diversion capabilities based on staged implementation and conditional requirements for each stage of implementation.

3.2.3 Federal Endangered Species Act

The SWP and CVP are currently operated in accordance with the 2008 USFWS Biological Opinion and the 2009 NMFS Biological Opinion, issued pursuant to Section 7 of the ESA. Both BiOps included Reasonable and Prudent Alternatives (RPAs) designed to allow the SWP and CVP to continue operating without causing jeopardy to listed species or adverse modification to designated critical habitat provided the RPAs were implemented.

On August 2, 2016, Reclamation and DWR jointly requested the Reinitiation of Consultation on the Coordinated Long-Term Operation of the CVP and SWP. The USFWS accepted the reinitiation request on August 3, 2016, and NMFS accepted the reinitiation request on August 17, 2016. Reclamation completed a biological assessment to support consultation under the federal Endangered Species Act (ESA) Section 7, which documents the potential impacts of the proposed action on federally listed endangered and threatened species that have the potential to occur in the study area and on critical habitat for these species. The biological assessment also fulfills consultation requirements for the Magnuson-Stevens Fishery Conservation and Management Act of 1976 for Essential Fish Habitat (EFH).

~~When t~~The new USFWS and NMFS Biological Opinions were ~~are~~ issued on October 22, 2019, and they~~,~~ ~~they will~~ include incidental take statements (ITS) for Delta Smelt, Winter-run Chinook Salmon, Spring-run Chinook Salmon, Green Sturgeon, and steelhead. ~~Although these Biologial Opinions have not yet been adopted,~~ DWR will comply with the ~~ITS~~2019 Biological Opinions in accordance with federal law ~~when they are adopted,~~ in addition to state requirements. As a result of the difference in species listed under the state and federal ESAs and the coordinated operation of the SWP and CVP, California's Proposed Project includes operations for the protection of federally listed steelhead and Green Sturgeon in addition to operations for the protection of state-listed species. These operations and the ITS for federally listed species result in reductions in SWP pumping in addition to the reductions that would be necessary to comply with state law.

3.2.4 California Endangered Species Act

In 2009, CDFW issued an Incidental Take Permit (ITP) for the ongoing and long-term operation of the SWP's existing facilities in the Delta for the protection of Longfin Smelt (LFS). CDFW also issued consistency determinations to DWR for the 2009 NMFS and 2008 USFWS BiOps for continued operation of the SWP and other actions related to water diversion, storage, and transport that are described in the BiOps. ~~CDFW determined that the BiOps, including the RPA requirements and related ITS, were consistent with CESA because the mitigation measures meet the conditions in Section 2081 of the Fish and Wildlife Code for CDFW to authorize incidental take of CESA species.~~

~~The 2009 Incidental Take Permit from CDFW for Longfin Smelt expires on December 31, 2019.~~ DWR is seeking a new ITP from CDFW pursuant to Section 2081 of the California Fish and Game Code. The new ITP will cover aquatic species listed under CESA that are subject to incidental take from long-term operation of the SWP (Delta Smelt, Longfin Smelt, Winter-run Chinook Salmon, and Spring-run Chinook Salmon). The 2009 Incidental Take Permit from CDFW for Longfin Smelt expires on December 31, 2019; but, on December 2, 2019, DWR submitted an Application for a Minor Amendment to extend the expiration date until a new ITP covering the fourth CESA-listed species is issued, whichever comes first.~~.~~

~~DWR has prepared this DEIR to address the continued operation of the SWP as described in the project description. CDFW will rely on this DEIR when issuing a decision on DWR's ITP application.~~

3.3 DESCRIPTION OF THE PROPOSED PROJECT

The Proposed Project~~, which is the preferred alternative in this Draft Environmental Impact Report (DEIR),~~ consists of multiple elements that characterize future operations of SWP facilities including Banks Pumping Plant, Skinner Fish Protection Facility, Clifton Court Forebay, Barker Slough Pumping Plant, and Suisun Marsh facilities; ~~,~~ modify ongoing programs being implemented as part of SWP operations;~~,~~ improve specific activities that would enhance protection of special-status fish species;~~,~~ ~~or~~ and support ongoing studies and research on these special-status species to improve the basis of knowledge and management of these species. Implementation of these elements is intended to continue operation of the SWP and deliver up to the full contracted water amounts while minimizing and fully mitigating the take of listed species consistent with CESA requirements. The duration of the ITP being sought from CDFW for the long-term operation of the SWP is for ten years.

For discussion purposes in this Draft Environmental Impact Report (DEIR), these elements are divided into four categories and consist of (1) proposed SWP operations that can be described in detail and assessed on a project-level basis; (2) proposed SWP operations that can only be described generally and assessed on a program-level basis; (3) proposed environmental protective measures that would offset, reduce, or otherwise mitigate potential environmental impacts on special-status species, and (4) adaptive management actions that include establishing a governance framework, a compliance and reporting program, specific drought- and dry-year actions, and independent review panels, as well as conducting Four-Year Reviews of management measures.

Table 3-3 identifies the actions and facilities associated with the long-term operation of the SWP that are included in the Proposed Project.

Table 3-3. Proposed Project Elements – Table 3-3 a – Table 3-3 d

Table 3-3 a. Proposed Project Elements – Proposed Project-Level SWP Operations and Facilities

Facility or Action	Proposed Project Actions	Action Goal or Objective
Existing Regulatory Requirements	Comply with D-1641 and USACE Permit SPK-1999-0715~~2100~~.	Continue to comply with existing limits and permit requirements to protect water quality for the beneficial uses of fish and wildlife, agriculture, and urban uses.
Minimum Export Rate	The combined CVP and SWP export rates at Jones Pumping Plant and Banks Pumping Plant will not be required to drop below 1,500 cfs.	Establish minimum export rate to protect human health and safety.
Old and Middle River Requirements	Manage OMR reverse flows based on species distribution, modeling, and risk analysis, with provisions for capturing storm flows.	Implement real-time OMR management to minimize entrainment and aquatic species loss during water operations at Banks Pumping Plant.
Barker Slough Pumping Plant (BSPP)	Continue operating BSPP to minimize effects on Delta Smelt and Longfin Smelt and continue implementing sediment removal and aquatic weed management actions as part of normal operations at Barker Slough Pumping Plant.	Implement actions as components of facility maintenance for continued water supply deliveries.
South Delta Temporary Barriers	Continue operation of three South Delta Temporary Agricultural Barriers according to existing terms and conditions.	Maintain ongoing annual installation of three South Delta Temporary Agricultural Barriers with the goal of maintaining surface water levels and circulation~~)~~ in the South Delta.
Suisun Marsh Operations	Operate the Suisun Marsh Salinity Control Gates, Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall in compliance with D-1641.	Operate the Suisun Marsh Salinity Control Gates to improve habitat conditions for the benefit of Delta Smelt.
Delta Smelt Summer-Fall Habitat Action	Operate the Suisun Marsh Salinity Control Gate for up to 60 days (not necessarily consecutive) in June through October of below normal, above normal, and wet years. Project operations would maintain a monthly average 2 ppt isohaline at 80 kilometers (km) from the Golden Gate Bridge in above-normal and wet water years in September and October. Food enhancement actions would be similar to the North Delta Food Subsidies and Colusa Basin Drain project, and Suisun Marsh Food Subsidies (Roaring River distribution system reoperation).	Operate the Suisun Marsh Salinity Control Gate, provide outflow, and conduct food enhancement actions to improve Delta Smelt food supply and habitat.
North Delta Food Subsidies and Colusa Basin Drain Project	Facilitate downstream transport of phytoplankton and zooplankton to areas inhabited by Delta Smelt.	Implement actions to transport productivity downstream to where it can be utilized by Delta Smelt.

Table 3-3 b. Proposed Project Elements – Proposed Program-Level Changes to SWP Operations and Facilities

Facility or Action	Proposed Project Actions	Action Goal or Objective
Water Transfers	Water transfers would occur during an expanded water transfer window, between July through November, with volumes up to 600 TAF.	Increase SWP operational flexibility.

Table 3-3 c. Proposed Project Elements – Proposed Environmental Protective Measures

Facility or Action	Proposed Project Actions	Action Goal or Objective
Clifton Court Forebay	Continue implementing actions to reduce mortality of listed fish species at the Clifton Court Forebay; these measures would include: (a) continued evaluation of predator relocation methods; and (b) controlling aquatic weeds.	Increase species survival and control weeds to reduce impacts to the SWP's physical facilities (clogging screens) and predation reduction.
Skinner Fish Facility	Continue implementing studies to better understand and continuously improve the performance of the Skinner Fish Facility, including: (a) changes to release site scheduling and rotation of release site locations to reduce post-salvage predation, and (b) continued refinement and improvement of the fish sampling and hauling procedures and infrastructure to improve the accuracy and reliability of data and fish survival.	Continue ongoing salvage fish at the Skinner Fish Facility and implement actions to reduce post-salvage predation and improve the accuracy and reliability of data and fish survival.
Longfin Smelt Science Program	DWR proposes to continue implementing studies to better understand LFS population distribution and abundance in San Francisco Bay and Delta, and to identify environmental factors that limit its abundance.	Study of environmental factors affecting LFS distribution and reproduction, and identification of management actions to improve the status of the population.
Studies to support Establishment of a Delta Fish Hatchery	Conduct further studies to locate, design, construct, and operate a hatchery facility that would be capable of producing a substantial number of Delta Smelt and other Delta fish species for reintroduction to the Delta and recovery of the species populations. A related action would provide an Adaptive Management tool to assess the effects of different management actions (e.g., cage studies).	Protect the species and provide resiliency.
Conduct Further Studies to Prepare for Delta Smelt Reintroduction from Stock Raised at the U.C. Davis Fish Conservation and Cultural Laboratory (FCCL)	Continue to support facilities and research to establish a Delta Smelt conservation population that is as genetically close as possible to the wild population and to provide a safeguard against extinction.	Protect the species and provide resiliency.
Additional elements related to real-time operation of the SWP	DWR proposes a governance structure for real-time operation of the SWP that includes compliance and performance reporting, monitoring, convening of independent panels, drought and dry year actions, and Four-Year Reviews.	Advancements in science and minimization of effects of project operations.

Table 3-3 d. Proposed Project Elements – Adaptive Management Actions

Facility or Action	Proposed Project Actions	Action Goal or Objective
Adaptive Management Plan	The Adaptive Management Plan (AMP) will be carried out to evaluate the efficacy of the operations and activities stated below. An Adaptive Management Team (AMT) will be established to carry out this AMP. The AMT will oversee efforts to monitor and evaluate the operations and related activities. In addition, the AMT will use structured decision-making to assess the relative costs and benefits of those operations and activities. The AMT will also identify proposed adaptive management changes to those operations and activities. The AMP will be developed before issuance of, and could be incorporated into, the Incidental Take Permit that DWR is seeking for CESA coverage for the Proposed Project.	The objectives of the AMP are to: (i) continue the long-term operation of the SWP in a manner that improves water supply reliability and water quality consistent with applicable laws, contractual obligations, and agreements; and (ii) use the knowledge gained from the scientific study and analysis described in the AMP to avoid, minimize and fully mitigate the adverse effects of SWP operations on CESA-listed aquatic species~~(1) continue the long-term operation of the SWP consistent with applicable laws, contractual obligations, and agreements and (2) ensure that the long-term operation of the SWP is consistent with CESA.~~

Notes:
AMP = Adaptive Management Plan
AMT = Adaptive Management Team
CESA = California Endangered Species Act
cfs = cubic feet per second
D-1641 = State Water Resources Control Board's Water Rights Decision 1641
DWR = California Department of Water Resources
FCCL = Fish Conservation and Culture Laboratory
km = kilometers
LFS = Longfin Smelt
OMR = Old and Middle River
ppt = parts per thousand
SWP = State Water Project
TAF = thousand acre-feet
USACE = U.S. Army Corps of Engineers

DWR is requesting an ITP for the exercise of discretion in operational decision-making, including how to comply with the terms of its existing water supply and settlement contracts (which include maximum deliveries under the terms of these contracts), and other legal obligations. DWR is not requesting an ITP from CDFW for the following actions:

- Flood control
- Oroville Dam and Feather River operations
- Prior execution of existing SWP contracts
- Coordinated Operation Agreement
- Any previously identified or potential future habitat restoration actions [1]
- ~~Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project~~
- Suisun Marsh Habitat Management Preservation and Restoration
- Suisun Marsh Preservation Agreement
- CVP facilities, operations, and agreements

[1] CESA coverage for habitat restoration actions will be obtained under separate CESA permitting processes.

These facilities and operations activities are already covered under existing permits or addressed by other legal authorities. The actions included as elements of the Proposed Project are described in the following discussion.

3.3.1 OMR Management

DWR, in coordination with Reclamation, proposes to operate the SWP in a manner that maximizes exports while minimizing direct and indirect impacts on state and federally listed fish species. Old and Middle River (OMR) flow is a surrogate indicator of the influence of export pumping at Banks Pumping Plant on hydrodynamics in the South Delta. The management of OMR flow, in combination with other environmental variables, can minimize or avoid entrainment of fish in the South Delta and at the SWP salvage facilities. DWR proposes to manage OMR flow by incorporating all available information into decision support for the management of OMR flow. The available information includes real-time monitoring of fish distribution, turbidity, temperature, hydrodynamic models, and entrainment models. The objective of the OMR management will be to provide focused protection for fish when necessary and to provide flexibility where possible. DWR, in coordination with existing multi-agency Delta-focused technical teams, will use estimates of species distribution and other environmental variables based on ongoing monitoring.

From the onset of OMR management to the end, DWR, in coordination with Reclamation, will operate to an OMR index that is no more negative than a 14-day moving average of -5,000 cfs unless Delta excess conditions ~~a storm event~~ occur~~s~~ (described below). ~~Grimaldo et al.~~NMFS (~~2017~~2009) indicated that -5,000 cfs OMR flow is an inflection point for fish entrainment. OMR flow could be more positive than -5,000 cfs if additional real-time OMR restrictions are triggered (described below) or constraints other than OMR flow control exports. The OMR flow index would be computed using an equation presented in Hutton (2008). An OMR flow index allows for shorter-term operational planning and real-time adjustments. DWR, in coordination with Reclamation, will make a change to exports within 3 days of the trigger when monitoring, modeling, and operational criteria indicate protection for fish is necessary. The 3-day period is consistent with the 2008 and 2009 Biological Opinions and allows for efficient power scheduling.

3.3.1.1 Onset of OMR Management

DWR, in coordination with Reclamation, would start OMR management when one or more of the following conditions have occurred, as shown in Figure 3-3.

- Integrated Early Winter Pulse Protection (First Flush Turbidity Event): To minimize project influence on migration (or dispersal) of Delta Smelt, DWR and Reclamation would reduce exports for 14 consecutive days so that the 14-day averaged OMR index for the period would not be more negative than −2,000 cfs, in response to “First Flush” conditions in the Delta. The population-scale migration of Delta Smelt is believed to occur quickly in response to inflowing freshwater and turbidity (Grimaldo et al. 2009; Sommer et al. 2011). Thereafter, best available scientific information suggests that fish make local movements, but there is no evidence for further population-scale migration (Polansky et al. 2018). The “First Flush” action may be triggered between December 1 and January 31. The triggers include a running 3-day average of the daily flows at Freeport that is greater than 25,000 cfs and a running 3-day average of the daily turbidity at Freeport that is 50 Nephelometric Turbidity Units (NTU) or greater; or, real-time monitoring indicates a high risk of migration and dispersal into areas at high risk of future entrainment.

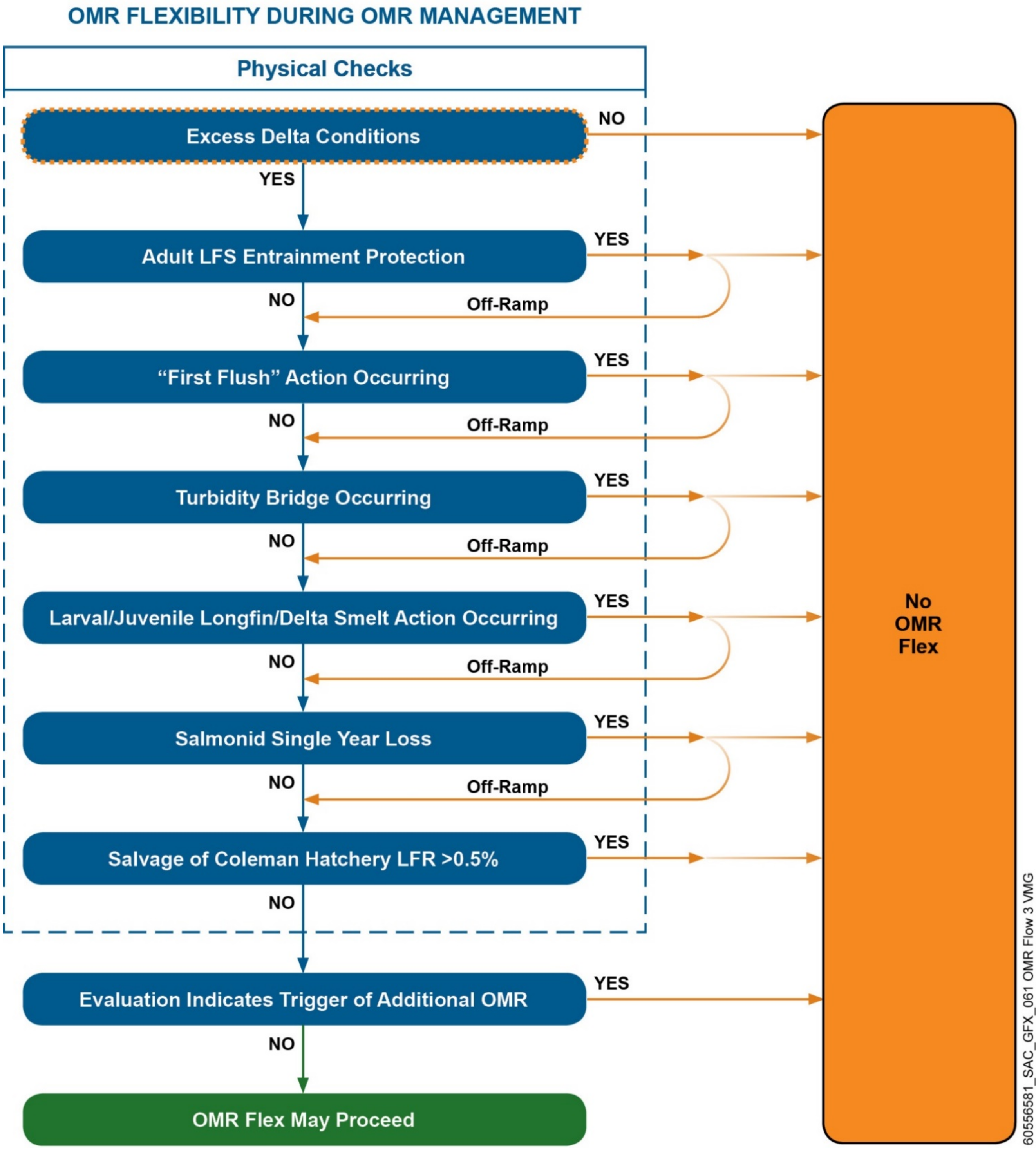


Figure 3-3. OMR Flexibility During OMR Management

- This "First Flush" action may only be initiated once during the December through January period.

- Salmonids Presence: After January 1, if more than 5% of any one or more salmonid species (wild young-of-the-year (YOY) Winter-run, wild YOY Spring-run, or wild California Central Valley Steelhead) are estimated to be present in the Delta, as determined by their appropriate monitoring working group based on available real-time data, historical information, and modeling (e.g., SAC PAS).
- Longfin Smelt protection: After December 1, trigger adult LFS entrainment protection, if:
  - the cumulative salvage index (defined as the total estimated LFS salvage at the CVP and SWP in the December through February period divided by the immediately previous Fall Midwater Trawl (FMWT) LFS annual abundance[2] exceeds five,[3] or
  - real-time monitoring indicates a risk of movement into areas that may be subject to high entrainment.

Adult LFS Entrainment Protection: From December 1 ~~through February 28, DWR, in coordination with Reclamation, will ensure that the OMR flow 14-day running average is no more negative than -5,000 cfs unless:~~

- ~~During any time OMR flow restrictions for Delta Smelt are being implemented, this measure will not result in additional OMR flow requirements for protection of adult LFS, or~~
- ~~2. When LFS spawning has been detected in the system, adult LFS migration and spawning action will terminate and Larval LFS Entrainment Protection will be implemented, or~~
- ~~3. Adult LFS migration and spawning action, including the OMR flow requirement, is not required or would cease if previously required when river flows are (a) greater than 55,000 cfs in the Sacramento River at Rio Vista or (b) greater than 8,000 cfs in the San Joaquin River at Vernalis, or~~
- ~~4. If subsequent to the high flows identified in number 3 above, flows go below 40,000 cfs in the Sacramento River at Rio Vista or below 5,000 cfs in the San Joaquin River at Vernalis, the OMR flow in the adult LFS migration and spawning action may resume if triggered previously and not precluded by another adult LFS migration and spawning action off-ramp. In the implementation of this resumption, in addition to river flows, DWR personnel will review survey data and other pertinent biological factors that influence the entrainment risk of adult LFS. If the technical analysis supports relaxation or ceasing of this OMR flow requirement, DWR will share its technical analysis and supporting documentation with CDFW, seek their technical assistance, and discuss the risk assessment and future operations. If CDFW does not agree with DWR's technical analysis, the Director of CDFW will immediately notify the Director of DWR in writing of the disagreement. The~~

[2] The Fall Midwater Trawl (FMWT) Survey annual abundance index for Longfin Smelt is calculated as the sum of September through December monthly abundance indices and is typically reported at about the same date as adult salvage begins in December. Early December salvage can be compared to September through November abundance as an approximation of the salvage index.

[3] Cumulative salvage index criteria may be modified as part of the adaptive management program in coordination with CDFW.

~~Directors will then confer and attempt to reach a resolution within 3 days. If within 3 days, (1) the Directors do not reach a resolution, and (2) CDFW provides an explanation and supporting documentation on how relaxing or ceasing of this OMR flow requirement would result in take that would not be minimized or fully mitigated, then DWR will not relax or cease OMR flow requirements. DWR will ensure that its proportional share of the OMR flow requirements described herein is satisfied. If either or both the conditions stated above are not met, DWR will continue with the operational change.~~

3.3.1.2 Real-time OMR Limits and Performance Objectives

DWR, in coordination with Reclamation, would operate to an OMR flow requirement that is more positive than a -5,000 cfs OMR flow based on conditions that would protect the following fish species and groups of species from entrainment:

- Longfin Smelt
- Delta Smelt
- Salmonids

The conditions for each of these species and species groups (salmonids) are described below.

Longfin Smelt Entrainment Protections

Additional Real-time Consideration for Adult Longfin Smelt

From ~~December 1~~onset of OMR protections for Adult Longfin Smelt through February 28, using the process described above, DWR and CDFW ~~personnel~~ will decide whether a more restrictive OMR flow requirement that -5,000 cfs is needed for adult Longfin Smelt protection.

- After onset of OMR protections for Adult Longfin Smelt through February 28, DWR, in coordination with Reclamation, will ensure that the OMR flow 14-day running average is no more negative than -5,000 cfs unless:
    1. During any time OMR flow restrictions for Delta Smelt are being implemented, this measure will not result in additional OMR flow requirements for protection of adult LFS, or
    2. When LFS spawning has been detected in the system, adult LFS migration and spawning action will terminate and Larval LFS Entrainment Protection will be implemented, or
    3. Adult LFS migration and spawning action, including the OMR flow requirement, is not required or would cease if previously required when river flows are (a) greater than 55,000 cfs in the Sacramento River at Rio Vista or (b) greater than 8,000 cfs in the San Joaquin River at Vernalis, or
    4. If subsequent to the high flows identified in number 3 above, flows go below 40,000 cfs in the Sacramento River at Rio Vista or below 5,000 cfs in the San Joaquin River at Vernalis, the OMR flow in the adult LFS migration and spawning action may resume if triggered previously and not precluded by another adult LFS migration and spawning action off-ramp. In the implementation of this resumption, in addition to river flows, DWR personnel will

review survey data and other pertinent biological factors that influence the entrainment risk of adult LFS. If the technical analysis supports relaxation or ceasing of this OMR flow requirement, DWR will share its technical analysis and supporting documentation with CDFW, seek its technical assistance, and discuss the risk assessment and future operations. If CDFW does not agree with DWR's technical analysis, the Director of CDFW will immediately notify the Director of DWR in writing of the disagreement. The Directors will then confer and attempt to reach a resolution within 3 days. If within 3 days, (1) the Directors do not reach a resolution, and (2) CDFW provides an explanation and supporting documentation on how relaxing or ceasing of this OMR flow requirement would result in take that would not be minimized or fully mitigated, then DWR will not relax or cease OMR flow requirements. DWR will ensure that its proportional share of the OMR flow requirements described herein is satisfied. If either or both the conditions stated above are not met, DWR will continue with the operational change.

~~review survey data, salvage data and other pertinent biological factors that influence the entrainment risk of adult LFS. DWR will share its technical analysis and supporting documentation with CDFW on an as-needed basis and seek their technical assistance. If the technical analysis supports a more restrictive OMR flow requirement than -5,000 cfs, DWR will discuss the risk assessment and future operations with Water Operations Management Team (WOMT) at its next meeting. If CDFW does not agree with DWR's technical analysis, the Director of CDFW will immediately notify the Director of DWR in writing of the disagreement. The Directors will then confer and attempt to reach a resolution within 3 days. If within 3 days, (1) the Directors do not reach a resolution and (2) CDFW provides an explanation and supporting documentation on how the change in the OMR flow requirement would result in take that would not be minimized or fully mitigated, then DWR will not change the OMR flow requirement. DWR will ensure that its proportional share of the OMR flow requirement described herein is satisfied. If either or both the conditions stated above are not met, DWR will continue with the operational change.~~

Larval and Juvenile Longfin Smelt

From January 1 through June 30, when a single Smelt Larva Survey (SLS) or 20 mm Survey (20 mm) sampling period results in one of the following triggers, DWR in coordination with Reclamation will ensure the OMR flow 14-day running average is no more negative than -5,000 cfs:

- LFS larvae or juveniles found in eight or more of the 12 SLS or 20 mm stations in the Central Delta and South Delta (Stations 809, 812, 815, 901, 902, 906, 910, 912, 914, 915, 918, 919), or
- LFS catch per tow exceeds 15 LFS larvae or juveniles in four or more of the 12 stations in the Central Delta and South Delta (Stations 809, 812, 815, 901, 902, 906, 910, 912, 914, 915, 918, 919).

If QWEST is negative and larval or monitoring detects juvenile LFS within the corridors of the Old and Middle rivers, DWR will assess potential entrainment impacts of fish in the corridors of the Old and Middle rivers relative to their estuarine-wide distribution from monitoring data (e.g., SLS and Enhanced Delta Smelt Monitoring Program [EDSM] for larvae; 20 mm Survey and EDSM for juveniles) using Particle Tracking Model (PTM) runs weighted by the distribution in the surveys. In addition to PTM outputs, DWR will use real-time hydrological conditions, salvage data, forecast models (e.g., statistics-based models of historical data), other potential hydrodynamic models, and water quality to assess entrainment risk and to determine appropriate OMR flow targets to minimize entrainment or entrainment risk, or both. In coordination with CDFW, DWR will determine the best available models, the model inputs, and the assessment methods for determining larval and juvenile Longfin Smelt entrainment risk.

DWR will determine if an OMR flow protection target is warranted and determine the timing (e.g., days or weeks) and magnitude of the action. Implemented OMR flow management actions will continue until it is determined that the risk is abated based on changes in real-time conditions or until the off-ramp has been met as described in the "End of OMR Management" section below. DWR will share its technical analysis and supporting documentation for the modified OMR flow requirement or determination of the abatement of risk with CDFW on an as-needed basis and seek their technical assistance. If CDFW does not agree with DWR's technical analysis, the Director of CDFW will immediately notify the Director of DWR in writing of the disagreement. The Directors will then confer and attempt to reach a resolution within 3 days. If within 3 days, (1) the Directors do not reach a resolution and (2) CDFW provides an explanation and supporting documentation on how the change in the OMR flow requirement or determination of the abatement of risk would result in take that would not be minimized or fully mitigated, then DWR will not change the OMR flow requirement. DWR will ensure that its proportional share of the OMR flow requirement described herein is satisfied. If either or both of the conditions stated above are not met, DWR will continue with the operational change.

Off-Ramps for Larval and Juvenile LFS Entrainment Protection

DWR will continue to manage OMR flows for the protection of Longfin Smelt until the off-ramp criteria have been met, as described in the "End of OMR Management" section below or until one of the following off-ramp criteria are met:

1. During periods when OMR flow restrictions for larval and juvenile Delta Smelt are being implemented, this measure shall not result in additional OMR flow requirements for protection of larval and juvenile LFS, or
2. When river flows meet one of the following requirements, larval and juvenile LFS protections would not trigger, or would be relaxed if triggered previously:
    - Greater than 55,000 cfs in the Sacramento River at Rio Vista
    - Greater than 8,000 cfs in the San Joaquin River at Vernalis
3. If subsequent to the high flows identified in (2), flows drop below 40,000 cfs in the Sacramento River at Rio Vista or below 5,000 cfs in the San Joaquin River at Vernalis, larval and juvenile LFS protection will resume if triggered previously. In implementing this resumption, in addition to river flows, the DWR personnel will review all abundance and distribution survey data and other pertinent biological factors that influence the entrainment risk of larval and juvenile LFS. If the technical analysis supports relaxation or cessation of this OMR flow requirement, DWR will share its technical analysis and supporting documentation with CDFW, seek their technical assistance, and discuss the risk assessment and future operations.

As Longfin Smelt are not a federally listed species and because DWR has limited control over OMR flows, DWR can take actions to make OMR flows more positive, but there are circumstances when the actual OMR flow may not respond to DWR's actions, particularly if the CVP is operating differently. DWR will make efforts to coordinate with Reclamation, but it is anticipated that Reclamation's operations would not include protective measures for Longfin Smelt~~, but Reclamation is not legally required to comply with the Longfin Smelt operations~~. DWR will ensure that its proportional share of the OMR flow requirements described for Longfin Smelt are satisfied.

Delta Smelt Entrainment Protections

Turbidity Bridge Avoidance (South Delta Turbidity)

After the Integrated Early Winter Pulse Protection (above) or February 1 (whichever comes first), until when a spent female is detected or April 1 (whichever is first), DWR, in coordination with Reclamation, would manage exports in order to maintain daily average turbidity in Old River at Bacon Island (OBI) at a level of less than 12 NTU. The purpose of this action is to minimize the risk to adult Delta Smelt in the corridors of the Old and Middle rivers, where they are subject to high entrainment risk. This action seeks to avoid the formation of a turbidity bridge from the San Joaquin River shipping channel to the South Delta fish facilities, which historically has been associated with elevated salvage of prespawning adult Delta Smelt. If the daily average turbidity at Bacon Island could not be maintained at less than 12 NTU, DWR, in coordination with Reclamation, would manage exports to achieve an OMR flow that is no more negative than -2,000 cfs until the daily average turbidity at Bacon Island drops below 12 NTU. However, if 5 consecutive days of OMR flow that is less negative than -2,000 cfs does not reduce daily average turbidity at Bacon Island below 12 NTU in a given month, DWR, in coordination with Reclamation, may determine that OMR restrictions to manage turbidity are infeasible and will instead implement an OMR flow target that is deemed protective based on turbidity and adult Delta Smelt distribution and salvage, but will not a more negative OMR flow than -5,000 cfs.

DWR and Reclamation recognize that readings at individual sensors can generate spurious results in real time. Such changes could be incorrectly interpreted as a full turbidity bridge, when in fact the cause a result of local conditions or sensor error. To avoid excessive OMR restrictions during a sensor error or a localized turbidity spike, DWR, in coordination with Reclamation, will consider and review data from other locations and sources. Additional information that will be reviewed include regional visualizations of turbidity, alternative sensors, and boat-based turbidity mapping, particularly if there was evidence of a local sensor error.

DWR will share its technical analysis and supporting documentation with CDFW on an as-needed basis and seek CDFW's technical assistance if it determines the OMR requirement could be off-ramped after 5-days of implementation of the Turbidity Bridge Avoidance action or if it determines that this action is not warranted. If CDFW does not agree with DWR's technical analysis, the Director of CDFW will immediately notify the Director of DWR in writing of the disagreement. The Directors will then confer and attempt to reach a resolution within 3 days. If within 3 days, (1) the Directors do not reach a resolution and (2) CDFW provides an explanation and supporting documentation on how off-ramping the Turbidity Bridge Avoidance action or not implementing this action would result in take that would not be minimized or fully mitigated, then DWR will implement (or continue to implement) this action. DWR will ensure that its proportional share of the OMR flow requirement described herein is satisfied. If either or both the conditions stated above are not met, DWR will continue with the operational change.

Larval and Juvenile Delta Smelt Protection

DWR, in coordination with Reclamation, will use results produced by life cycle models approved by CDFW and USFWS to manage the annual entrainment levels of larval and juvenile Delta Smelt. The USFWS models will be publicly vetted and peer reviewed prior to March 15, 2020. CDFW and USFWS will coordinate with the Delta Fish Monitoring Working Group to identify a Delta Smelt recruitment level that Reclamation and DWR can use in OMR flow management. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment such as OMR flows. In this context, recruitment is defined as the estimated number of post-larval Delta Smelt in June per number of spawning adults in the prior February-March period.

DWR, in coordination with Reclamation, CDFW, and USFWS will operationalize the life cycle model results through the use of real-time monitoring for the spatial distribution of Delta Smelt. On or after March 15 of each year, if QWEST is negative and larval or juvenile Delta Smelt are detected within the corridors of the Old and Middle rivers based on real-time sampling of spawning adults or YOY life stages, Reclamation and DWR, or both, will run hydrodynamic models and forecasts of entrainment informed by the EDSM or other relevant survey data to estimate the percentage of larval and juvenile Delta Smelt that could be entrained. If necessary, DWR and Reclamation will manage exports to limit entrainment to be protective, based on the modeled recruitment levels. DWR, in coordination with Reclamation, will re-run hydrodynamic models when operational changes or new sampling data indicate a potential change in entrainment risk. This process will continue until the off-ramp criteria have been met, as described in the “End of OMR Management” section below. In the event the life cycle models cannot be operationalized in a manner that can be used to inform real-time operations, Reclamation, DWR, CDFW, and USFWS will coordinate to develop an alternative plan to provide operational actions protective of this life stage.

If CDFW does not agree with the operational actions determined above, the Director of CDFW will immediately notify the Director of DWR in writing of the disagreement. The Directors will then confer and attempt to reach a resolution within 3 days. If within 3 days, (1) the Directors do not reach a resolution and (2) CDFW provides an explanation and supporting documentation on how the operational actions determined above would result in take that would not be minimized or fully mitigated, DWR will then implement the operational action agreeable to CDFW. DWR will ensure that its proportional share of the OMR flow requirement described herein is satisfied. If either or both the conditions stated above are not met, DWR will continue with the operational actions determined above.

Salmonid Entrainment Loss Protections

Cumulative Loss Thresholds

DWR, in coordination with Reclamation, would target exceedance of cumulative loss thresholds over the duration of the 2019 BiOps for natural Winter-run Chinook Salmon, hatchery Winter-run Chinook Salmon, natural Central Valley Steelhead from December through March, and natural Central Valley Steelhead from April 1 through June 15.

DWR, in coordination with Reclamation, proposes to avoid exceeding cumulative loss thresholds by 2030 as follows:

- Natural Winter-run Chinook Salmon (cumulative loss = 8,738)
- Hatchery Winter-run Chinook Salmon (cumulative loss = 5,356)
- Natural Central Valley Steelhead from December through March (cumulative loss = 6,038)
- Natural Central Valley Steelhead from April 1 through June 15 (cumulative loss = 5,826).

Natural Central Valley Steelhead would be separated into two time periods to protect San Joaquin-origin fish that historically appear in the Mossdale trawls later than Sacramento-origin fish. The loss threshold and loss tracking for hatchery Winter-run Chinook Salmon do not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook Salmon is based on length-at-date criteria.

The cumulative loss thresholds would be based on the cumulative historical loss from 2010 through 2018. DWR and Reclamation's performance objectives are intended to avoid loss such that the cumulative loss threshold (measured as the 2010-2018 average cumulative loss multiplied by 10 years) will not be exceeded by 2030.

If at any time prior to 2024, DWR, in coordination with Reclamation, were to exceed 50% of the cumulative loss threshold, DWR, in coordination with Reclamation, would convene an independent panel to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the cumulative loss threshold, if any.

In the year 2024, DWR, in coordination with Reclamation, would convene an independent panel to review the first 5 years of actions and determine whether continuing these actions is likely to reliably maintain the trajectory associated with this performance objective for the duration of the period.

If during real-time operations, DWR, in coordination with Reclamation, were to exceed the cumulative loss threshold, DWR, in coordination with Reclamation, would immediately seek technical assistance from CDFW and NMFS, as appropriate, on the coordinated operation of the SWP and CVP, respectively for the remainder of the OMR management period. In addition, prior to the next OMR management season, DWR in coordination with Reclamation would convene an independent review panel to review the actions contributing to this loss trajectory and make recommendations for modifications or additional actions to stay within the permitted take.

Single-Year Loss Thresholds

In each year, DWR, in coordination with Reclamation, would avoid exceeding an annual loss threshold equal to 90% of the greatest salvage loss that occurred in the historical record from 2010 through 2018 for each of the following:

- Natural Winter-run Chinook Salmon (loss = 1.17% of juvenile production estimate [JPE])
- Hatchery Winter-run Chinook Salmon (loss = 0.12% of JPE)
- Natural Central Valley Steelhead from December through March (loss =1,414)
- Natural Central Valley Steelhead from April through June 15 (loss = 1,552)

Natural Central Valley Steelhead would be separated into two time periods to protect San Joaquin-origin fish that historically appear in the Mossdale trawls later than Sacramento-origin fish. The loss threshold and loss tracking for hatchery Winter-run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook Salmon is based on length-at-date criteria.

During the year, if SWP and CVP operations were to exceed the average annual loss threshold, DWR in coordination with Reclamation would review recent fish distribution information and operations with the fisheries agencies at the Water Operations Management Team (WOMT) and seek technical assistance on future planned operations. DWR, Reclamation, USFWS, NMFS, and CDFW could elevate an issue from WOMT to a Directors' discussion, as appropriate.

During the year, if SWP and CVP operations exceed 50% of the annual loss threshold, DWR, in coordination with Reclamation, would restrict OMR to a 14-day moving average OMR index that is no more negative than −3,500 cfs, unless DWR, in coordination with Reclamation, determines that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.

The -3,500 OMR flow operational criteria adjusted and informed by this risk assessment would remain in effect for the rest of the season. DWR and Reclamation would seek CDFW and NMFS technical assistance on the risk assessment and real-time operations.

During the year, if Reclamation and DWR exceed 75% of the annual loss threshold, Reclamation and DWR will restrict OMR to a 14-day moving average OMR flow index that is no more negative than -2,500 cfs unless DWR and Reclamation determine that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.

The -2,500 OMR flow operational criteria adjusted and informed by this risk assessment will remain in effect for the rest of the season. DWR and Reclamation will seek CDFW and NMFS technical assistance on the risk assessment and real-time operations.

Regarding the risk assessments (identified above), DWR and Reclamation will evaluate and adjust OMR restrictions under this section by preparing a risk assessment that considers several factors, including but not limited to, real-time monitoring, historical trends of salmonids exiting the Delta and entering the South Delta, fish detected in salvage, and relevant environmental conditions. Risks will be measured against the potential to exceed the next single-year loss threshold. DWR and Reclamation will share its risk assessment and supporting documentation with CDFW, USFWS, and NMFS; seek their technical assistance; discuss the risk assessment and future operations with WOMT at its next meeting; and elevate issues to the Directors as appropriate.

DWR will share its risk assessment and supporting documentation with CDFW on an as-needed basis and seek their technical assistance if it determines the OMR requirement could be off-ramped. If CDFW does not agree with DWR's technical analysis, the Director of CDFW will immediately notify the Director of DWR in writing of the disagreement. The Directors will then confer and attempt to reach a resolution within 3 days. If within 3 days, (1) the Directors do not reach a resolution and (2) CDFW provides an explanation and supporting documentation on how off-ramping the OMR flow requirement would result in take that would not be minimized or fully mitigated, then DWR will not off-ramp the OMR flow requirement. DWR will ensure that its proportional share of the OMR flow requirement described herein is satisfied. If either or both the conditions stated above are not met, DWR will continue with the operational change.

If during real-time operations, Reclamation and DWR were to exceed the single-year loss threshold, Reclamation and DWR would immediately seek technical assistance from CDFW, USFWS, and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR would, prior to the next OMR management season, convene an independent panel to review the OMR Management Action. The purpose of the independent review would be to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the annual loss threshold, if any.

DWR, in coordination with Reclamation, would continue monitoring and reporting salvage at the Jones and Tracy fish facilities. DWR and Reclamation would continue the release and monitoring of yearling Coleman National Fish Hatchery (NFH) Late Fall-run and yearling Spring-run Chinook Salmon surrogates. DWR, in coordination with Reclamation, would use the reported real-time salvage counts along with qualitative and quantitative tools such as the "Salmonid Entrainment Model" to inform operations.

OMR Flexibility During Delta Excess Flow Conditions

DWR, in coordination with Reclamation, may operate to a more negative OMR flow but no more negative than -6,250 cfs on a 5-day average to capture excess flows in the Delta. Excess flows occur typically from storm-related events and are defined as flows in excess of that required to meet water quality control plan flow and salinity requirements and other applicable regulations. DWR, in coordination with Reclamation, would continue to monitor fish in real time and would operate in accordance with the "Additional Real-time OMR Restrictions," previously described.

Figure 3-3 shows the physical checks that would preclude implementation of an OMR flexibility action. As shown, if any other OMR flow limit is active, an OMR flexibility action would be precluded.

Unless the following species protections occur, DWR has the discretion to capture excess flows if:

1. Integrated Early Winter Pulse Protection or additional real-time OMR restrictions are triggered, and the required OMR flow is more positive or less negative than -5,000 cfs. Under such conditions, DWR and Reclamation have already determined that a more restrictive OMR flow is required.
2. An evaluation of environmental and biological conditions by DWR, in coordination with Reclamation, indicates more negative OMR would likely trigger an additional real-time OMR restriction.
3. Salvage of yearling Coleman NFH Late Fall-run (as yearling Spring-run Chinook Salmon surrogates) exceeds 0.5% within any of the release groups.
4. DWR, in coordination with Reclamation, identifies changes in spawning, rearing, foraging, sheltering, or migration behavior beyond those anticipated to occur under OMR management.

DWR, in coordination with Reclamation, would continue to monitor conditions and could resume management of OMR flows to levels no more negative than −5,000 cfs if conditions indicate the defined off-ramps are necessary to avoid additional adverse impacts. If OMR flow flexibility causes the conditions in Real-Time OMR Limits and Performance Measures, DWR in coordination with Reclamation would implement additional real-time OMR flow restrictions.

DWR will share its technical analysis and supporting documentation with CDFW on an as-needed basis and seek their technical assistance if it determines the OMR flow flexibility is warranted. If CDFW does not agree with DWR’s technical analysis, the Director of CDFW will immediately notify the Director of DWR in writing of the disagreement. The Directors will then confer and attempt to reach a resolution within 3 days. If within 3 days (1) the Directors do not reach a resolution and (2) CDFW provides an explanation and supporting documentation on how OMR flow flexibility would result in take that would not be minimized or fully mitigated, DWR will not implement OMR flow flexibility. DWR will ensure that its proportional share of the OMR flow requirement described herein is satisfied. If either or both the conditions stated above are not met, DWR will continue with the operational change.

End of OMR Management

OMR flow criteria may control operations until June 30 or when the following species-specific off-ramps have occurred, whichever is earlier.

- Longfin Smelt and Delta Smelt: When the daily mean water temperature at the CCF reaches 77 degrees Fahrenheit (°F) (25 degrees Celsius [°C]) for 3 consecutive days.
- Salmonids: When more than 95% of Winter-run Chinook Salmon and Spring-run Chinook Salmon have migrated past Chipps Island, as determined by DWR and Reclamation’s monitoring working group, or after daily average water temperatures at Mossdale exceed 72°F (22.2 °C) for 7 days during June (the 7 days do not have to be consecutive).

Real-Time Decision-Making and Loss Thresholds

When real-time monitoring demonstrates that criteria in “Additional Real-Time OMR Restrictions and Performance Objectives” are not supported, then Reclamation and DWR may confer with the Directors of NMFS, USFWS, and CDFW if they desire to operate to a more negative OMR flow than what is specified in “Additional Real-Time OMR Limits and Performance Objectives.” Upon mutual agreement, the Directors of NMFS and USFWS may authorize DWR and Reclamation to operate to a more negative OMR flow than the “Additional Real-Time OMR Restrictions,” but no more negative than -5,000 cfs. The Director of CDFW may authorize DWR to operate to a more negative OMR flow than the “Additional Real-Time OMR Restrictions,” but no more negative than -5,000 cfs. This process would be separate from the risk analysis process described above.

If CDFW does not agree, the Director of CDFW will immediately notify the Director of DWR in writing of the disagreement. The Directors will then confer and attempt to reach a resolution within 3 days. If within 3 days (1) the Directors do not reach a resolution and (2) CDFW provides an explanation and supporting documentation on how the action would result in take that would not be minimized or fully mitigated, then DWR will not implement this action. DWR will ensure that its proportional share of the OMR flow requirement described herein is satisfied. If either or both the conditions stated above are not met, DWR will continue with the operational change.

3.3.2 Minimum Export Rate

Water rights, contracts, and agreements specific to the Delta include D-1641, COA and other related agreements pertaining to CVP and SWP operations and Delta watershed users. In order to meet health and safety needs, critical refuge supplies, and obligations to senior water rights holders, the combined CVP and SWP export rates at Jones Pumping Plant and Banks Pumping Plant will not be required to drop below 1,500 cfs. Reclamation and DWR propose to use the Sacramento River, San Joaquin River, and Delta channels to transport water to export pumping plants located in the South Delta.

3.3.3 Delta Smelt Summer-Fall Habitat Action

The Delta Smelt Summer-Fall Habitat Action is intended to improve Delta Smelt food supply and habitat, thereby contributing to the recruitment, growth, and survival of Delta Smelt. The current conceptual model states that Delta Smelt habitat should include low-salinity conditions of 0 to 6 parts per thousand (ppt), turbidity of approximately 12 NTU, temperatures below 25°C, food availability, and littoral or open water physical habitats (FLaSH Synthesis:15-25). The Delta Smelt Summer-Fall Habitat Action is being undertaken recognizing that the highest-quality habitat in this large geographical region includes areas with complex bathymetry, in deep channels close to shoals and shallows, and in proximity to extensive tidal or freshwater marshlands and other wetlands. The Delta Smelt Summer-Fall Habitat Action is to provide the aforementioned habitat components in the same geographic area through a range of actions to improve water quality and food supplies.

DWR and Reclamation propose to use structured decision-making to implement Delta Smelt habitat actions. In the summer and fall (June through October) of below-normal, above-normal and wet years, based on the Sacramento Valley Index, the environmental and biological goals are, to the extent practicable, the following:

- Maintain low-salinity habitat in Suisun Marsh and Grizzly Bay when water temperatures are suitable.
- Manage the low salinity zone to overlap with turbid water and available food supplies.

- Establish contiguous low-salinity habitat from Cache Slough Complex to Suisun Marsh.

The action will initially include modifying project operations to maintain a monthly average 2 ppt isohaline at 80 km (X2) from the Golden Gate in above-normal and wet water years in September and October. DWR and Reclamation will also implement additional measures that are expected to achieve additional benefits. These measures include, but are not limited to:

- Suisun Marsh Salinity Control Gates (SMSCG) operations for up to 60 days (not necessarily consecutive) in June through October of below-normal and above-normal years. This action may also be implemented in wet years, if preliminary analysis shows expected benefits.
- Food enhancement action (for example, those included in the Delta Smelt Resiliency Plan to enhance food supply). These projects include the North Delta Food Subsidies and Colusa Basin Drain project, and Suisun Marsh Food Subsidies (Roaring River distribution system reoperation). DWR and Reclamation will monitor dissolved oxygen at Roaring River distribution system drain location(s) during Delta Smelt food distribution actions.

These considerations (listed above) and implementation of other actions will be more fully defined and developed through the structured decision-making or other review process. The review will include selection of appropriate models, sampling programs, and other information to be used. The process will be completed prior to implementation and may be improved in subsequent years as additional information is synthesized and reviewed, as described below.

Reclamation and DWR will develop a Delta Smelt Summer-Fall Habitat Action Plan to meet the environmental and biological goals in years when summer-fall habitat actions are triggered. In above normal and wet years, operating to a monthly average X2 of 80 km in September and October is the initial operation. In every action year, Reclamation and DWR will propose, based on discussions with the USFWS and CDFW, a suite of actions that would meet the action's environmental and biological goals. This action would be coordinated with Reclamation and categorized as an in-basin use for COA purposes. In the event that Reclamation does not meet its share of the Delta outflow to meet 80 km X2, DWR will implement its share of this action.

3.3.3.1 Food Enhancement Summer-fall Actions

North Delta Food Subsidies and Colusa Basin Drain Project: DWR proposes to implement actions to improve flow conditions in the North Delta in summer and fall, thereby facilitating downstream transport of phytoplankton and zooplankton. While the Cache Slough Complex and the lower Yolo Bypass are known to have relatively high levels of food resources, ~~local~~ water diversions within these vicinities create net negative flows during summer and fall that may inhibit downstream food transport. By enhancing summer and fall flows through the Yolo Bypass, downstream transport of food could be improved.

DWR and partners would test two different ways to improve flow conditions in the north Delta. For the first approach, water would be ~~provided~~ diverted by Sacramento River water districts, such as Reclamation District 108 and Glenn Colusa Irrigation District. The water districts would use their facilities to move freshwater into Colusa Drain. By adjusting the operations of Knights Landing Outfall Gates and Wallace Weir, much of this water would be routed into the Yolo Bypass.

The second approach would use agricultural drain water in fall, which is available ~~in fall~~ when valley rice fields discharge irrigation water at the end of the growing season. Agricultural drain water would be routed into the Yolo Bypass via Knights Landing Ridge Cut.

DWR proposes flow pulses would include summer actions using fresh Sacramento River water and fall actions using agricultural drain water from Colusa Drain. Initial results suggest that a target pulse of 27 TAF over a 4-week period would improve downstream transport of phytoplankton. This flow volume is not sufficient to inundate the floodplain in the Yolo Bypass, nor would it constitute a consumptive use of water because the water used for this action would be allowed to move through the North Delta and contribute to Delta outflow.

This food subsidy action is an adaptive management action that relies on monitoring and evaluation in order to optimize its efficacy. Similarly, the action depends on partnerships with Reclamation to make water available and local water users including Reclamation District 108, Glenn Colusa Irrigation District, Conaway Ranch, and Swanston Ranch. All actions should be developed in consultation with the needs of local water users and landowners. Food enhancement action design and implementation would be determined through the Summer-Fall Adaptive Management process.

Roaring River Distribution System Reoperations: Infrastructure in the Roaring River Distribution System may help drain food-rich water from the canal into Grizzly Bay to augment Delta Smelt food supplies in that area.

3.3.3.2 Delta Smelt Summer-Fall Habitat Action Adaptive Management Planning

Conceptual Model

The Delta Smelt Summer-Fall Habitat Action is intended to improve Delta Smelt food supply and habitat, thereby contributing to improved Delta Smelt habitat conditions. The current conceptual model is that Delta Smelt habitat should include low salinity conditions of 0 to 6 ppt, turbidity of approximately 12 NTU, temperatures below 25°C (77 °F), food availability, and littoral or open water physical habitats (FLaSH Synthesis, pp. 15-25). The Delta Smelt Habitat Action is being undertaken recognizing that the highest quality habitat in this large geographical region includes areas with complex bathymetry, in deep channels close to shoals and shallows, and in proximity to extensive tidal or freshwater marshlands and other wetlands. The Delta Smelt Habitat Action is to provide these habitat components in the same geographic area through a range of actions to improve water quality and food supplies.

Planning Process

The adaptive management process would be investigating the way in which SWP-CVP operations interact with the full range of components of Delta Smelt habitat. The process would be investigating the extent that providing flow and/or low salinity conditions of various volumes and locations improves the quality and quantity of Delta Smelt habitat in the summer and fall, and whether Delta Smelt survival, viability, and/or abundance improves in relation to the Delta Smelt Habitat Actions. The planning process will also consider other tradeoffs, including effects on other species.

An adaptive management plan will be developed following issuance of the Notice of Determination (NOD). The framework for the adaptive management plan is as follows:

- DWR and Reclamation shall form a Delta Coordination Group (Reclamation, DWR, USFWS, NMFS, CDFW, and representatives from federal and state water contractors).
- The Delta Coordination Group would use one of the existing structured decision-making models or adopt a new model to analyze proposed summer-fall habitat actions, making predictions regarding the potential outcomes for various implementation scenarios. This structured decision-making process would inform each year's Habitat Action Plan.
- Within 6 months of signing the NOD, the Delta Coordination Group would meet to select a structured decision-making model and complete initial model runs (and annual model runs thereafter) testing various approaches to satisfying the environmental and biological goals, using the available tool box of approaches.
- Each year, the Delta Coordination Group would develop a Habitat Action Plan accounting for forecasted hydrology and temperatures over the summer and fall. The Habitat Action Plan would describe how the proposed action would meet the environmental and biological goals of the action. The Habitat Action Plan would include the hypotheses to be tested, the suite of actions and operations to test the hypotheses, and the expected outcomes. The Habitat Action Plan would be informed by the annual results of the structured decision-making process. In recognition of the time required for annual planning, the Habitat Action Plan process would occur every year so the Plan would be prepared in time for review by the USFWS and CDFW in the event the action is triggered.
- CDFW and USFWS would review the Habitat Action Plan in each year in which an action is triggered and confirm that the impacts of the action are within what was analyzed in the BiOp and the California Fish and Game Code Section 2081 permit, and that the action is consistent with the project description.
- After the completion of each summer-fall habitat action, DWR and Reclamation will share preliminary monitoring results through the Delta Coordination Group. At the beginning of the next water year, DWR and Reclamation would provide a synthesis of the monitoring results to the Delta Coordination Group. The Delta Coordination Group would review the synthesis of results and use the results of the monitoring to inform a subsequent structured decision-making modeling exercise using the tool box of available approaches.
- The Delta Smelt Summer-Fall Habitat Action would be included in the Four-Year Reviews under the Governance section of this Proposed Action. The structured decision-making model and the multi-year science and monitoring plan would be part of this Peer Review.

3.3.4 Real-time Water Operations Process

DWR, in coordination with Reclamation, would implement activities, monitor performance, and report on compliance with the commitments in the Proposed Project. Implementing the proposed action would require coordination between CDFW, DWR, USFWS, NMFS, Reclamation, and the SWP-CVP water contractors. The federal government is proposing a Real-Time Operations Charter to facilitate federal coordination with the State.

Investments in science, monitoring, and decision support tools since the 2008 and 2009 federal Biological Opinions, state Consistency Determinations, and the Fish and Game Code Section 2081 permit for Longfin Smelt provide the ability to reduce reliance on professional opinion and increase the use of qualitative and quantitative models to assess risk in real time based on the real-time monitoring of species and relevant other physical and biological factors. While DWR and Reclamation hold the responsibility for operating the SWP and CVP in a coordinated manner, many agencies and organizations assist in monitoring field conditions to provide information that assists in real-time decisions. Communication on real-time conditions and the implementation of water operations provides assurance that DWR, in coordination with Reclamation, is meeting the commitments within the Proposed Project.

Portions of the Proposed Project rely on real-time monitoring to inform DWR and Reclamation on how to minimize and/or avoid stressors on listed species. The Proposed Project seeks to take advantage of the expertise within the state and federal fish agencies in the real-time monitoring of species distribution and life stage. DWR, in coordination with Reclamation, would then use qualitative and quantitative tools to perform risk analyses that inform operations. Actions to address stressors in real-time include Old and Middle River Flow Management.

Some elements of the Proposed Project include seasonal input by the state and federal regulatory agencies on scheduling actions to benefit the fishery. Actions requiring seasonal input from CDFW include the Delta Smelt Summer-Fall Habitat Action.

DWR, in coordination with Reclamation, would demonstrate compliance with the commitments of the Proposed Project and provide sufficient information for evaluation of federal initiation triggers through regular monitoring and reporting. New information and changing conditions may exceed a federal reinitiation trigger and could require subsequent federal ESA Section 7 consultation. As the SWP and CVP must coordinate operations, a federal reinitiation of Section 7 consultation would require discussions with CDFW and possible need for a permit amendment.

- Real-Time Operation participants
- Action Agencies: DWR and Reclamation
- Regulatory Agencies: USFWS, NMFS, CDFW, SWRCB, USACE
- Stakeholders: state and federal water contractors
- Decision-Making for Real-Time Operations

Nothing in this project description modifies the rights and responsibilities of the agencies. Decisions shall be made consistent with the authorizing legislation and the regulations and policies under the federal and state Endangered Species Acts, as appropriate.

DWR and Reclamation shall retain sole discretion for:

- Water Operations of the SWP and CVP, including allocations, under Reclamation Law and the State Water Project, as appropriate
- Agency appropriations (budget requests, fund alignment, contracting, etc.)
- Section 7 Action Agency and Applicant (consultation)
- Coordination and cooperation with Public Water Agencies (PWAs) as required by contracts and agreements

CDFW, USFWS, and NMFS shall retain sole discretion for:

- Consultation under Section 7 of the federal ESA and California Fish and Game Code, as appropriate and the associated Incidental Take Statements/Permits
- Agency Appropriations

State Water Resources Control Board shall retain the sole discretion for:

- Enforcement as allowable under federal and state law (e.g., Clean Water Act and Porter-Cologne Water Quality Control Act)

State and federal water contractors shall retain all existing authority and discretion and are participating in a technical and policy advisory capacity.

DWR would continue to coordinate with USACE, as appropriate, under existing permits as wells as in venues such as the Interagency Ecological Program. Other agencies (e.g., the U.S. Geological Survey [USGS]) may also be involved in monitoring physical conditions in the Delta.

3.3.4.1 Annual Process

Reclamation and DWR will continue to provide standard reporting on real-time operations, environmental conditions, and biological parameters, such as species distribution, life stage, and dynamics. These data are available daily through Reclamation and DWR websites and additional tools such as CDEC, NWIS, RWIS, SacPAS, Bay-Delta Live, and SHOWR.

Monitoring for the proposed real-time management include:

- Delta flow, temperature, and salinity stations
- Chinook Salmon biological information:
  - Juvenile abundance and timing: Implementation of OMR management (Sacramento Trawl and Chipps Island Trawl)
  - Delta distribution: Informs OMR actions and is currently supported through beach seines, acoustic tagging, and EDSM

- Salvage count: Informs the direct impacts on listed fish
- Genetic identification: Informs the salvage of listed Chinook Salmon species versus non-listed Chinook Salmon species

- Delta Smelt biological information:
  - Turbidity stations: Inform the potential for a "turbidity bridge" that would inform OMR actions
  - Temperature stations: Informs the transition between life stages and the need for protective measures
  - Water quality stations: Track the movement of the low salinity zone and parameters associated with the food web (e.g., chlorophyll)
  - Delta distribution: Informs the entrainment risk due to OMR actions and would be supported by EDSM
  - Fish condition: Informs when adults have spawned and the need for larval protections
- Longfin Smelt biological information:
  - Water quality stations: Track the movement of the low salinity zone and parameters associated with the food web (e.g., chlorophyll)
  - Delta distribution: Informs the entrainment risk due to OMR actions
  - Fish condition: Informs when adults have spawned and the need for larval protections

Status and Trend Monitoring

Status and trend monitoring characterizes the population of species and their environments over time including the impacts of stressors from sources other than the CVP and SWP. Recovery plans characterize the status and trends differently depending upon the species in the general categories of abundance, production, life history diversity, and geographic diversity. In addition to the Core Monitoring, a number of additional programs are anticipated to continue and will continue to be funded by DWR. The majority of monitoring programs are supported by Reclamation and DWR for CVP, SWP, and Delta watersheds~~, the majority of which are supported by Reclamation and DWR for CVP, SWP, and Delta watersheds~~:

- Hatchery Proportion (Constant Fractional Marking)
- Genetic Analyses of California Salmonid Populations: Parentage Based Tagging (PBT) of salmonids in California Hatcheries
- Fall Midwater Trawl
- 20-mm Survey monitoring to determine distribution and relative abundance of Delta Smelt and Longfin Smelt
- Spring Kodiak Trawl
- Estuarine and Marine Fish Abundance and Distribution Survey
- Smelt Larva Survey (SLS)
- Summer Townet Survey

- Environmental Monitoring Program (EMP)

The coordinated operation of the SWP requires the following deliverables throughout the year. In addition to those identified herein, Reclamation would have additional deliverables that would be provided to USFWS and NMFS related to the operation of the CVP.

DWR and Reclamation will provide products on the schedule identified below:

1. Monitoring Program for Core Water Operations, Ongoing
2. December through June, Weekly and Biweekly, Real-Time Species Distribution and Life Stage
3. Monthly (and as needed), Water Operation Status
4. Monthly (and/or as needed), Specific operations for:
    a. Old and Middle River Reverse Flow Storm Events (December through June)
    b. Delta Smelt Fall Habitat and Suisun Marsh Salinity Control Gates (May)
5. Seasonal and Annual Compliance Reporting
    a. September, Annual Summary of Water Supply and Fish Operations

3.3.5 Monitoring Workgroups

DWR and Reclamation would continue to convene Monitoring Workgroups as needed. Reclamation would be solely responsible for convening Watershed Workgroups for each of the Upper Sacramento, American, and Stanislaus watersheds. Each of Reclamation's Watershed Workgroups would be responsible for real-time synthesis of fisheries monitoring information and providing recommendations on scheduling specific volumes of water for restorations actions described in the federal proposed action. DWR, in coordination with Reclamation, would convene the Delta Monitoring Workgroup which would be responsible for integrating species information across watersheds, including Delta Smelt, Winter-run Chinook Salmon and other salmonids and sturgeon. In addition to the Delta Monitoring Workgroup, the program may include a Smelt Monitoring and Salmonid monitoring teams. The Delta Monitoring Workgroup will include technical representatives from federal and state agencies and stakeholders and will provide information to DWR and Reclamation on species abundance, species distribution, life stage transitions, and relevant physical parameters.

A Water Operations Team (WOMT) comprised of agency managers will coordinate on overall water operations to oversee the implementation of various real-time provisions. The WOMT shall be responsible for overseeing the Watershed Monitoring Workgroups and elevating disagreements to the Directors of CDFW, DWR, Reclamation, USFWS and NMFS, where necessary. The coordinated state and federal monitoring group structure is as follows:

- Directors
- WOMT
- Delta Monitoring Workgroup
    - Smelt Monitoring Team
    - Salmon Monitoring Team

- Program Teams

The WOMT shall coordinate the preparation of seasonal and annual reporting in coordination with the Watershed Monitoring Teams.

DWR would continue to coordinate with the Interagency Ecological Program for permitting and coordination for physical and biological monitoring. It would also continue to coordinate with the Collaborative Science and Adaptive Management Program for synthesis of monitoring and studies. In the event that either of these groups is unwilling or unable to provide for the commitments in the Proposed Project, DWR (in coordination with Reclamation) would confer with CDFW, USFWS, and NMFS on alternative implementation plans.

3.3.6 Four-Year Reviews

In January of 2024 and January of 2028, DWR, in coordination with Reclamation, would convene an independent panel to review OMR management and measures to improve survival through the South Delta and the Delta Smelt Summer-Fall Habitat Action.

Establishment of independent review panels composed of subject matter experts is a key component of DWR proposed adaptive management approach to operation of the SWP CDFW, NMFS, and USFWS may provide technical assistance and input regarding the panel and its panel charge. The panel would evaluate the efficacy of these and other project actions and make recommendations.

The independent panels would review actions for consistency with applicable guidance and will provide information and recommendations to DWR. DWR, in consultation with Reclamation, will provide the results of the independent review to CDFW, NMFS, and USFWS. DWR will coordinate with Reclamation to document a response to the independent review.

3.3.7 Drought and Dry Year Actions

DWR shall coordinate with Reclamation to develop a voluntary toolkit of drought actions that could be implemented at the discretion of DWR and/or Reclamation. On October 1~~st~~, if the prior water year was dry or critical, DWR, in coordination with Reclamation, shall meet and confer with USFWS, NMFS, CDFW, and Public Water Agencies on voluntary measures to be considered if drought conditions continue into the following year. If dry conditions continue, DWR, in coordination with Reclamation, will regularly meet with this group (and potentially other agencies and organizations) to evaluate hydrologic conditions and the potential for continued dry conditions that may necessitate the need for development of a drought contingency plan (that may include actions from the toolkit) for the water year.

By February of each year following a critical hydrologic year type, DWR, in coordination with Reclamation, shall report on the measures employed and assess their effectiveness. The toolkit shall be revisited at a frequency of not more than 5-year intervals.

3.3.8 Continued Installation of South Delta Temporary Barriers

DWR proposes to continue operating three temporary agricultural barriers at the Old River at Tracy, Middle River, and Grant Line Canal each year, when necessary to maintain operations of agricultural water users. These three rock barriers are designed to act as flow control structures, trapping tidal waters behind them after a high tide. These barriers improve water levels and circulation for local South Delta farmers and collectively are referred to as agricultural barriers.

The objectives of operating the three temporary barriers are to increase water levels, circulation patterns, and water quality in the South Delta area for local agricultural diversions. DWR installs and removes the temporary rock barriers at the following locations:

- Middle River near the Victoria Canal, about 0.5 mile south of the confluence of the Middle River, Trapper Slough, and the North Canal
- Old River near Tracy, approximately 0.5 mile east of the Delta-Mendota Canal intake
- Grant Line Canal, approximately 400 feet east of the Tracy Boulevard Bridge

The agricultural barriers will continue to be installed under existing permits starting in May provided San Joaquin River flow at Vernalis is low enough to enable installation, typically less than 5,000 cfs. All three agricultural barriers operate until the fall and must be completely removed by November 30 of each year. Full closure of the Grant Line Canal Barrier requires NMFS, USFWS, and CDFW approval and a demonstrated need for the full closure based on actual conditions and modeling. Barriers would include at least one open culvert, to allow fish passage when water temperatures are less than 22°C (77 °F).

DWR is not proposing to install Head of Old River Barrier as part of this consultation.

3.3.9 Barker Slough Pumping Plant Operations

BSPP diverts water from Barker Slough into the NBA for delivery in Napa County and to the Solano County Water Agency (SCWA). The NBA intake is approximately 10 miles from the Sacramento River at the northwest end of Barker Slough. The maximum pumping capacity of this facility is 175 cfs. The annual maximum diversion is 125 TAF.

DWR will work with the USFWS and CDFW to develop Delta Smelt minimization measures ~~by the end of the 2019 calendar year~~. These minimization measures will aim to protect larval Delta Smelt from entrainment through the BSPP and will consider reduction in diversion through the NBA at the appropriate spring period and appropriate water year types by using effective detection measures or an appropriate proxy.

BSPP will be operated to protect larval Longfin Smelt from January 15 through March 31 of dry and critically dry years. The Water Year type is as defined in D-1641 for the Sacramento River Basin. If the Water Year type changes after January 1 to below normal, above normal, or wet, this action will be suspended. If the Water Year type changes after January to dry or critical, this action will occur.

DWR personnel in coordination with CDFW staff will review weekly the abundance and distribution survey data and other pertinent biological factors that influence the entrainment risk and detection of larval Longfin Smelt at Station 716. When conditions warrant BSPP's maximum 7-day average will not exceed ~~50~~60 cfs from January 15 through March 31 within 5 days. During the 5-day period, the rate of diversion at BSPP will not increase. This restriction will be removed when larval Longfin Smelt are no longer detected at Station 716.

Operation of BSPP also includes ongoing maintenance of the facility. Maintenance activities included in the Proposed Project include fish screen cleaning, sediment removal, and aquatic weed removal. Each of these activities is described below.

3.3.9.1 Fish Screen Cleaning

The 10 pump bays are 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. The screens are routinely cleaned to prevent excessive head loss and minimize increases in localized approach velocities (CDFG 2009). Fish screen cleaning is conducted concurrently with aquatic weed removal as noted in Table 3-4 below.

3.3.9.2 Sediment Removal

Sediment accumulated on the concrete apron in front of the fish screen and in the pump wells behind the fish screen would be removed by suction dredge. Removal of sediment from within the pump wells would occur as needed~~, year-round~~.

Removal of sediment from the front apron would occur during summer and early fall months and during the annual NBA shutdown in March. The NBA is annually taken off-line for one to two-weeks for routine maintenance and repairs, and the BSPP is non-operational during this period. The timing and duration of sediment removal at BSPP are summarized in Table 3-4 below.

Sediment would be tested and disposed at a suitable location or existing landfill.

3.3.9.3 Aquatic Weed Removal

Aquatic weed removal system consists of grappling hooks attached by chains to an aluminum frame. A boom truck, staged on the platform in front of the BSPP pumps, will lower the grappling system into the water to retrieve the accumulated aquatic vegetation. The removed aquatic weeds will be transported to two aggregate base spoil sites located near the pumping plant.

Removal of aquatic weeds from the BSPP fish screens would typically occur during summer and fall months when aquatic weed production is highest. Floating aquatic vegetation, i.e., water hyacinth, may need to be removed during spring months if water hyacinth becomes entrained into Barker Slough and accumulates in front of BSPP fish screens. The timing and duration of aquatic weed removal at BSPP are summarized in Table 3-4 below.

Table 3-4. Timing and Duration of Sediment and Weed Removal at BSPP

Activity	Dates	Frequency	Duration
Aquatic weed removal1	July 1—30	Weekly	5 hours
Aquatic weed removal1	Aug. 1—Sep. 30	Daily	5-8 hours +
Aquatic weed removal1	Oct. 1—Nov. 15	Weekly	5 hours
Aquatic weed removal1	Nov. 16—June 30	Monthly	4 hours
Sediment removal (suction dredging)	March or October	Annually	2-3 days (in water work) 7-10 days (entire project, including land-based mobilization)

Note: Aquatic weed removal is conducted concurrently with fish screen cleaning.

3.3.10 Clifton Court Forebay Operations

Clifton Court Forebay operations included in the Proposed Project include predator management and aquatic weed removal and disposal. Each of these operations is described below.

3.3.10.1 Predator Management

Fish entering the CCF must travel approximately 2.1 miles across the CCF to reach the Skinner Fish Facility. The loss of fish between the CCF Radial Gates and the Skinner Fish Facility is termed pre-screen loss (PSL). PSL includes, but is not limited to, predation by fish, birds, and other predatory species. Studies conducted by DWR and CDFW indicate that PSL of juvenile Chinook Salmon varies from 63% to 99% (Gingras 1997) and PSL of juvenile steelhead was 82 ± 3% (Clark et al. 2009). Predation by Striped Bass is thought to be the primary cause of high PSL in the CCF (Brown et al. 1996, Gingras 1997, Clark et al. 2009).

DWR proposes to continue the development of predator control methods within CCF including, but not limited to:

- Continued evaluation of the performance of various predator relocation methods
- Controlling aquatic weeds

Clifton Court Forebay Predator Studies

The Enhanced Predatory Fish Removal and Relocation Study~~Predator Reduction Interim Measure~~ is a combination of the most effective predator removal elements of previous predator reduction efforts; the Clifton Court Forebay Predation Study, the Predator Reduction Electrofishing Study, and the Predator Fish Relocation Study. The intent of this interim measure is to maximize the removal of predators from Clifton Court Forebay and relocate them to Bethany Reservoir, thereby reducing pre-screen losses.

3.3.10.2 Aquatic Weed Removal and Disposal

DWR will apply herbicides or will use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in the CCF (Table 3-~~4~~5). Herbicides may include Aquathol K or copper-based herbicides. Algaecides may include peroxygen-based algaecides (e.g., PAK 27). These products are used to control algal blooms that can degrade drinking water quality through production of taste and odor compounds or algal toxins. Dense growth of submerged aquatic weeds 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 trash racks. This mass of uprooted and broken vegetation essentially forms a watertight plug at the trash racks 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 and excessive weight on the louver array causing collapse of the structure. 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. In addition, dense stands of aquatic weeds provide cover for unwanted predators that prey on listed species within the CCF. Aquatic weed control is included as a conservation measure to reduce mortality of ESA-listed fish species within the CCF (see Section *3.11.3, Skinner Fish Facility Improvements*).

~~pump cavitation at Banks Pumping Plant when the stems of the rooted plant break free and drift into the trash racks. This mass of uprooted and broken vegetation essentially forms a watertight plug at the trash racks 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 and excessive weight on the louver array causing collapse of the structure. 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. In addition, dense stands of aquatic weeds provide cover for unwanted predators that prey on listed species within the CCF. Aquatic weed control is included as a conservation measure to reduce mortality of ESA-listed fish species within the CCF (see Section *3.11.3, Skinner Fish Facility Improvements*).~~

Mechanical Removal

Mechanical methods are used to manually remove aquatic weeds. A debris boom and an automated weed rake system continuously remove weeds entrained on the trash racks. During high weed load periods such as late summer and fall when the plants senesce and fragment or during periods of hyacinth entrainment, boat-mounted harvesters are operated on an as-needed basis to remove aquatic weeds in the Forebay and the intake channel upstream of the trash racks and louvers. The objective is to decrease the weed load on the trash racks and to improve flows in the channel. Effectiveness is limited due to the sheer volume of aquatic weeds and the limited capacity and speed of the harvesters. Harvesting rate for a typical weed harvester ranges from 0.5 to 1.5 acres per hour or 4 to 12 acres per day. Actual harvest rates may be lower due to travel time to off-loading sites, unsafe field conditions such as high winds, and equipment maintenance.

Table 3-~~4~~5. Methods to Control Aquatic Weeds and Algal Blooms in Clifton Court Forebay

Algae and Weed Treatments	Control Target	Period of Use	Limits to Application	Other Conditions of Use
Aquathol K, an endothall-based aquatic herbicide and Copper-based compounds, including copper sulfate pentahydrate and chelated copper herbicides	Pondweeds, Egeria densa, cyanobacteria, and green algae	As needed, from June 28 to August 31~~, when the average daily water temperature in the CCF is at or above 25°C~~	The herbicide application would not begin until after the radial gates have been closed. Applications of Aquathol K for pondweed control will be applied at a concentration of 2 to 3 ppm. Applications of copper herbicides for aquatic weed control will be applied at a concentration of 1ppm with an expected dilution of 0.75 ppm dispersal in the water column. Application for algal control will be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. The radial gates would remain closed for 12 to 24 hours after completion of the application.	The radial intake gates at the entrance to the CCF would be closed before application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility, and to prevent any possibility of aquatic pesticides diffusing into the Delta. The radial gates would remain closed for a minimum of 12 and up to 24 hours after treatment, to allow the recommended contact time between the aquatic pesticide and the treated vegetation or cyanobacteria in the CCF, and to reduce residual endothall concentrations for drinking water compliance. The radial gates would be re-opened after a minimum of 36 hours (24 hours pre-treatment closure plus 12 hours post-treatment closure). No more than 50% of the surface area of CCF will be treated at one time. Water quality samples to monitor copper and endothall concentrations within or adjacent to the treatment area, per NPDES permit requirements, will be collected before, during and after application.
-	-	As needed, prior to June 28 or after August 31, when the average daily water temperature in the CCF is at or above 77°F (25°C)	When the average daily water temperature in the CCF is at or above 25°C, and when Delta Smelt and salmonid protective measures are not activated: prior to treatment outside the June 28 to August 31 time frame, DWR would notify and confer with CDFW, NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment. The herbicide application would not begin until after the radial gates have been closed. The radial gates would remain closed for 12 to 24 hours after completion of the application. Herbicides application concentrations will remain the same.	If the average daily water temperature in the CCF is at or above 25°C and if Delta Smelt, salmonids, and Green Sturgeon are not at additional risk from the treatment as agreed by CDFW, NMFS and USFWS: close the radial intake gates at the entrance to the CCF before the application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility, and to prevent any possibility of aquatic pesticides diffusing into the Delta

Algae and Weed Treatments	Control Target	Period of Use	Limits to Application	Other Conditions of Use
Aquathol K and Copper-based herbicides, continued	Pondweeds, Egeria densa, cyanobacteria, and green algae	As needed, prior to June 28 or after August 31, when the average daily water temperature in the CCF is below 77°F (25°C)	During periods of activated Delta Smelt and salmonid protective measures when the average daily water temperature in the CCF is below 25°C, if the following conditions are met: prior to treatment outside the June 28 to August 31 time frame, DWR would notify and confer with CDFW, NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment. The herbicide application would not begin until after the radial gates have been closed for 24 hours or after the period of predicted Delta Smelt and salmonid survival in the CCF (e.g., after predicted mortality has occurred because of predation or other factors) has been exceeded. The radial gates would remain closed for 24 hours after completion of the application, unless it is agreed that rapid dilution of the herbicide would be beneficial to reduce the exposure duration to listed fishes present in the CCF. Herbicides application concentrations will remain the same.	If the average daily water temperature in the CCF is below 25°C and if Delta Smelt, salmonids, and Green Sturgeon are not at additional risk from the treatment as agreed by CDFW, NMFS and USFWS: close the radial intake gates at the entrance to the CCF before the application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility, and to prevent any possibility of aquatic pesticides diffusing into the Delta
Peroxygen-based algaecides (e.g., PAK 27)	Cyanobacteria	As needed, year-round	The radial gates would be closed before the application of the algaecide to prevent any possibility of the algaecide diffusing into the Delta. The radial gates may be re-opened immediately after the treatment, as the required contact time would be less than 1 minute and no residual by-product of concern would exist. Applied concentrations will be in the range of 0.3 to 10.2 ppm hydrogen peroxide.	No more than 50% of the surface area of CCF will be treated at one time. Dissolved oxygen concentration will be measured prior to and immediately following application within and adjacent to the treatment zone.

Notes:
°C = degrees Celsius
CCF = Clifton Court Forebay
CDFW = California Department of Fish and Wildlife
DWR = California Department of Water Resources
ESA = federal Endangered Species Act
NMFS = National Marine Fisheries Service
NPDES = National Pollutant Discharge Elimination System
ppm = parts per million
USFWS = U.S. Fish and Wildlife Service

Aquatic Herbicide Application

Aquatic weed and algae treatments would occur on an as-needed basis depending upon the level of vegetation biomass, the cyanotoxin concentration from the harmful algal blooms (HABs), or the concentration of taste and odor compounds. The frequency of aquatic herbicide applications to control aquatic weeds is not expected to occur more than twice per year, as demonstrated by the history of past applications. Aquatic herbicides are ideally applied early in the growing season when plants are susceptible to them during rapid growth and formation of plant tissues; or later in the season, when plants are mobilizing energy stores from their leaves towards their roots for overwintering senescence. The frequency of algaecide applications to control HABs is not expected to occur more than once every few years, as indicated by monitoring data and demonstrated by the history of past applications. Treatment areas are typically about 900 acres, and no more than 50% of the 2,180 total surface acres.

Aquatic weed assemblages change from year to year in the CCF from predominantly *Egeria densa* to one dominated by curly-leaf pondweed, sago pondweed, and southern naiad. To effectively treat a dynamic aquatic weed assemblage and HABs, multiple aquatic pesticide compounds are required to control aquatic weeds and algal blooms in the CCF. The preferred products are the following:

- Aquathol K, an endothall-based aquatic herbicide that is effective on pondweeds
- Copper-based compounds that are effective on *E. densa*, cyanobacteria, and green algae; copper-based aquatic herbicides, including copper sulfate pentahydrate and chelated copper herbicides
- Peroxygen-based algaecides (e.g., PAK 27) that are effective on cyanobacteria

Aquathol K

The dipotassium salt of endothall is used for control of aquatic weeds and is the active ingredient in Aquathol® K (liquid formulation). Aquathol K is a widely used herbicide to control submerged weeds in lakes and ponds, and the short residual contact time (12 to 48 hours) makes it effective in both still and slow-moving water. Aquathol K is effective on many weeds, including hydrilla, milfoil, and curly-leaf pondweed, and begins working on contact to break down cell structure and inhibit protein synthesis. Without the ability to grow, the weed dies. Full kill takes place in 1 to 2 weeks. As weeds die, they sink to the bottom and decompose. Aquathol K is not effective at controlling E. densa.

Aquathol K is registered for use in California and has effectively controlled pondweeds and southern naiad in the CCF and in other lakes. Endothall has low acute and chronic toxicity effects on fish. The LC50 for salmonids is 20 to 40 times greater than the maximum concentration allowed to treat aquatic weeds. The U.S. Environmental Protection Agency (EPA) maximum concentration allowed for Aquathol K is 5 ppm. A recent study (Courter et al. 2012) of the effect of Cascade® (same endothall formulation as Aquathol K) on salmon and steelhead smolts showed no sublethal effects until exposed to 9 to 12 ppm, that is, two to three times greater than the 5 ppm maximum concentration allowed by the EPA and about four to six times greater than the 2 to 3 ppm applied in past CCF treatments. In the study, steelhead and salmon smolts showed no statistical difference in mean survival between the control group and treatment groups, however, steelhead showed slightly lower survival after 9 days at 9 to 12 ppm. Based on the studies with salmonids, Aquathol K applied at or below the EPA maximum allowable concentration of 5 ppm poses a low to no toxicity risk to salmon, steelhead, and other fish. No studies have assessed the exposure risk to Green Sturgeon.

When aquatic plant survey results indicate that pondweeds are the dominant species in the CCF, Aquathol K will be selected due to its effectiveness in controlling these species. Aquathol K will be applied according to the label instructions, with a target concentration dependent upon plant biomass, water volume, and forebay depth. The target concentration of treatments is 2 to 3 ppm, which is well below the concentration of 9 to 12 ppm where sublethal effects have been observed (Courter et al. 2012). DWR monitors herbicide concentration levels during and after treatment to ensure levels do not exceed the Aquathol K application limit of 5 ppm. Additional water quality testing may occur following treatment for drinking water intake purposes. Samples are submitted to a laboratory for analysis. There is no “real time” field test for endothall. No more than 50% of the surface area of the CCF will be treated at one time. A minimum contact time of 12 hours is needed for biological uptake and treatment effectiveness, but the contact time may be extended up to 24 hours to reduce the residual endothall concentration for National Pollutant Discharge Elimination System (NPDES) compliance purposes.

Copper Based Aquatic Herbicides and Algaecides

Copper herbicides and algaecides include chelated copper products and copper sulfate pentahydrate crystals. When aquatic plant survey results indicate that E. densa is the dominant species, copper-based compounds will be selected due to their effectiveness in controlling this species. Application of Aquathol K does not affect *E. densa*. Copper-based algaecides are effective at controlling algal blooms (cyanobacteria) that produce cyanotoxins or taste and odor compounds.

Copper herbicides and algaecides will be applied in a manner consistent with the label instructions, with a target concentration dependent upon target species and biomass, water volume and the depth of the forebay. Applications of copper herbicides for aquatic weed control will be applied at a concentration of 1 ppm with an expected dilution to 0.75 ppm upon dispersal in the water column. Applications for algal control will be applied at a concentration of 0.2 to 1 ppm with expected dilution within the water column. DWR will monitor dissolved copper concentration levels during and after treatment to ensure levels do not exceed the application limit of 1 ppm, per NPDES permit required procedures. Treatment contact time will be up to 24 hours. If the dissolved copper concentration falls below 0.25 ppm during an aquatic weed treatment, DWR may opt to open the radial gates after 12 hours but before 24 hours to resume operations. Opening the radial gates prior to 24 hours would enable the rapid dilution of residual copper and thereby shorten the exposure duration of ESA-listed fish to the treatment. No more than 50% of the surface area of the CCF will be treated at one time.

Peroxygen-based Algaecides

The PAK 27 algaecide active ingredient is sodium carbonate peroxyhydrate. An oxidation reaction occurs immediately upon contact with the water destroying algal cell membranes and chlorophyll. There is no contact or holding time requirement, as the oxidation reaction occurs immediately and the byproducts are hydrogen peroxide and oxygen. There are no fishing, drinking, swimming, or irrigation restrictions following the use of this product. PAK 27 has NSF/ANSI Standard 60 Certification for use in drinking water supplies at maximum-labeled rates and is certified for organic use by the Organic Materials Reviews Institute (OMRI).

PAK 27, or an equivalent product, will be applied in a manner consistent with the label instructions, with permissible concentrations in the range of 0.3 to 10.2 ppm hydrogen peroxide. No more than 50% of the surface area of the CCF will be treated at one time.

Herbicide Application Procedure

The following are operational procedures to minimize impacts on listed species during aquatic herbicide treatment for application of Aquathol K and copper-based products and algaecide treatment for application of peroxide-based algaecides in the CCF:

- Apply Aquathol K and copper-based aquatic pesticides, as needed, from June 28 to August 31.
- Apply Aquathol K and copper-based aquatic pesticides, as needed, prior to June 28 or after August 31 if the average daily water temperature within the CCF is at or above 77°F (25°C) and if Delta Smelt, salmonids, and Green Sturgeon are not at additional risk from the treatment, as confirmed by NMFS and USFWS.
    - Prior to treatment outside of the June 28 to August 31 time frame, DWR will notify and confer with NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
- Apply Aquathol K and copper-based aquatic pesticides, as needed, during periods of activated Delta Smelt and salmonid protective measures and when the average daily water temperature in the CCF is below 77°F (25°C) if the following conditions are met:
    - Prior to treatment outside of the June 28 to August 31 time frame, DWR will notify and confer with NMFS and USFWS on whether ESA-listed fish species are present and at risk from the proposed treatment.
    - The herbicide application does not begin until after the radial gates have been closed for 24 hours or after the period of predicted Delta Smelt and salmonid survival within the CCF (e.g., after predicted mortality has occurred due to predation or other factors) has been exceeded.
    - The radial gates remain closed for 24 hours after the completion of the application unless it is conferred that rapid dilution of the herbicide would be beneficial to reduce the exposure duration to listed fishes present within the CCF.
- Apply peroxygen-based aquatic algaecides, as needed, year-round.
- There are no anticipated impacts on fish with the use of peroxygen-based aquatic algaecides in the CCF during or following treatment.
- Monitor the salvage of listed fish at the Skinner Fish Facility prior to the application of the aquatic herbicides and algaecides in the CCF.
- For Aquathol K and copper compounds, the radial intake gates will be closed at the entrance to the CCF prior to the application of pesticides to allow fish to move out of the targeted treatment areas and toward the salvage facility and to prevent any possibility of aquatic pesticide diffusing into the Delta.

- For Aquathol K and copper compounds, the radial gates will remain closed for a minimum of 12 and up to 24 hours after treatment to allow for the recommended duration of contact time between the aquatic pesticide and the treated vegetation or cyanobacteria in the forebay, and to reduce residual endothall concentration for drinking water compliance purposes. (Contact time is dependent upon pesticide type, applied concentration, and weed or algae assemblage.) Radial gates would be reopened after a minimum of 36 hours (24 hours pre-treatment closure plus 12 hours post-treatment closure).
- For peroxide-based algaecides, the radial gates will be closed prior to the application of the algaecide to prevent any possibility of the algaecide diffusing into the Delta. The radial gates may reopen immediately after the treatment, as the required contact time is less than 1 minute and there is no residual by-product of concern.
- Application will be made by a licensed applicator under the supervision of a California Certified Pest Control Advisor.
- Aquatic herbicides and algaecides will be applied by boat or by aircraft.
    - Boat applications will be by subsurface injection system for liquid formulations and by a boat-mounted hopper dispensing system for granular formulations. Applications would start at the shoreline and move systematically farther offshore, enabling fish to move out of the treatment area.
    - Aerial applications of granular and liquid formulations will be by helicopter or aircraft. No aerial spray applications will occur during wind speeds above 15 mph to prevent spray drift.
- Application would be to the smallest area possible that provides relief to SWP operations or water quality. No more than 50% of the CCF will be treated at one time.
- Water quality samples to monitor copper and endothall concentrations within or adjacent to the treatment area, per the NPDES permit requirements, will be collected before, during and after application. Additional water quality samples may be collected during the following treatment for drinking water compliance purposes. No monitoring of copper or endothall concentrations in the sediment or detritus is proposed.
- No monitoring of peroxide concentration in the water column will occur during and after application as the reaction is immediate and there is no residual by-product of concern. Dissolved oxygen concentration will be measured prior to and immediately following application within and adjacent to the treatment zone.
- A spill prevention plan will be implemented in the event of an accidental spill.

Aquatic weed and algae treatments would occur on an as-needed basis. The timing of application is an avoidance measure and is based on the life history of Chinook Salmon and steelhead in the Central Valley's Delta region and of Delta Smelt. Green Sturgeon are present in the area year-round. Migrations of juvenile Winter-run Chinook Salmon and Spring-run Chinook Salmon primarily occur outside of the summer period in the Delta. Central Valley Steelhead have a low probability of being in the South Delta during late June, when temperatures exceed 77°F (25°C), through the first rainfall flush event, which can occur as late at December in some years (Grimaldo 2009). Delta Smelt are not expected to be in the CCF during this time period. Delta Smelt are not likely to survive when water temperatures reach a daily average of 77°F (25°C), and they are not expected to occur in the Delta prior to the first flush event. Therefore, the likelihood of herbicide exposure to Chinook Salmon, Central Valley Steelhead, and Delta Smelt during the proposed herbicide treatment time frame in the CCF is negligible.

Additional protective measures will be implemented to prevent or minimize adverse impacts from herbicide applications. As described above, applications of aquatic herbicides and algaecides will be contained within the CCF. The radial intake gates to the CCF will be closed prior to, during, and following the application. The radial gates will remain closed during the recommended minimum contact time based on herbicide type, application rate, and aquatic weed or algae assemblage. In addition, following the gate closure and prior to the applications of Aquathol K and copper-based pesticides, the water is drawn down in the CCF via the Banks Pumping Plant. This drawdown helps facilitate the movement of fish in the CCF toward the fish diversion screens and into the fish protection facility, lowers the water level in the CCF to decrease the total amount of herbicide needed to be applied per volume of water, and aids in the dilution of any residual pesticide post-treatment. Following reopening of the gates and refilling of the CCF, the rapid dilution of any residual pesticide and the downstream dispersal of the treated water into the California Aqueduct via the Banks Pumping Plant will reduce the exposure time of any ESA-listed fish species present in the CCF.

Avoidance and Minimization Practices

DWR implements the following best management practices during aquatic weed harvesting at the CCF to avoid and minimize potential impacts on sensitive resources:

- A pre-construction survey for nesting birds and burrowing owls is conducted by a qualified biologist within 2 weeks prior to the start of work. If burrowing owls are observed within 500 feet of the Proposed Project, non-disturbance buffers are established and/or a qualified biological monitor is present during disposal activities.
- On the first day of work, and as needed once work has begun, a qualified biologist surveys for floating grebe nests within the CCF and identifies avoidance areas to prevent take of nests.
- All on-site personnel participate in environmental awareness training for special-status species with the potential to occur in the project area.
- If any wildlife is observed within the aquatic weed removal and disposal areas, work is halted immediately, and the wildlife are allowed to move out of the area on their own.
- Work does not take place during rain events or within 24 hours of significant precipitation when special-status species could potentially be traveling to breeding ponds.
- Aquatic weed disposal and vehicle travel is contained within the established roadways and identified work area.

3.3.11 Skinner Fish Facility Improvements

The Skinner Fish Facility has behavioral barriers to keep 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 rack. Smaller fish are diverted from the intake channel into bypasses by a series of behavioral barriers (metal louvers), while the main flow of water continues through the louvers and toward the pumps. These fish pass through a secondary system of louvers or screens and pipes into seven holding tanks, where a subsample is counted and recorded. The salvaged fish then are returned to the Delta in oxygenated tank trucks. The sampling frequency at Skinner Fish Facility is generally 30 minutes of every 2 hours but may be reduced based upon the presence of excessive numbers of fish or debris based upon procedures developed by CDFW. See Appendix G of the 2019 Biological Assessment for a summary of study results (Reclamation 2019).

DWR proposes to continue to salvage fish with the Skinner Fish Facility which is located about 2 miles upstream from the Banks Pumping Plant. In addition, DWR proposes the following:

- Operational changes to salvage release scheduling and location to reduce post-salvage predation
- Continued refinement and improvement of the fish sampling and hauling procedures and infrastructure to improve the accuracy and reliability of data and fish survival

3.3.12 Longfin Smelt Science Program

CDFW, DWR and the State Water Contractors (SWC) entered into an agreement in 2014 to implement a multiyear Longfin Smelt Science Program. The Longfin Science Program was described in a Study Plan that identified the Napa River, Coyote Creek, and other areas that required further study of environmental factors affecting the species distribution and reproduction. In addition, the Study Plan focused studies on sampling efficiency, including time of day, water transparency, and tidal conditions. The Study Plan was intended to address eight research questions, six of which will be examined over the course of an initial 5-year period of field study and data analysis. The Longfin Smelt Science Program would be continued. An updated Study Plan would be developed jointly with DWR, CDFW and the SWC and would address issues that include external issues influencing population abundance, distribution, and catchability, including vertical migration behavior and water transparency and other factors that support growth and survival. A primary goal of this effort is to improve management of Longfin Smelt, and to identify potential management action that could improve its status.

A Longfin Smelt Life-Cycle Model will be developed as part of the proposed Longfin Smelt Science Program. DWR, CDFW and SWC will work collaboratively using the best available science to develop a mathematical life cycle model for Longfin Smelt, verified with field data collection, as a quantitative tool to characterize the effects of abiotic and biotic factors on Longfin Smelt populations.

3.3.13 Conduct Further Studies to Prepare for Delta Smelt Reintroduction from Stock Raised at the UC Davis Fish Conservation and Cultural Laboratory

DWR is proposing to continue supporting the operation and research being conducted by the University of California, Davis (UC Davis), Fish Conservation and Culture Laboratory (FCCL).

The two main goals of the FCCL are to maintain a refuge Delta Smelt population in captivity that is as genetically close as possible to the wild population and provide a safeguard against extinction. The culture technique has been improved continuously over the years and the survival rate of cultured Delta Smelt at the FCCL is high (UC Davis 2019).

The FCCL is undertaking multiple research projects that will continue to add to the understanding of Delta Smelt and other species. The laboratory works collaboratively with other researchers from different agencies and institutions, assisting them with research projects and providing them with experimental fish populations of all life stages. The FCCL currently is expanding and renovating existing facilities, increasing the capacity for culture and research. Ongoing and future studies include the following:

- The FCCL currently is conducting studies to characterize and better understand Delta Smelt spawning behavior. Because spawning behavior has never been observed in the wild and has not been formally described yet, it is unclear how and where Delta Smelt naturally spawn. In ongoing experiments, the laboratory is conducting studies that characterize Delta Smelt spawning behavior under natural conditions and examining spawning substrate preferences. The findings from these studies will be critical to continued recovery and conservation efforts.
- The FCCL is investigating the optimum conditions for hatching Delta Smelt eggs in the wild. The current laboratory practice has been optimized to hatch good-quality eggs within 10 days of spawning, although it is important to consider the conditions in which the eggs are spawned in the wild. The laboratory is studying the effects of salinity and flow rate on the survival and condition of Delta Smelt eggs. This information will inform the proposed egg frame trials as well as the conservation of suitable breeding grounds.
- The FCCL is testing the possibilities of using an egg frame, created by the Lake Suwa Fishing Collective in Hokkaido, Japan for future restoration of Delta Smelt in the Delta. The frame was designed for hatching Wakasagi (*Hypomesus nipponensis*) into a body of water with constant flow. The water flow condition around the eggs in the frame will be studied using computational flow dynamics, and the results will be used to suggest a suitable environment for applying the egg frame in the Delta.
- The FCCL is taking steps toward promoting survival of individual families by conducting trials using small culture containers that can rear single families at a time. This method could reduce competition between families and increase the survival of each individual family. The FCCL is carrying out trials to assess this factor by individually incubating an equal number of eggs from one, four, or eight family groups; parentage analysis will assess the survival of each family in these groups.
- The FCCL was able to increase survival rates to a level sufficient for the successful culturing of Delta Smelt from the egg through adult stage; the first complete life cycle in captivity was established in 2000–2001. Currently, the FCCL focuses on improving existing rearing techniques, with the goals of increasing the system's efficacy and rearing success. Some of the laboratory's current areas of emphasis are as follows:

- Tank size and system parameters: As fish develop from newly hatched larvae to adults, they are transferred multiple times between fish-rearing systems to fulfill the needs of each life stage. Black interior tanks are used for all fish, as clear and acrylic tanks have been found to stress fish. Light is administered to the tanks, with varying intensities corresponding to what has been deemed optimal for each life stage. Each recirculating system provides ultraviolet (UV) sterilization, both particle and biological filtration, and heat pumps for temperature control. Currently, the FCCL is testing stocking densities and feeding rates for each tank and also is developing smaller culturing systems for research purposes.
- Turbidity effect: Early-larval and late-larval stages require different turbidity environments to promote feeding. Although it is not completely understood why larval stages require turbidity, it is thought that the suspended particles provide a visual contrast that enables larval stages to better find their prey. Turbidity is introduced via the addition of concentrated algae. As fish mature into the adult stage, algal addition gradually is decreased to gently transition the fish into clearer water environments.
- Weaning strategies: As the smelt develop, they are transitioned from a live prey diet to a dry feed diet. The FCCL currently is researching this topic to determine the best time for weaning.
- Salinity: In their natural environment, Delta Smelt inhabit estuary areas of relatively low salinity. The precise environmental salinity values vary seasonally, in accordance with each year's freshwater availability. In collaboration with researchers at UC Davis, the FCCL is conducting experiments that analyze the physiological effects of salinity on Delta Smelt.

3.3.14 Continue Studies to Establish a Delta Fish Species Conservation Hatchery

The Delta Smelt (*Hypomesus transpacificus*) is currently in severe decline within its native range in the Sacramento-San Joaquin Delta. Delta Smelt have declined to such low numbers that it is difficult to detect them in traditional surveys, and it is possible that the species cannot sustain itself without additional recovery actions. In an effort to conserve the species, a refuge population has been maintained at the UC Davis FCCL in Byron, CA since 2006 (a smaller population exists as a backup to the FCCL at Livingston Stone Hatchery in Shasta Lake, CA). The refuge population provides fish for research purposes, but more importantly, is a reservoir of Delta Smelt genetic diversity that has been specifically managed for potential wild population supplementation or reintroduction.

Currently, FCCL fish have not been released into the Delta, except as part of a predation study in a South Delta fish facility (Castillo et al. 2012). Yet under the present circumstances, there is a need to at least have an emergency plan to guide possible release of refuge fish into the wild. Logic suggests that the easiest and most effective course of action at present may be to supplement the wild population before it goes extinct. Unfortunately, little is known about the most effective way to release Delta Smelt into the Delta for the purpose of recovering the species.

In recognition of this issue, since 2017 DWR has facilitated studies with the overarching goal of determining the best methods to manage Delta Smelt releases from the refuge population to benefit the wild with maximum survival, retention of genetic diversity, and minimal risk to the wild population. A first step was the organization of a public workshop that identified some of the major scientific uncertainties and to guide future studies (Lessard et al. 2018). This workshop has led to DWR's collaborative work with UC Davis, USFWS, CDFW, and Reclamation to conduct initial investigations. The current work plan includes work on genetics, pathology, behavior, a Hatchery and Genetic Management Plan, and test use of hatchery fish in experimental enclosures placed in the wild. Ultimately, the goal of this work is to develop an adaptive population supplementation plan that will assemble current knowledge about Delta Smelt, describe successful supplementation/reintroduction approaches for other fish species, identify research priorities, recommend monitoring approaches for evaluating supplementation strategies, and detail facility upgrade requirements for the refuge population.

DWR is proposing to continue collaborative laboratory and field work to develop a strategy for successful reintroduction of Delta Smelt to their natural environment in the wild and prevention of extinction. Since previous field work on hatchery Smelt required the project team to secure CESA coverage for this project, we propose to include this work in our Project Description to allow continued laboratory and field research to support possible future supplementation. Some of this work on cultured fish could also be useful in the design and evaluation of different management approaches such as flow actions and tidal wetlands restoration projects. As in previous years, the work would be led by a hatchery advisory team, which could be the existing multi-agency group (CDFW, USFWS, Reclamation, DWR, UC Davis, USGS) or a potential new group organized by CDFW and USFWS.

For 2020 it is anticipated that the primary research activities will be deployment of custom smelt cages in multiple habitats (channel, tidal wetlands) and geographic areas (Suisun, Sacramento River, N~~n~~orth Delta), genetic analysis of the wild and hatchery population, pathology, and behavioral studies. The specific details of the work will be subject to input and review by the agency hatchery advisory group. However, it is anticipated that caged smelt could be an important tool to help evaluate different management actions (see Adaptive Management Plan below).

No construction will occur as part of this proposal. Similarly, none of these studies are intended to directly augment the smelt population. Nor are they intended to promote supplementation as an alternative to other conservation measures. Instead, cultured fish may be a future tool to help make other management actions more effective and easier to evaluate (e.g., flow, habitat restoration). Depending on study results, future decisions to proceed with supplementation would be subject to separate reviews under CESA, FESA, and CEQA.

3.3.15 WATER TRANSFERS

DWR and Reclamation propose to continue facilitating transfers of SWP water and other water supplies through CVP and SWP facilities, including north-to-south transfers and north-to-north transfers. The quantity and timing of Keswick releases would be similar to those that would occur absent the transfer. Water transfers would occur through various methods, including, but not limited to, groundwater substitution, release from storage, and cropland idling, and would include individual and multi-year transfers. The effects of developing supplies for water transfers in any individual year or a multi-year transfer is evaluated outside of this proposed action. North-to-South water transfers would occur from July through November in total annual volumes up to those described in Table 3-~~5~~6.

Table 3-~~5~~6. Proposed Annual North-to-South Water Transfer Volume

Water Year Type	Maximum Transfer Amount (TAF)
Critical	Up to 600
Dry (following Critical)	Up to 600
Dry (following Dry)	Up to 600
All other years	Up to 360

Note: TAF = thousand acre-feet

As part of this proposed action, DWR and Reclamation will provide a transfer window from July 1 through November 30. Real-time operations may restrict transfers within the transfer window so that Reclamation and DWR can meet other authorized project purposes, e.g., when pumping capacity is needed for CVP or SWP water.

3.3.16 Adaptive Management Plan

The Adaptive Management Plan (AMP) will be carried out to evaluate the efficacy of the operations and activities stated below. An Adaptive Management Team (AMT)~~-~~, composed of one designated representative and one designated alternate each from DWR, DFW, and SWC, will be established to carry out this AMP. The AMT will oversee efforts to monitor and evaluate the operations and related activities. In addition, the AMT will use structured decision-making to assess the relative costs and benefits of those operations and activities. The AMT will also identify proposed adaptive management changes to those operations and activities. The AMP will be developed before issuance of, and could be incorporated into, the ITP DWR is seeking for CESA coverage for the Proposed Project. Any proposed adaptive management changes should provide equivalent or superior conservation benefits to the listed species at equal or lesser societal costs. The objectives of the AMP are to: (i) continue the long-term operation of the SWP in a manner that improves water supply reliability and water quality consistent with applicable laws, contractual obligations, and agreements and (ii) use the knowledge gained from the scientific study and analysis described in the AMP to avoid, minimize and fully mitigate the adverse effects of SWP operations on CESA-listed aquatic species.

~~More specifically,~~Overall, the intent of this AMP is to:

- Create an adaptive management plan for ongoing SWP operations, as it operates in coordination with the CVP that will assist DWR in complying with applicable California law, including CESA.
- Develop and implement a monitoring protocol necessary to implement the adaptive management plan, working in coordination with CSAMP and the DSP as appropriate.
- Identify the scope of the AMP, that is, the operations and activities that will be subject to adaptive management.
- Describe the decision-making and governance structure that will be used to implement the AMP including adaptive management changes.
- Describe the mechanisms that will be used to communicate among the Implementing Entities (defined as DWR, DFW and SWC) as will be identified in the AMP, and with the broader stakeholder community regarding implementation of the AMP.

- Describe funding for the AMP.
- Describe the relationship between the AMP and real-time operations.

Each existing operation and activity and each adaptive management change must be accompanied by (1) a set of criteria that the Implementing Entities can use to determine whether the action is having the anticipated impacts (e.g., take limits derived from salvage data) and (2) monitoring that will provide the data necessary in order to determine whether the performance measures are being met. It may be necessary to undertake additional monitoring and research that builds on existing efforts in order to carry out this adaptive management program. The AMP would draw upon the Collaborative Science and Adaptive Management Program (CSAMP) and the Delta Science Program (DSP), where appropriate, to assist with these monitoring and research efforts as well as program evaluation.

The AMP extends to specified SWP operations and activities undertaken by DWR concomitant to those operations. They include the following:

- Operation of Harvey O. Banks Pumping Plant to comply with OMR flow requirements
- Delta Smelt Summer-Fall Habitat Action, including food enhancement actions
- Cultured Delta Smelt studies
- Installation of the South Delta temporary barriers
- Spring outflow actions
- Additional summer-fall actions
- Clifton Court Forebay predator management
- Monitoring associated with all of the foregoing

While the AMP described in this document pertains only to specified SWP operations and activities undertaken by DWR concomitant to those operations and will be used to support the 2081 permit issued for operation of the SWP, upon unanimous agreement among the Implementing Entities, it may be (1) expanded in the future to include other operations and activities, or (2) implemented in a coordinated manner with other adaptive management programs covering such operations and activities. These may include ongoing operations of the CVP and implementation of voluntary agreements or other activities associated with the SWP operations.~~undertaken under the oversight of the State Water Resources Control Board.~~

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4 ENVIRONMENTAL SETTING AND IMPACT ANALYSIS

4.1 SCOPE OF ANALYSIS

4.1.1 ISSUES ELIMINATED FROM DETAILED CONSIDERATION IN THE DEIR

Before beginning preparation of this Draft Environmental Impact Report (DEIR), an Initial Study was prepared to consider the wide range of environmental resource topics contained in Appendix G of the State CEQA Guidelines. The Initial Study is provided in Appendix A. Based on this Initial Study, the scope of this DEIR has been focused on those environmental resources that potentially would be significantly affected by implementation of the Proposed Project, and the following environmental topics have been eliminated from detailed consideration in this DEIR:

- Aesthetics
- Agriculture and Forestry Resources
- Air Quality
- Biological Resources (Terrestrial)
- Cultural Resources
- Energy
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards and Hazardous Materials
- Land Use and Planning
- Mineral Resources
- Noise
- Population and Housing
- Public Services
- Recreation
- Transportation
- Utilities and Service Systems

The following environmental topics are addressed in this DEIR:

- Hydrology
- Surface Water Quality
- Aquatic Resources
- Tribal Cultural Resources

The Initial Study, provided in Appendix A of this DEIR, concluded that the proposed long-term operations of the State Water Project (SWP) would not result in significant impacts on hydrology or surface water resources. However, because implementation of the Proposed Project would alter existing hydrology, such changes could result in impacts on resources dependent upon existing hydrologic conditions. These resources include water quality and aquatic biological resources.

In order to provide the reader with an understanding of the potential project impacts on water quality and aquatic biological resources, this DEIR presents a description of the existing hydrologic setting and compares it with the estimated hydrology associated with the Proposed Project in the following discussion. The DEIR then analyzes potential impacts on water quality and aquatic biological resources that could result from the changes to hydrology.

4.1.2 Environmental Baseline

An Environmental Impact Report (EIR) must include a description of the physical conditions in the project's vicinity, often referred to as the "baseline." Lead agencies refer to the baseline when determining whether a project's impact is significant. Pursuant to Section 15125(a), generally, the baseline should consist of conditions that exist at the time the Notice of Preparation (NOP) is published. Where Existing Conditions change or fluctuate over time and where necessary to provide the most accurate picture practically possible of the project's impacts, a lead agency may define Existing Conditions by referencing historic conditions or conditions expected when the project becomes operational, or both, that are supported with substantial evidence. The purpose of this requirement is to give the public and decision makers the most accurate and understandable picture practically possible of the project's impacts.

The baseline in this DEIR consists of the physical conditions that existed at the time of NOP publication on April 19, 2019; however, modeling was used to identify the Existing Conditions, rather than using a snapshot of actual conditions on April 19, 2019, pursuant to Section 15125(a), as described above. One aspect of the baseline is the manner in which the SWP and Central Valley Project (CVP) jointly operate to meet Delta regulatory requirements under the Coordinated Operation Agreement (COA). As noted in Chapter 2, the COA was originally executed in 1986 and subsequently updated in 2018 through the 2018 COA Addendum. The baseline used in this DEIR includes the 2018 COA Addendum, as opposed to the unmodified 1986 version of the COA, to accurately reflect the Existing Conditions in the Delta as of April 19, 2019. In addition, a discussion of changes to surface water hydrology and water quality associated with implementing the 2018 COA Addendum in comparison to the original 1986 COA is provided in Appendix B. As explained in Appendix B, implementation of the 2018 COA Addendum resulted in minimal change to surface water hydrology in the Delta and upstream waterways. This minimal change resulted in a negligible change to Delta and upstream water quality. Therefore, using the 2018 COA Addendum as a baseline condition represents not only the existing physical conditions, but also closely reflects historical conditions under the original 1986 COA.

In addition to the COA, as updated by the 2018 COA Addendum, the baseline for this EIR includes State Water Resources Control Board Decision 1641, the 2008 USFWS and 2009 NMFS Biological Opinions on the Coordinated Long-term Operation of the CVP and SWP, 2009 Incidental Take Permit for State Water Project Delta Facilities and Operations, among other regulatory requirements.

4.1.3 IMPACT OF CLIMATE CHANGE

As explained in the Initial Study (provided in Appendix A), the Proposed Project would have no impact either directly or indirectly on Greenhouse Gas Emissions. CEQA generally does not require any further analysis of climate change impacts, such as an evaluation of the environment's impacts on a project, unless the project may exacerbate existing environmental hazards. The Proposed Project is not expected to exacerbate any hazards, such as flood potential, because river flows and SWP pumping would remain within historical operating range. Thus, no further climate change analysis is required for this EIR.

Even though climate change effects need not be discussed further in this EIR, DWR voluntarily chose to prepare a sensitivity analysis of operational changes to the Existing Conditions and the Proposed Project scenarios under climate change and sea level rise conditions. The purpose of the sensitivity analysis is to present, for informational purposes, a more comprehensive picture about the incremental changes between operations under the Existing Conditions and the Proposed Project scenarios under the projected climate conditions. This section discusses the result of the sensitivity analysis.

The Existing Conditions and the Proposed Project scenarios were simulated using CalSim II (see Appendix F for further details) assuming projected climate change and sea level rise conditions. The operations results from these simulations were analyzed to understand if the incremental changes between the Existing Conditions and the Proposed Project scenarios remain similar with and without climate change. For this analysis the CalSim II model inputs were updated to reflect the projected changes in climate centered around year 2035. The hydrology inputs were updated based on the ensemble of 20 individual CMIP5 (Coupled Model Intercomparison Project 5) projections selected by DWR's California Climate Change Technical Advisory Group (CCTAG). These hydrologic changes were modeled along with two sea level rise values, 15 cm and 45 cm. The two sea level rise values bracket the latest sea level rise projections in the 2018 OPC guidance (OPC 2018) for the year 2035.

The relative incremental changes in the flows in the Delta and other waters affected by SWP operations due to the Proposed Project under the future climate and sea level rise scenarios around year 2035 are expected to be similar to the Proposed Project under Existing Conditions. While future climate and sea level rise will alter some of the magnitude and patterns of the flows, the relative incremental changes due to the Proposed Project are expected to be similar to changes under the Existing Conditions scenario. Appendix F provides the detailed results from the climate change sensitivity analysis.

Because the hydrologic characteristics would remain similar, the analysis of water quality in the Delta and other waters affected by SWP operations, as influenced by hydrology, would also remain similar between the Existing Conditions scenario and the two future climate change scenarios estimated in the Year 2030. Aquatic biological resources in the Delta and other waters affected by SWP operations under the Proposed Project scenario would also be expected to remain similar between current climate and the two future climate change scenarios estimated in the Year 2035. No additional analysis or discussion of impacts of climate change on the environmental resources addressed in the DEIR is warranted.

4.1.4 Approach to Modeling

The discussions presented in this DEIR rely on analyses by professional experts and calculations performed by various computer and mathematical models. The following sections identify and describe the various computer models that constitute a major component of the DEIR findings and conclusions.

4.1.4.1 CalSim II

CalSim II is a reservoir–river basin planning model, developed by DWR and Reclamation to simulate the operations of the CVP and SWP over a range of different hydrologic conditions. Inputs to CalSim II include water demands (including water rights), stream accretions and depletions, reservoir inflows, irrigation efficiencies, and parameters to calculate return flows, non-recoverable losses, and groundwater operations. Sacramento Valley and tributary rim-basin hydrology uses an adjusted historical sequence of monthly stream flows over an 82-year period (1922 to 2003). Adjustments to historic water supplies are imposed, based on future land use conditions and historical meteorological and hydrologic conditions. The resulting hydrology represents the water supply available from Central Valley streams to the CVP and SWP at a future level of development. Water rights deliveries to non-CVP and non-SWP water rights holders are not modified in the CalSim II simulations included in this DEIR. CalSim II produces outputs for river flows and diversions, reservoir storage, Delta flows and exports, Delta inflow and outflow, deliveries to project and non-project users, and controls on project operations.

The CalSim II model monthly simulation of an actual daily (or even hourly) operation of the CVP and SWP results in several limitations in use of the model results. The model results must be used in a comparative manner, to reduce the effects of generalized monthly assumptions that are indicative of real-time operations but do not specifically match real-time observations. The CalSim II model contains several assumptions regarding the operation of the CVP and SWP system and uses a water balance approach to simulate those operations. The outputs are provided on a monthly time step. The model assumptions and water balance approach to modeling the large and complex CVP and SWP system may result in minor differences in simulations with the same assumptions under some limited circumstances. These minor differences require careful interpretation of CalSim II model results (e.g., using results in a comparative manner) to understand if the difference is a meaningful change or a limitation of the model. The CalSim II model output includes minor fluctuations of up to 5% because of model assumptions and approaches. Therefore, for analytical purposes if the quantitative differences in a CalSim model output parameter between the Existing Conditions and Proposed Project model scenarios are 5% or less, the conditions between the scenarios are considered to be "similar." Differences in CalSim outputs of greater than 5% would not necessarily constitute an impact on a specific resources, but would be considered actual physical differences that could be expected to occur.

Under extreme hydrologic and operating conditions where not enough water supply exists to meet all requirements, CalSim II uses a series of operating rules to reach a solution, to allow continuation of the simulation. These operating rules are recognized to be a simplified version of the very complex decision processes that CVP and SWP operators use in actual extreme conditions. Therefore, model results and potential changes under these extreme conditions should be evaluated on a comparative basis between alternatives and are an approximation of extreme operating conditions. For example, CalSim II model results show simulated occurrences of extremely low storage conditions at CVP and SWP reservoirs during critical drought periods, when storage is at dead-pool levels, at or below the elevation of the lowest level outlet. Simulated occurrences of reservoir storage conditions at dead-pool levels may occur coincidentally with simulated impacts that are determined to be potentially significant. When reservoir storage is at dead-pool levels, instances may occur in which flow conditions fall short of minimum flow criteria, salinity conditions may exceed salinity standards, diversion conditions may fall short of allocated diversion amounts, and operating agreements may not be met.

4.1.4.2 Delta Simulation Model II

DWR's Delta Simulation Model II (DSM2) is a one-dimensional mathematical model for dynamic simulation of one-dimensional hydrodynamics, water quality and particle tracking in a network of riverine or estuarine channels. DSM2 can calculate stages, flows, velocities, mass transport processes for conservative and non-conservative constituents including salts, water temperature, dissolved oxygen, and trihalomethane formation potential, and transport of individual particles. DSM2 thus provides a powerful simulation package for analysis of complex hydrodynamic, water quality, and ecological conditions in riverine and estuarine systems.

DSM2 currently consists of three modules, all of which come with the current distribution: HYDRO, QUAL, and PTM. HYDRO simulates one-dimensional hydrodynamics including flows, velocities, depth, and water surface elevations. HYDRO provides the flow input for QUAL and PTM. PTM simulates pseudo 3-D transport of neutrally buoyant particles based on the flow field simulated by HYDRO. PTM has multiple applications ranging from visualization of flow patterns to simulation of discrete organisms such as fish eggs and larvae.

The HYDRO and PTM modules were used for the analyses contained herein. See Appendix E for a more detailed description of the DSM2-HYDRO and DSM2-PTM methodologies applied for the analyses herein.

4.1.4.3 Semi-Implicit Cross-scale Hydroscience Integrated System Model

The Bay-Delta Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM) is an application of the 3D open source SCHISM hydrodynamic and water quality suite to the San Francisco Bay Delta estuary. The project is a collaboration between DWR and the Virginia Institute of Marine Sciences.

Target applications include the following:

- Habitat creation and conveyance options for the Delta
- Salinity intrusion changes during drought conditions or sea level rise
- Velocity changes following the installation of drought barriers
- Fate of mercury produced in the Liberty Island complex
- Temperature, flow, and food production in the estuary as part of a 3-model full life cycle bioenergetic model of salmon

See Appendix D for a more detailed description of the SCHISM methodologies applied for the analyses herein.

4.1.4.4 Delta Passage Model

The Delta Passage Model (DPM) simulates the migration of Chinook Salmon smolts entering the Delta from the Sacramento River and Mokelumne River, and estimates survival to Chipps Island. The DPM uses available time-series data and values taken from empirical studies or other sources to parameterize model relationships and inform uncertainty, thereby using the greatest amount of data available to dynamically simulate responses of smolt survival to changes in water management. Although the DPM is based primarily on studies of Late Fall-run Chinook Salmon Chinook, it is applied here for Winter-run, Spring-run, Fall-run, and Late Fall-run Chinook Salmon by adjusting emigration timing and assuming that all migrating Chinook Salmon smolts will respond similarly to Delta conditions. The DPM results presented herein reflect the current version of the model, which continues to be reviewed and refined, and for which a sensitivity analysis has been completed to examine various aspects of uncertainty related to the model's inputs and parameters.

The DPM is based on a detailed accounting of migratory pathways and reach-specific mortality as Chinook Salmon smolts travel through a simplified network of reaches and junctions. The biological functionality of the DPM is based on the foundation provided by Perry et al. (2010) as well as other acoustic tagging–based studies (SJRGA 2008, 2010; Holbrook et al. 2009) and coded-wire tag (CWT)–based studies (Newman and Brandes 2010; Newman 2008). Uncertainty is explicitly modeled in the DPM by incorporating environmental stochasticity and estimation error whenever available.

The major model functions in the DPM are as follows:

- Delta Entry Timing, which models the temporal distribution of smolts entering the Delta for each race of Chinook Salmon
- Fish Behavior at Junctions, which models fish movement as they approach river junctions
- Migration Speed, which models reach-specific smolt migration speed and travel time
- Route-Specific Survival, which models route-specific survival response to non-flow factors
- Flow-Dependent Survival, which models reach-specific survival response to flow
- Export-Dependent Survival, which models survival response to water export levels in the Interior Delta reach

See Appendix E for a more detailed description of the DPM methodologies applied for the analyses herein.

4.1.4.5 Survival, Travel Time, and Routing Simulation Model

The Survival, Travel Time, and Routing Simulation model (STARS) is a stochastic, individual-based simulation model designed to predict survival of a cohort of fish that experience variable daily river flows as they migrate through the Delta. The parameters on which the STARS model is based were derived from a Bayesian mark-recapture model that jointly estimated reach-specific travel time, migration routing, and survival of juvenile Chinook Salmon. This model extends the work of Perry and others (2010) to estimate the impact of the Delta Cross Channel (DCC) and Delta inflows as measured in the Sacramento River at Freeport (U.S. Geological Survey [USGS] stream gage 11447650) on survival, travel time, and routing of juvenile Chinook Salmon in eight reaches of the Delta.

See Appendix E for a more detailed description of the STARS methodologies applied for the analyses herein.

4.1.4.6 Appropriate Use of Modeling

Modeling used in this document is for a planning analysis based on CalSim II simulations. A planning analysis is conducted to understand long-term changes in the Central Valley Project (CVP) and State Water Project (SWP) system due to a proposed change. CalSim II includes a generalized and simplified representation of a complex water resources system, and as such, its results cannot be compared to historical observed data. Even so, the models used are informative and helpful in understanding the performance and potential impacts (both positive and negative) of the operation of a project and its interaction with the water resources system under consideration. Even though some of the models used in this planning analysis such as DSM2 are calibrated and validated to represent physical processes, given the nature of the boundary conditions used (derived from CalSim II), DSM2 results would only tend to represent generalized long-term trends. Similarly, all the models used in the analysis that uses CalSim II outputs as inputs should primarily be used to understand the potential long-term trends. Note that level of confidence, in the results of any well calibrated predictive model is only as good as the level of confidence in the input boundary conditions used.

Even though CalSim II does not replicate the recent historic conditions, the 82-years simulated generally represent the range of recent hydrologic conditions. It also includes a generalized representation of existing regulations, facilities and demands. CalSim II simulates water volumes, flows, and water quality, and does not have the capability to simulate fish or turbidity. However, fish presence and turbidity are the primary factors in determining the permissible OMR flow direction and magnitude, which at times (January through mid-June) acts as a constraint on export levels in real-time operations. To represent operations governed by fish presence or other real-time variables, CalSim II includes simplifying operational assumptions based on historical data, which is a common practice especially with representing fishery-based actions in a planning analysis. Real-time operations can vary, and the general operating conditions may not represent all the possibilities associated with fish-based regulatory criteria. Information included in Section 4.2.1 demonstrates that CalSim II Existing

Conditions scenario results reasonably encompass the range of Delta hydrologic conditions over the last decade. Despite its limitations, CalSim II offers the best tool available to simulate SWP and CVP operational alternatives over a range of hydrologic conditions. Comparative analysis of different operational regimes (including regulatory conditions) using CalSim II allows for reasonable inference of how differently the projects might perform under the differing conditions.

4.2 HYDROLOGY

This section describes the changes to hydrology due to implementation of the Proposed Project. Changes to surface water hydrology, by themselves, are not considered a significant impact based on the Initial Study (provided in Appendix A). Description of potential changes to hydrology are presented to provide a basis for understanding the potential impacts to other secondary environmental resources evaluated in this DEIR.

4.2.1 ENVIRONMENTAL SETTING

This section describes the surface water resources and water supplies managed by the SWP and potential changes to surface water resources that could occur by implementing the proposed long-term SWP operations. Changes to SWP operations may result in changes to surface water hydrology in the lower Sacramento River, downstream from the Feather River confluence, the Delta and Suisun Bay, and water deliveries to south-of-Delta SWP water users. A CalSim II computer model was used to calculate flow conditions and storage volumes for reservoirs and rivers that would be affected by SWP operations.

As explained below in Section 4.2.2, changes in surface water hydrology, by themselves, are not considered significant environmental impacts. Any environmental impacts that could result from the hydrologic changes described in this section, including impacts on water quality and biological resources are analyzed in other sections of this DEIR.

4.2.1.1 SACRAMENTO RIVER

Flows from the Sacramento River, Feather River, Sutter Bypass, and Natomas Cross Canal join upstream from Verona. When these flows exceed 62,000 cfs, a large portion of the flows enters the Yolo Bypass, a natural overflow area west of the Sacramento River, by spilling over Fremont Weir. The Sacramento River Flood Control Project modified the basin, allowing Sacramento River flood flows to enter the Yolo Bypass over the Fremont and Sacramento weirs. The Yolo Bypass conveys floodwaters around the Sacramento metropolitan area and reconnects to the Sacramento River at Rio Vista (DWR 2013b). Tributaries entering the Yolo Bypass include flows from the Cache Creek Detention Basin, Willow Slough, and Putah Creek. Flows also enter the Yolo Bypass from the Colusa Basin, including flows from the Colusa Basin Drain through the Knights Landing ridge cut.

The SWP operations only have direct impacts on the lower Sacramento River, downstream from the Feather River confluence. Releases from Oroville Dam flow down the Feather River, and the combined flows of the Sacramento and Feather rivers continue southward toward the Delta. Simulated results from the Existing Conditions CalSim II model and recent historical observed data of flows in the

Sacramento River at Freeport (near the northern boundary of the Delta) are shown in Figures 4.2-1 and 4.2-2. Simulated results are based on the 82-year simulation period. Figure 4.2-1 presents 82-year CalSim II model results in box-and-whisker format indicating the range of hydrology modeled for each month. Lines of historical observed flows at Freeport (water years 2008 to 2019) are overlaid atop the box-and-whisker plot. Figure 4.2-2 presents CalSim II model results of Freeport flow during critical water years as black points and historical data of critical water years in the 2008 2019 period as lines. These figures illustrate that the 82-year hydrology and simulated operations in CalSim II generally encompasses the recent historical flows. Despite being generally representative of historical range, CalSim II and other models used in this analysis cannot be compared to historical data. CalSim II applies constant regulations, facilities, and demands to 82-years of hydrologic data. See Appendix H for more details regarding appropriate use of model results. As shown in the figures, flows in the Sacramento River generally peak during winter and spring storm events and stay low in summer and fall months due to less or no precipitation.

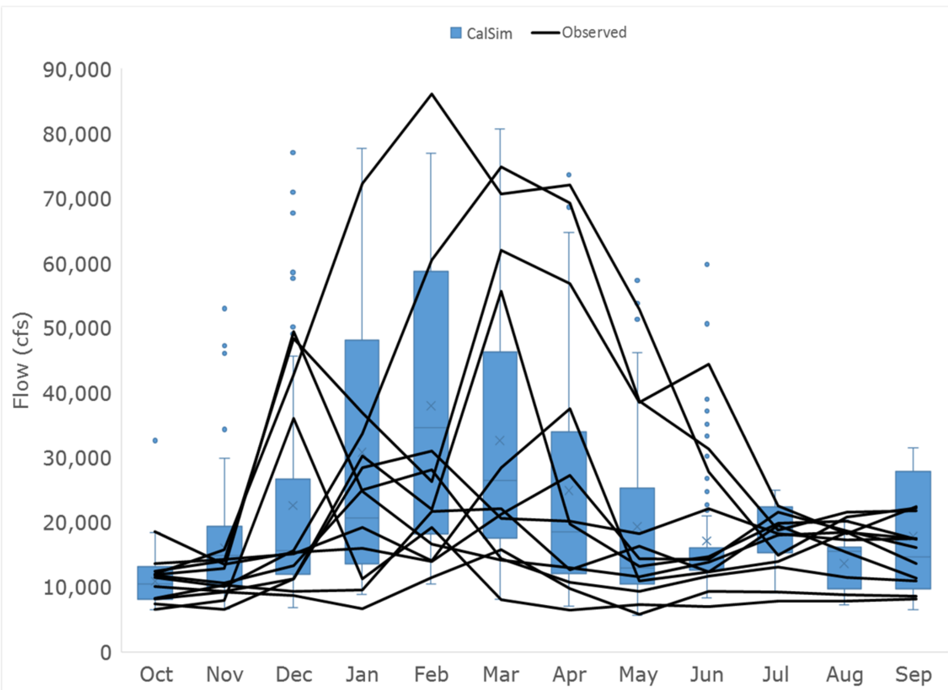


Figure 4.2-1. Sacramento River at Freeport, Historical and Modeled Existing Conditions Flow

4.2.1.2 Sacramento and San Joaquin Bay-Delta

The Delta and Suisun Marsh and Bay encompass about 1,315 square miles and convey about 40% of water draining from the state (DWR 2013a). The Delta and Suisun Marsh and Bay are a complex of channels and islands at the confluence of the Sacramento and San Joaquin rivers. The SWP uses the Delta to convey water to State and federal pumps in the South Delta. Inflows to the Delta occur primarily from the Sacramento River system (including the Yolo Bypass), the San Joaquin River, and eastside tributaries that flow directly into the Delta (Mokelumne, Calaveras, and Cosumnes rivers). About 77% of the water enters the Delta from the Sacramento River system, about 15% enters from the San Joaquin River system, and about 8% enters from the eastside tributaries (Mokelumne, Calaveras, and Cosumnes rivers) (DWR 1994).

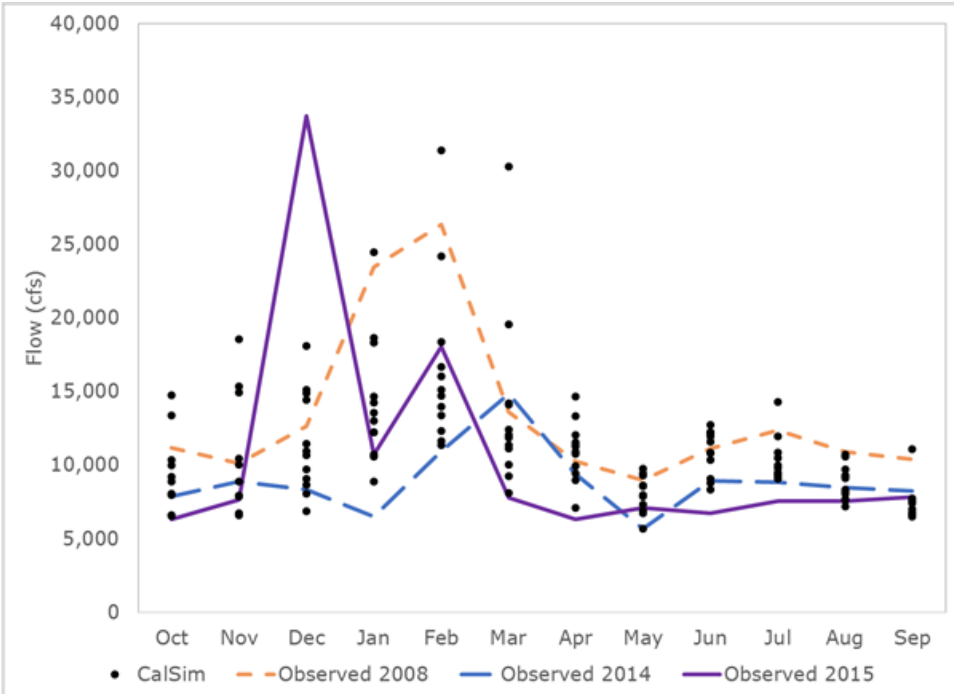


Figure 4.2-2. Sacramento River at Freeport, Critical Year Historical and Modeled Existing Conditions Flow

Water flow paths in the North Delta and Central Delta primarily are determined by flows in the Sacramento River; however, operations of the South Delta pumps can alter the direction of flow in the Central Delta from a westward direction to a southerly flow path toward the South Delta pumps.

Flow paths in the Delta are also affected by operation of the federal DCC gates, which divert flows from the Sacramento River (upstream of Walnut Grove) to the lower Mokelumne River, and through the central and South Delta in Old and Middle rivers to the channels near the South Delta pumps. Generally, opening the DCC gates can reduce salinity in some central and South Delta channels, particularly in the summer months, through the transport of relatively lower salinity Sacramento River water into the Central Delta (DWR et al. 2013).

The San Joaquin River, the second largest contributor to Delta freshwater inflows, enters the Delta from the south and flows toward the north and west. San Joaquin River channel flow volume and directions are affected by tides, local in-Delta water diversions, CVP operations, and SWP operations (DWR et al. 2013). Flow in the Delta channels can change direction because of tidal exchange, ebbing and flooding with the two tides per day. On average, tidal inflows to the Delta are approximately equal to tidal outflows. The tidal range can vary by about 30% between spring tide and neap tide conditions. Tidal flows at Martinez can be as high as 600,000 cfs. Because the Delta is tidally influenced, water surface elevations can vary from less than 1 foot in the east Delta to more than 5 feet in the west Delta on a daily basis (DWR 2013a).

In addition to tides, local in-Delta water diversions, CVP operations, and SWP operations influence Delta hydraulics, including periodic reverse flows (flows upstream towards the San Joaquin River) in Old and Middle rivers. The measurement of reverse flows in Old and Middle rivers is referred to as

OMR. Reverse flows also occur in the False River in the west Delta and Turner Cut in the San Joaquin River. Reverse flows can cause more saline water to move farther inland (DWR et al. 2013).

To maintain water levels in several South Delta waterways, historically DWR has implemented the seasonal South Delta Temporary Barrier Project (TBP), which consists of three temporary rock agricultural barriers, as described in Section 3.1.2.6, *South Delta Temporary Barrier Project*, and a temporary rock barrier at the Head of Old River (HOR) as described in Section 3.1.2.7, *Head of Old River Barrier*. Tidal flows in the South Delta have a major influence on Delta surface water circulation.

4.2.1.3 SWP AND CVP DELTA WATER FACILITIES

Water flows through the South Delta towards the approach channel for the CVP Jones Pumping Plant and the five radial gates that allow water to flow into the 31-thousand acre-foot (TAF) Clifton Court Forebay (CCF), which regulates water flows into the Banks Pumping Plant. The capacity of the Banks Pumping Plant is 10,300 cfs; however, the rate of diversion of water into the CCF is generally restricted to 6,680 cfs as a 3-day average inflow to the CCF and 6,993 cfs as a 1-day average inflow, in accordance with regulatory conditions of the U.S. Army Corps of Engineers (USACE). CCF diversions may increase between December 15 and March 15 by up to one-third of the San Joaquin River flow at Vernalis if those flows are equal to or greater than 1,000 cfs. The SWP is allowed to export an additional 500 cfs between July 1 and September 30 in some water years when SWP exports are reduced to protect listed fish species.

The CVP Jones Pumping Plant has a permitted diversion capacity of 4,600 cfs; however, the operating capacity is limited to 4,200 cfs in a lower portion of the downstream Delta-Mendota Canal.

Water conveyed from the SWP Banks Pumping Plant and CVP Jones Pumping Plant flows in aqueducts to deliver water to downstream users. A portion of the water from the pumping plants flows to the 2.027-million-acre-foot (MAF) San Luis Reservoir, operated jointly by Reclamation and DWR (up to 1.062 MAF of SWP water and up to 0.965 MAF of CVP water). San Luis Reservoir storage generally increases in late fall through early spring when south of Delta demands is lower than in the summer. Water from the San Luis Reservoir is released into the California Aqueduct, which conveys water supplies southward to the Central Coast, Antelope Valley, and Southern California. The first segment of the California Aqueduct extends downstream from San Luis Reservoir to a location near Kettleman City. This upstream segment is called the San Luis Canal and is owned jointly by the SWP and CVP. The remaining portions of the California Aqueduct are owned by SWP.

D-1641 authorized the joint use of the Jones and Banks pumping plants (referred to as the Joint Point of Diversion [JPOD]) with conditional limitations, staged implementation, and required response coordination plans related to maintaining South Delta water elevations for local riparian water users and south and Central Delta water quality in accordance with regulatory criteria by state agencies.

Simulated results from the Existing Conditions CalSim II model and recent historical observed data of total Delta exports (sum of the Jones Pumping Plant and Banks Pumping Plant) are shown in Figures 4.2-3 through 4.2-5. Simulated results are based on the 82-year simulation period. Figure 4.2-3 presents 82-year CalSim II model results in box-and-whisker format indicating the range of modeled exports for each month. Black lines of historical exports (water years 2008 to 2019) are overlaid atop the box-and-whisker plot. Existing Conditions CalSim II model results of Delta exports during dry water years are shown in Figure 4.2-4 as black points and historical data of dry water years in the 2008-2019 period as lines. Figure 4.2-5 shows similar information for historical water years. These figures illustrate that the 82-year hydrology and simulated operations in CalSim II generally encompass the recent historical exports. As noted earlier, CalSim II and other models used in this analysis cannot be compared to historical data.

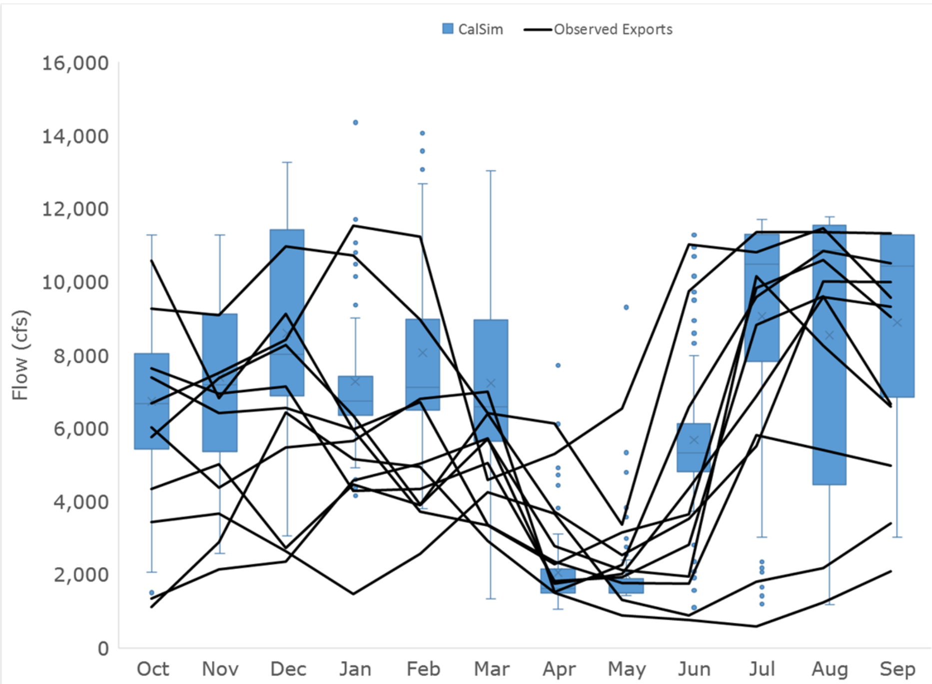


Figure 4.2-3. Total Delta Exports, Historical and Modeled Existing Conditions

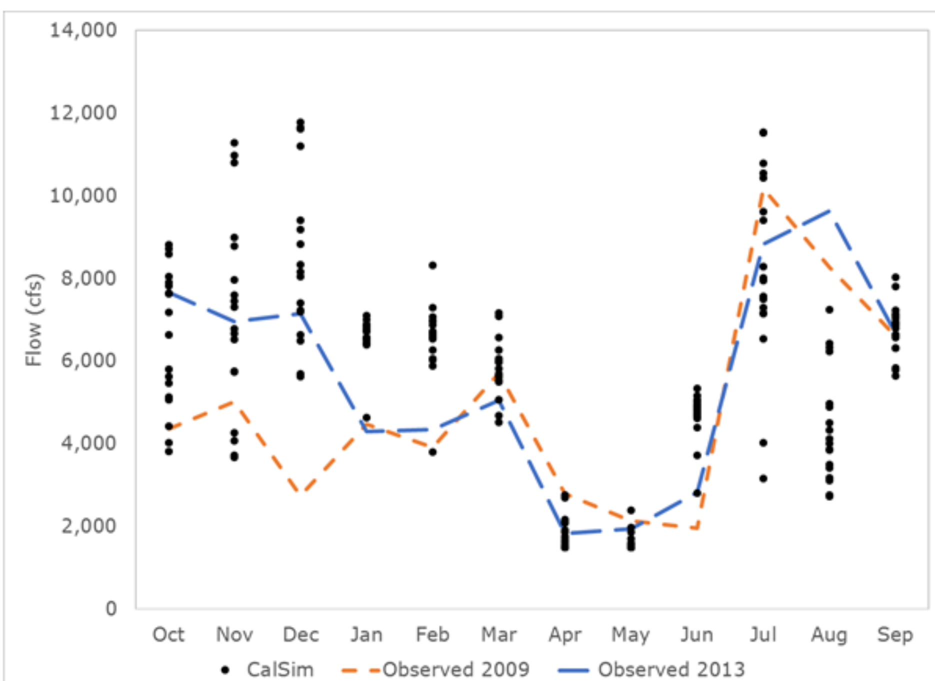


Figure 4.2-4. Total Delta Exports, Dry Year Historical and Modeled Existing Conditions

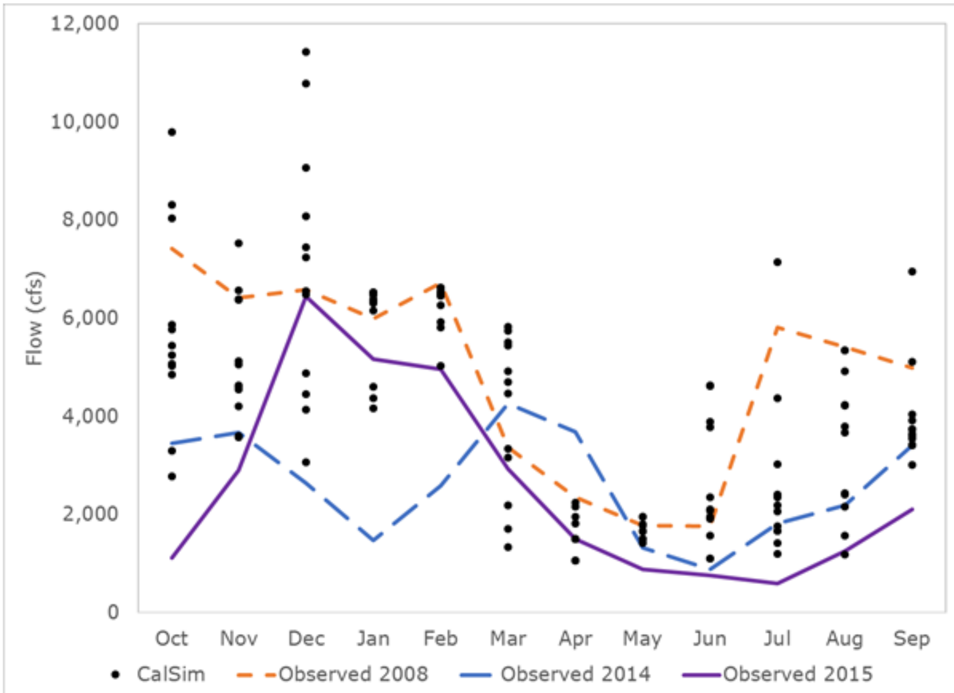


Figure 4.2-5. Total Delta Exports, Critical Year Historical and Modeled Existing Conditions

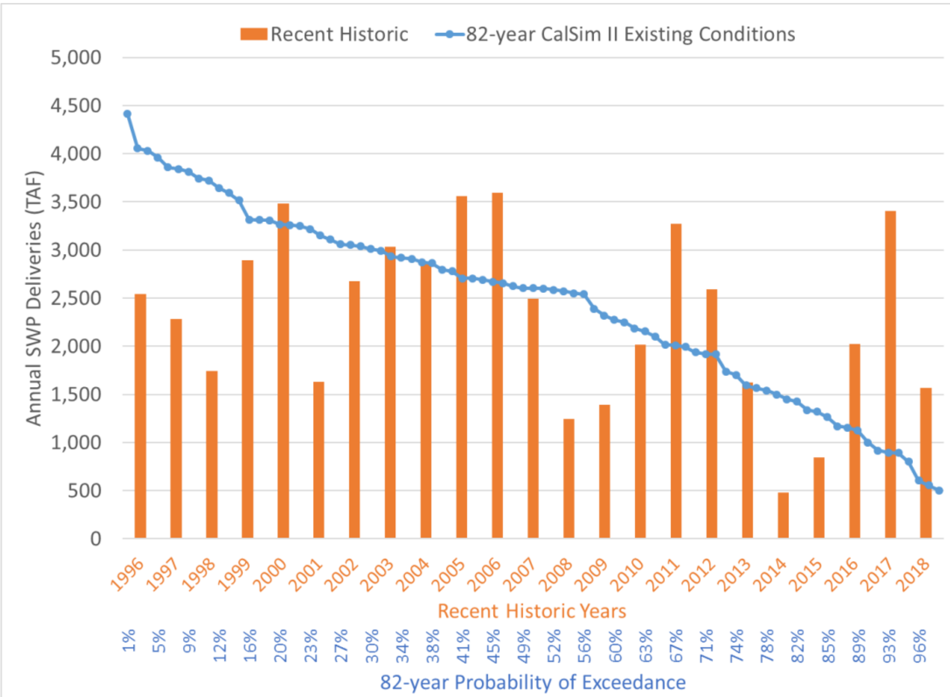
4.2.1.4 Water Supplies Used by State Water Project Water Users

The SWP water supplies are the only water supplies available to some water users, including communities served by the Antelope Valley–East Kern Water Agency. Other SWP water users rely on other surface water supplies and groundwater. However, when the SWP water supplies are limited because of lack of precipitation, the other surface water supplies also are limited.

Several SWP water users also rely on other imported water supplies, including water from the Solano Project, which is used by the Solano County Water Agency; water from the Hetch Hetchy Water Project, which is used by the Alameda County Water District, Santa Clara Valley Water District, and Zone 7 Water Agency; and water from the Colorado River, which is used by portions of the service area of the Metropolitan Water District of Southern California, Desert Water Agency, and Coachella Valley Water District.

In response to recent reductions in SWP water supply reliability, water agencies have been making improvements to regional and local water supplies through enhanced water conservation efforts, wastewater effluent and stormwater recycling, construction of local surface water and groundwater storage facilities, and construction of desalination treatment plants for brackish water sources and ocean water sources. In addition, many agencies have constructed conveyance facilities to allow sharing of water supplies between communities, including the recent Bay Area Regional Water Supply Reliability project, providing conveyance opportunities between several SWP water users in the San Francisco Bay Area.

Figure 4.2-6 shows the modeled Existing Conditions and historical annual SWP deliveries. The probability of exceedance of the modeled annual SWP deliveries for the 82-years from the Existing Conditions CalSim II simulation are plotted (blue line) along with the recent historical annual SWP deliveries (orange columns) in the figure. This figure shows that the CalSim II deliveries are representative of recent historic deliveries because modeled and observed are in the same range.



Recent historical deliveries are shown as orange columns for 1996 to 2018 period. Modeled deliveries are plotted as probability of exceedance curve (blue line) using the 82 year results. Note that the historical deliveries for the years 1996-2008 are provided for reference; the Existing Conditions CalSim II model is representative of the regulatory conditions in the years 2009 through 2018.

Figure 4.2-6. Annual Total SWP Deliveries, Historical and Modeled Existing Conditions

4.2.2 Comparison of Proposed Project with the Existing Conditions

This section describes the changes to hydrology associated with implementation of the Proposed Project compared to the Existing Conditions scenario. Detailed modeling results using the CalSim II computer model for all water-year types and long-term averages are provided in Appendix C. However, the CalSim II model, provided in Appendix H, does not model the proposed adult Longfin Smelt entrainment protections for adult, larval and juvenile Longfin Smelt, and it does not model larval and juvenile Delta Smelt entrainment protection. Therefore, modeled Proposed Project OMR flow and Delta outflow may be higher (and lower exports) than the modeled values during winter and spring months. In general, the CalSim II model has a generalized representation of protection criteria based on real-time fish presence (Appendix H).

The Proposed Project would modify existing operations, downstream surface water flows, and diversions at selected SWP facilities and related waterways. Descriptions of estimated changes in hydrology are presented to provide a basis for understanding potential impacts on designated beneficial uses. Where applicable, estimated SWP contribution to hydrologic changes are provided. Approach and methodology for estimating SWP contribution to change are provided in Appendix H.

Discussions of the potential impacts on designated beneficial uses and other environmental resources are presented in separate sections, as appropriate. For example, estimated changes to Delta outflow could affect surface water quality or aquatic resources, which is further discussed in Section 4.3, "Surface Water Quality" and Section 4.4, "Aquatic Resources," respectively. Therefore, the changes in Delta outflow are discussed in this section as part of the analysis of hydrology, while the potential influence of the change to Delta outflow on water quality or aquatic resources and associated habitat is presented in Sections 4.3 and 4.4, respectively.

4.2.2.1 Comparison of Sacramento River Flows into Delta, Delta Outflow, and OMR Flows

Sacramento River at Freeport

As shown in Figure 4.2-7, CalSim II model results indicate that over the 82-year simulation period, Sacramento River inflow to the Delta under the Proposed Project would decrease by 1,968 cfs (11%) and 1,687 cfs (11%) in September and November, respectively, compared to the Existing Conditions scenario, and remain similar in other months. Estimated SWP contribution to long-term flow changes may range from 30% to 60%, depending on the month. A detailed discussion regarding estimates to SWP contribution of flow changes is provided in Appendix H.

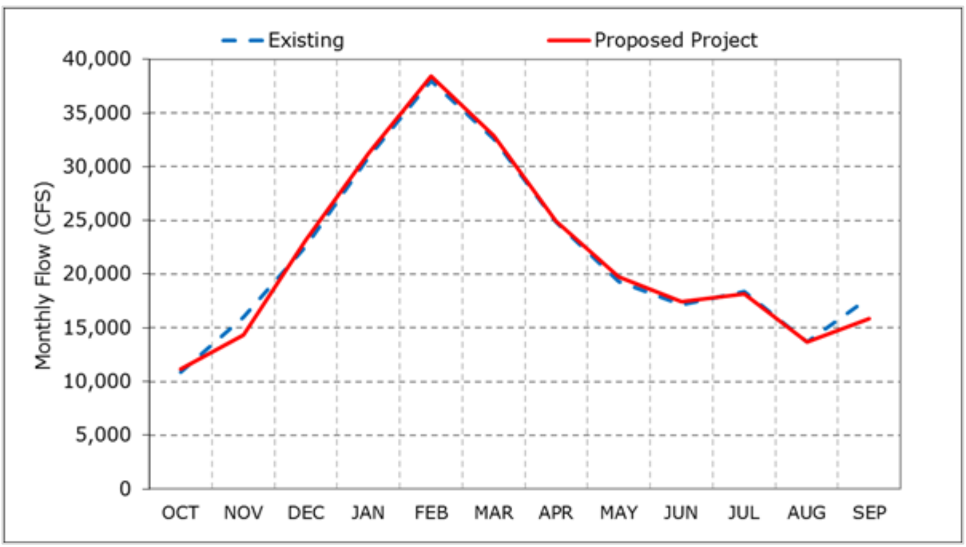


Figure 4.2-7. Sacramento River Freeport, Comparison of Long-Term SWP-CVP Operations

Proposed operations would reduce Sacramento River flow in September and November in years following a wet water year. In years following above-normal water years, the estimated Sacramento River flow at Freeport would increase in September and decrease in November. The range of the estimated SWP contribution to these changes is about 20% to 65%. In below-normal, dry, and critical water years, Sacramento River flow under the Proposed Project scenario will remain similar to the flow under the Existing Conditions scenario.

Delta Outflow

With implementation of the Proposed Project scenario, Delta outflow would be reduced in April, May, September, and November, when compared to the Existing Conditions scenario. The SWP's estimated contribution to long-term flow changes ranges from 30% to 60%, depending on the month. Delta outflow would remain similar in all other months. Delta outflow mean monthly flow patterns under the Existing Conditions and the Proposed Project scenarios over the 82-year simulation period are shown in Figure 4.2-8.

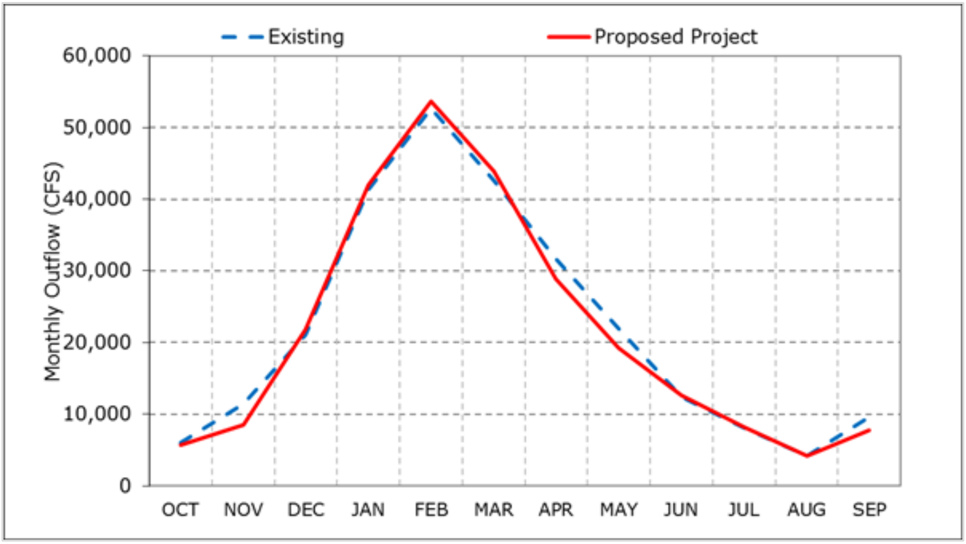


Figure 4.2-8. Delta Outflow, Comparison of Long-Term SWP-CVP Operations

Delta outflow would be reduced in April and May because export patterns would change with implementation of the Proposed Project. In wet, above-normal, below-normal, and dry years Delta outflow decreases by up to 17% in April and May. In critical years, Delta outflow under the Proposed Project scenario would remain similar to that under the Existing Conditions scenario.

In years following wet water years, Delta outflow decreases in September and November due to the proposed Delta Smelt Summer-Fall Habitat Action. Similarly, in years following above-normal water years, Delta outflow increases in September and decreases in November. Delta outflow in fall months remains similar in all other water year types. Aside from decreases in April and May of wet, above-normal, below-normal and dry years, Delta outflow under the Proposed Project scenario in other months remains similar to the Existing Conditions scenario in all water year types.

Old and Middle River Flow

Mean monthly OMR flow would be negative in all months because of South Delta CVP and SWP pumping operations over the 82-year simulation period, as shown in the Figure 4.2-9. With implementation of the Proposed Project, the mean monthly OMR flows, as modeled, would increase in March by 753 cfs and decrease by up to 2,040 cfs in late-spring months (April and May).

In wet, above-normal, below-normal, and dry water years, OMR flows would increase by up to 1,056 cfs in March and decrease up to 3,202 cfs in April and May when compared to OMR flows under the Existing Conditions scenario. Changes in April and May would result in a large percentage change in the OMR negative flow because OMR flows under the Existing Conditions scenario are nearly zero in these months.

In critical water years, OMR flows would increase by up to 810 cfs in May and October. Conversely, OMR flows would decrease by up to 615 cfs in August and November with implementation of the Proposed Project. As noted above, estimated SWP contribution to long-term Delta outflow changes may range from 30% to 60%, depending on the month.

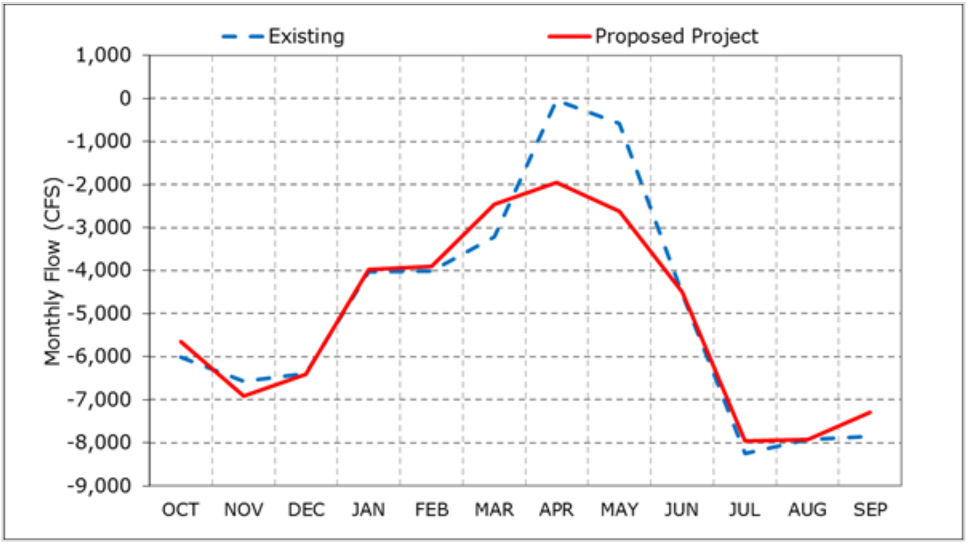


Figure 4.2-9. Old and Middle River Flow, Comparison of Long-Term SWP-CVP Operations

4.2.2.2 Comparison of SWP Banks Pumping Plant Exports and SWP Deliveries

With implementation of the Proposed Project, SWP South Delta exports at Banks Pumping Plant would potentially increase by up to 1,480 cfs (170%) in April, 1,414 cfs (174%) in May, and 1,442 cfs (44%) in November. A potential pumping decrease of 576 cfs (15%) in March would occur with implementation of the Proposed Project.

In wet, above-normal, and below-normal water years, the SWP Banks Pumping Plant exports under the Proposed Project scenario would potentially increase by up to 1,977 cfs in April, 2,123 cfs in May, 601 cfs in October, and 1,929 cfs in November, and would potentially decrease by up to 864 cfs in March, compared to exports under the Existing Conditions scenario.

In dry-water years, SWP Banks Pumping Plant exports under the Proposed Project scenario would potentially increase by 941 cfs (135%) in April, 706 cfs (112%) in May, 179 cfs (35%) in August, and 969 cfs (32%) in November.

In critical water years, SWP Banks Pumping Plant exports would potentially increase by 306 cfs (44%) in April, 105 cfs (23%) in May, 181 cfs (28%) in July, 164 cfs (34%) in August, and 1,039 cfs (54%) in November compared to exports under the Existing Conditions scenario. Additional details are provided in Appendix C.

Over the long-term, average modeled annual SWP Banks Pumping Plant pumping is increasing by about 222 TAF under the Proposed Project scenario compared to the Existing Conditions scenario.

Table 4.2-1 shows existing and proposed total annual SWP deliveries over the long term and for dry and critical water years over the 82-year simulation period. Reported values only reflect SWP deliveries and exports and do not include any CVP wheeling or water transfers.

Table 4.2-1. Annual SWP Regional Deliveries of the Proposed Project Compared to Existing Conditions

Region	Delivery Type	Average (Annual)	Existing Conditions (TAF[a])	Proposed Project (TAF[a])	Change from the Existing Conditions to Proposed Project (TAF[a]/%)
Sacramento River Hydrologic Region	SWP FRSA Contract Delivery	Long-Term[b] Dry and Critical[c]	952 908	952 908	0 (0%) 0 (0%)
Sacramento River Hydrologic Region	SWP M&I Contract Delivery	Long-Term Dry and Critical	30 20	31 22	1 (4%) 2 (10%)
San Joaquin River Hydrologic Region (not including Friant-Kern and Madera Canal water users)	SWP Ag Contract Delivery (including Article 21)	Long-Term Dry and Critical	3 2	4 2	1 (7%) 0 (0%)
San Francisco Bay Hydrologic Region	SWP M&I Contract Delivery (including Article 21, includes transfers to SWP contractors)	Long-Term Dry and Critical	202 125	215 138	13 (6%) 13 (10%)
Central Coast Hydrologic Region	SWP M&I Contract Delivery	Long-Term Dry and Critical	40 22	43 24	3 (7%) 2 (7%)
Tulare Lake Hydrologic Region	SWP M&I Contract Delivery	Long-Term Dry and Critical	77 42	83 47	6 (7%) 4 (10%)
Tulare Lake Hydrologic Region	SWP Ag Contract Delivery) (including Article 21	Long-Term Dry and Critical	585 310	639 342	54 (9%) 31 (10%)
South Lahontan Hydrologic Region	SWP M&I Contract Delivery (including Article 21)	Long-Term Dry and Critical	260 155	281 175	21 (8%) 20 (13%)
South Coast Hydrologic Region	SWP M&I Contract Delivery (including Article 21, includes transfers to SWP contractors)	Long-Term Dry and Critical	1,242 763	1,363 884	121 (10%) 121 (16%)
South Coast Hydrologic Region	SWP Ag Contract Delivery (including Article 21)	Long-Term Dry and Critical	7 4	8 4	1 (10%) 0 (8%)
Total for All Regions[d]	Total SWP Supplies Contract Delivery (FRSA, Ag, and M&I from SWP)	Long-Term Dry and Critical	3,399 2,352	3,618 2,546	219 (6%) 193 (8%)

Notes:

a. Based on CALSIM-II modeling over the 82-year simulation period.

b. “Long-Term” is the average quantity for the period of October 1921 through September 2003.

c. Dry and critical years average is the average quantity for the combination of the State Water Resources Control Board D-1641 40-30-30 dry and critical years for the period of October 1921 through September 2003.

d. Values do not include deliveries associated with Central Valley Project (CVP) Cross-Valley Canal contracts, CVP Joint Point of Diversion (JPOD) exchanges, and water transfers under the Lower Yuba River Accord (Component 1).

Ag = Agricultural
FRSA = Feather River Service Allocation
M&I = municipal and industrial
SWP = State Water Project
TAF = thousand acre-feet

Long-term average annual total SWP deliveries would potentially increase by 219 TAF (6%) under the Proposed Project scenario compared to the Existing Conditions scenario. Relative delivery increases would be greatest in above-normal, below-normal, and dry years.

In the dry and critical water years, proposed long-term average annual SWP deliveries would increase by 193 TAF (8%), compared to deliveries under the Existing Conditions scenario. For the most part, the Proposed Project would result in greater relative increases in deliveries in dry and critical water years.

4.3 SURFACE WATER QUALITY

4.3.1 ENVIRONMENTAL SETTING

Water quality conditions in the project area are described in this section in relation to criteria established by federal and State laws and regulations that protect identified beneficial uses. The Porter Cologne Water Quality Control Act (Porter-Cologne Act) established the State Water Resources Control Board (SWRCB) and divided the state into nine regions, each overseen by a Regional Water Quality Control Board (RWQCB). The Porter-Cologne Act requires the RWQCBs to prepare and periodically update basin plans. In accordance with Section 13050(f) of the Porter-Cologne Act, the basin plans must identify beneficial uses of water, adopt water quality objectives to protect the beneficial uses, and develop implementation programs for achieving the objectives.

Water quality criteria in the basin plans also must be developed in accordance with the federal Water Pollution Control Act Amendments of 1972, also known as the Clean Water Act (CWA), and as subsequently amended. The CWA established the institutional structure for the U.S. Environmental Protection Agency (EPA) to regulate discharges of pollutants into waters of the United States, establish water quality standards to protect designated beneficial uses, conduct planning studies, and provide funding for specific grant projects. In California, the EPA designated the SWRCB to act as its agent to develop and enforce water quality objectives and implement water quality control plans (basin plans). The SWRCB designated Regional Water Quality Control Boards (RWQCBs) to develop basin plans, designate the beneficial uses of waters in each basin, set water quality objectives to protect those beneficial uses pursuant to Section 303 of the CWA, and implement federal policies for antidegradation to protect public health or welfare, enhance the quality of water, and serve the purposes of the CWA. In accordance with the CWA, the RWQCBs evaluate proposed actions that could change flow patterns and water quality in discharges into the water bodies, including land use practices that affect drainage and water diversion patterns. The RWQCBs issue National Pollutant Discharge Elimination System permits for surface water discharges and Waste Discharge Permits for other discharges to provide discharge limitations that would not adversely affect beneficial uses.

The Bay Delta Water Quality Control Plan (WQCP) for the Sacramento and San Joaquin river basins serves as the basin plan for much of the area with the water supplies for the CVP-SWP project. The WQCP designates drinking water municipal and domestic supply beneficial use for most waters in the Central Valley, including the Delta. The WQCP includes narrative objectives for chemical constituents, taste and odor, sediment, suspended material, and toxicity, and numeric objectives for chemical constituents and salinity; it incorporates by reference the primary and secondary maximum contaminant levels specified in state regulations, including Title 22 of the California Code of Regulations for waters designated for municipal uses.

Water quality criteria were adopted by the SWRCB and Central Valley RWQCB to protect these water users and ecological resources in the Sacramento and San Joaquin rivers and the Delta. Specifically, the SWRCB adopted the 1995 Bay-Delta Plan on May 22, 1995, which became the basis of D-1641 (adopted December 29, 1999, and revised March 15, 2000). D-1641 includes water right permit terms and conditions to implement water quality objectives to protect agricultural and municipal and industrial

(M&I) beneficial uses in the Delta, as well as water quality objectives to protect fish and wildlife beneficial uses in the Delta and Suisun Marsh. DWR operates the SWP in accordance with obligations under D-1641. The Delta is a source of drinking water supply to more than 25 million people or 60% of the state's population, agricultural water supply, and wildlife refuge water supplies. The water supplies include water rights issued by the SWRCB to the SWP, the CVP, and individuals. Beneficial uses for water bodies in the study area are summarized in Table 4.3-1.

Table 4.3-1. Designated Beneficial Uses in the Study Area

Designated Beneficial Uses	Sacramento River: Feather River Confluence to Delta	Feather River: Oroville Dam to Sacramento River	Yolo Bypass	Sacramento-San Joaquín Delta
Municipal and Domestic Supply	X	X	N/A	X
Agricultural Supply	X	X	X	X
Industrial Service Supply	X	N/A	N/A	X
Industrial Process Supply	N/A	N/A	N/A	X
Groundwater Recharge	N/A	N/A	N/A	X
Navigation	N/A	N/A	N/A	X
Hydropower Generation	N/A	N/A	N/A	N/A
Water Contact Recreation	X	X	X	X
Non-Contact Water Recreation	X	X	X	X
Commercial and Sport Fishing	N/A	N/A	N/A	X
Warm Fresh water Habitat	X	X	X	X
Cold Fresh water Habitat	X	X	X	X
Wildlife Habitat	X	X	X	X
Rare, Threatened, or Endangered Species	N/A	N/A	X	X
Migration of Aquatic Organisms	X	X	X	X
Spawning, Reproduction, and/or Early Development	X	X	X	X
Shellfish Harvesting	N/A	N/A	N/A	X
Estuarine Habitat	N/A	N/A	N/A	X

Sources: Central Valley RWQCB 2004, 2011; San Francisco Bay RWQCB 2013; SWRCB 2006
Notes:
N/A = not applicable
X = is a beneficial use

Water quality in these water bodies is influenced by precipitation, discharge of human-made constituents, and several naturally occurring constituents, such as salinity and nutrients (including organic carbon) that are necessary components of the ecosystem and that can vary with natural hydrology and tidal cycles of the estuary. Human-made constituents of concern, such as pathogens and contaminants, result from point and non-point source discharges into the Sacramento and San Joaquin rivers and the Delta. Direct diversions from the water bodies and indirect diversions (due to groundwater withdrawals in connected aquifers) can affect concentrations of constituents or other conditions (e.g., temperature downstream of reservoirs). In accordance with Section 303(d) of the CWA, the RWQCBs periodically reviews water quality conditions and determines if the conditions impair beneficial uses of each water body. This information is used to prepare lists of impaired water bodies in each basin that do not comply with applicable water quality standards. The RWQCBs can develop Total Maximum Daily Load (TMDL) criteria that identify the greatest pollutant volume that a water body can receive from discharges and still protect designated beneficial uses. Potential changes due to activities related to discharges, diversions, or water flow changes are reviewed by the RWQCBs to determine if the results of these changes would be compliant with the TMDL criteria. TMDLs adopted or being developed to protect the beneficial uses are summarized in Table 4.3-2.

Table 4.3-2. Total Maximum Daily Load Status in the Study Area

Water Body	Mercury	Toxicity	Pesticides	Other Constituents
Sacramento River from Keswick Reservoir to Delta	N/A	TMDL by 2019	N/A	N/A
Sacramento River from Knights Landing to the Delta	TMDL being developed	N/A	Dieldrin TMDL by 2022	N/A
Lake Oroville and Feather River to Sacramento River	TMDL by 2022	TMDL by 2019	Group A TMDL being developed Chlorpyrifos TMDL by 2019	PCB TMDL by 2022
San Luis Reservoir	TMDL by 2021	N/A	N/A	N/A
Delta	TMDL approved 2008	TMDL by 2019	Chlordane and Dieldrin in the northern Delta TMDL being developed Chlorpyrifos, DDT, Diazinon, Dioxin, Furan compounds, and Group A TMDLs being developed	PCB TMDL being developed Selenium TMDL being developed Invasive species TMDL by 2019

Source: SWRCB 2011A
Note:
DDT = dichlorodiphenyltrichloroethane
N/A = not applicable
PCB = polychlorinated biphenyl
TMDL = total maximum daily load

4.3.2 Water Quality Constituents That Could Be Affected by the Proposed Project

Changes in Delta surface water quality conditions related to changes in SWP operations under the Proposed Project could be related to changes in salinity (as measured by chloride or electrical conductivity).

Changes in other constituents are not anticipated. The primary sources of nutrients in the Delta are related to natural sources (e.g., weathering of rocks and soil in rivers upstream of the Delta); nutrients from the oceans; runoff from undeveloped, agricultural, and urban land uses; and wastewater treatment plant effluent. Nutrient loadings from land uses and effluent discharge are limited by regulatory processes. The Proposed Project would not affect other contaminants, including nutrients and methylmercury, because the project would only include project operations and would not affect mercury sources or the extent of wetlands.

Salinity, a measure of dissolved salts in water, in the tidally influenced Delta can cause adverse impacts on domestic supply, agriculture, industry, and wildlife (Reclamation 2015). Salinity concentrations tend to increase from the North Delta to the South Delta, and from the east Delta to the west Delta. Salinity in the Delta over time and space follows predictable patterns. Salinity at given location is influenced by higher saline water from the San Joaquin River, less saline water from the Sacramento River and eastside streams, localized agricultural drainage, ocean salt exchange due to tidal influence upstream from Suisun Bay, and the losses from South Delta pumping and other Delta diversions. The highest salinity occurs in the late summer months, when the hydrologic dry-season causes low Delta inflows and sea water intrusion occurs.

High salinity in irrigation water inhibits water and nutrients intake by agricultural crops, resulting in yield reduction. To protect salt-sensitive crops during the irrigation season and other beneficial uses, electrical conductivity objectives were established in the SWRCB (2006) Bay-Delta WQCP. The criteria vary by month and water-year type for the lower Sacramento River at Emmaton; the San Joaquin River at Jersey Point, San Andreas Landing, Airport Way Bridge, and Vernalis; Old River near Middle River and at Tracy Road Bridge; South Fork Mokelumne River at Terminus; West Canal at the Clifton Court Forebay gates; and Delta-Mendota Canal at Jones Pumping Plant, as summarized in Table 4.3-3.

Table 4.3-3. Major Salinity Water Quality Objectives in the Study Area

Location of Water Quality Objective	Parameter	Description	Water Year: Time Period or Values
Contra Costa Canal at Pumping Plant #1 or San Joaquin River Antioch Water Works Intake	Chloride	Maximum mean daily 150 mg/L chloride for at least the number of days shown during the calendar year. Must be provided in intervals of not less than two weeks duration.	Wet: Less than 150 to 240 days Above-Normal: Less than 150 to 190 days Below-Normal: Less than 150 to 175 days Dry: Less than 150 to 165 days Critical: Less than 150 to 155 days
Contra Costa Canal at Pumping Plant #1 and West Canal at gates of Clifton Court Forebay and Jones Pumping Plant and Cache Slough at City of Vallejo Intake and Barker Slough at North Bay Aqueduct Intake	Chloride	Maximum mean daily, in mg/L	All Water Year Types (Wet, Above-Normal, Below-Normal, Dry, Critical): 250 all year
Sacramento River at Emmaton	Electrical Conductivity	Maximum 14-day running average of mean daily EC (mmhos/cm)	Wet: 0.45 from April 1 to August 15 Above-Normal: 0.45 from April 1 to June 30, and 0.63 from July 1 to August 15 Below-Normal: 0.45 from April 1 to June 19, and 1.14 from June 20 to August 15 Dry: 0.45 from April 1 to June 14, and 1.67 from June 15 to August 15 Critical: 2.78 from April 1 to August 15
San Joaquin River at Jersey Point	Electrical Conductivity	Maximum 14-day running average of mean daily EC (mmhos/cm)	Wet: 0.45 from April 1 to August 15 Above-Normal: 0.45 from April 1 to August 15 Below-Normal: 15 Dry: 0.45 from April 1 to June 19, and 0.74 from June 20 to August 15 Critical: 0.45 from April 1 to June 14, and 1.35 from June 15 to August 15 and 2.20 from April 1 to August 15

Location of Water Quality Objective	Parameter	Description	Water Year: Time Period or Values
South Fork Mokelumne River at Terminus	Electrical Conductivity	Maximum 14-day running average of mean daily EC (mmhos/cm)	Wet, Above-Normal, Below-Normal, Dry: 0.45 from April 1 to August 15 Critical: 0.54 from April 1 to August 15
San Joaquin River at San Andreas Landing	Electrical Conductivity	Maximum 14-day running average of mean daily EC (mmhos/cm)	Wet, Above-Normal, Below Normal: 0.45 from April 1 to August 15 Dry: 0.45 from April 1 to June 24 and 0.58 from June 25 to August 15 Critical: 0.87 from April 1 to August 15
San Joaquin River at and between Prisoners Point and Jersey Point	Electrical Conductivity	Fish and Wildlife Beneficial Use Objective Maximum 14-day running average of mean daily EC (mmhos/cm)	All Water Year Types (Wet, Above-Normal, Below-Normal, Dry, Critical): 0.44 from April 1 to May 31
San Joaquin River at Airport Way Bridge, Vernalis and San Joaquin River at Brandt Bridge Site, and Old River near Middle River and Old River at Tracy Road Bridge	Electrical Conductivity	Maximum 30-day running average of mean daily EC (mmhos/cm)	All Water Year Types (Wet, Above-Normal, Below-Normal, Dry, Critical): 0.7 from April 1 through August 31 and 1.0 from September 1 through March 31
West Canal at mouth of Clifton Court Forebay and Delta-Mendota Canal at Jones Pumping Plant	Electrical Conductivity	Maximum monthly average of mean daily EC (mmhos/cm)	All Water Year Types (Wet, Above-Normal, Below-Normal, Dry, Critical): 1.0 all year

Source: SWRCB 2006
Notes:
EC = electrical conductivity
mg/L = milligrams per liter
mmhos/cm = millimhos per centimeter

To protect M&I beneficial uses, salinity water quality criteria include a mean daily salinity of 150 mg/L as chloride for at least 150 days per year for the Contra Costa Canal Pumping Plant #1 (at Rock Slough), which serves Contra Costa Water District or the City of Antioch Water Works Intake. In addition, 250 mg/L of salinity as chloride is the maximum allowed concentration at Contra Costa Canal Pumping Plant #1 (at Rock Slough), West Canal at the Clifton Court Forebay intake gates, Jones Pumping Plant approach channel, Cache Slough at the City of Vallejo intake, and Barker Slough at the North Bay Aqueduct Intake.

Delta waterways were placed on the Section 303(d) list of impaired water bodies approved by EPA in 2010 for electrical conductivity (SWRCB 2011a). The Suisun Marsh wetlands were placed on the 303(d) list that was approved by EPA in 2010 for impairment by salinity as measured by chlorides and total dissolved solids (SWRCB 2011a). Salinity water quality criteria for fish and wildlife beneficial uses vary by location, month, and water-year type for San Joaquin River from Jersey Point to Prisoners Point, Sacramento River at Collinsville, Montezuma Slough at National Steel, Montezuma Slough near Beldon's Landing, Chadbourne Slough at Sunrise Duck Club, and Suisun Slough 300 feet south of Volanti Slough.

Salinity impacts are also evaluated with respect to “X2,” the horizontal distance from the Golden Gate Bridge up the axis of the Delta estuary, where a tidally averaged near-bottom salinity concentration of 2 parts of salt in 1,000 parts of water occurs. X2 is a constantly fluctuating position in the continuum between the Delta freshwater (salinity less than 2 parts per thousand [ppt]) upstream and San Francisco Bay tidal influence downstream (salinity greater than 2 ppt). The 2000 SWRCB Water Rights Decision 1641 (D-1641) provides the water quality objectives, or the SWP and CVP operations include “Spring X2” criteria from February through June to protect fish and wildlife beneficial uses.

4.3.3 Impacts of the Proposed Project

This section describes the changes to water quality associated with implementation of the Proposed Project scenario compared to the Existing Conditions scenario. CalSim II and DSM2 model results, presented as exceedance plots, are provided in Appendix C.

The Proposed Project would modify existing operations, Delta surface water flows, and diversions at selected SWP facilities and related waterways. Changes to hydrology may affect water quality in the SWP system in the Delta. The changes to surface water flows are discussed in detail in Section 4.2, “Hydrology.”

4.3.2.1 Thresholds of Significance

Significance criteria represent the thresholds that were used to identify whether an impact would be potentially significant. Appendix G of the State CEQA Guidelines identifies the following criteria for water quality:

(a) Would the Project:

- Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality?
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would:
  - result in substantial erosion or siltation on- or off-site;
  - substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or offsite;
  - create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff; or
- In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation?
- Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?

The evaluation criteria used for this impact analysis represent a combination of the of the State CEQA Guidelines Appendix G criteria and professional judgment that considers scientific and factual data, as well as current regulations, standards, and/or consultation with agencies, and knowledge of the area.

For this analysis, the Proposed Project would result in a potentially significant impact if it would cause the following:

- A violation of any water quality standard or waste discharge requirement, or otherwise substantially degrade water quality

If a water quality constituent declines because the Proposed Project scenario is implemented rather than the Existing Conditions scenario, the impact would not be potentially significant unless it would result in exceeding applicable limits and would violate a standard or other requirement. Changes to water quality may result in secondary impacts on other beneficial water uses or environmental resources. Such secondary impacts are discussed in their respective sections. For instance, potential changes in Delta salinity are discussed in this section as part of the analysis of surface water quality, and the potential impacts of the changes in Delta salinity on aquatic resources and associated habitat are presented in Section 4.4, "Aquatic Resources."

4.3.3.2 Methods of Analysis

Changes in salinity resulting from implementation of the Proposed Project would be limited to the Delta. Salinity indicators used in this analysis include EC and chloride. CalSim II artificial neural network (ANN), an algorithm to calculate X2 distance and EC at select compliance locations, and DSM2, a one-dimensional hydrodynamic and water quality simulation model, were used to evaluate changes in salinity (as represented by EC) in the Delta and at the CVP and SWP South Delta export pumps. Descriptions of CalSim II, ANN, and DSM2 are provided in Appendix C and Appendix H.

4.3.3.3 Evaluation of the Proposed Project

Water quality conditions were analyzed to determine if there were changes in salinity in the Delta due to implementation of the Proposed Project compared to the Existing Conditions scenario, and these conditions are provided in Appendix C. The joint impacts of CVP and SWP operational changes on salinity conditions in the Delta at Emmaton, Jersey Point, Clifton Court Forebay, CCWD intakes in Rock Slough, Old River and Victoria Canal, and Barker Slough under the Proposed Project compared to the Existing Conditions scenario are summarized below. The estimated proportional impact of SWP operation will vary from 30% to 65%, depending on month and water year type. More details regarding the estimation of SWP proportional impact are provided in Appendix H.

Emmaton

As compared to the Existing Conditions scenario, modeled electrical conductivity increased average electrical conductivity at Emmaton by 47 µmhos/cm (11%), 260 µmhos/cm (19%), and 160 µmhos/cm (18%) in January, November, and December, respectively, with electrical conductivity remaining similar in other months. Increases in salinity are only observed in fall and early winter following a wet or above-normal water year.

Jersey Point

As compared to the Existing Conditions scenario, modeled electrical conductivity increased average electrical conductivity at Jersey Point by 92 µmhos/cm (14%), 377 µmhos/cm (29%) and 360 µmhos/cm (32%) in January, November, and December, respectively, and remains similar in other months.

Clifton Court Forebay

As compared to the Existing Conditions scenario, modeled electrical conductivity increased at Clifton Court Forebay by 82 µmhos/cm (15%) and 109 µmhos/cm (22%) in January and December, respectively. In all other months, electrical conductivity at Clifton Court Forebay would be similar to conductivity under the Existing Conditions scenario.

CCWD Intakes in Rock Slough, Old River and Victoria Canal

Compared to the Existing Conditions scenario, modeled electrical conductivity at Rock Slough under the Proposed Project scenario would increase by 79 µmhos/cm (15%), 75 µmhos/cm (14%), and 179 µmhos/cm (33%) in January, November, and December, respectively. Under the Proposed Project, modeled electrical conductivity would decrease by 33 µmhos/cm (11%) and 61 µmhos/cm (20%) in April and May, respectively, and remains similar in all other months.

Compared to the Existing Conditions scenario, modeled electrical conductivity in Old River at State Highway 4 under the Proposed Project scenario would increase by 79 µmhos/cm (14%) and 143 µmhos/cm (28%) in January and December, respectively. In all other months, electrical conductivity in Old River at State Highway 4 would be similar to conductivity under the Existing Conditions scenario.

Compared to the Existing Conditions scenario, modeled electrical conductivity at Victoria Canal under the Proposed Project scenario would increase by 56 µmhos/cm (10%) and 60 µmhos/cm (13%) in January and December, respectively. In all other months, electrical conductivity at Victoria Canal would be similar to conductivity under the Existing Conditions scenario.

Barker Slough

Modeled long-term average chloride concentrations at the SWP North Bay Aqueduct under the Proposed Project scenario would be similar to concentrations under the Existing Conditions scenario.

D-1641 Compliance

The Proposed Project would be operated to meet all D-1641 compliance standards. Changes in the frequency of modeled salinity exceedance between the Proposed Project and the Existing Conditions scenarios are shown in Tables 4.3-4 and 4.3-5. The model results indicate changes between 0% and 2%. Given the model assumptions and limitations discussed below, 2% change in frequency of exceedance between the Proposed Project and the Existing Conditions scenarios are considered similar.

Table 4.3-4. Modeled Change in Frequency of D-1641 Exceedance with CalSim II

Location	Regulation	Change from the Existing Conditions to Proposed Project
Sacramento River at Emmaton	D-1641 AG	0%
Contra Costa Canal at Pumping Plant #1	D-1641 M&I	2%
San Joaquin River at Jersey Point	D-1641 AG	0%
Spring X2	D-1641 USFWS	0%

Notes:
AG = agriculture
D-1641 = State Water Resources Control Board's Water Rights Decision 1641
M&I = municipal and industrial

Table 4.3-5. Modeled Change in Frequency of D-1641 Exceedance with DSM2

Location	Regulation	Change from the Existing Conditions to Proposed Project
Barker Slough at North Bay Aqueduct Intake	D-1641 M&I	0%
Sacramento River at Emmaton	D-1641 AG	2%
Sacramento River at Collinsville	D-1641 USFWS	0%
San Joaquin River at Jersey Point	D-1641 AG	0%
San Joaquin River at Jersey Point	D-1641 USFWS	1%
San Joaquin River at San Andreas Landing	D-1641 AG	0%
San Joaquin River at Prisoners Point	D-1641 USFWS	0%
Contra Costa Canal at Pumping Plant #1	D-1641 M&I	1%
South Fork Mokelumne River at Terminus	D-1641 AG	0%
Chadbourne Slough at Sunrise Duck Club	D-1641 USFWS	0%
Montezuma Slough near Beldon's Landing	D-1641 USFWS	0%
Montezuma Slough at National Steel	D-1641 USFWS	0%
Suisun Slough 300 ft. South of Volanti Slough	D-1641 USFWS	0%
Cache Slough at City of Vallejo	D-1641 MI	0%
Barker Slough at North Bay Aqueduct Intake	D-1641 MI	0%
West Canal at Mouth of Clifton Court Forebay	D-1641 AG	0%
West Canal at Mouth of Clifton Court Forebay	D-1641 M&I	0%
Delta-Mendota Canal at Tracy Pumping Plant	D-1641 AG	0%
Delta-Mendota Canal at Tracy Pumping Plant	D-1641 M&I	0%

Notes:
AG = agriculture
D-1641 = State Water Resources Control Board's Water Rights Decision 1641
DSM2 = Delta Simulation Model II
M&I = municipal and industrial
USFWS = U.S. Fish and Wildlife Service

Although modeling suggests exceedances may occur, these exceedances are an artifact of model assumptions and model limitations, which are primarily related to differences in CALSIM II and DSM2 modeling time steps. Some of the other limitations that may cause modeled exceedances include representation of partial-month D-1641 requirements on a monthly time step, calibration of CalSim II ANN, and the use of CalSim II outputs based on operational decisions on a monthly time step as inputs to DSM2 (Nader-Tehrani 2016).

DWR does not anticipate that these exceedances would occur in real time. SWP and CVP have a high degree of success in meeting D-1641 requirements, as demonstrated by the historical record (Leahigh, 2016). Therefore, D-1641 compliance under the Proposed Project is similar to D-1641 compliance under the Existing Conditions scenario.

More detailed D-1641 compliance results are provided in Appendix H. Modeling results at the three D-1641 south Delta agricultural compliance locations are not presented. The salinity conditions in the South Delta are predominantly controlled by the San Joaquin River inflow salinity and salinity from other localized sources. DWR and Reclamation have reported to the State Water Board that these standards are beyond the reasonable control of the SWP and CVP due to localized impacts and the lack of sufficient circulation within the South Delta channels. The joint obligation to meet the South Delta salinity standards is found in D-1641 and is further addressed as part of Order 2010-0002 (Leahigh, 2016). Pursuant to the order, DWR and Reclamation have been and will continue to report to the SWRCB regarding water quality at these south Delta locations. Proposed project operations will not affect actions pursuant to CDO WR 2010-0002.

Finding

The Proposed Project generally would increase salinity during the late fall and early winter in the years following wet and above-normal water years. Despite the potential for salinity increases, SWP will comply with D-1641 standards. The salinity standards in D-1641 were established specifically to protect water quality, including beneficial uses for fish and wildlife and agricultural and urban uses. The Proposed Project would not result in a violation of any water quality standard or waste discharge requirement, or otherwise substantially degrade water quality. Therefore, changes to water quality are **less than significant**.

Mitigation

None required.

4.4 AQUATIC BIOLOGICAL RESOURCES

This section of the DEIR describes the aquatic biological resources within the geographic potentially influenced by the Proposed Project. It identifies potential direct and indirect impacts on special-status, recreationally important, and commercially important fish species resulting from the Proposed Project. The project area for aquatic resources is delineated by the following waters:

- Sacramento River from its confluence with the Feather River downstream to the legal Delta boundary at the I Street Bridge in the city of Sacramento;
- Sacramento-San Joaquin Delta; and
- Suisun Marsh and Bay.

The rationale for including these water bodies in the geographic area potentially affected by the Proposed Project and excluding other areas is provided in Appendix G.

4.4.1 Environmental Setting

4.4.1.1 Special-Status Fish of Focal Interest

Many fish species use the project area during all or some portion of their life histories. A review of the California Natural Diversity Data Base as well as reviews of previous environmental documents for similar projects (e.g., Reclamation 2019; Sites Project Authority and US Bureau of Reclamation 2017) were conducted to identify special-status and commercially or recreationally important species that could occur within the geographic scope addressed in this DEIR. Certain fish species were selected to be the focus of evaluation in this DEIR based on their use of the Sacramento River from the confluence with the Feather River to the Delta and the Delta, as well as their potential sensitivity to the Proposed Project. Fish species of focal evaluation include those species within the project area that fall within any of the following categories:

- Species listed by the federal government as threatened or endangered
- Species listed by the State as threatened or endangered
- Species that are formally proposed for federal listing or are candidates for federal listing as threatened or endangered
- Species that are candidates for State listing as threatened or endangered
- Species that meet the definitions of threatened or endangered under CEQA
- Species identified by the California Department of Fish and Wildlife (CDFW) as species of special concern (SSC) and species designated by California statute as fully protected (i.e., California Fish and Game Code, Section 5515 [fish])
- Species that are recreationally or commercially important

Based on these categories, 20 fish species of focal evaluation were identified with the potential to occur at locations that could be directly or indirectly affected by the Proposed Project. Table 4.4-1 presents a summary of these species and their species-specific protective status, commercial or recreational importance, and occurrence within the project area.

4.4.1.2 Lower Sacramento River

For the evaluation of fish and aquatic resources in this DEIR, the lower Sacramento River flows for approximately 20.4 miles from its confluence with the Feather River at Verona (River Mile [RM][4] 79.8) to the northern boundary of the legal Delta at the I Street Bridge in the city of Sacramento (RM 59.4). Along with its tributaries, the lower Sacramento River provides migratory, spawning, rearing, and resident habitat for a variety of focal evaluation fish species included in Table 4.4-1. Except for Central California Coast (CCC) Distinct Population Segment (DPS) Steelhead, Longfin Smelt, and Central California Roach, all of the fish species in Table 4.4-1 are reported to occur at least seasonally in the Sacramento River in the reach from Verona downstream to the I Street Bridge.

[4] RM = River Mile. RM 0 begins on the Sacramento River at Collinsville, Solano County, California.

Table 4.4-1. Focal Aquatic Species Evaluated in the DEIR

Common Name	Scientific Name	Federal Status[1]	State Status[1]	Tribal, Economically Recreationally Important[2]	Occurrence within Area of Analysis
Pacific Lamprey	*Entosphenus tridentatus*	–	SSC	Y	Sacramento River, Delta
River Lamprey	*Lampetra ayresi*	–	SSC	Y	Sacramento River, Delta
White Sturgeon	*Acipenser transmontanus*	–	SSC	Y	Sacramento River, Delta, Suisun Marsh and Bay
Green Sturgeon, Southern DPS	*Acipenser medirostris*	FT	SSC	Y	Sacramento River, Delta, Suisun Marsh and Bay
Steelhead, Central California Coast DPS	*Oncorhynchus mykiss irideus*	FT	–	Y	Suisun Marsh and Bay
Steelhead, Central Valley DPS	*Oncorhynchus mykiss irideus*	FT	–	Y	Sacramento River, Delta, Suisun Marsh and Bay
Chinook Salmon, Central Valley Fall-run ESU	*Oncorhynchus tshawytscha*	SC	SSC	Y	Sacramento River, Delta, Suisun Marsh and Bay
Chinook Salmon, Central Valley Late Fall-run ESU	*Oncorhynchus tshawytscha*	SC	SSC	Y	Sacramento River, Delta, Suisun Marsh and Bay
Chinook Salmon, Sacramento River Winter-run ESU	*Oncorhynchus tshawytscha*	FE	SE	Y	Sacramento River, Delta, Suisun Marsh and Bay
Chinook Salmon, Central Valley Spring-run ESU	*Oncorhynchus tshawytscha*	FT	SE	Y	Sacramento River, Delta, Suisun Marsh and Bay
Longfin Smelt	*Spirinchus thaleichthys*	FC	ST	N	Delta, Suisun Marsh and Bay
Delta Smelt	*Hypomesus transpacificus*	FT	SE	N	Delta, Suisun Marsh and Bay
Sacramento Splittail	*Pogonichthys macrolepidotus*	–	SSC	N	Sacramento River, Delta, Suisun Marsh and Bay
Hardhead	*Mylopharodon conocephalus*	–	SSC	N	Sacramento River, Delta
Central California Roach	*Lavinia symmetricus*	–	SSC	N	Sacramento River, Delta
Striped Bass	*Morone saxatilis*	–	–	Y	Sacramento River, Delta, Suisun Marsh and Bay
Largemouth Bass	*Micropterus salmoides*	–	–	Y	Sacramento River, Delta, Suisun Marsh and Bay
Smallmouth Bass	*Micropterus dolomieu*	–	–	Y	Sacramento River, Delta, Suisun Marsh and Bay
Spotted Bass	*Micropterus punctulatus*	–	–	Y	Sacramento River, Delta, Suisun Marsh and Bay
American Shad	*Alosa sapidissima*	–	–	Y	Sacramento River, Delta
Killer Whale, Southern Resident DPS[3]	*Orcinus orca*	FE	–	N	Not applicable

Sources: CDFW 2019a; Moyle et al. 2015.

Notes: DPS = Distinct Population Segment; DEIR = Draft Environmental Impact Report; ESU = Evolutionarily Significant Unit

[1] Listing Statuses:
FC = federal candidate for listing
FE = federally listed as endangered
FT = federally listed as threatened
SC = federal species of concern (National Marine Fisheries Service)
SE = state-listed as endangered
SSC = state species of special concern
ST = state-listed as threatened

[2] Species of importance due to existing regulatory management that limits commercial or recreational harvesting and/or of tribal significance.

[3] Killer Whales of the Southern Resident DPS (federal status FE) are included because Chinook Salmon form much of their diet in the ocean.

Fish in the Lower Sacramento River

Many fish and aquatic species use the Sacramento River during all or some portion of their lives. While many of the species identified in Table 4.4-1 use the upper Sacramento River and its tributaries to complete various elements of their life histories, the focus of this section is the fish that use the 20.4-mile section of the river from the confluence with the Feather River to the Delta. The focal fish species from Table 4.4-1 that occur in the Sacramento River downstream from the confluence of the Feather River are listed below, followed by a brief summary of their life history activities that take place in the river:

- Pacific Lamprey
- River Lamprey
- White Sturgeon
- Green Sturgeon
- Central Valley Steelhead
- Fall-run and late Fall-run Chinook Salmon
- Winter-run Chinook Salmon
- Spring-run Chinook Salmon
- Sacramento Splittail
- Hardhead
- Striped Bass
- Non-native freshwater bass (Largemouth Bass, Smallmouth Bass, and Spotted Bass)
- American Shad
- Central Valley Roach

Pacific Lamprey

Pacific Lamprey is a native anadromous fish species. Historically, Pacific Lamprey were widely distributed from Mexico north along the Pacific Rim to Japan. Populations have declined in abundance and have become restricted in distribution throughout California, Oregon, Washington, and Idaho. Threats to Pacific Lamprey within California may include dams, stream degradation, poor water quality, and impacts of climate change. They are culturally important to indigenous people throughout their range and play a vital role in the ecosystem as food for mammals, fish and birds; as nutrient cycling and storage; and as a prey buffer for other species (USFWS 2019).

Data from midwater trawls in Suisun Bay and the lower Sacramento River indicate that adults likely migrate into the Sacramento River and its tributaries from late fall (November) through early summer (June) (Hanni et al. 2006). Adult Pacific Lamprey, either immature or spawning stage, have been detected at the Glenn Colusa Irrigation District (GCID) diversion from December through July and nearly all year at the Red Bluff Diversion Dam (RBDD) (Hanni et al. 2006). Hannon and Deason (2008) documented Pacific Lamprey spawning in the American River between early January and late May, with peak spawning typically occurring in early April. Spawning in the lower Sacramento River is expected to occur during a similar time frame. Pacific Lamprey ammocoetes rear in parts of the

Sacramento River for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping at sites on the mainstem Sacramento River indicate that outmigration of Pacific Lamprey peaks from early winter through early summer, but some outmigration is observed year-round at both the RBDD and the GCID diversion dam (Hanni et al. 2006).

Lampreys have similar habitat requirements to anadromous salmonids and require cold, clear water for spawning and incubation. They also require a wide range of habitats across life stages (Moyle et al. 2015). Typically, diverse habitats include a mix of habitat types, deep pools, complex habitat features (such as boulders and large wood), low-velocity rearing areas with fine sand or silt, and silt-free cobble areas upstream of rearing areas.

Based on the channel, flow, and substrate characteristics in the reach, the Sacramento River in the Verona to I Street Bridge reach provides an adult upstream migration corridor through the reach to suitable spawning and rearing habitats. Specifically, a lack of suitable substrate and a lack of habitat complexity indicate that this reach is unsuitable for spawning.

River Lamprey

The life history of the River Lamprey is not fully understood. River Lampreys are anadromous, and they live a predaceous life when in the ocean. Adults migrate back into freshwater in the fall and spawn during the winter or spring months in small tributary streams, although the timing and extent of migration in California is poorly known (Beamish 1980; Moyle 2002; Moyle et al. 2015). The habitat requirements and environmental tolerances of spawning adults and ammocoetes have not been studied in California. Presumably, like other lampreys, adult River Lampreys need clean, gravelly riffles in permanent streams for spawning, while ammocoetes require sandy to silty backwaters or stream edges in which to bury themselves, where water quality is continuously high and temperatures do not exceed 25 °C (77 °F) (Moyle et al. 2015). Larval lampreys or ammocoetes probably spend the first 3 to 5 years within a freshwater stream. Macrothalmia migrate from their natal streams and enter the ocean in late spring.

Like Pacific Lamprey, adult and juvenile River Lamprey use this reach of the Sacramento River as a migration corridor only (based on lack of spawning substrate and complex habitats).

White Sturgeon

In California, White Sturgeon are most abundant within the Delta region, but the population spawns mainly in the Sacramento River. Recently, it has been confirmed that White Sturgeon spawn in the San Joaquin River (Jackson et al. 2016), and a small part of the population is also thought to spawn in the Feather River (Moyle 2002). In addition to spawning, White Sturgeon embryo development and larval rearing occur in the Sacramento River (Moyle 2002; Israel et al. 2008). White Sturgeon are found in the Sacramento River primarily downstream from the RBDD site (TCCA 2008), and most spawning occurs between Knights Landing and Colusa (Schaffter 1997).

The population status of White Sturgeon in the Sacramento River is unclear. Overall, limited information on trends in adult and juvenile abundance in the Delta population suggests that numbers are declining (Reis-Santos et al. 2008). Spawning stage adults generally move from estuarine and ocean habitats into the lower reaches of the Sacramento River during winter prior to spawning, then migrate upstream in response to higher flows to spawn from February to early June (Schaffter 1997; McCabe and Tracy 1994). Most spawning in the Sacramento River occurs in April and May (Kohlhorst 1976). YOY White Sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower Sacramento River and Delta (McCabe and Tracy 1994; Israel et al. 2008).

White Sturgeon use the Verona to I Street Bridge of the Sacramento River as an adult migratory pathway to spawning areas upstream, and juveniles returning to the estuary use this reach also as an outmigrant pathway. Sturgeon are not known to be resident in this reach.

Green Sturgeon

The Sacramento River provides habitat for Green Sturgeon spawning, adult holding, foraging, and juvenile rearing. Suitable spawning temperatures and spawning substrate exist for Green Sturgeon in the Sacramento River upstream and downstream from the RBDD (USBR 2008). Although the upstream extent of historical Green Sturgeon spawning in the Sacramento River is unknown, the observed distribution of sturgeon eggs, larvae, and juveniles indicates that spawning occurs from Hamilton City to as far upstream as the Inks Creek confluence and possibly up to the Cow Creek confluence (Brown 2007; Poytress et al. 2013). Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, CDFG (2002) indicated that Green Sturgeon spawn in late spring and early summer. Peak spawning is believed to occur between April and June. Adult Green Sturgeon that migrate upstream in April, May, and June are completely blocked by the Anderson-Cottonwood Irrigation District diversion dam (NMFS 2009b), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible.

Larval Green Sturgeon have been regularly captured during their dispersal stage at about 2 weeks old (24 to 34 millimeters [mm] in fork length) in rotary screw traps at the RBDD (CDFG 2002), and at about 3 weeks old when captured at the GCID intake (Van Eenennaam et al. 2001). Young Green Sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (CDFG 2002). Rearing habitat condition and function may be affected by variation in annual and seasonal river flow and temperature characteristics.

Adult and juvenile Green Sturgeon use the Verona to I Street Bridge of the Sacramento River as a migratory pathway. Green Sturgeon are not known to be resident in this reach.

Central Valley Steelhead

Although steelhead can be divided into two life history types, Summer-run Steelhead and Winter-run Steelhead, based on their state of sexual maturity at the time of river entry, only Winter-run Steelhead are found in Central Valley rivers and streams. Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in other tributaries, and a few naturally spawning steelhead are produced in the American and Feather rivers (McEwan and Jackson 1996).

Adult steelhead migrate upstream past the Fremont Weir between August and March, and primarily from August through October; they migrate upstream past the RBDD during all months of the year, but primarily during September and October (NMFS 2009a). The primary spawning area used by steelhead in the Sacramento River is well upstream of the confluence with the Feather River. Unlike salmon, steelhead may live to spawn more than once and generally rear in freshwater streams for 2 to 4 years before outmigrating to the ocean. Both spawning areas and migratory corridors are used by juvenile steelhead for rearing prior to outmigration. The segment of the Sacramento River between the Delta and the confluence with the Feather River functions primarily as a migration channel. Limited rearing habitat may exist in areas of setback levees, although these areas are primarily located upstream of Colusa (NMFS 2009a).

The Verona to I Street Bridge reach of the Sacramento River serves as a migratory corridor for both adult and outmigrant juvenile steelhead.

Fall-run and Late Fall-run Chinook Salmon

Fall-run Chinook Salmon are an ocean-maturing type of salmon adapted for spawning in lowland reaches of big rivers, including the mainstem Sacramento River. Late Fall-run Chinook Salmon are mostly a stream-maturing type (Moyle 2002). Adult Late Fall-run Chinook Salmon typically hold in the river upstream of the Feather River confluence for 1 to 3 months before spawning, while Fall-run Chinook Salmon generally spawn shortly after entering freshwater. The majority of young Fall-run Chinook Salmon migrate to the ocean during the first few months following emergence, although some may remain in freshwater and migrate as yearlings. Late Fall-run juveniles typically enter the ocean after 7 to 13 months of rearing in freshwater, at 150 to 170 mm in fork length, which is considerably larger and older than Fall-run Chinook Salmon (Moyle 2002).

The primary Sacramento River spawning area used by Fall-run and Late Fall-run Chinook Salmon lies well above the Feather River confluence, with the highest densities for each of the runs in the reach between Keswick Dam and the RBDD.

The Verona to I Street Bridge reach of the Sacramento River serves as a migratory corridor for both adult and outmigrant juvenile Fall-run and Late Fall-run Chinook Salmon.

Winter-run Chinook Salmon

Adult Winter-run Chinook Salmon return to freshwater during winter but delay spawning until spring and summer. Adults enter freshwater in an immature reproductive state, similar to Spring-run Chinook Salmon, but Winter-run Chinook Salmon move upstream through the lower Sacramento River during winter months much more quickly.

The following discussion is included directly from the NMFS Biological Opinion on Long-term Operation of the Central Valley Project and the State Water Project (2019):

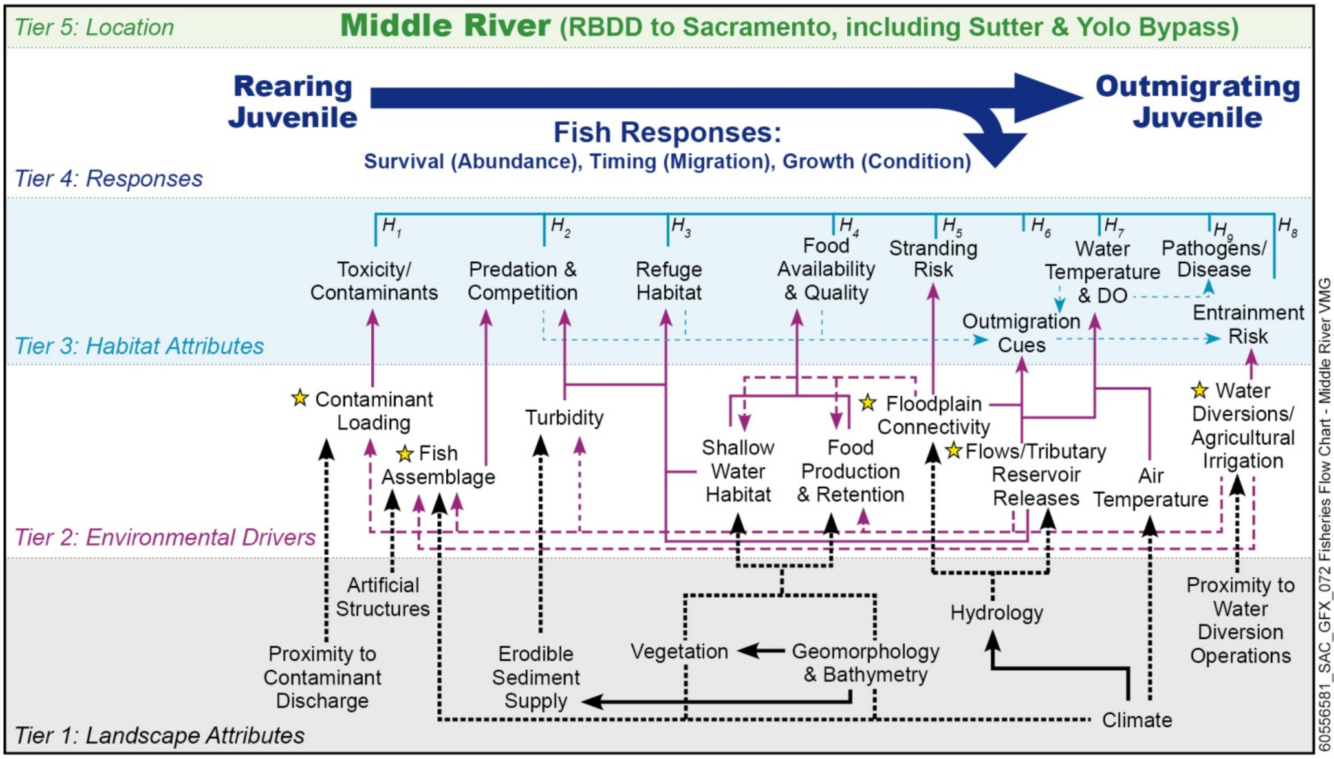
> Historically, Winter-run Chinook Salmon population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s. In recent years, since carcass surveys began in 2001, the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively. From 2007 to 2017, the population has shown a precipitous decline, averaging 2,733 during this period, with a low of 827 adults in 2011.

> This recent declining trend is likely due to a combination of factors such as poor ocean productivity, drought conditions from 2007 to 2009, low in-river survival, and extreme drought conditions in 2012 to 2016. In 2015, the population was 3,015 adults, slightly above the 2007 to 2012 average, but below the high (17,296) for the last 10 years. While 2018 adult returns were also relatively low (2,639) escapement in 2019 appears to have risen above these recent lows, as the most recent preliminary estimates from September of 2019 (~8,000 individuals) are more than double the number of adults reported for 2015. Data from recent years also appear to indicate juvenile production since 2015 has been increasing; passage estimates of unclipped winter-run Chinook salmon juvenile outmigrants based on rotary trap observations at Red Bluff Diversion Dam were over three times higher in 2018 (1,168,270) than in 2015 (338,904), and preliminary data from 2019 had already exceeded the 2018 year total estimates by the end of September.

Holding and spawning activities take place in the Sacramento River well upstream of the Feather River confluence. Spawning occurs in May through July, with the peak in June and July. Fry emergence occurs from mid-June through mid-October, and fry disperse to areas downstream from the spawning grounds for rearing. Outmigration from the upper Sacramento River to the Delta occurs primarily from December through April. Outmigrating Winter-run Chinook Salmon juveniles usually pass Knights Landing, directly upstream of the confluence with the Feather River, once flows at Wilkins Slough rise to about 14,000 cubic feet per second (cfs). Most juvenile Winter-run Chinook Salmon outmigrate past Chipps Island by the end of March (Del Rosario et al. 2013).

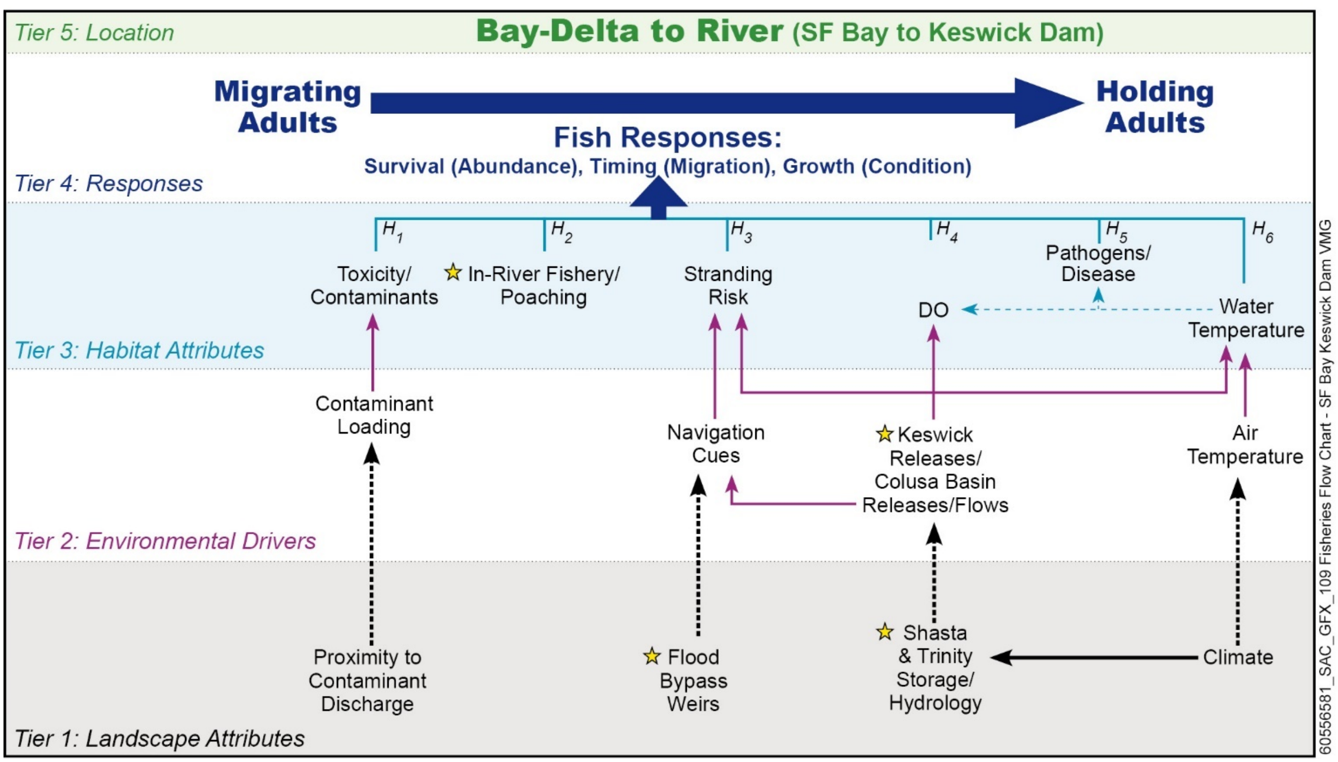
The Verona to I Street Bridge reach of the Sacramento River serves as a migratory corridor for both adult and outmigrant juvenile Winter-run Chinook Salmon.

The California Central Valley Interagency Ecology Program (IEP) formed two synthesis teams known as the Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) with the goal of developing conceptual models for anadromous salmonids and sturgeon that use the Delta and Sacramento River during different stages of their life history. From this effort, Windell et al. (2017) developed a conceptual model for assessing the biotic and abiotic factors that affect juvenile Winter-run Chinook Salmon during rearing and outmigration in the Sacramento River and tidal estuary, as well as adults immigrating from the San Francisco Bay to the upper reaches of the Sacramento River where spawning occurs. The models incorporate these life stages in various reaches of the Sacramento River from the Keswick Dam to the Delta and in the tidal estuary to the San Francisco Bay. Two conceptual models are applicable to the Sacramento River from the Feather River confluence to the Delta. The Rearing to Outmigrating Juveniles in Middle Sacramento River and Adult Migration from Ocean to Upper Sacramento River conceptual models extend beyond the reach of the Sacramento River potentially affected by the Proposed Project, but both models are inclusive of the reach. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting the life stages that could potentially be affected by the Proposed Project are shown in Figure 4.4-1 and Figure 4.4-2.



Source: Adapted from Windell et al. 2017. Note: Hypotheses are referenced by the H-number for habitat attributes, and potential management actions discussed by Windell et al. (2017) are denoted by stars.

Figure 4.4-1. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Rearing Juvenile to Outmigrating Juvenile in the Sacramento River



Source: Adapted from Windell et al. 2017. Note: Hypotheses are referenced by the H-number for habitat attributes, and potential management actions discussed by Windell et al. (2017) are denoted by stars.

Figure 4.4-2. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Migrating Adults from the Ocean to Holding Adults in the Sacramento River

As seen in these conceptual models, a number of landscape attributes, environmental drivers, and habitat attributes are hypothesized to play a role in the migration timing, growth, and survival of Winter-run Chinook Salmon. However, not all of these factors are influenced by SWP facilities or operations.

Spring-run Chinook Salmon

Historically, Spring-run Chinook Salmon in the Sacramento River Basin were found in the upper and middle reaches (1,000 to 6,000 feet in elevation) of the Sacramento River as well as in smaller tributaries of the upper river below Shasta Dam (NMFS 2009a). Naturally spawning populations of Spring-run Chinook Salmon currently are restricted to accessible reaches of the upper Sacramento River, which are outside the project area; however, all Spring-run Chinook Salmon migratory life stages must pass through the lower Sacramento River between the Delta and the Feather River confluence.

Outmigration timing is highly variable, as Spring-run Chinook Salmon may migrate downstream as young-of-the-year (YOY) or as juveniles or yearlings. The outmigration period for Spring-run Chinook Salmon extends from November to early May, with up to 69% of the YOY fish outmigrating through the lower Sacramento River during this period (CDFG 1998). Peak movement of juvenile Spring-run Chinook Salmon in the Sacramento River at Knights Landing, directly upstream of the confluence with the Feather River, occurs in December and in March (Snider and Titus 1998, 2000a, 2000b, 2000c; Vincik et al. 2006; Roberts 2007). Migratory cues, such as increased flows, increasing turbidity from runoff, changes in day length, or intraspecific competition from other fish in their natal streams, may spur outmigration of juveniles from the upper Sacramento River Basin when they have reached the appropriate stage of maturation (NMFS 2009a).

The Verona to I Street Bridge reach of the Sacramento River serves as a migratory corridor for both adult and outmigrant juvenile Spring-run Chinook Salmon.

Sacramento Splittail

Historically, Sacramento Splittail were widespread in the Sacramento River from Redding to the Delta (Rutter 1908, as cited in Moyle et al. 2004). This distribution has become somewhat reduced in recent years (Sommer et al. 1997, 2007b). During drier years there is evidence that spawning occurs farther upstream (Feyrer et al. 2005). Adult splittail migrate upstream in the lower Sacramento River to above the mouth of the Feather River and into the Sutter Bypass and the Yolo Bypass (Sommer et al. 1997; Feyrer et al. 2005; Sommer et al. 2007b).

Nonreproductive adult Sacramento Splittail are most abundant in moderately shallow, brackish areas, but can be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004). Adults typically migrate upstream from brackish areas in January and February and spawn in freshwater on inundated floodplains in March and April (Moyle et al. 2004; Sommer et al. 2007b). In the Sacramento River drainage, the most important spawning areas appear to be the Yolo and Sutter bypasses; however, some spawning occurs almost every year along the river edges and backwaters created by small increases in flow. Splittail spawn in the Sacramento River from Colusa to Knights Landing in most years (Feyrer et al. 2005).

Most juvenile splittail move from upstream areas downstream into the Delta from April through August (Meng and Moyle 1995; Sommer et al. 2007b). The production of YOY Sacramento Splittail is largely influenced by extent and period of inundation of floodplain spawning habitats, with abundance spiking following wet years and declining after dry years (Sommer et al. 1997; Moyle et al. 2004; Feyrer et al. 2006).

The Verona to I Street Bridge reach of the Sacramento River serves as a migratory corridor for Sacramento Splittail to spawning areas upstream. There also may be some local splittail spawning and rearing in this reach of the river, depending on flow conditions.

Hardhead

Hardhead are widely distributed in streams at low to mid-elevations in the Sacramento-San Joaquin and Russian River drainages (Leidy 1984, Moyle 2002). Their range extends from the Pit River (south of the Goose Lake drainage), Modoc County, in the north to the Kern River, Kern County, in the south (Moyle and Daniels 1982). In the Sacramento River drainage, Hardhead are found in most large tributaries as well as in the Sacramento River itself (Moyle 2002). Hardhead are often found at low to mid-elevations in relatively undisturbed habitats of larger streams (Moyle and Daniels 1982, Mayden et al. 1991) with high water quality (clear, cool). In the Sacramento River, however, they are common in both the mainstem and tributaries up to 1500 meters (m) in elevation (Reeves 1964).

Hardhead mature following their second year and spawn in the spring, mainly in April and May (Reeves 1964), judging by the upstream migrations of adults into smaller tributary streams during this time of the year (Moyle 2002).

Hardhead are considered a resident fish in the Verona to I Street Bridge reach of the Sacramento River. Detailed life history and habitat use information for this fish in this reach is not available.

Striped Bass

Striped Bass is anadromous and non-native; adult Striped Bass are distributed mainly in the lower bays and ocean during summer and in the Delta during fall and winter. Spawning takes place in spring from April to mid-June (Leet et al. 2001), at which time Striped Bass swim upstream to spawning grounds. Striped Bass are not believed to spawn or rear in the Sacramento River upstream of the RBDD (TCCA 2008). Most Striped Bass spawning occurs in the lower Sacramento River between Colusa and the confluence of the Sacramento and Feather rivers (Moyle 2002). About one-half to two-thirds of the eggs are spawned in the Sacramento River, and the remainder in the Delta (Leet et al. 2001). After spawning, most adult Striped Bass move downstream into brackish and salt water for summer and fall.

Eggs are free-floating and negatively buoyant. The eggs hatch as they drift downstream, and larvae occur in shallow and open waters of the lower reaches of the Sacramento and San Joaquin rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait.

The Sacramento River between Verona and the I Street Bridge functions primarily as a migration corridor for both adults and drifting eggs and larvae.

Non-Native Freshwater Bass (Largemouth Bass, Smallmouth Bass, and Spotted Bass)

Three species of introduced predatory fish—Largemouth Bass, Smallmouth Bass, and Spotted Bass—are highly regarded from a recreational perspective. All three are found commonly in the Sacramento River between Verona and the I Street Bridge. These fish are all resident in this reach, although they may move widely. Typically, as ambush predators on salmonids and other fishes they used instream structure from which to hunt prey (i.e., boat docks, pilings, rock piles). Their collective predation impact on outmigrant salmonids is unknown.

American Shad

American Shad are native to the Atlantic Coast and are an introduced species to the Pacific Coast. They were first introduced to the Sacramento River in 1871, and they remain abundant in the Sacramento River, its delta, and its major tributaries. American Shad are an important sportfish.

As described in Reclamation (2019), American Shad spend most of their adult life at sea and may make extensive migrations along the coast. American Shad become sexually mature while in the ocean and migrate through the Delta to spawning areas in the Sacramento, Feather, American, and Yuba rivers. Some spawning also takes place in the lower San Joaquin, Mokelumne, and Stanislaus rivers (USFWS 1995). The spawning migration may begin as early as February, but most adults migrate into the Delta in March and early April (Skinner 1962). Migrating adults generally take 2 to 3 months to pass through the Sacramento–San Joaquin Estuary (Painter et al. 1979). Fertilized eggs are slightly negatively buoyant, are not adhesive, and drift in the current. Newly hatched larvae are found downstream from spawning areas and can be rapidly transported downstream by river currents because of their small size. Juvenile shad rear in the Sacramento River below Knights Landing, in the Feather River below Yuba City, and in the Delta; rearing also takes place in the Mokelumne River near the DCC to the San Joaquin River. No rearing occurs in the American and Yuba rivers (Painter et al. 1979). Some juvenile shad may rear in the Delta for up to a year before outmigrating to the ocean (USFWS 1995). Outmigration from the Delta begins in late June and continues through November (Painter et al. 1979).

Seasonally, adult American Shad are an important sport fish in the reach of the Sacramento River between Verona to the I Street Bridge.

Central California Roach

Central California Roach are found in tributaries to the Sacramento and San Joaquin rivers and tributaries to San Francisco Bay. Central California Roach are generally found in small streams and are particularly well adapted to life in intermittent watercourses; dense populations are frequently observed in isolated pools (Fry 1936; Moyle et al. 1982; Leidy 2007). Roach are most abundant in mid-elevation streams in the Sierra Nevada foothills and in lower reaches of some San Francisco Bay streams but they may also be found in the main channels of some rivers, such as the Stanislaus (Roehrig 1988) and Tuolumne (Moyle 2002) rivers. Roach tolerate a relatively wide range of temperatures and dissolved oxygen levels, as evidenced by the fact that they occupy habitats as varied as cold, clear, well-aerated “trout” streams (Moyle et al. 1982; Roscoe 1993) and intermittent streams where they can survive extremely high temperatures (30 to 35˚C) and low dissolved oxygen levels (1 to 2 ppm) (Moyle et al. 1982; Knight 1985; Castleberry et al. 1990).

In the tributary streams to the San Francisco Bay, roach occupy suitable habitats from headwaters to the mouth but are intolerant of saline waters (Moyle 2002). They have been recorded in salinities up to 3 ppt, but perish before salinities reach 9 to 10 ppt (Moyle unpublished data). In headwater reaches of San Francisco Bay tributaries, Central California Roach typically co-occur with Rainbow Trout (*Oncorhynchus mykiss*), juvenile Sacramento Sucker (*Catostomus occidentalis*), and Prickly or Riffle Sculpin (*Cottus asper* and *gulosis*, respectively) (Leidy 2007). In small, warm, intermittent estuary streams, roach are most often found with juvenile Sacramento Suckers and are occasionally found with Green Sunfish (*Lepomis cyanellus*) (Leidy 2007). In lower mainstem stream channels, roach occur as part of a predominately native fish assemblage that, depending on location, is characterized by combinations of Pacific Lamprey, Sacramento Pikeminnow, Hardhead, Sacramento Sucker, Riffle Sculpin, Prickly Sculpin, and Tule Perch (*Hysterocarpus traskii*) (Leidy 2007). Central California Roach cannot coexist with large populations of alien fishes, especially centrarchids such as Green Sunfish and black basses (*Micropterus* spp.). Central California Roach may reside in the lower Sacramento River between the Delta and the confluence with the Feather River year-round and spawn in the reach during the months of March through June, when water temperatures become suitable.

4.4.1.3 Lower Sacramento River Aquatic Habitat

The Sacramento River between the confluence with the Feather River and the Sacramento River to where the Sacramento River enters the legal Delta (i.e., Verona [RM 79.8] to the I Street Bridge [RM 59.4]) encompasses 20.4 miles of main river channel with a wide range of aquatic habitat characteristics. Some physical parameters of habitat for this river reach (for example, discharge, water temperature, and water quality) have been monitored for long periods of time. Other parameters, such as substrate, instream structure, and overhead shaded riparian canopy, which are also important to fish, have not been well characterized.

A close view of this 20.4 mile river reach using Google Earth Pro reveals substantial geomorphic changes to the river channel from its native state. At the present time, this segment of the river is a single-thread, narrowly confined, leveed channel that has been almost completed hardened with large rock revetment, which eliminates channel erosion and the channel meandering that once occurred. The levees at the channel margin have blocked the river’s access to historical wetlands and seasonally inundated floodplains. The levees and revetment have resulted in simplified habitat for focus fish species in the Verona to I Street Bridge reach. Figure 4.4-3 shows a typical view of the river channel to the north of the Interstate 5 Bridge. A narrow zone of riparian and upland vegetation is typically found on the river-side of the levees. Agriculture is the primary land use along the river until the cities of Sacramento and West Sacramento are reached, where the urban landscape prevails (Figure 4.4-4). Figure 4.4-4 shows that on the Sacramento County side of the river, urbanization in the form of private residences has occurred along significant distances of the river reach. This urbanization has resulted in the addition of more than 170 private boat docks, with their supporting facilities, to the aquatic environment.

Source: Adapted from Google Earth 2019.

Figure 4.4-3. Sacramento River Upstream of the Interstate 5 Bridge, near Woodland, California

Source: Adapted from Google Earth 2019.

Figure 4.4-4. Lower Sacramento River in the Vicinity of Sacramento and West Sacramento

Also added to the riverscape in this reach are marinas, boat launching ramps, an unknown number of water diversion facilities, irrigation and flood control return flow facilities, bridges, wing-dikes, sunken boats and other structures, and numerous instream structures of unknown current purpose. This list does not include numerous upstream facilities that influence the environmental conditions faced by fish in this river reach.

Also of importance is the fact that tidal influence extends up the Sacramento to Verona, with greater tidal variations occurring downstream during low river stages.

Geomorphology

Downstream from the Feather River confluence (RM 0-80), the river is mildly sinuous (average sinuosity about 1.3), and the channel is confined on both sides by natural levees enhanced by decades of man-made improvements. The channel in this reach is of uniform width and does not migrate. The channel is typically narrower and deeper than in upstream reaches. The present-day channel is flanked by fine-grained cohesive banks with erosion due to both mass failures and fluvial erosion (e.g., wave-wash).

The frequency of bank revetment along the Sacramento River is high; 75% armored from RM 20 to RM 80 (Stillwater Sciences 2012).

Riparian Community

The Sacramento River was historically bordered by extensive riparian habitat. Prior to the construction and operation of reservoirs, winter rainfall events caused extensive flooding and spring snowmelt that watered and fertilized the riparian corridor, enabling up to 500,000 acres of riparian forest to grow along the river (Katibah 1984). Riparian recruitment models and establishment models (Mahoney and Rood 1998; Bradley and Smith 1986) as well as empirical field studies (Scott et al. 1997) emphasize that hydrologic and fluvial processes play a central role in controlling the elevational and lateral extent of riparian plant species. These processes are important for pioneer species, such as cottonwood and willows, that establish at elevations close to the active river channel. Within the reach of the Sacramento River potentially affected by the Proposed Project (from the confluence with the Feather River to the I Street Bridge), it is believed that riparian forests, including valley oak woodlands, occurred on the natural levees on both sides of the river. This band of riparian habitat was once connected to the riparian vegetation growing along the Sacramento River’s many tributaries and sloughs without being interrupted by today’s levees.

Today, much of the total runoff is captured and stored in reservoirs for gradual release during the summer and fall months, contributing to a reduction in riparian forest. From RM 20 to RM 80 (which includes the reach of the Sacramento River potentially affected by the Proposed Project, Verona to the I Street Bridge), 16% (as a percentage of the shoreline length) of the instream woody debris (IWD) remains under existing physical bank conditions (Stillwater Sciences 2012), while 77% (as a percentage of the shoreline length) of the ground cover vegetation remains and only 21% (as a percentage of the shoreline length) of the overhead shade remains (Stillwater Sciences 2012).

Spawning Habitat

Because anadromous salmonids generally have the most restrictive habitat requirements of the species listed in Table 4.4-1, habitat for each life stage of anadromous salmonids in the Sacramento River is described, below.

The segment of the Sacramento River between the confluence with the Feather River and the Delta does not provide spawning opportunities for anadromous salmonids due principally to the lack of suitable water temperature and coarse gravel used by salmonids to construct redds (Reclamation 2019). The spawning distributions of Spring-run, Fall-run, and Late Fall-run Chinook Salmon populations are primarily upstream of the RBDD. The spawning distribution of steelhead in the 20.4-mile segment of the Sacramento River is poorly understood. However, steelhead spawning likely occurs in reaches of the river well upstream of the subject segment due to the similarity of physical and water quality requirements shared by steelhead and Chinook Salmon.

Fish Passage and Entrainment

Numerous water diversion facilities are located along the Sacramento River. Herren and Kawasaki (2001) documented up to 431 diversions from the Sacramento River between Shasta Dam and the City of Sacramento as of April 1997. The exact number of agricultural diversions along the Sacramento River between Verona and the I Street Bridge is unknown, but they are believed to be numerous and of various types, capacities, and timings of use. Most are unscreened. The two largest diversions to the Natomas Basin operated by the Natomas Central Mutual Water Company (Sankey and Pritchard Lake) have been screened in recent years to reduce juvenile salmonid entrainment. A third diversion to the Natomas Basin (Elkhorn) is not yet screened but plans for screening this facility are pending (Davis, Natomas Central Mutual Water Company, *pers. Comm*., 2019).

There are no fish passage issues in the Sacramento River reach from Verona to the I Street Bridge.

Predation

On the mainstem Sacramento River, high rates of predation have been known to occur at the diversion facilities and areas where rock revetment has replaced natural river bank vegetation (NMFS 2009a). Chinook Salmon fry, juveniles, and smolts are more susceptible to predation at these locations because Sacramento Pikeminnow (*Ptychocheilus grandis*) and Striped Bass congregate in areas that provide predator refuge (Williams 2006; Tucker et al. 2003).

4.4.1.4 Bay-Delta

Ecologically, the Delta consists of three major landscapes and geographic regions: (1) the North Delta freshwater flood basins, which are composed primarily of freshwater inflow from the Sacramento River system; (2) the South Delta distributary channels, which are composed of predominantly San Joaquin River system inflow; and (3) the Central Delta tidal islands landscape, wherein the Sacramento, San Joaquin, and east side tributary flows converge and tidal influences from San Francisco Bay are greater.

Fish in the Delta

The Delta provides unique and, in some places, highly productive habitats for a variety of fish species, including euryhaline and oligohaline resident species and anadromous species. Adult anadromous fish use the Delta during upstream migration, and rearing juvenile anadromous fish use the Delta for feeding and growing as they migrate downstream to the ocean. Conditions in the Delta influence the abundance and productivity of all fish populations that use the system. Fish communities currently in the Delta are dominated by non-native species, but include a mix of native species, some with low abundance, and a variety of introduced fish, some with high abundance (Matern et al. 2002; Feyrer and Healey 2003; Nobriga et al. 2005; Brown and May 2006; Moyle and Bennett 2008; Grimaldo et al. 2012).

IEP has been monitoring fish populations in the Delta and San Francisco Estuary for decades. Survey methods have included beach seining, midwater trawls, Kodiak trawls, otter trawls, and other methods (Honey et al. 2004) to sample the fish assemblage throughout the estuary. Three of the most prominent resident pelagic fishes captured in the surveys (Delta Smelt, Longfin Smelt, and Striped Bass) have shown substantial long-term population declines (Kimmerer et al. 2000; Bennett 2005; Rosenfield and Baxter 2007). Reductions in pelagic fish abundance since 2002 have been recognized as a serious water and fish management issue and have become known as the Pelagic Organism Decline (POD) (Sommer et al. 2007a).

In response to the POD, IEP formed a study team in 2005 to evaluate the potential causes of the decline. Since completion of the first set of studies in late 2005, alternative models have been developed based on available data and the professional judgment of the POD-Modeling Team regarding the extent to which individual drivers are likely to affect each species and life stage. The nine drivers identified (Baxter et al. 2010) were: (1) mismatch of larvae and food; (2) reduced habitat space; (3) adverse water movement/transport; (4) entrainment; (5) toxic effects on fish; (6) toxic effects on fish food items; (7) harmful cyanobacteria *Microcystis aeruginosa* blooms; (8) non-native overbite clam (*Potamocorbula amurensis*) effects on food availability; and (9) disease and parasites.

The focal fish species that occur in the Delta are taken from Table 4.4-1 and include:

- Pacific Lamprey
- River Lamprey
- White Sturgeon
- Green Sturgeon
- Central Valley Steelhead
- Fall-run and Late Fall-run Chinook Salmon
- Winter-run Chinook Salmon
- Spring-run Chinook Salmon
- Longfin Smelt
- Delta Smelt
- Sacramento Splittail
- Hardhead

- Central Valley Roach
- Striped Bass
- Non-native freshwater bass (Largemouth Bass, Smallmouth Bass, and Spotted Bass)
- American Shad

Pacific Lamprey

The Pacific Lamprey is a widely distributed species that uses the Delta for upstream migration as adults, for downstream migration as juveniles, and for rearing as ammocoetes (Hanni et al. 2006; Moyle et al. 2009). Pacific Lampreys are present in the north, central, and south Delta, and ammocoetes are present year-round in all of the regions (DWR et al. 2013). Limited information on the status of Pacific Lamprey in the Delta exists, but the number of Pacific Lamprey inhabiting the Delta is likely greatly suppressed compared with historical levels, as suggested by the loss of access to historical habitat and apparent population declines throughout California and the Sacramento–San Joaquin River Basin (Moyle et al. 2009).

Limited data indicate most adult Pacific Lamprey migrate though the Delta enroute to upstream holding and spawning grounds in the early spring through early summer (Hanni et al. 2006). As documented in other large river systems, it is likely that some adult migration through the Delta occurs from late fall and winter through summer and possibly over an even broader period (Robinson and Bayer 2005; Hanni et al. 2006; Moyle et al. 2009; Clemens et al. 2012; Lampman 2011). Data from the Fall Midwater Trawl (FMWT) Survey in the lower Sacramento and San Joaquin rivers and Suisun Bay suggest that peak outmigration of Pacific Lamprey through the Delta coincides with high-flow events from fall through spring (Hanni et al. 2006). Some outmigration likely occurs year-round, as observed at sites farther upstream (Hanni et al. 2006) and in other river systems (Moyle 2002). Some Pacific Lamprey ammocoetes likely spend part of their extended (5 to 7 years) freshwater residence rearing in the Delta, particularly in the upstream freshwater portions (DWR et al. 2013).

River Lamprey

Western River Lamprey occur in coastal streams from just north of Juneau, Alaska, south to San Francisco Bay. In California, they have been recorded in the Sacramento and San Joaquin Delta while migrating, in tributaries to the San Francisco Estuary (Napa River, Sonoma Creek, Alameda Creek), and in tributaries to the Sacramento and San Joaquin rivers (e.g., Tuolumne River, Stanislaus River, Cache Creek).

Western River Lamprey population trends are unknown in California, but it is likely that they have declined, concomitant with degradation and fragmentation of suitable spawning and rearing habitat in rivers and tributaries throughout their range in the state, along with declines in prey species (e.g., Chinook and Coho Salmon, steelhead, etc.). There are relatively few records from California, which makes up the southern end of their range.

Western River Lamprey has not been studied in California (Moyle 2002); therefore, the information in this account is based on studies in British Columbia (Roos et al.1973, Beamish and Williams 1976, Beamish 1980, Beamish and Youson 1987).

During the summer months, larval River Lamprey (ammocoetes) begin the transformation into adults when they are about 12 centimeters in total length (cm TL). Metamorphosis may take 9 to 10 months, the longest time known for any lamprey (Moyle et al. 2015). Newly metamorphosed lampreys may aggregate immediately upriver from salt water and enter the ocean in late spring. Adults apparently only spend 3 to 4 months in salt water where they grow rapidly, reaching 25 to 31 cm TL.

River Lampreys prey on fishes in the size range of 10 to 30 cm TL; the most common prey appear to be herring and salmon. Unlike other species of lamprey in California, River Lamprey typically attach to the back of the host fish, above the lateral line, where they feed on muscle tissue. Feeding continues even after death of the prey. River Lamprey predation may negatively affect prey populations if both prey and predator are concentrated in small areas (Beamish and Neville 1995). River Lamprey can apparently feed in either salt water or freshwater.

Adults migrate back into freshwater in the fall and spawn from April through July in small tributary streams (Vladykov and Follett 1958; Moyle 2002) at a water temperature of 15ºC (Hart 1973). Spawning occurs mostly in gravel and rocks (Scott and Crossman 1973; Hart 1973; Moyle 2002) and occasionally sand. Adults create saucer-shaped depressions in gravelly riffles for spawning by moving rocks with their mouths. Fecundity estimates for two females from Cache Creek, Yolo County, were 37,300 eggs from one female of 17.5 cm TL and 11,400 eggs for one female of 23 cm TL (Vladykov and Follett 1958). It is assumed that adults die after spawning, although this life history attribute has not been carefully documented in California. Ammocoetes remain in silt-sand backwaters and eddies, and they feed on algae and microorganisms. River Lamprey spend an unknown amount of time as ammocoetes (probably 3 to 5 years), so their total life span is likely 6 to 7 years.

Adult River Lamprey pass through the Delta on their migration upstream to spawn, and in the free-swimming or benthic macrophthalmia stage, they pass through the Delta during their outmigration to the Pacific Ocean.

White Sturgeon

White Sturgeon are late-maturing and infrequent spawners, which makes them vulnerable to overexploitation and other sources of adult mortality. White Sturgeon are believed to be most abundant within the Bay-Delta region (Moyle 2002). Both nonspawning adults and juveniles can be found throughout the Delta year-round (Radtke 1966; Kohlhorst et al. 1991; Moyle 2002; DWR et al. 2013). When not undergoing spawning or ocean migrations, adults and subadults are usually most abundant in brackish portions of the Bay-Delta (Kohlhorst et al. 1991). The population status of White Sturgeon in the Delta is unclear, but it is not presently listed. Overall, information on trends in adults and juveniles suggests that numbers are declining (Moyle 2002; NMFS 2009a).

The Delta population of White Sturgeon spawns mainly in the Sacramento and Feather rivers, with occasional spawning in the San Joaquin River (Moyle 2002; Jackson 2013). Spawning-stage adults generally move into the lower reaches of rivers during winter prior to spawning and migrate upstream in response to higher flows to spawn from February to early June (McCabe and Tracy 1994; Schaffter 1997).

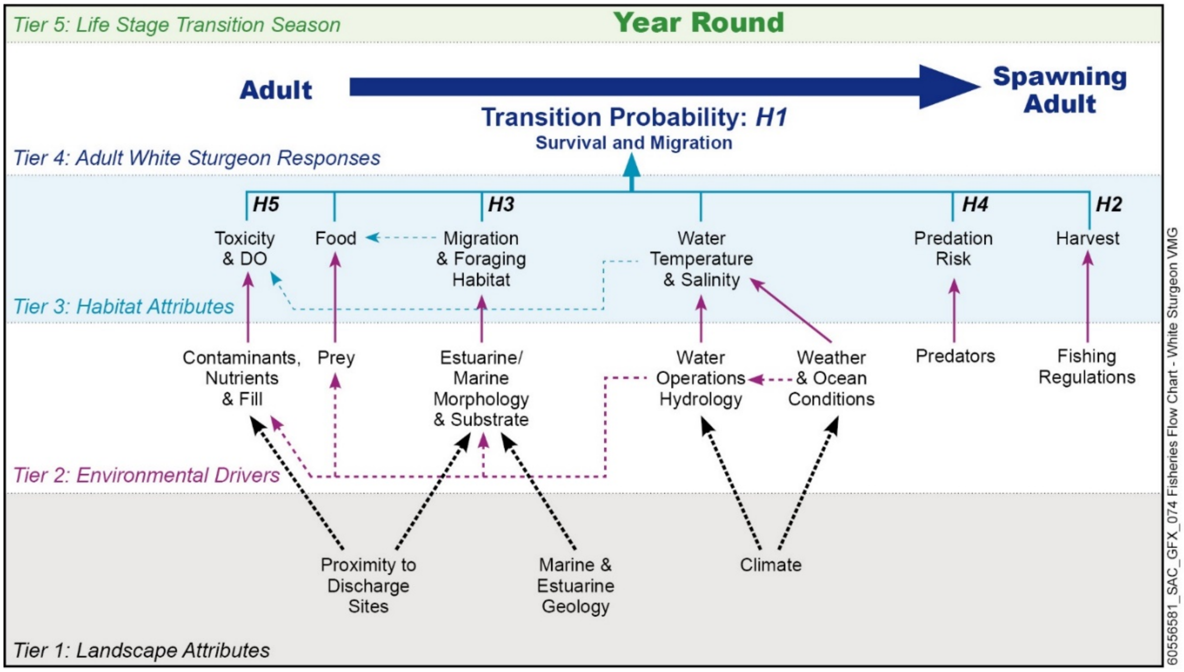
After absorbing yolk sacs and initiating feeding, YOY White Sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower rivers and the Delta (McCabe and Tracy 1994). White Sturgeon larvae have been observed to be flushed farther downstream in the Delta and Suisun Bay in high outflow years but are restricted to more interior locations in low outflow years (Stevens and Miller 1970).

Salinity tolerance increases with increasing age and size (McEnroe and Cech 1985), allowing White Sturgeon to access a broader range of habitat in the San Francisco Estuary (Israel et al. 2008). During dry years, White Sturgeon have been observed following brackish waters farther upstream, while the opposite occurs in wet years (Kohlhorst et al. 1991). Adult White Sturgeon tend to concentrate in deeper areas and tidal channels with soft bottoms, especially during low tides, and typically move into intertidal or shallow subtidal areas to feed during high tides (Moyle 2002). These shallow water habitats provide opportunities for feeding on benthic organisms and small fishes (Israel et al. 2008; Kogut 2008). White Sturgeon also have been found in tidal habitats of medium-sized tributary streams to the San Francisco Estuary, such as Coyote Creek and Guadalupe River in the South Bay and the Napa and Petaluma rivers and Sonoma Creek in the North Bay (Leidy 2007).

Numerous factors similar to those for Green Sturgeon likely affect the White Sturgeon population in the Delta. Survival during early life history stages may be adversely affected by insufficient flows, lack of rearing habitat, predation, warm water temperatures, decreased dissolved oxygen, chemical toxicants in the water, and entrainment at diversions (Cech et al. 1984; Israel et al. 2008). Historical habitats, including shallow intertidal feeding habitats, have been lost in the Delta because of channelization. Overexploitation by recreational fishing and poaching also likely has been an important factor adversely affecting the numbers of adult Sturgeon (Moyle 2002), although new regulations were implemented in 2007 by CDFW to reduce harvesting. Substantial passage problems, such as the Fremont Weir (Sommer et al. 2014), exist in the migratory routes for White Sturgeon, although modifications have recently been made to this structure and additional ones will be implemented in the near future.

IEP formed two synthesis teams, known as SAIL, with the goal of developing conceptual models for anadromous salmonids and sturgeon that use the Delta and Sacramento River for during different stages of their life history. From this effort, Heublein et al. (2017) developed a set of conceptual submodels for assessing the biotic and abiotic factors that affect White Sturgeon during five life-stage transitions, including eggs to larvae, larvae to juvenile, juvenile to adult, adult to spawning adult, and spawning adult to egg or post-spawn adult. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting adult White Sturgeon are shown in Figure 4.4-5.

Adult and juvenile White Sturgeon use the Delta as a migration corridor and are known to reside in the Delta for extended periods of time (Heublein et al. 2017).



Source: Adapted from Heublein et al. 2017a.

Figure 4.4-5. Conceptual Submodel for Adult White Sturgeon Transitioning from Adult to Spawning Adult

Green Sturgeon reach maturity around 14 to 16 years of age and can live to be 70 years old; they return to their natal rivers every 3 to 5 years for spawning (Van Eenennaam et al. 2005). Adult Green Sturgeon move through the Delta from February through April, arriving at holding and spawning locations along 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 before moving back downstream in the fall (Vogel 2008; Heublein et al. 2009), or they may migrate immediately back downstream through the Delta. Radio-tagged adult Green Sturgeon have been tracked moving downstream past Knights Landing during summer and fall, typically in association with pulses of flow in the river (Heublein et al. 2009); such behavior is similar to that exhibited by adult Green Sturgeon on the Rogue River and Klamath River systems (Erickson et al. 2002; Benson et al. 2007).

Green Sturgeon

Similar to other estuaries along the west coast of North America, adult and subadult Green Sturgeon frequently congregate in the San Francisco Estuary during summer and fall (Lindley et al. 2008). Specifically, adults and subadults may reside for extended periods in the Central Delta as well as in Suisun and San Pablo bays, presumably for feeding, because bays and estuaries are preferred feeding habitat rich in benthic invertebrates (e.g., amphipods, bivalves, and insect larvae). Sturgeon are at risk of harmful accumulations of toxic pollutants in their tissues, especially pesticides such as pyrethroids and heavy metals such as selenium and mercury, in part because of their bottom-oriented feeding habits (Israel and Klimley 2008; Stewart et al. 2004).

Juvenile Green Sturgeon and White Sturgeon are periodically (although rarely) collected from the lower San Joaquin River at south Delta water diversion facilities and other sites (NMFS 2009a; Aasen

2011, 2012). Green Sturgeon are salvaged from the south Delta project diversion facilities and are generally juveniles greater than 10 months but less than 3 years old (USBR 2008). NMFS (2005b) suggested that the high percentage of San Joaquin River flows contributing to the Tracy Fish Collection Facility (TFCF) could mean that some entrained Green Sturgeon originated in the San Joaquin River Basin. Jackson (2013) reported spawning by White Sturgeon in the San Joaquin River, and anglers have reported catching a few Green Sturgeon in recent years in the San Joaquin River (CDFG 2012).

After hatching, larvae and juveniles migrate downstream toward the Delta in the late fall or early winter, usually with a flow increase from a rain event. Juveniles are believed to use the Delta for rearing for the first 1 to 3 years of their lives before moving out to the ocean and are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, especially within the Central Delta and Suisun Marsh and Bay. Project operations at the DCC have the potential to reroute Green Sturgeon as they outmigrate through the lower Sacramento River to the Delta (Israel and Klimley 2008; Vogel 2011). When the DCC is open, there is no passage delay for adults, but juveniles could be diverted from the Sacramento River into the interior Delta. This has been shown to reduce the survival of juvenile Chinook Salmon (Brandes and McLain 2001; Newman and Brandes 2010; Perry et al. 2012), but it is unknown whether it has similar effects on Green Sturgeon.

IEP formed two synthesis teams, known as SAIL, to develop conceptual models as part of the SAIL synthesis for anadromous salmonids and sturgeon that use the Delta and Sacramento River during different stages of their life history. From this effort, Heublein et al. (2017) developed a set of conceptual submodels for assessing the biotic and abiotic factors that affect Green Sturgeon during five transitional life stages:

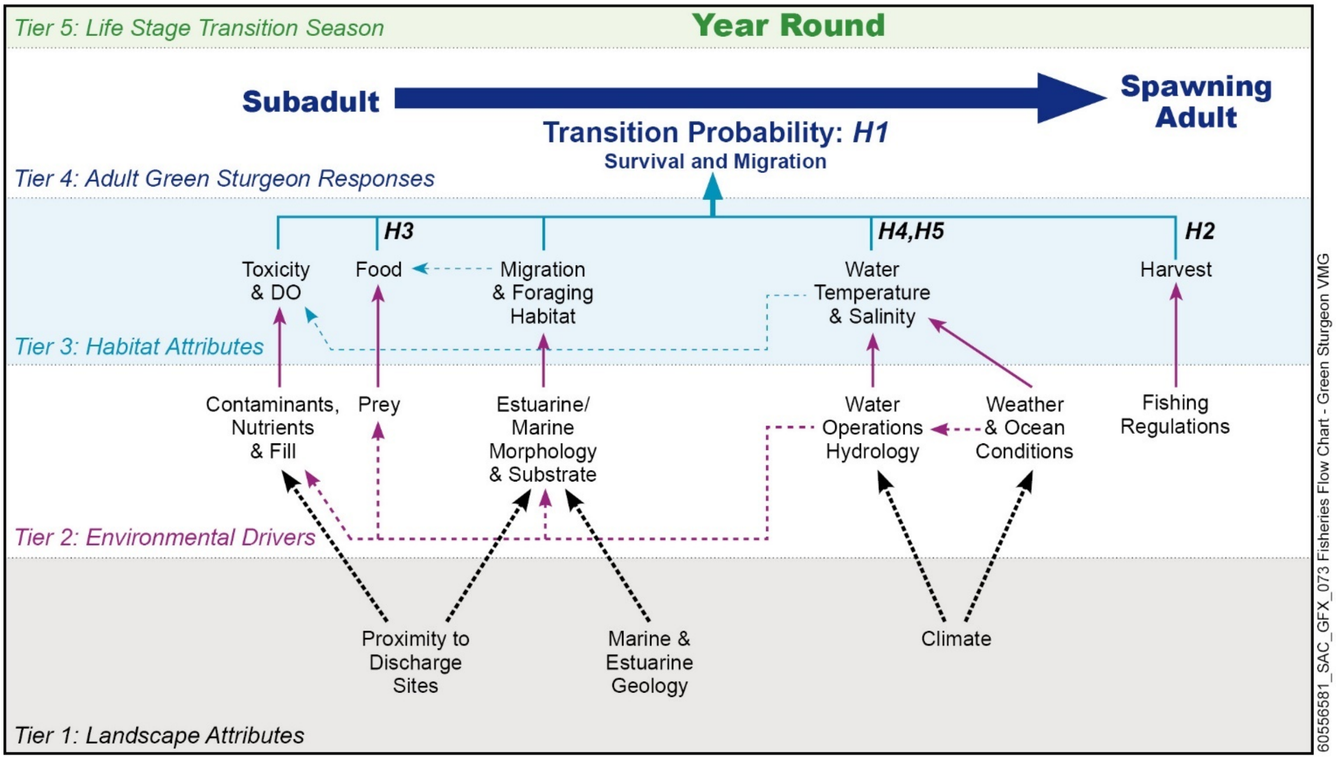
- Egg to larvae
- Larvae to juvenile
- Juvenile to subadult
- Subadult to spawning adult
- Spawning adult to egg or post-spawn adult

The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting the species during the transition from subadult to spawning adult are shown in Figure 4.4-6.

Adult and juvenile Green Sturgeon use the Delta as a migration corridor and are known to reside in the Delta for extended periods of time (Heublein et al. 2017).

Central Valley Steelhead

Upstream migration of steelhead begins with estuarine entry from the ocean as early as July and continues through February or March in most years (McEwan and Jackson 1996; NMFS 2009a). Steelhead populations occur primarily within the watersheds of the Sacramento River Basin, although not exclusively. Steelhead can spawn more than once, with postspawn adults (typically females) potentially moving back downstream through the Delta after completion of spawning in their natal streams.



Source: Adapted from Heublein et al. 2017b.

Figure 4.4-6. Conceptual Submodel for Green Sturgeon Transitioning from Subadults to Spawning Adults

Upstream migrating adult steelhead enter the Sacramento River and San Joaquin River basins through their respective mainstem river channels. Steelhead entering the Mokelumne River system (including Dry Creek and the Cosumnes River) and the Calaveras River system to spawn are likely to move up the mainstem San Joaquin River channel before branching off into the channels of their natal rivers, although some may detour through the South Delta waterways and enter the San Joaquin River through the HOR.

Steelhead entering the San Joaquin River Basin appear to have a later spawning run, with adults entering the system starting in late October through December, indicating that migration up through the Delta may begin a few weeks earlier. During fall, warm water temperatures and low dissolved oxygen concentrations in the south Delta waterways have been suggested as potential barriers to upstream migration (NMFS 2009a). Reduced water temperatures as well as rainfall runoff and flood control release flows provide the stimulus to adult steelhead holding in the Delta to move upriver toward their spawning reaches in the San Joaquin River tributaries. Adult steelhead may continue entering the San Joaquin River Basin through winter.

Juvenile steelhead can be found in all waterways of the Delta, but particularly in the main channels leading from their natal river systems (NMFS 2009a). Juvenile steelhead are recovered in USFWS trawls from October through July at Chipps Island and at Mossdale. Chipps Island catch data indicate there is a difference in the outmigration timing between wild and hatchery-reared steelhead smolts from the Sacramento and eastside tributaries. Hatchery fish are typically recovered at Chipps Island from January through March, with a peak in February and March corresponding to the schedule of hatchery releases of steelhead smolts from the Central Valley hatcheries (Nobriga and Cadrett 2001; USBR

2008). The timing of wild (unmarked) steelhead outmigration is more spread out. Based on salvage records at the CVP and SWP fish collection facilities, outmigration occurs over approximately 6 months, with the highest levels of recovery in February through June (Aasen 2011, 2012). Steelhead are salvaged annually at the project export facilities (e.g., 4,631 fish were salvaged in 2010, and 1,648 in 2011) (Aasen 2011, 2012).

Outmigrating steelhead smolts enter the Delta primarily from the Sacramento or San Joaquin rivers. Mokelumne River steelhead smolts can either follow the north or south branches of the Mokelumne River through the Central Delta before entering the San Joaquin River, although some fish may enter farther upstream if they diverge from the south branch of the Mokelumne River into Little Potato Slough. Calaveras River steelhead smolts enter the San Joaquin River downstream from the Port of Stockton. Although steelhead have been routinely documented by CDFW in trawls at Mossdale since 1988 (SJRGA 2011), it is unknown whether successful outmigration occurs outside the seasonal installation of the barrier at the HOR (between April 15 and May 15 in most years). Prior to the installation of the HORB, steelhead smolts exiting the San Joaquin River Basin could follow one of two routes to the ocean, either staying in the mainstem San Joaquin River through the Central Delta or entering the HOR and migrating through the South Delta and its associated network of channels and waterways.

Data from 2011 and 2012 show probability of survival levels for juvenile steelhead migrating from the San Joaquin River to be 0.32 to 0.54, which is higher than probability of survival levels for Fall-run Chinook Salmon (SST 2017). Similarly, probability of survival levels for steelhead migrating from the Sacramento River in 2009 and 2010 was 0.47 and 0.58, respectively (SST 2017a).

Adult and juvenile steelhead use the Delta as a migration corridor, and adults may hold for some period of time in the Delta before migrating upstream to spawn.

Fall-run and Late Fall-run Chinook Salmon

Central Valley Fall-run and Late Fall-run Chinook Salmon pass through the Delta as adults migrating upstream and juveniles outmigrating downstream. Adult Fall-run and Late Fall-run Chinook Salmon migrating through the Delta must navigate the many channels, avoid direct sources of mortality, and minimize exposure to sources of nonlethal stress. In addition, outmigrating juveniles are subject to predation and entrainment in the project export facilities and smaller diversions.

Adult Fall-run Chinook Salmon migrate through the Delta and into Central Valley rivers from June through December. Adult Late Fall-run Chinook Salmon migrate through the Delta and into the Sacramento River from October through April. Adult Central Valley Fall-run and Late Fall-run Chinook Salmon migrating into the Sacramento River and its tributaries primarily use the western and northern portions of the Delta, whereas adults entering the San Joaquin River system to spawn use the western, central, and southern portions of the Delta as a migration pathway.

Most Fall-run Chinook Salmon fry rear in freshwater from December through June, with outmigration as smolts occurring primarily from January through June. In general, Fall-run Chinook Salmon fry abundance in the Delta increases following high winter flows. Smolts that arrive in the estuary after rearing upstream migrate quickly through the Delta and Suisun and San Pablo bays. A small number of juvenile Fall-run Chinook Salmon spend more than a year in freshwater and outmigrate as yearling smolts the following November through April. Late Fall-run fry rear in freshwater from April through the following April and outmigrate as smolts from October through February (Snider and Titus 2000a). Juvenile Chinook Salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay (MacFarlane and Norton 2002).

Results of mark-recapture studies conducted using juvenile Chinook Salmon released into both the Sacramento and San Joaquin rivers have shown high mortality during passage downstream through the rivers and Delta (Brandes and McLain 2001; Newman and Rice 2002; Buchanan et al. 2013; Buchanan et al. 2018). Juvenile salmon migrating from the San Joaquin River generally experience greater mortality than fish outmigrating from the Sacramento River. In years when spring flows are reduced and water temperatures are increased, mortality is typically higher in both rivers. Closing the DCC gates and installing the HORB to reduce the movement of juvenile salmon into the South Delta from the Sacramento and San Joaquin rivers, respectively, may contribute to improved survival of outmigrating juvenile Chinook Salmon from these watersheds.

Although not directly comparable to these previous CWT studies in the San Joaquin River, Buchanan et al. (2013) found that survival of acoustically tagged hatchery-origin (Feather River) juvenile Chinook Salmon was either not statistically different between routes (2009) or was higher through the South Delta via the Old River route than via the San Joaquin River (2010). In addition, most fish in the Old River that survived passage through the Delta had been salvaged from the federal water export facility on the Old River and trucked around the remainder of the Delta (Buchanan et al. 2013; SJRGA 2013). Buchanan et al. (2013) indicated that the differences in their results compared to past CWT studies may reflect that an alternative non-physical barrier was being used during their investigation to examine its ability to keep fish out of the Old River instead of the HORB, which is a physical barrier that reduces not only the number of fish but also the majority of flows from entering the Old River. Nonphysical barriers may deprive smolts routed to the San Joaquin River of the increased flows needed for improved survival and may have created habitat for increased predation at the site (Buchanan et al. 2013). A review of annual survival estimates for juvenile salmon migrating through the Delta from 2010 through 2015 reveals generally low probability of survival levels ranging from 0 to 0.05, even in the relatively high flow year of 2011 (Buchanan 2018).

Juvenile Fall-run and Late Fall-run Chinook Salmon migrating through the Delta toward the Pacific Ocean use the Delta, Suisun Marsh and Bay, and the Yolo Bypass for rearing to varying degrees, depending on their life stage (fry versus juvenile), size, river flows, and time of year. Movement of juvenile Chinook Salmon in the estuarine environment is driven by the interaction between tidally influenced salt water intrusion through San Francisco Bay and freshwater outflow from the Sacramento and San Joaquin rivers (Healey 1991). A modeling investigation conducted by Perry et al. (2018) on the interacting effects of river flows and tides on salmon travel time, routing, and survival found that travel time through the Delta was inversely related to river volume inflow and that the probability of juveniles entering the interior Delta declined as inflow increased, suggesting enhancements to overall through-Delta survival.

In the Delta, tidal and floodplain habitat areas provide important rearing habitat for foraging juvenile salmonids, including Fall-run Chinook Salmon. Studies have shown that juvenile salmon may spend 2 to 3 months rearing in these habitat areas, and losses resulting from land reclamation and levee construction are considered to be major stressors (Williams 2010). The channeled, leveed, and riprapped river reaches and sloughs common in the Delta typically have low habitat diversity and complexity, have low abundance of food organisms, and offer little protection from predation by fish and birds.

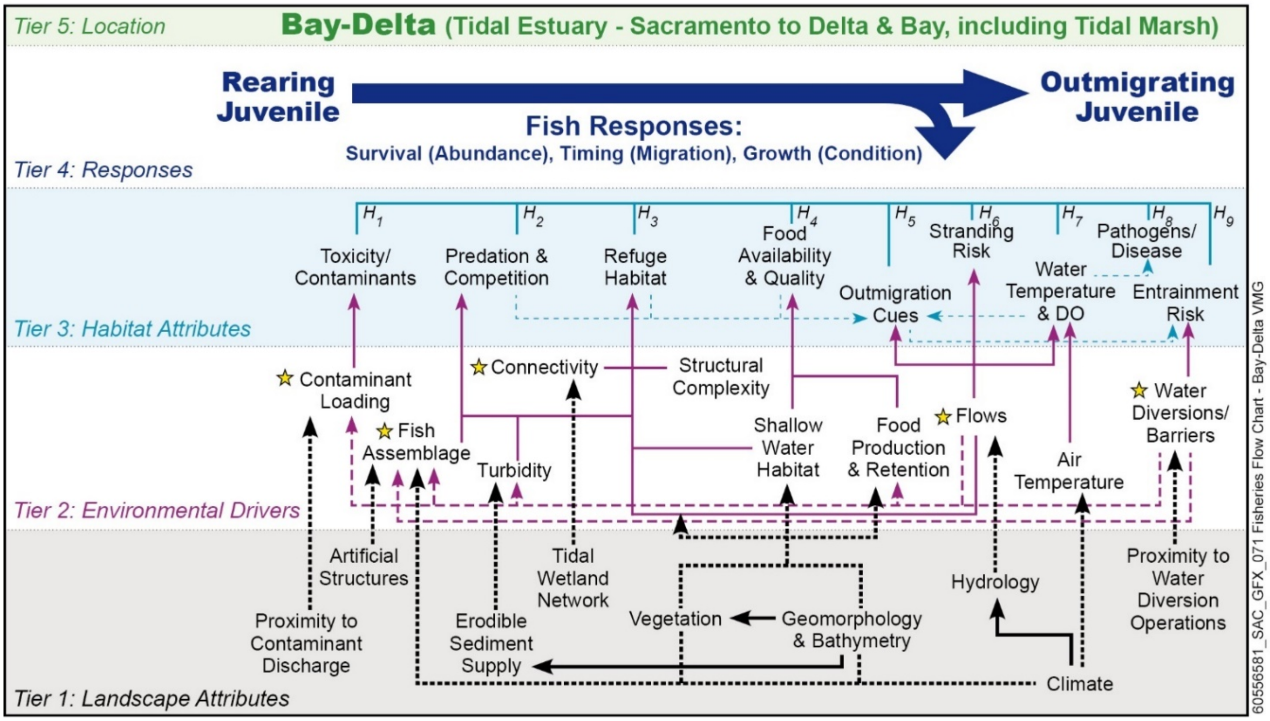
Adult and juvenile Fall-run and Late Fall-run Chinook Salmon use the Delta as a migration corridor. Some fry and juvenile Fall-run and Late Fall-run Chinook Salmon use the Delta for rearing

Winter-run Chinook Salmon

Winter-run Chinook Salmon use the Delta for upstream migration as adults and for downstream migration and rearing as juveniles (Del Rosario et al. 2013). Adults migrate through the Delta during winter and into late spring (May/June) enroute to their spawning grounds in the mainstem Sacramento River downstream from Keswick Dam (USFWS 2001, 2003). Adults are believed to primarily use the mainstem Sacramento River for passage through the Delta (NMFS 2009a). After entry into the Delta, juvenile Winter-run Chinook Salmon remain and rear in the Delta until they are 5 to 10 months of age (based on scale analysis) (Fisher 1994; Myers et al. 1998). Although the duration of residence in the Delta is not precisely known, Del Rosario et al. (2013) suggested that it can be up to several months. Winter-run Chinook Salmon juveniles have been documented in the North Delta (e.g., the Sacramento River, Steamboat Slough, Sutter Slough, Miner Slough, Yolo Bypass, and Cache Slough complex); the Central Delta (e.g., the Georgiana Slough, DCC, Snodgrass Slough, and Mokelumne River complex below Dead Horse Island); South Delta channels, including the OMR and the joining waterways between the OMR (e.g., Victoria Canal, Woodward Canal, and Connection Slough); and the west-Central Delta, including the mainstem channels of the Sacramento and San Joaquin rivers and Threemile Slough (NMFS 2009a).

Sampling at Chipps Island in the West Delta suggests that Winter-run Chinook Salmon exit the Delta as early as December and as late as May, with a peak in March (Brandes and McLain 2001; Del Rosario et al. 2013). The peak timing of the outmigration of juvenile Winter-run Chinook Salmon through the Delta is corroborated by recoveries of winter-run-sized juvenile Chinook Salmon from the SWP Skinner Delta Fish Protection Facility and the CVP Tracy Fish Collection Facility (TFCF) in the South Delta (NMFS 2009a).

IEP formed two synthesis teams, known as SAIL, with the goal of developing conceptual models for anadromous salmonids and sturgeon that use the Delta and Sacramento River for during different stages of their life history. As part of the SAIL synthesis effort, Windell et al. (2017) developed a conceptual model for assessing the biotic and abiotic factors that affect juvenile Winter-run Chinook Salmon during rearing and outmigration in and through the Delta. The model incorporates rearing and migration in the tidal Sacramento River downstream from the I Street Bridge in the city of Sacramento, the Delta, as well as the Suisun, San Pablo, and San Francisco bays. The hypothesized landscape attributes, environmental drivers, and habitat attributes affecting this life stage transition are shown in Figure 4.4-7.



Source: Adapted from Windell et al. 2017.

Note: Hypotheses are referenced by the H-number for habitat attributes, and potential management actions discussed by Windell et al. (2017) are denoted by stars.

Figure 4.4-7. Conceptual Model of Drivers Affecting the Transition of Winter-run Chinook Salmon from Rearing Juvenile to Outmigrating Juvenile in the Bay-Delta

As seen in the conceptual model, a number of landscape attributes, environmental drivers, and habitat attributes are hypothesized to play a role in migration timing, growth, and survival of juvenile salmon as they transit the Delta and bays. These factors are likely to play a significant role in determining the timing and length of migration and rearing activities.

Winter-run Chinook Salmon use the Delta for upstream migration as adults and for downstream migration and rearing as juveniles.

Spring-run Chinook Salmon

The Delta is an important migratory route for all remaining populations of Spring-run Chinook Salmon. Like all salmonids migrating up through the Delta, adult Spring-run Chinook Salmon must navigate the many channels and avoid direct sources of mortality (e.g., fishing and predation), but also must minimize exposure to sources of nonlethal stress (e.g., high temperatures) that can contribute to prespawn mortality in adult salmonids (Budy et al. 2002; Naughton et al. 2005; Cooke et al. 2006; NMFS 2009a). Habitat degradation in the Delta caused by factors such as channelization and changes in water quality can present challenges for outmigrating juveniles. In addition, outmigrating juveniles are subjected to predation and entrainment in the project export facilities and smaller diversions (NMFS 2009a).

Spring-run Chinook Salmon returning to spawn in the Sacramento River system enter the San Francisco Estuary from the ocean in January to late February and move through the Delta prior to entering the Sacramento River. Several populations of Spring-run Chinook Salmon occur in the Sacramento River Basin, but populations that occurred in the San Joaquin River and its tributaries have been extirpated. The Sacramento River channel is the main Spring-run Chinook Salmon migration route through the Delta. However, adult Spring-run Chinook Salmon may stray into the San Joaquin River side of the Delta in response to water from the Sacramento River Basin flowing into the interconnecting waterways that join the San Joaquin River channel through the DCC, Georgiana Slough, and Threemile Slough. Closure of the DCC radial gates is intended to minimize straying, but some southward net flow still occurs naturally in Georgiana and Threemile sloughs.

Juvenile Spring-run Chinook Salmon show two distinct outmigration patterns in the Central Valley: outmigrating to the Delta and ocean during their first year of life as YOY or holding over in their natal streams and outmigrating the following fall and winter as yearlings. Peak movement of juvenile Spring-run Chinook Salmon in the Sacramento River at Knights Landing generally occurs in December and again in March. However, juveniles also have been observed migrating between November and the end of May (Snider and Titus 1998, 2000a, 2000b, 2000c; Vincik et al. 2006; Roberts 2007).

YOY Spring-run Chinook Salmon presence in the Delta peaks during April and May, as suggested by the recoveries of Chinook Salmon in the CVP and SWP salvage operations and the Chipps Island trawls of a size consistent with the predicted size of Spring-run fish at that time of year. However, it is difficult to distinguish the YOY Spring-run Chinook Salmon outmigration from that of the Fall-run Chinook Salmon due to the similarity in their spawning and emergence times and size. Together, these two runs generate an extended pulse of Chinook Salmon smolts outmigrating through the Delta throughout spring, frequently lasting into June. Spring-run Chinook Salmon juveniles also overlap spatially with juvenile Winter-run Chinook Salmon in the Delta (NMFS 2009a). Typically, juvenile Spring-run Chinook Salmon are not found in the channels of the eastern side of the Delta or the mainstem of the San Joaquin River upstream of Columbia and Turner Cuts.

Spring-run Chinook Salmon use the Delta for upstream migration as adults and for downstream migration as juveniles and yearlings.

Longfin Smelt

Longfin Smelt populations occur along the Pacific Coast of North America, and the San Francisco Estuary represents the southernmost population. Longfin Smelt generally occur in the Delta; Suisun, San Pablo, and San Francisco bays; and the Gulf of the Farallones, just outside San Francisco Bay. Longfin Smelt are not a focus of any specific RPA actions because the species is not federally listed under the ESA. However, DWR’s 2009 Incidental Permit authorizing incidental take of Longfin Smelt associated with the SWP operations required restoration of 800 acres of tidal habitat to benefit Longfin Smelt. In addition, RPA actions that benefit Delta Smelt, salmonids, and sturgeon, including increasing Delta outflow, have the potential to benefit other fish, including Longfin Smelt, given their similar habitat requirements and trophic feeding levels.

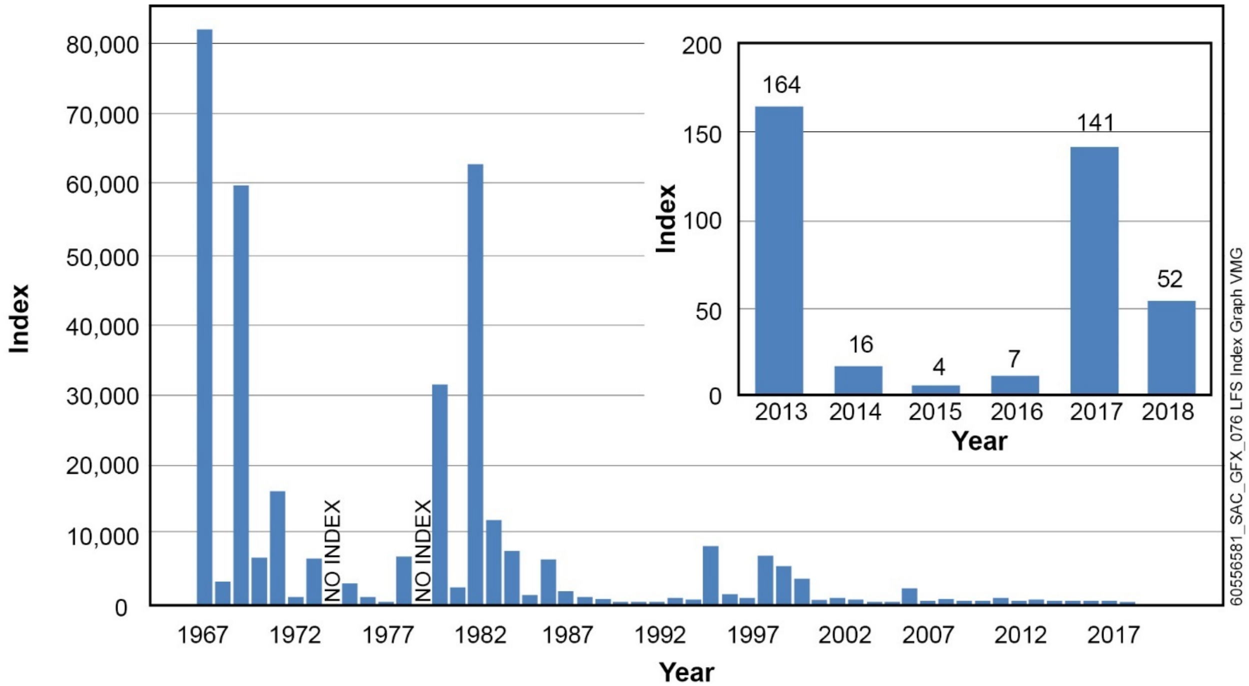
Longfin Smelt are anadromous and spawn in fresh or low salinity water in the Bay-Delta (Grimaldo et al. 2017), generally at 2 years of age (Moyle 2002). They migrate upstream to spawn during late fall through winter, with most spawning from November through April (CDFG 2009). Previous studies suggested that spawning in the Sacramento River occurs from just downstream from the confluence of the Sacramento and San Joaquin rivers upstream to about Rio Vista and that spawning on the San Joaquin River extends from the confluence upstream to about Medford Island (Moyle 2002). More recent studies suggest hatching and early rearing occurs in a much broader region and higher salinity (2 to 12 ppt than previously recognized (Grimaldo et al. 2017). Spawning likely also occurs in Suisun Marsh and the Napa River (CDFG 2009), and possibly in other tributaries to San Francisco Bay.

Longfin Smelt larvae are most abundant in the water column usually from January through April (USBR 2008). As previously noted, larval Longfin Smelt rear in low salinity to brackish water (2 to 12 ppt; Grimaldo et al. 2017). Larger Longfin Smelt feed primarily on opossum shrimps and other invertebrates (Feyrer and Healey 2003). Copepods and other crustaceans can also be important food items, especially for smaller fish (USBR 2008).

Longfin Smelt in the San Francisco Estuary are broadly distributed in both time and space, and interannual distribution patterns are relatively consistent (Rosenfield and Baxter 2007). Seasonal patterns in abundance and occurrence in the nearshore ocean suggest that the population is at least partially anadromous (Rosenfield and Baxter 2007; Garwood 2017), and the detection of Longfin Smelt within the estuary throughout the year suggests that, as with Striped Bass, anadromy is one of several life history strategies or contingents in this population.

The relative population size of Longfin Smelt in the San Francisco Estuary is measured by indices of abundance generated from different sampling programs. The abundance of age 0 and older fish is best indexed by the CDFW Fall Midwater Trawl and Bay Study, while the abundance of larvae and young juveniles is best indexed by the CDFW 20-mm Survey. The relationship between these indices and actual population sizes is unknown. Although the Fall Midwater Trawl data suggest a sharp decline in Longfin Smelt abundance during the last decade, some of that decline might be attributable to a downstream movement in the Longfin Smelt distribution into regions better covered by the Bay Study fish survey. The Bay Study uses two types of trawls, an otter trawl and a midwater trawl. The Longfin Smelt abundance index created from the Fall Midwater Trawl is consistent with the trend in the Bay Study midwater trawl but not the Bay Study otter trawl. In addition, the proportion of false zeros in the survey data (where the Bay Study midwater trawl failed to detect any Longfin Smelt when they were detected in the otter trawl) has been increasing (Reclamation 2019, Appendix O, O-81).

The abundance of Longfin Smelt in the estuary has fluctuated over time but has exhibited statistically significant step-declines around 1989 to 1991 and in 2004 (Thomson et al. 2010). A synthesis of prior studies conducted by USFWS in its 12-Month Finding on a Petition to List the San Francisco Bay-Delta Population of the Longfin Smelt as Endangered or Threatened (USFWS 2012) reported that increased Delta outflow in winter and spring is the largest factor possibly affecting Longfin Smelt abundance. The most commonly applied index of abundance is calculated from the FMWT Survey, for which indices were at historical lows during the recent drought before experiencing a several-fold increase in 2017 (Figure 4.4-8).



Source: Adapted from CDFW 2019b.

Figure 4.4-8. Longfin Smelt Fall Midwater Trawl Abundance Indices (All Ages), 1967–2018

Habitat for Longfin Smelt is open water, largely away from shorelines and vegetated inshore areas except perhaps during spawning. This includes all of the large embayments in the estuary and the deeper areas of many of the larger channels in the western Delta. Longfin Smelt abundance indices have been correlated with Delta outflow, and thus it is thought that habitat suitability in these areas for Longfin Smelt is somehow influenced by variation in freshwater flow, although the mechanism remains unknown (Jassby et al. 1995; Bennett and Moyle 1996; Kimmerer 2004; Kimmerer et al. 2009).

Water exports and inadvertent entrainment at the SWP and CVP export facilities are anthropogenic sources of mortality for Longfin Smelt. The export facilities are known to entrain most species of fish in the Delta (Brown et al. 1996). Longfin Smelt entrainment mainly occurs from December to May, with peak adult entrainment from December to February (Grimaldo et al. 2009). In water year 2011, Aasen (2012) reported four adult Longfin Smelt were salvaged at the project export facilities, compared with much higher numbers in the early 2000s and late 1980s. The number of Longfin Smelt entrained in recent years has been reduced likely because of changes in export operations and a decline in abundance.

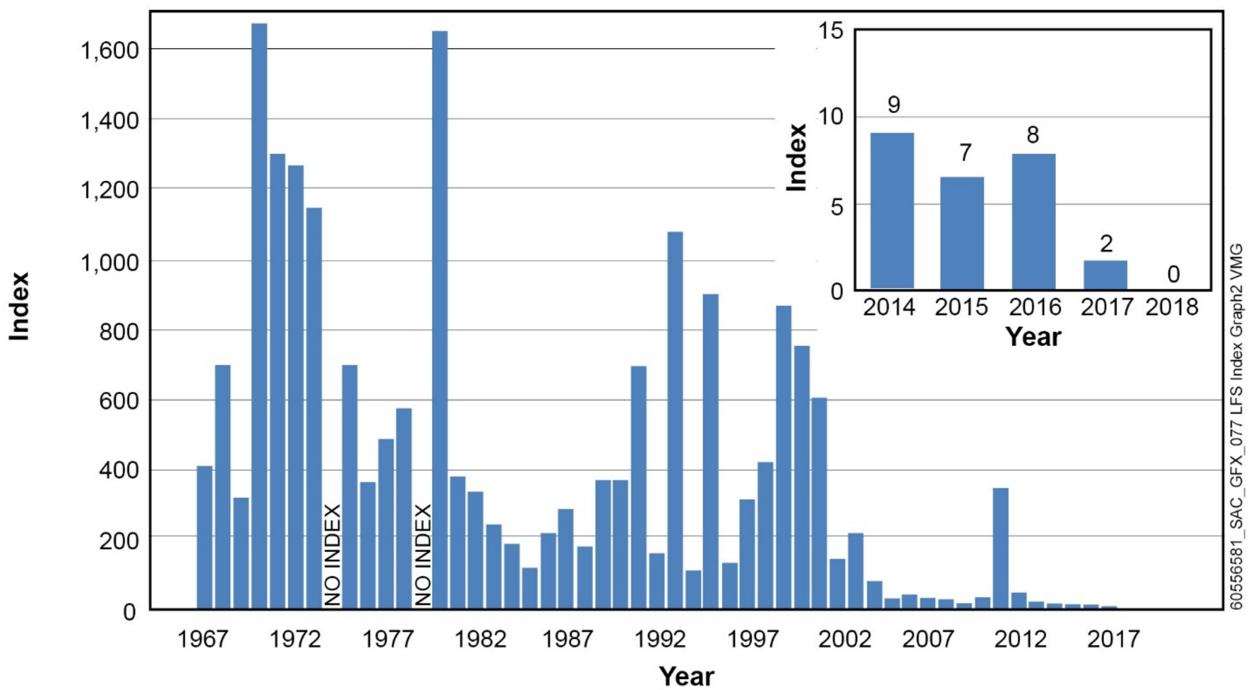
Longfin Smelt use the Delta during all life stages and in recent years those found in the Delta are found predominantly in the western Delta.

Delta Smelt

Delta Smelt are endemic to the Delta and Suisun Marsh (Moyle et al. 1992; Bennett 2005). Declines in the Delta Smelt population led to their listing under the ESA as threatened in 1993 (USFWS 2008). Delta Smelt are one of four pelagic fish species (including Longfin Smelt, Threadfin Shad, and juvenile Striped Bass) documented to be in decline based on FMWT abundance indices (Sommer et al. 2007a).

The causes of the declines have been extensively studied and are thought to include a combination of factors, such as decreased habitat quantity and quality, increased mortality rates, and reduced food availability (Feyrer et al. 2007; Sommer et al. 2007a; Moyle and Bennett 2008; Baxter et al. 2010; Mac Nally et al. 2010; Maunder and Deriso 2011; Rose et al. 2013a, 2013b; Sommer and Mejia 2013). Two statistical analyses that used similar data but different statistical methods (Mac Nally et al. 2010; Thomson et al. 2010) examined the dynamics of the four fish species. Both analyses identified several covariates that were correlated to abundance of the fish, but they could not resolve the cause of the recent declines. Analyses indicated the decline was caused by multiple factors, including temperature, food limitation, hydrodynamics, and growth rates (Rose et al. 2013a).

Indices of Delta Smelt abundance have continued to decline and the number of fish collected in sampling programs, such as the trawl surveys conducted by IEP, have dropped even lower in recent years. Figure 4.4-9 shows the FMWT abundance indices for Delta Smelt from 1967 to 2018 (CDFW 2019c). No Delta Smelt were collected in the 2018 FMWT; the 2018 Delta Smelt index was 0, making it the lowest in FMWT history (CDFW 2019c). Results for Delta Smelt from other surveys (Spring Kodiak Trawl Survey and Summer Townet Survey) were also low in 2018, when the 20-mm Survey index could also not be calculated because of the low catch (Tempel 2018).



Source: Adapted from CDFW 2019b

Figure 4.4-9. Delta Smelt Fall Midwater Trawl Abundance Indices (All Ages), 1967–2018

Studies conducted to synthesize available information about Delta Smelt indicate that Delta Smelt have been documented throughout their geographic range during much of the year (Merz et al. 2011; Sommer and Mejia 2013; Brown et al. 2014). Studies indicate that in fall, prior to spawning, Delta Smelt are found in the Delta, Suisun, and San Pablo bays, the Sacramento River and San Joaquin River confluence, Cache Slough, and the lower Sacramento River (Murphy and Hamilton 2013). By spring, they move to freshwater areas of the Delta region, including the Sacramento River and San Joaquin

River confluence, the upper Sacramento River, and Cache Slough (Brown et al. 2014; Murphy and Hamilton 2013). There is also a freshwater resident life history type (Bush 2017), occurring primarily in the Cache Slough region year-round (Sommer et al. 2011).

Sommer et al. (2011) described adult Delta Smelt initiating upstream spawning migrations during winter in association with “first flush” freshets. Others report this seasonal change as a multidirectional and more circumscribed dispersal movement to freshwater areas throughout the Delta region (Murphy and Hamilton 2013). After arriving in freshwater staging habitats, adult Delta Smelt hold until spawning commences during favorable water temperatures in the late winter and spring (Bennett 2005; Grimaldo et al. 2009; Sommer et al. 2011). Delta Smelt spawn over a wide area throughout much of the Delta, including some areas downstream and upstream of the Delta as conditions allow. Although the specific substrates or habitats used for spawning by Delta Smelt are not known, spawning habitat preferences of closely related species suggest that spawning may occur in shallow areas over sandy substrates (Bennett 2005). The habitats used by larval Delta Smelt before they move into the pelagic areas also are not known (Swanson et al. 1998; Sommer et al. 2011).

During and after larval rearing in freshwater, many young Delta Smelt move with river and tidal currents to remain in favorable rearing habitats, often moving increasingly into the low salinity zone (generally defined as the area where salinity ranges from around 0.5 or 1 to 6 (practical salinity units [psu]) to avoid seasonally warm and highly transparent waters that typify many areas in the Central Delta (IEP MAST 2015). Bennett and Burau (2015) showed that during winter, Delta Smelt aggregate near frontal zones at the shoal-channel interface, moving laterally into the shoals on ebb tides and back into the channel on flood tides. They suggest that this migration strategy can minimize the energy spent swimming against strong river and tidal currents, as well as predation risks by remaining in turbid water.

During summer and fall, many juvenile Delta Smelt continue to grow and rear in the low salinity zone until maturing the following winter (Bennett 2005). Some Delta Smelt also rear in upstream areas such as the Cache Slough complex and the Sacramento Deep Water Ship Channel, depending on habitat conditions (Sommer and Mejia 2013).

During summer and fall, the distribution of juvenile Delta Smelt rearing is influenced by the position of the low salinity zone, although their distribution can also be influenced by temperature and turbidity (Bennett 2005; Feyrer et al. 2007, 2010; Kimmerer et al. 2009; Sommer and Mejia 2013). The geographical position of the low salinity zone varies primarily as a function of freshwater outflow. Thus, the low salinity zone typically lies farther east in summer and fall during low outflow conditions and drier water years and farther west during high outflow conditions (Jassby et al. 1995).

Higher outflow causes the low salinity zone to more frequently overlap with the Suisun Marsh and Bay region, which is broader and shallower and typically has greater turbidity than the mainstem Sacramento and San Joaquin rivers. The overlap of the low salinity zone with the Suisun Marsh and Bay results in a dramatic increase in a habitat index calculated by Feyrer et al. 2010. However, others (e.g., Manly et al. 2015) have questioned the use by Feyrer et al. (2010) of outflow and X2 location as an indicator of Delta Smelt habitat because other factors may be influencing survival. Murphy and Weiland (2019) suggested that the low salinity zone is not a reliable indicator of Delta Smelt habitat and reported that Delta Smelt can be found in the lower Sacramento River, east of the Delta in largely freshwater conditions as well as in western regions of the Delta, such as Suisun Bay, where salinity levels are typically higher. As both these conditions bound the range of the species, the location of X2 does not determine the location of other important resources such as food or predators.

In addition to salinity, turbidity is thought to be an important factor associated with habitat use; Delta Smelt show a strong preference for higher turbidity water (Feyrer et al. 2007, 2010; Sommer and Mejia 2013), and turbidity may be a key habitat feature and cue initiating the Delta Smelt spawning migration (Bennett and Burau 2015). Turbidity has decreased in recent decades within the Delta (Kimmerer 2004; Schoellhamer 2011), which has likely contributed to declines in the environmental quality of Delta Smelt habitat (Feyrer et al. 2007, 2010). Higher turbidities are believed to allow Delta Smelt to hide from open-water predators, such as Striped Bass (Gregory and Levings 1998; Nobriga et al. 2005) and contribute to feeding success (Lindberg et al. 2000; IEP 2015).

Water temperature is another important environmental factor that affects Delta Smelt habitat and population dynamics (Sommer and Mejia 2013). A longer period of optimal water temperatures in cooler years increases the number of spawning events and cohorts produced (Bennett 2005). During rearing, summer water temperatures also have been shown to be an important predictor of Delta Smelt occurrence, based on multidecadal analyses of Summer Tow Net Survey data (Nobriga et al. 2008).

The quality and availability of food also have important effects on the abundance and distribution of Delta Smelt (Sommer and Mejia 2013; Kimmerer 2008). Delta Smelt feed primarily on zooplankton (Slater and Baxter 2014), and Nobriga (2002) showed that Delta Smelt larvae with food in their guts typically co-occurred with higher calanoid copepod densities. Food quality and availability have varied substantially, largely because of the history of non-native species introduction into the San Francisco Estuary (Baxter et al. 2008; Winder and Jassby 2011). The decline of zooplankton in the western Delta has been hypothesized to be related to several factors, including increased ammonium concentrations from wastewater effluent and agricultural runoff (Wilkerson et al. 2006; Dugdale et al. 2007; Miller et al. 2012; Glibert et al. 2011, 2014) and the introduction of invasive clams (Kimmerer et al. 1994; Feyrer et al. 2003).

In 2011 and 2012, an unanticipated change in water management operations led to relatively large phytoplankton blooms in the western Delta, including in the Sacramento River near Rio Vista. Historically, rice fields along the Colusa Basin Drain are flooded in fall to decompose the rice stubble, and the water is released through the Knights Landing Outfall gates into the Sacramento River. In 2011 and 2012, construction at the outfall gates required the water to be diverted into the Yolo Bypass, resulting in higher than normal flows. These events temporarily resulted in a fall pulse flow in the Yolo Bypass that increased the volume of flow by more than 300% to 900% (Frantzich 2014). Concurrently, a substantial increase in nutrients, phytoplankton, and zooplankton was observed in the Yolo Bypass and Cache Slough. In 2013, the fall pulse flow of rice drainage water did not occur in the Yolo Bypass, and nutrient concentrations did not increase. These nutrient inputs, when they occur, and corresponding increases in phytoplankton and zooplankton production, could contribute to improved foraging opportunities for Delta Smelt. Based on these observations, pulse flows to supply nutrients to the Delta have been included as part of the Delta Smelt Resiliency Strategy.

Results in prior years indicate that entrainment and salvage-related mortality of Delta Smelt associated with water pumping and CVP/SWP exports from the Delta occur primarily from December to July (Kimmerer 2008; Grimaldo et al. 2009; Baxter et al. 2010). Entrainment occurs when migrating and spawning adult Delta Smelt and their larvae overlap in time and space with turbid net reverse (southward, or upstream) flows in the channels of the Old and Middle rivers (Kimmerer 2008; Grimaldo et al. 2009; Baxter et al. 2010).

In January 2015, the IEP Management Analysis and Synthesis Team (MAST) published a report to provide an assessment and conceptual model of factors affecting Delta Smelt throughout its life cycle (IEP MAST 2015). One focus of the report was an evaluation of a notable increase in abundance of some Delta Smelt life stages in 2011, which indicated that the Delta Smelt population could potentially rebound when conditions are favorable for spawning, growth, and survival.

The IEP MAST's updated conceptual model described the hypothesized habitat conditions and ecosystem drivers affecting each Delta Smelt life stage across seasons and how the seasonal effects contributed to the annual success of the species. The conclusions of the report highlighted some key points about Delta Smelt and their habitat, using 2011 as the example year in relation to a prior wet year (2006) and two drier years (2005 and 2010). In summary, the report concluded that Delta Smelt likely benefitted from the following favorable habitat conditions in 2011:

1. Adults and larvae may have benefitted from high winter 2010 and spring 2011 outflows due to reduced entrainment risk and other possibly improved habitat conditions, prolonged cool spring water temperatures, and possibly good food availability in late spring.
2. Juvenile Delta Smelt may have benefitted from cool water temperatures in late spring and early summer as well as from relatively good food availability and low levels of harmful Microcystis.
3. Subadults may have benefitted from good food availability and from favorable habitat conditions in the large low salinity zone, located more toward Suisun Bay in 2010.

More recently, researchers have developed models that incorporate factors that influence the spatiotemporal abundance of Delta Smelt. Using extensive, spatially resolved catch time series data for 13 separate annual cohorts of Delta Smelt, Polanksy et al. (2018) developed a suite of models that advanced the understanding of factors influencing abundance of the species.

Delta Smelt use the Delta region during all life stages.

Sacramento Splittail

Sacramento Splittail are found primarily in marshes, turbid sloughs, and slow-moving river reaches throughout the Delta subregion (Sommer et al. 1997, 2008). Sacramento Splittail are most abundant in moderately shallow, brackish tidal sloughs and adjacent open-water areas, but they also can be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004).

Adult Sacramento Splittail typically migrate upstream from brackish areas in January and February and spawn in freshwater in March and April, particularly on inundated floodplains when they are available (Sommer et al. 1997; Moyle et al. 2004; Sommer et al. 2008). A substantial amount of splittail spawning occurs in the Yolo and Sutter bypasses and the Cosumnes River area of the Delta (Moyle et al. 2004). Spawning also can occur in the San Joaquin River during high-flow events (Sommer et al. 1997, 2008). However, not all adults migrate significant distances to spawn, as evidenced by spawning in the Napa and Petaluma rivers (Feyrer et al. 2005).

Although juvenile Sacramento Splittail are known to rear in upstream areas for a year or more (Baxter 1999), most move to the Delta after only a few weeks or months of rearing in floodplain habitats along the rivers (Feyrer et al. 2006). Juveniles move downstream into the Delta from April to August (Meng and Moyle 1995; Feyrer et al. 2005). Sacramento Splittail recruitment is largely limited by the extent and period of inundation of floodplain spawning habitats, with abundance observed to spike following wet years and dip after dry years (Moyle et al. 2004). However, the life span of 5 to 7 years buffers the adult population abundance (Sommer et al. 1997; Moyle et al. 2004). Other factors that may adversely affect the Sacramento Splittail population in the Delta include entrainment, predation, changed estuarine hydraulics, non-native species (Moyle et al. 2004), pollutants (Greenfield et al. 2008), and limited food.

Hardhead

Hardhead are widely distributed in streams at low to mid-elevations in the Sacramento-San Joaquin and Russian River drainages (Leidy 1984; Moyle 2002). Hardhead are often found at low to mid-elevations in relatively undisturbed habitats of larger streams (Moyle and Daniels 1982; Mayden et al. 1991) with high water quality (clear, cool). In the Sacramento River, however, they are common in both the mainstem and tributaries up to 1,500 m in elevation (Reeves 1964).

It is likely that Hardhead would have a much broader distribution in the absence of alien predatory fishes, especially centrarchid basses. In general, where bass are common, Hardhead are absent or rare (Brown and Moyle 2005). Hardhead do not now occur in the Delta due to the abundance of centrarchid basses and other predatory fish. Examination of fish salvage records from the state and federal water project screening facilities does not show any Hardhead salvaged at these facilities in recent years, thus supporting the conclusion that Hardhead do not currently occupy habitats in the Delta.

Central California Roach

Central California Roach do not occur in the Delta, if they ever did historically, due to the abundance of centrarchid basses and other predatory fish and the salinity fluctuations in parts of the Delta (Moyle 2002). Examination of fish salvage records from the state and federal water project screening facilities does not show any Central California Roach salvaged at these facilities, thus supporting the conclusion that roach do not occupy habitats in the Delta.

Striped Bass

Striped Bass is a recreationally important anadromous species introduced into the Sacramento–San Joaquin River Basin between 1879 and 1882 (Moyle 2002). Despite their non-native status and piscivorous feeding habits, Striped Bass are considered important because they are a major game fish in the Delta. Striped Bass use the Delta as a migratory route and for rearing and seasonal foraging. Striped Bass spend the majority of their lives in salt water, returning to freshwater to spawn. When not migrating for spawning, adult Striped Bass in the Bay-Delta are found in San Pablo Bay, San Francisco Bay, and the Pacific Ocean (Moyle 2002). Adult Striped Bass spend about 6 to 9 months of the year in San Francisco and San Pablo bays (Hassler 1988). Striped Bass also use deeper areas of many of the larger channels in the Delta in addition to large embayments such as Suisun Bay.

Spawning occurs in spring, primarily in the Sacramento River between Sacramento and Colusa and in the San Joaquin River between Antioch and Venice Island (Farley 1966). Eggs are free-floating and negatively buoyant and hatch as they drift downstream, with larvae occurring in shallow and open waters of the lower reaches of the Sacramento and San Joaquin rivers, the Delta, Suisun Bay, Montezuma Slough, and the Carquinez Strait. According to Hassler (1988), the distribution of larvae in the estuary depends on river flow. In low-flow years, all Striped Bass eggs and larvae are found in the Delta, while in high-flow years, the majority of eggs and larvae are transported downstream into Suisun Bay.

YOY Striped Bass distribute themselves in accordance with the estuarine salinity gradient (Kimmerer 2002b; Feyrer et al. 2007), indicating that salinity is a major factor affecting their habitat use and geographic distributions. Kimmerer (2002b) found that distributions of fish species, including Striped Bass, substantially overlapped with the low salinity zone. Older Striped Bass are increasingly flexible about their distribution relative to salinity (Moyle 2002).

The entrainment of Striped Bass has been observed at the project export facilities, including the CCF (Stevens et al. 1985; Bowen et al. 1998; Aasen 2012). In water year 2011, salvage of Striped Bass at export facilities (approximately 550,000 fish) continued the generally low trend observed since the mid-1990s. Prior to 1995, annual Striped Bass salvage was generally above 1 million fish (Aasen 2012). DWR et al. (2013) reported that Striped Bass longer than 24 mm were effectively screened at the TFCF and bypassed the pumps. However, planktonic eggs, larvae, and juveniles smaller than 24 mm in length received no protection from entrainment.

Striped Bass, primarily YOY, are one of the pelagic fish of the upper estuary that have shown substantial variability in their population sizes, with evidence of long-term declines (Kimmerer et al. 2000; Sommer et al. 2007a). A substantial portion of the abundance patterns has been associated with variation of outflow in the estuary (Jassby et al. 1995; Kimmerer et al. 2001; Loboschefsky et al. 2012), although this is disputed by some (Bourez 2011). However, surveys showed that population levels for YOY Striped Bass began to decline sharply around 1987 and 2002 (Thomson et al. 2010), despite relatively moderate hydrology, which typically supported at least modest fish production (Sommer et al. 2007a). Moyle (2002) cites climatic factors, entrainment at project export facilities in the South Delta, other diversions, pollutants, reduced estuarine productivity, invasions by alien species, and human exploitation as the causes of the decline in Striped Bass. Kimmerer et al. (2000, 2001) attribute the decline in juvenile YOY Striped Bass to declining carrying capacity, likely related to food limitation. Loboschefsky et al. (2012) showed that there had been no long-term decline for age 1 and older Striped Bass as of 2004.

Striped Bass use the Delta as a migratory route and for rearing and seasonal foraging.

Non-Native Freshwater Bass (Largemouth Bass, Smallmouth Bass, and Spotted Bass)

The Sacramento-San Joaquin Delta is ranked among the top ten best black bass fishing locations in the United States. Black bass, a collective term for the genus Micropterus, have a long history in California. This group includes Largemouth Bass, Smallmouth Bass, and Spotted Bass, the three species listed in Table 4.4-1. Although bass were intentionally stocked in new environments because of their sportfishing appeal, the same aggressive behavior that makes these fish desirable freshwater game species also makes them voracious predators and a threat to other species. Black bass can disturb native ecosystems by negatively affecting native fish populations (Sanderson et al. 2009). Black bass are well established in the Delta, the most invaded estuary in the world (Feyrer and Healey 2003).

In the last two decades, the abundance of centrarchids in the littoral zone has increased, while some native species and species that were previously abundant in the pelagic zone have declined (Brown and Michniuk 2007; Marhardja et al. 2017).

<u>Largemouth Bass</u>

Largemouth Bass are most common in warm, shallow waters with moderate clarity and beds of aquatic plants. This includes farm ponds, lakes, reservoirs, sloughs, and river backwaters. Largemouth Bass are now one of the most abundant piscivores in the Delta. This increase in Largemouth Bass abundance coincided with the spread of Brazilian waterweed (*Egeria densa*), a submerged aquatic plant that resides in the littoral zone and was first reported in the Delta in 1946 (Light et al. 2005). Recent work has shown that juvenile Largemouth Bass are indeed associated with Brazilian waterweed-dominated habitats in the Delta littoral zone (Conrad et al. 2016; Young et al. 2018).

Largemouth Bass can survive temperatures up to 36°C to 37°C (96.8°F to 98.6 °F), but 27°C (80.6 °F) is generally preferred. They can also survive in water with dissolved oxygen levels as low as 1 mg/L, but will avoid areas with salinities higher than 3 ppt and are intolerant of high alkalinity levels (UC ANR 2019a). The majority of Largemouth Bass are solitary hunters that stalk around a piece of submerged debris or roam widely in open water. Foraging happens throughout the daylight hours but is most intense at dusk before becoming almost completely nonexistent at night. Pursuit and ambush strategies are both used to catch prey, and a Largemouth Bass's behavioral preference will change with the availability of prey and the habitat. This changing of behavior will often lead to a Largemouth Bass specializing in a single type of prey at least for a short period of time but switching this focus numerous times throughout the individual's lifetime (UC ANR 2019a). In general, fry feed on crustaceans and rotifers before taking on insects and fish fry at 50 to 60 mm in length and becoming primarily piscivorous at 100 to 125 mm in length (Weinersmith et al. 2019). Crayfish, tadpoles, or frogs may also be preferred once a Largemouth Bass has grown large enough to digest them.

All life stages of Largemouth Bass can occur in the freshwater regions of the Delta.

Smallmouth Bass

Smallmouth Bass are most common in large, clear lakes and cool, clear streams with large amounts of cover. In streams they prefer complex habitat with a variety of pools, riffles, runs, rocky bottoms, and overhanging trees, while lake populations concentrate in narrow bays along shores where rocky shelves project under water. Optimal water temperature differs with age, as adults tend to stay in areas 25°C to 27°C (77°F to 80.6 °F), while younger fish prefer areas 29°C to 31°C (84.2°F to 87.8 °F), reflecting their more shallow water environment. Regardless of age, however, temperatures greater than 35°C are metabolically stressful, and temperatures over 38°C (100.4 °F) are lethal. Smallmouth Bass are also restricted in their habitat choice by the amount of dissolved oxygen in the water. While they can survive in areas with 1 to 3 milligrams of oxygen per liter, they require at least 6 mg/L for normal growth rates (UC ANR 2019b). Juveniles and populations in crowded lakes may school, but this is rare and the majority are solitary hunters that stalk around some kind of submerged debris. This will localize populations to such a degree that several reproductively independent groups can exist within a single lake. Foraging occurs throughout the day but is most intense in the evening and the early morning. Crustaceans and aquatic insects make up the majority of a Smallmouth Bass's diet until it reaches 3 to 5 cm TL, at which point crayfish and fish become more important. By the time an individual reaches 10 to 15 cm TL, these larger food items will dominate the diet. Smallmouth Bass are opportunistic, however, and insects, amphibians, and small mammals are not uncommon sources of food (UC ANR 2019b).

Smallmouth Bass reach maturity in their third or fourth spring, at which point they move into more shallow water. Spawning begins in May and can continue into June or July. Males construct nests 30 to 60 cm in diameter, preferably in rubble, gravel, or sand 1 meter deep with submerged logs, boulders, and other submerged objects acting as cover. This is only the optimal environment, however, and nests can be found on a variety of substrates varying in depth from 0.5 m to 5 m. These nests may be built close together, but they are not colonial and males will defend the nests against other males as vigorously as they would against predators. Spawning is initiated by a female repeatedly swimming by a nest, changing colors, and keeping her head down in a mating posture. Eventually the pair circle the nest, with the male nipping at the female and the female occasionally rubbing her abdomen on the nest floor. The pair will then settle into the nest and release their eggs and milt simultaneously. Smallmouth Bass are mostly monogamous, but the larger fish spawn earlier in the season and may have the opportunity to spawn again. Each female may release 2,000 to 21,000 eggs into her nest. The males guard the embryos and fan water over them to provide more oxygen. After hatching it will take 1 to 2 weeks before fry become free swimming, and the male will still guard them for another 1 to 4 weeks after that until they are too active to be herded. At 2 to 3 cm TL, the young will disperse to shallow water where high mortality rates are suffered due to predation and high stream flows. Those that survive generally grow to between 6 cm and 18 cm in their first year, and between 25 to 41 cm in their fourth, while stream populations grow at a decidedly slower rate. The largest individual on record weighed 4.1 kilograms (UC ANR 2019b).

All life stages of Smallmouth Bass can occur in the freshwater regions of the Delta.

Spotted Bass

Spotted Bass are most common in moderately sized, clear, low-gradient rivers and reservoirs. In streams they spend most of their time hiding in pools, avoiding riffles or backwaters with heavy plant growth. Reservoir populations stay along steep rocky banks towards the upstream end of the reservoir. During the summer they can be found in temperatures between 24°C and 31°C (75.2 and 87.8 °F), and despite a low tolerance for brackish water, they have been found in salinities up to 10 ppt. Juveniles can easily be seen schooling in shallow areas close to shore, but adults are more solitary and spend most of their time 1 meter to 4 meters deep or even further down when temperatures equalize in winter. Like most fish, the Spotted Bass's diet expands as a fish gets older. Fry focus mostly on zooplankton and small insects, moving on to crustaceans and larger aquatic insects as juveniles. Individuals between 75 mm and 150 mm feed on aquatic insects, fish, crayfish, and terrestrial insects, eventually focusing most of their energy on crayfish (UC ANR 2019c).

Maturity is reached in the second or third year and spawning occurs when temperatures reach 15°C to 18°C (59°F to 64.4 °F), continuing until temperatures reach 22°C to 23°C (71.6°F to 73.4 °F) in early June. Males move to shallow water in March and early April, where they construct nests 40 to 80 cm in diameter. Lake nests are built in areas 0.5 to 4.5 meters deep with large rocks and rubble or gravel, while nearly any area with low current can be used in rivers. These nests may be built close together, but they are not colonial and males will defend the nests as vigorously against other males as they would against predators. Spawning is initiated by a female repeatedly swimming by a male's nest, changing colors, and keeping her head down in a mating posture. Eventually the pair circles the nest, with the male nipping at the female and the female occasionally rubbing her abdomen on the nest floor. The pair will then settle into the nest and release their eggs and milt simultaneously. Spotted Bass are mostly monogamous, but some males may have more than one nest. Each female will lay 2,000 to 14,000 eggs per nest. The male will tend to and defend the nest for up to 4 weeks until the fry disperse at 30 millimeters total length (mm TL). Growth varies with habitat. Warmwater reservoirs support the highest growth, and cold streams support the slowest. On average, however, individuals reach 65 to 170 mm TL in their first year and 245 to 435 mm TL in their fourth. Few live longer than 4 to 5 years, and the largest recorded individual for California was 450 mm TL (UC ANR 2019c).

All life stages of Spotted Bass can occur in the freshwater regions of the Delta.

American Shad

American Shad is a recreationally important anadromous species introduced into the Sacramento–San Joaquin River Basin in the 1870s (Moyle 2002). American Shad spend most of their adult life at sea and may make extensive migrations along the coast. American Shad become sexually mature while in the ocean and migrate through the Delta to spawning areas in the Sacramento, Feather, and American rivers. Some spawning also takes place in the lower San Joaquin, Mokelumne, and Stanislaus rivers (USFWS 1995). The spawning migration may begin as early as February, but most adults migrate into the Delta in March and early April (Skinner 1962). Migrating adults generally take 2 to 3 months to pass through the Delta (Painter et al. 1979).

Fertilized eggs are slightly negatively buoyant, are not adhesive, and drift in the current. Newly hatched larvae are found downstream from spawning areas and can be rapidly transported downstream by river currents because of their small size. Juvenile Shad rear in the Sacramento River below Knights Landing, the Feather River below Yuba City, and the Delta; rearing also takes place in the Mokelumne River near the DCC to the San Joaquin River. No rearing is known to occur in the American and Yuba rivers (Painter et al. 1979). Some juvenile American Shad may rear in the Delta for up to a year before outmigrating to the ocean (USFWS 1995). Outmigration from the Delta begins in late June and continues through November (Painter et al. 1979).

Juvenile American Shad are frequently encountered in the Delta during the FMWT Survey and in fish salvage monitoring at the South Delta SWP and CVP fish facilities (DWR et al. 2013). American Shad's use of the Delta has been observed to vary with salinity (e.g., X2 position) and outflows (Kimmerer 2002a).

American Shad are entrained at the TFCF (Bowen et al. 1998) and in the CCF mostly during May through December when young American Shad migrate downstream. The American Shad population in the Sacramento–San Joaquin River Basin has declined since the late 1970s, most likely because of the combination of changing ocean conditions and increased diversion of water from rivers and the Delta, and possibly because of pesticides (Moyle 2002). Salvage of American Shad at project export facilities in water year 2011 represented nearly 659,000 fish (Aasen 2012), with similar but slightly lower salvage in 2010 (545,125 fish) (Aasen 2011).

American Shad use the Delta for upstream migration as adults and for downstream migration and rearing as juveniles.

Bay-Delta Aquatic Habitat

Flow management in the Delta altered the aquatic habitat by (1) changing aspects of the historical flow regime (timing, magnitude, duration) that supported life history traits of native species; (2) limiting access to or quality of habitat; (3) contributing to conditions better suited to invasive, non-native species (reduced spring flows, increased summer inflows and exports, and low and less-variable interior Delta salinity [Moyle and Bennett 2008]); and (4) causing net reverse flows in channels leading to project export facilities that can entrain fish (Mount et al. 2012). Native species of the Delta are adapted to and depend on variable flow conditions at multiple scales, which is influenced by the region's dramatic seasonal and interannual climatic variation. In particular, most native fishes evolved reproductive or outmigration timing associated with historical peak flows during spring (Moyle 2002).

The impacts of water export on Delta flow and velocity have been studied using hydrodynamic models by a variety of researchers. A summary of these effects was recently provided by the Salmonid Scoping Team (SST 2017b). The SST concluded that the effect of the SWP water exports on Delta flow and velocity varied as a function of distance from the facility as well as a function of export volume, total Delta inflow and tidal action. While export rates had little effect on distributaries such as Georgiana Slough, a much greater effect exists in the South Delta, particularly in Old River near the export facilities.

Water temperatures in the Delta follow a seasonal pattern of winter cold-water conditions and summer warm-water conditions, largely because of the region's Mediterranean climate with its alternating cool-wet and hot-dry seasons. Currently in the Delta, the most significant changes in water temperatures have been in the form of increased summer water temperatures over large areas of the Delta because of high summer ambient air temperatures and, to a lesser extent, the increased temperature of river inflows, reduced quantities of freshwater inflow, and modified tidal and groundwater hydraulics (Kimmerer 2004; Mount et al. 2012; NRC 2012; Wagner et al. 2011). Water temperatures in summer now approach or exceed the upper thermal tolerances (e.g., 20°C to 25°C for cold-water fish species such as salmonids and Delta-dependent species such as Delta Smelt. This is especially true in parts of the South Delta and San Joaquin River, potentially restricting the distribution of these species and precluding previously important rearing areas (NRC 2012).

Landscape-scale changes resulting from flood management infrastructure, along with flow modification, have eliminated most of the historical hydrologic connectivity of floodplains and aquatic ecosystems in the Delta and its tributaries, thereby degrading and diminishing Delta habitat for native plant and animal communities (Mount et al. 2012). In addition, large-scale reclamation of tidal wetlands has also contributed to the degradation of habitat for Delta fishes. The large reduction of hydrologic variability and landscape complexity, coupled with degradation of water quality, has supported invasive aquatic species that have further degraded conditions for native species. Due to the combination of these factors, the Delta appears to have undergone an ecological regime shift unfavorable to many native species (Baxter et al. 2010), including Delta Smelt, Longfin Smelt, Sacramento Splittail, Green Sturgeon and White Sturgeon, and juvenile Chinook Salmon (Jassby et al. 1995; Kimmerer 2002a; Rosenfield and Baxter 2007; Kimmerer et al. 2009; Fish 2010; Perry et al. 2012; Thomson et al. 2010; Feyrer et al. 2010; Loboschefsky et al. 2012; Mount et al. 2012; Heublein et al. 2017).

In response to these landscape conditions, DWR is working with California EcoRestore to advance the restoration of at least 30,000 acres of tidal wetland, floodplain habitat, and riparian habitat throughout the Delta. DWR is the lead agency on 28 of the 30 EcoRestore projects, including but not limited to Decker Island, Bradmoore Island, Lookout Slough Tidal Habitat Restoration and Flood Improvement Project, Winter Island, and the Tule Red Project (DWR 2019b). Once the projects are constructed, they will be adaptively managed to improve habitat for Delta Smelt and other species. DWR is also working with other resource agencies, including CDFW which is leading the effort, to explore the feasibility of restoring a portion of Franks Tract to reduce invasive weeds and predation while increasing turbidity and fish food production (CDFW 2018).

Salinity is a critical factor influencing the distribution of plant and animal communities in the Delta. Although estuarine fish species are generally tolerant of a range of salinity, this tolerance varies by species and life stage. Some species can be highly sensitive to excessively low or high salinity during physiologically vulnerable periods, such as reproductive and early life stages. Although the Delta is tidally influenced, most of the Delta contains freshwater year-round due to inflows from rivers. However, the South Delta can have low salinity because of agricultural return water. In addition, the tidally influenced low salinity zone can move upstream into the Central Delta.

A measure of the spatial geography of salinity in the western Delta is X2, which is the distance in kilometers from the Golden Gate Bridge to the point where the salinity on the bottom is 2 ppt. The location of X2 has been used to help define the extent of habitat available for oligohaline pelagic organisms and their prey and has been correlated with the abundance of some species and the amount of suitable habitat for Delta Smelt in fall (Feyrer et al. 2007, 2010; USFWS 2008). Based on an analysis of historical monitoring data, Feyrer et al. (2007) defined the abiotic habitat of Delta Smelt as a specific envelope of salinity and turbidity that changes over the course of the species' life cycle. However, Murphy and Weiland (2019) suggest that the low salinity zone is not a reliable indicator of Delta Smelt habitat and by extension the distribution of the species within the Delta, given that the species frequently occurs outside the zone or that large parts of the zone do not have Delta Smelt. In recent decades, it has been suggested that lower outflows have tended to shift X2 during fall farther upstream out of the wide expanse of Suisun Bay into the much narrower channels near the confluence of the Sacramento and San Joaquin rivers (near Collinsville), thereby reducing the spatial extent of low-salinity habitat believed to be important for some species such as Delta Smelt (USFWS 2008, 2011; Kimmerer et al. 2009; Baxter et al. 2010). More recent studies comparing Delta outflow during pre-project and post-project time periods do not support the conclusion that project operations have significantly moved X2 more upstream in September, October, and November, relative to pre-project conditions (Hutton et al. 2015). Compared to pre-project conditions, Hutton et al. (2015) found no trend in X2 in July, October, and November, and the water projects were making conditions fresher in August and September.

Feyrer et al. (2007, 2010) conclude that an overall negative trend in habitat quality has occurred for Delta Smelt and Striped Bass (and potentially other fish species), as measured by water quality attributes and midwater trawl catch data since 1967, with Delta Smelt and Striped Bass experiencing the most apparent declines in abundance, distribution, and a related index of environmental quality. Mac Nally et al. (2010) evaluated 54 potential relationships between the four POD species' declines and environmental factors and found that few covariate relationships were expressed clearly for more than one of the four declining fish species. X2 in spring had a strong negative relationship with Longfin Smelt, spring calanoids and mysids, but none of the other POD species, while X2 in fall was negatively related only to Striped Bass abundance. Other factors, such as the introduction of non-native clam species (Feyrer et al. 2003; Kimmerer et al. 1994), shifts in phytoplankton and zooplankton community composition (Winder and Jassby 2011; Glibert et al. 2011), expansion of invasive aquatic weeds, and contaminants (Fong et al. 2016), also contribute to reducing habitat quality. The abundance of several taxa have been correlated with X2 (Jassby et al. 1995; Kimmerer 2002a, 2002b), suggesting that the quantity or suitability of estuarine habitat may increase when outflows are high. However, recent analyses by Kimmerer et al. (2009) indicated that neither changes in area or volume of low salinity water (habitat) appear to account for this relationship, except for Striped Bass and American Shad, which suggests that X2 may be indexing other environmental variables or processes rather than simple extent of habitat (Baxter et al. 2010).

Nutrients and Food Web Support

Nutrients are essential components of terrestrial and aquatic environments because they provide a resource base for primary producers. Typically, in freshwater aquatic environments, phosphorous is the primary limiting macronutrient, whereas in marine aquatic environments, nitrogen tends to be limiting. A balanced range of abundant nutrients provides optimal conditions for maximum primary production, a robust food web, and productive fish populations. However, changes in nutrient loadings and forms, excessive amounts of nutrients, and altered nutrient ratios can lead to a suite of problems in aquatic ecosystems, such as low dissolved oxygen concentrations, un-ionized ammonia, excessive growth of toxic forms of cyanobacteria, and changes in components of the food web. Nutrient concentrations in the Delta have been well studied (Jassby et al. 2002; Kimmerer 2004; Van Nieuwenhuyse 2007; Glibert et al. 2011, 2014).

Estuaries are commonly characterized as highly productive nursery areas for numerous aquatic organisms. Nixon (1988) noted that there is a broad continuum of primary productivity levels in different estuaries, which affects fish production and abundance. Compared to other estuaries, pelagic primary productivity in the upper San Francisco Estuary is relatively poor, and a relatively low fish yield is expected (Wilkerson et al. 2006). In the Delta and Suisun Marsh, this appears to result from turbidity, clam grazing (Jassby et al. 2002), and nitrogen and phosphorus dynamics (Wilkerson et al. 2006; Van Nieuwenhuyse 2007; Glibert et al. 2011, 2014).

A significant long-term decline in phytoplankton biomass (chlorophyll a) and primary productivity to low levels has occurred in the Suisun Bay region and the Delta (Jassby et al. 2002). Shifts in nutrient concentrations, such as high levels of ammonium and nitrogen relative to phosphorus (i.e., the ratios of nitrogen to phosphorous and ammonium to nitrate), may contribute to the phytoplankton reduction and to changes in algal species composition in the San Francisco Estuary (Wilkerson et al. 2006; Dugdale et al. 2007; Lehman et al. 2005, 2008b, 2010; Glibert et al. 2011, 2014). Low and declining primary productivity in the estuary may be contributing to the long-term pattern of relatively low and declining biomass of pelagic fishes (Jassby et al. 2002).

The introductions of two clams from Asia have led to major alterations in the food web in the Delta. Overbite clams (*Potamocorbula amurensis*) are most abundant in the brackish and saline water of Suisun Bay and the western Delta, and Asian clams (*Corbicula fluminea*) are most abundant in the freshwater of the Central Delta. These filter feeders significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes such as Delta Smelt and young Chinook Salmon (Feyrer et al. 2007; Kimmerer 2002a; Kimmerer and Thompson 2014).

In addition, introduction of the clams led to the decline of native copepods of higher food quality and the establishment of poorer quality non-native copepods. The clams have been blamed for the decline in *Neomysis mercedis* (Orsi and Mecum 1996; Feyrer et al. 2003), the shift in distribution of anchovies (Kimmerer 2006) and YOY Striped Bass (Kimmerer et al. 2000; Feyrer et al. 2003; Sommer et al. 2007), as well as the decline in diatoms (Kimmerer 2005) and several zooplankton species (Kimmerer et al. 1994). The impact of the clams on Chlorophyll a and the Bay-Delta ecosystem is also reflected by a shift in many of the original correlations between species abundance and X2, that occurred after the establishment of the clams (Kimmerer 2002b; Sommer et al. 2007).

More recently, the cyclopoid copepod, *Limnoithona*, has rapidly become the most abundant copepod in the Delta since its introduction in 1993 (Hennessy and Enderlein 2013). This species is hypothesized to be a low-quality food source and intraguild predator of native and non-native calanoid copepods (CRA 2005 as cited in Reclamation 2019). The overbite clam also has been implicated in the reduction of the native opossum shrimp, a preferred food of Delta native fishes such as Sacramento Splittail and Longfin Smelt (Feyrer et al. 2003). Reductions in food availability and food quality have led to lower fish foraging efficiency and reduced growth rates (Moyle 2002).

Studies on food quality have been relatively limited in the San Francisco Estuary, with limited information available regarding long-term trends. Nonetheless, several studies have documented or suggested the food limitations for aquatic species in the estuary, including zooplankton (Mueller-Solger et al. 2002; Kimmerer et al. 2005), Delta Smelt (Bennett 2005; Bennett et al. 2008), Chinook Salmon (Sommer et al. 2001), Sacramento Splittail (Greenfield et al. 2008), Striped Bass (Loboschefsky et al. 2012), and Largemouth Bass (Nobriga 2009).

Turbidity

Turbidity is an important water quality component in the Delta that affects physical habitat through sedimentation and food web dynamics by means of attenuation of light in the water column. Light attenuation, in turn, affects the extent of the photic zone where primary production can occur and the ability of predators to locate prey and for prey to escape predation.

Turbidity has been declining in the Delta, as indicated by sediment data collected by USGS since the 1950s (Wright and Schoellhamer 2004), and the decline has important implications for food web dynamics and predation. Higher water clarity is at least partially caused by increased water filtration and plankton grazing by highly abundant overbite clams and other benthic organisms (Kimmerer 2004; Greene et al. 2011) and potentially by filtration by high densities of aquatic vegetation (Hestir et al. 2016). High nutrient loads coupled with reduced sediment loads and higher water clarity could contribute to plankton and algal blooms and overall increased eutrophic conditions in some areas (Kimmerer 2004).

The first high-flow events of winter create turbid conditions in the Delta, which can be drawn into the South Delta during reverse flow conditions in the OMR. Delta Smelt may follow turbid waters into the southern Delta, increasing their proximity to project export facilities and, therefore, their entrainment risk (USFWS 2008). In response to the Delta Smelt Resiliency Strategy, DWR assessed the feasibility of adding sediment to increase turbidity in the low salinity zone of the Delta to improve Delta Smelt habitat conditions. Computer modeling was performed to assess (1) whether sediment supplementation is feasible, (2) the magnitude of supplement that would be required to affect turbidity, and (3) the spatial and temporal extent of supplementation to affect overall turbidity in the low salinity zone of the Delta (CNRA 2017). The results of the modeling predicted that 3,350 cubic yards per day of sediment release was needed to increase turbidity by 10 nephelometric turbidity units (NTU) from Emmaton and Mallard Island (Bever and MacWilliams 2018).

Contaminants

Contaminants can change ecosystem functions and productivity through numerous pathways. Trends in contaminant loadings and their ecosystem effects are not well understood in the San Francisco Estuary (Johnson et al. 2010; Brooks et al. 2012; Fong et al. 2016). A large body of research has been conducted on contaminant occurrence and effects on aquatic organisms in the Delta. A wide array of contaminants, including pesticides, metals, pharmaceuticals, and personal care products, have been detected in Delta water and sediment. Recent monitoring programs are routinely detecting multiple pesticides in each water sample from the Delta. For example, Fong et al. (2016) report that "For example, 27 pesticides or degradation products were detected in Sacramento River samples, and the average number of pesticides per sample was six. In San Joaquin River samples, 26 pesticides or degradation products were detected, and the average number detected per sample was 9." The effects of chemical mixtures on aquatic organisms is generally unknown but many chemicals may have additive or synergistic effects. Anthropogentic toxins cause significant disruption to development, reduce growth and recruitment, and increase mortality (Johnson et al. 2010).

In addition to anthropogenic contaminants, natural toxins are associated with blooms of *Microcystis aeruginosa*, a cyanobacterium that releases a potent toxin known as microcystin. Toxic microcystins cause food web impacts at multiple trophic levels, and histopathological studies of fish liver tissue suggest that fish exposed to elevated concentrations of microcystins have developed liver damage and tumors (Lehman et al. 2005, 2008b, 2010; Acuna et al. 2012a and 2012b).

There are longstanding concerns related to mercury and selenium in the Sacramento and San Joaquin watersheds, the Delta, and San Francisco Bay. DWR is conducting an additional study to determine imports and exports of mercury and methylmercury from freshwater tidal wetlands in the Delta and Suisun Marsh per the Sacramento San Joaquin Delta Methylmercury TMDL and Basin Plan Amendment (Lee et al. 2015; Wood et al. 2010). Current research shows that tidal wetlands do not export mercury or methylmercury in large amounts, although seasonal differences occur and imports and exports are heavily influenced by flow and whether the wetland is associated with a floodplain (Mitchell et al. 2012; Lee et al. 2015, Lee et al. in progress). Methylmercury increases in concentration at each level in the food chain and can cause concern for people and birds that eat piscivorous fish (e.g., Striped Bass) and benthic fishes such as sturgeon. Studies summarized by Alpers et al. (2008) indicate that mercury in fish has been linked to hormonal and reproductive effects, liver necrosis, and altered behavior in fish. A study by Lee at al. (2011) on dietary methylmercury noted significant abnormalities in the liver and kidneys, lower growth rates, and higher mortality in both Green Sturgeon and White Sturgeon, but particularly in Green Sturgeon. With regard to selenium, benthic foragers like diving ducks, sturgeon, and Sacramento Splittail have the greatest risk of selenium toxicity. Beckon and Maurer (2008) suggest that salmonids are probably among the species that are most sensitive to selenium, while Delta Smelt are likely to be at low risk of selenium toxicity. The invasion of the non-native bivalves (e.g., overbite clams) has resulted in increased bioavailability of selenium to benthivores in San Francisco Bay (Linville et al. 2002).

Baxter et al. (2008) prepared a 2007 synthesis of results as part of a POD Progress Report, including a summary of prior studies of contaminants in the Delta. The summary included studies, which suggested that phytoplankton growth rates may be inhibited by localized high concentrations of herbicides (Edmunds et al. 1999). Toxicity to invertebrates has been noted in water and sediments from the Delta and associated watersheds (Kuivila and Foe 1995; Weston et al. 2004, 2014, 2019). The 2004 Weston study of sediment toxicity recommended additional study of the effects of the pyrethroid insecticides on benthic organisms. Undiluted drainwater from agricultural drains in the San Joaquin River watershed can be acutely toxic (quickly lethal) to fish (e.g., Chinook Salmon and Striped Bass) and have chronic effects on growth, likely because of high concentrations of major ions (e.g., sodium and sulfates) and trace elements (e.g., chromium, mercury, and selenium) (Saiki et al. 1992).

A more recent synthesis of contaminant studies described multiple lines of evidence that contaminants affect species of concern in the Bay-Delta (Fong et al. 2016). Fong et al. (2016) reported that many contaminants detected in Delta waters exceed regulatory standards and most water samples contain multiple contaminants. They also summarize the multiple studies that have found sublethal, lethal, chronic, and acute toxicity of Bay-Delta water to test species and Delta species of concern, including Delta Smelt and salmon.

Fish Passage and Entrainment

With its complex network of channels, low eastern and southern tributary inflows, and reverse currents created by pumping for water exports, the Delta presents a challenge for anadromous and resident fish during upstream and downstream migration. These complex conditions can lead to straying, extended exposure to predators, and entrainment during outmigration. Tidal elevations, salinity, turbidity, Delta inflow, meteorological conditions, season, habitat conditions, and project exports all have the potential to influence fish movement, currents, and ultimately the level of entrainment and fish passage success and survival. These issues are the subject of extensive research and adaptive management efforts (IRP 2010, 2011).

North Delta Fish Passage and Entrainment

In the North Delta, migrating fish have multiple potential pathways as they move upstream into the Sacramento or Mokelumne river systems. Michel et al. (2010, 2015) used acoustic telemetry to examine survival of Late Fall-run Chinook Salmon smolts outmigrating from the Sacramento River through the Delta and San Francisco Estuary. Survival was lowest in the freshwater portion (Delta) and the brackish portion of the estuary relative to survival in the riverine portion of the migration route. Marston et al. (2012) studied stray rates for immigrating San Joaquin River Basin adult salmon that stray into the Sacramento River Basin. Results indicated that it was unclear whether reduced San Joaquin River pulse flows or elevated exports caused increased stray rates. The DCC, when open, can divert fish into the interior Delta from the Sacramento River as they emigrate. The opening of the DCC when salmon are returning to spawn to the Mokelumne and Cosumnes rivers is believed to lead to increased straying of these fish into the American and Sacramento rivers because of confusion over olfactory cues. Experimental DCC closures have been scheduled during the Fall-run Chinook Salmon migration season for selected days, coupled with pulsed flow releases from reservoirs on the Mokelumne River, in an attempt to reduce straying rates of returning adults. These closures have corresponded with reduced recoveries of Mokelumne River Hatchery fish in the American River system and increased returns to the Mokelumne River Hatchery (EBMUD 2012).

Outmigrating juvenile fish moving down the mainstem Sacramento River can also enter the DCC when the gates are open and travel through the Delta via the Mokelumne and San Joaquin River channels. In the case of juvenile salmonids, this shifted route from the North Delta to the Central Delta increases their mortality rate (Kjelson and Brandes 1989; Brandes and McLain 2001; Newman and Brandes 2010; Perry et al. 2010, 2012). Steel et al. (2012) found that the best predictor of which route was selected was the ratio of mean water velocity between the two routes. Salmon migration studies show losses of approximately 65% for groups of outmigrating fish that are diverted from the mainstem Sacramento River into the waterways of the central and southern Delta (Brandes and McLain 2001; Vogel 2004, 2008; Perry and Skalski 2008). Perry and Skalski (2008) found that, by closing the DCC gates, total through-Delta survival of marked fish to Chipps Island increased by nearly 50% for fish moving downstream in the Sacramento River system. Closing the DCC gates appears to redirect the migratory path of outmigrating fish into Sutter and Steamboat sloughs and the Sacramento River and away from Georgiana Slough, resulting in higher survival rates. Species that may be affected include juvenile Green Sturgeon, steelhead, and Winter-run and Spring-run Chinook Salmon (NMFS 2009a).

However, analysis by Perry et al. (2015, 2018) suggests that the mechanisms governing route selection are more complex. Their analysis revealed the strong influence of tidal forcing on the probability of fish entrainment into the interior Delta. The probability of entrainment into both Georgiana Slough and the DCC was highest during reverse-flow flood tides, and the probability of fish remaining in the Sacramento River was near zero during flow reversals (Perry et al. 2015). The magnitude and duration of reverse flows at this river junction decrease as inflow of the Sacramento River increases. Consequently, reduced Sacramento River inflow increases the frequency of reverse flows at this junction, thereby increasing the proportion of fish that are entrained into the interior Delta, where mortality is high (Perry 2010).

Fish passage in the North Delta also can be affected by water quality. Water quality in the mainstem Sacramento River and its distributary sloughs can be poor at times during summer, creating conditions that may stress migrating fish or even impede migration. These conditions include low dissolved oxygen and high water temperatures. For adult Chinook Salmon, dissolved oxygen concentration less than 3 to 5 mg/L can impede migration (Hallock et al. 1970), as can mean daily water temperatures of 70°F to 73°F (approximately 21°C to 23°C), depending on whether water temperatures are rising or falling (Strange 2010). Dissolved oxygen levels are generally greater than 5 mg/L throughout the Delta, but water temperatures can exceed these thresholds during summer and fall. Contaminants at concentrations that have been detected in the Delta have also been found to impair olfactory responses in many fish, which can lead to straying (Fong et al. 2016; Sandahl et al. 2007; and Tierney et al. 2010).

The SWP Barker Slough Pumping Plant, located on a tributary to Cache Slough, may cause larval fish entrainment. The intake is equipped with a positive barrier fish screen to prevent fish at least 25 mm in size from being entrained. CDFW found low levels of entrainment of larval Delta Smelt less than 20 mm at Barker Slough during the mid-1990s to mid-2000s, and pumping rates are reduced when Longfin Smelt larvae are present in the vicinity to minimize entrainment into the North Bay Aqueduct.

Central and South Delta Fish Passage and Entrainment

The South Delta intake facilities include the CVP and SWP export facilities; local agency intakes, including Contra Costa Water District intakes; and agricultural intakes. Contra Costa Water District intakes and the Contra Costa Canal Pumping Plant include fish screens. However, most of the remaining intakes do not include fish screens. Water flow patterns in the South Delta are influenced by water diversion actions and operations, seasonal temporary barriers, and tides and river inflows to the Delta (Kimmerer and Nobriga 2008). Water from the San Joaquin River mainly moves downstream through the HOR and through the channels of the Old and Middle rivers and Grant Line and Fabian-Bell canals toward the South Delta intake facilities. Conversely, when water to the north of the diversion points for the two facilities moves southward (upstream), the net flow is negative (toward) the pumps. When the temporary barriers are installed from April through November, internal reverse circulation is created within the channels isolated by the barriers from other portions of the South Delta. These conditions are most pronounced during late spring through fall when San Joaquin River inflows are low and water diversion rates are typically high. Drier hydrologic years also reduce the frequency of net downstream flows in the South Delta and mainstem San Joaquin River. While Delta flows are tidal and naturally reverse twice daily, Delta diversions can create net reverse flows, which may draw some fish toward project facilities (Arthur et al. 1996; Kimmerer et al. 2008; Grimaldo et al. 2009).

A portion of fish that enter the Jones Pumping Plant approach channel and the CCF are salvaged at screening and fish salvage facilities, transported downstream by trucks, and released. NMFS (2009a) estimates that the direct loss of fish from the screening and salvage process is in the range of 65% to 83.5% for fish from the point they enter the CCF or encounter the trash racks at the CVP facilities. In addition, mark-recapture experiments indicate that most fish are probably subject to predation prior to reaching the fish salvage facilities (e.g., in the CCF) (Gingras 1997; Clark et al. 2009; Castillo et al. 2012). Aquatic organisms (e.g., phytoplankton and zooplankton) that serve as food for fish also are entrained and removed from the Delta (Jassby et al. 2002; Kimmerer et al. 2008; Brown et al. 1996). Fish entrainment and salvage are of particular concern during dry years when the distributions of young Striped Bass, Delta Smelt, Longfin Smelt, and other migratory fish species may shift closer to the project facilities (Stevens et al. 1985; Sommer et al. 1997).

Salvage estimates reflect the number of fish entrained by project exports, but these numbers alone do not account for other sources of mortality related to the export facilities. These numbers do not include pre-screen losses that occur in the waterways leading to the diversion facilities, which may in some cases reduce the number of salvageable fish (Gingras 1997; Clark et al. 2009; Castillo et al. 2012). Pre-screen losses are reported to account for most Delta Smelt mortality (Castillo et al. 2012). In addition, larval fish are not salvaged because they cannot be diverted from the export facilities by existing fish screens. The number of fish salvaged also does not include losses of fish that pass through the louvers intended to guide fish into the fish collection facilities or the losses during collection, handling, transport, and release back into the Delta.

The life stage of the fish at which entrainment occurs may be important for population dynamics (IRP 2011). For example, winter entrainment of Delta Smelt, Longfin Smelt, and Threadfin Shad may correspond to migration and spawning of adult fish, and spring and summer exports may overlap with development of larvae and juveniles. The loss of prespawning adults and all their potential progeny may have greater consequences than entrainment of the same number of larvae or juvenile fish.

While swimming through South Delta channels, fish can be subjected to stress from poor water quality (seasonally high temperatures, low dissolved oxygen, high water transparency, and *Microcystis* blooms) and low water velocities, which create lacustrine-like conditions. Any of these factors can cause elevated mortality rates by weakening or disorienting the fish and increasing their vulnerability to predators (Vogel 2011).

Considerable debate remains regarding the relationship between the export to inflow ratio on the survival of Fall-run Chinook Salmon and Central Valley Steelhead. The Salmon Scoping Team evaluated data from multiple studies and found a positive relationship between April and May ratios of inflow to exports (I:E) and through-Delta survival of San Joaquin River Fall-run Chinook Salmon when the HORB is in place. They also found that Fall-run Chinook Salmon survival in the San Joaquin River from Mossdale to the Turner Cut junction tends to increase for higher I:E values but data for the tidal portion of the Delta are mixed, with Chinook Salmon survival being highest for an I:E ratio of approximately 2, and lowest for I:E ratios of approximately 1 or greater than 4. They found no evidence linking survival through the facilities to I:E (SST 2017).

For steelhead, the SST (2017) found survival in the South Delta tended to increase for higher levels of I:E, but observations are limited to 2 years of AT data available (2011 and 2012). Survival increased from the Turner Cut junction to Chipps Island, and overall from Mossdale to Chipps Island, as the April to May I:E increased. However, the pattern was weaker than the survival pattern observed for inflow based on SST scatterplots. Survival estimates from Mossdale to the Turner Cut junction were similar regardless of I:E based on SST scatterplots. Survival from the CVP trash rack through the facility to Chipps Island, and from the CCF radial gates to Chipps Island, increased with I:E for fish released during April and May (SST 2017). They further conclude that the high correlation between inflow and exports limits the ability to evaluate survival over a range of I:E ratios. Although not directly comparable, this contrasts with the results of Zeug and Cavallo (2013), who also found little evidence that large-scale water exports or inflows influenced CWT recovery rates in the ocean from 1993 to 2003.

In contrast, Cunningham et al. (2015) found a negative influence of the export/inflow ratio on the survival of Fall-run Chinook Salmon populations and a negative influence of increased total Delta exports on the survival of Spring-run Chinook Salmon populations. An increase in total exports of 1 standard deviation from the 1967 to 2010 average was predicted to result in a 68.1% reduction in the survival of Deer, Mill, and Butte Creek Spring-run Chinook Salmon. Similarly, an increase in the ratio of Delta water exports to Delta inflow of 1 standard deviation was expected to reduce survival of the four Fall-run Chinook Salmon populations by 57.8% (Cunningham et al. 2015). Although a mechanistic explanation for the reduction in survival remains elusive, "direct entrainment mortality seems an unlikely mechanism given the success of reclamation and transport procedures, even given increased predation potential at the release site. Changes to water routing may provide a more reasonable explanation for the estimated survival influence of Delta water exports" (Cunningham et al. 2015).

Delaney et al. (2014) reported results of a mark-recapture experiment examining the survival and movement patterns of acoustically tagged juvenile steelhead emigrating through the Central Delta and South Delta. Their results indicated that most tagged steelhead remained in the mainstem San Joaquin River (77.6%). However, approximately one quarter (22.4%) of tagged steelhead entered Turner Cut. Route-specific survival probability for tagged steelhead using the Turner Cut route was 27.0%. The survival probability for tagged steelhead using the mainstem route was 56.7% (Delaney et al. 2014). Travel times for tagged steelhead also differed between these two routes, with steelhead using the mainstem route reaching Chipps Island significantly sooner than those that used the Turner Cut route. Travel time was not significantly affected by the limited Old and Middle River (OMR) flow treatments examined in their study. While not significant, there was some evidence that fish movement toward each export facility could be influenced by the relative volume of water entering the export facility (Delaney et al. 2014).

Research conducted during 2010 and 2011 showed that upriver movements of adult Delta Smelt are achieved through a form of tidal rectification or active tidal transport by using lateral movement to shallow edges of channels on ebb tides to maintain their position (IRP 2010, 2011; Bennett and Burau 2015). Turbidity gradients could be involved in the lateral positioning of Delta Smelt within the channels, but large-scale turbidity pulses through the system may not be necessary to trigger upriver migrations of Delta Smelt if they are already occupying sufficiently turbid water (IRP 2011). Understanding of tidal and turbidity effects on Delta Smelt behavior may have important implications for the Delta Smelt monitoring programs that are the basis for biological triggers for implementing OMR restrictions.

There are more than 2,200 diversions in the Delta (Herren and Kawasaki 2001). These irrigation diversion pipes are shore-based, typically small (30 to 60 cm pipe diameter), and operated via pumps or gravity flow, and most lack fish screens. These diversions increase total fish entrainment and losses and alter local fish movement patterns (Kimmerer and Nobriga 2008). Delta Smelt have been found in samples of Delta irrigation diversions, as well as larger wetland management diversions downstream. However, Nobriga et al. (2004) found that the low and inconsistent entrainment of Delta Smelt measured in the study reflected offshore habitat use by Delta Smelt and relatively small hydrodynamic influence of the diversions.

Non-Native Invasive Species

Non-native invasive species influence the Delta ecosystem by increasing competition and predation on native species, reducing habitat quality (as result of invasive aquatic macrophyte growth), and reducing food supplies by altering the aquatic food web. Not all non-native species are considered invasive. CDFG (2008) defines invasive species as "species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat." Some introduced species have minimal ability to spread or increase in abundance. Others have commercial or recreational value (e.g., Striped Bass, American Shad, and Largemouth Bass).

Many non-native fishes have been introduced into the Delta for sport fishing (game fish such as Striped Bass, Largemouth Bass, Smallmouth Bass, Bluegill, and other sunfish), as forage for game fish (Threadfin Shad, Golden Shiner, and Fathead Minnow), for vector control (Inland Silverside, Western Mosquitofish), for human food use (Common Carp, Brown Bullhead, and White Catfish), and from accidental releases (Yellowfin Goby, Shimofuri Goby, and Shokihaze Goby) (Moyle 2002). Introduced fish may compete with native fish for resources and, in some cases, may prey on native species.

Because of invasive species and other environmental stressors, native fishes have declined in abundance throughout the region (Matern et al. 2002; Brown and Michniuk 2007; Sommer et al. 2007a; Mount et al. 2012). Habitat degradation, changes in hydrology and water quality, and stabilization of natural environmental variability are all factors that generally favor non-native, invasive species (Mount et al. 2012; Moyle et al. 2012).

As described in *Nutrients and Food Web Support* above, the introductions of two clams from Asia have led to major alterations in the food web in the Delta. Overbite clams (*Potamocorbula amurensis*) and Asian clams (*Corbicula fluminea*) \ significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes, such as Delta Smelt and young Chinook Salmon (Feyrer et al. 2007; Kimmerer 2002b).

Predation

Predation is an important factor that influences the behavior, distribution, and abundance of prey species in aquatic communities to varying degrees. Predation can have differing effects on a population of fish, depending on the size or age selectivity, mode of capture, mortality rates, and other factors. Predation is a part of every food web, and native Delta fishes were part of the historical Delta food web. Because of the magnitude of change in the Delta from historical times and the introduction of non-native predators, it is logical to conclude that predation may have increased in importance as a mortality factor for Delta fishes, with some observers suggesting that it is likely the primary source of mortality for juvenile salmonids in the Delta (Vogel 2011). NMFS (2014) rated predation of juvenile Winter-run Chinook Salmon and Spring-run Chinook Salmon during rearing and outmigration as a stressor of “Very High” importance. Predation occurs by fish, birds, and mammals, including sea lions.

A panel of experts was convened to review data on predation in the Delta and draw preliminary conclusions on the effects of predation on salmonids. The panel acknowledged that the system supports large populations of fish predators that consume juvenile salmonids (Grossman et al. 2013). However, the panel concluded that because of extensive flow modification, altered habitat conditions, native and non-native fish and avian predators, temperature and dissolved oxygen limitations, and the overall reduction in salmon population size, it was unclear what proportion of juvenile salmonid mortality could be attributed to predation. The panel further indicated that predation, while the proximate cause of mortality, may be influenced by a combination of other stressors that make fish more vulnerable to predation.

Striped Bass, White Catfish, Largemouth Bass and other centrarchids, and Silversides are among the introduced, non-native species that are notable predators of smaller-bodied fish species and juveniles of larger species in the Delta. Along with Largemouth Bass, Striped Bass are believed to be major predators on larger-bodied fish in the Delta. In open-water habitats, Striped Bass are most likely the primary predator of juvenile and adult Delta Smelt (DWR et al. 2013) and can be an important open-water predator on juvenile salmonids (Johnston and Kumagai 2012). Native Sacramento Pikeminnow may also prey on juvenile salmonids and other fishes. Limited sampling of smaller pikeminnows did not find evidence of salmonids in the foregut of Sacramento Pikeminnow (Nobriga and Feyrer 2007), but this does not mean that Sacramento Pikeminnow do not prey on salmonids in the Delta.

Largemouth Bass abundance has increased in the Delta over the past few decades (Brown and Michniuk 2007). Although Largemouth Bass are not pelagic, their presence at the boundary between the littoral and pelagic zones makes it probable that they opportunistically consume pelagic fishes. The increase in salvage of Largemouth Bass occurred during the time period when Brazilian waterweed was expanding its range in the Delta (Brown and Michniuk 2007). The beds of Brazilian waterweed provide good habitat for Largemouth Bass and other species of centrarchids. Largemouth Bass have a much more limited distribution in the estuary than Striped Bass, but a higher per capita impact on small fishes (Nobriga and Feyrer 2007). Increases in Largemouth Bass may have had a particularly important effect on Threadfin Shad and Striped Bass, whose earlier life stages occur in littoral habitat (Grimaldo et al. 2004; Nobriga and Feyrer 2007).

Invasive Mississippi Silversides are another potentially important predator of larval and pelagic fishes in the Delta. This introduced species was not believed to be an important predator on Delta Smelt, but studies using DNA techniques detected the presence of Delta Smelt in the guts of 12.5% of Mississippi Silversides sampled in midchannel trawls across a variety of habitats in the North Delta and identified turbidity as a significant predictor of predation (Baerwald et al. 2012; Schreier et al. 2016). This finding may suggest that predation impacts could be significant, given the increasing numbers of Mississippi Silversides in the Delta (Mahardja et al. 2016) and decreasing trends in turbidity (Feyrer et al. 2007).

Predation of fish in the Delta is known to occur in specific areas, for example, at channel junctions and areas that constrict flow or confuse migrating fish and provide cover for predatory fish (Vogel 2011). Sabal (2014) found similar results at Woodbridge Dam on the Mokelumne River where the dam was associated with increased Striped Bass per capita salmon consumption, which decreased outmigrant juvenile salmon survival by 10% to 29%. CDFW (CDFG 1992) identified subadult Striped Bass as the major predatory fish in the CCF. In 1993, for example, Striped Bass made up 96% of the predators removed (Vogel 2011). Cavallo et al. (2012) studied tagged salmon smolts to test the effects of predator removal on outmigrating juvenile Chinook Salmon in the South Delta. Their results suggested that predator abundance and migration rates strongly influenced survival of salmon smolts. Exposure time to predators has been found to be important for influencing survival of outmigrating salmon in other studies in the Delta (Perry et al. 2012).

DWR examined the species distribution and abundance of salvaged fish at the SWP pumping facilities to determine whether alternative release scenarios between salvaged Delta Smelt and predatory species would increase smelt survival. An initial evaluation of historical records on species distribution of salvaged fish lead to the conclusion that adjusting salvage operations to stop returning predatory fish to the Delta would have little impact on Delta Smelt survival (CNRA 2017, p. 3).

Aquatic Macrophytes

Aquatic macrophytes are an important component of the biotic community of Delta wetlands and can provide habitat for aquatic species, serve as food, produce detritus, and influence water quality through nutrient cycling and dissolved oxygen fluctuations. Whipple et al. (2012) described likely historical conditions in the Delta, which have been modified extensively, with major impacts on the aquatic macrophyte community composition and distribution. The primary change has been a shift from a high percentage of emergent aquatic macrophyte wetlands to open water and hardened channels.

The introduction of two non-native invasive aquatic plants, water hyacinth and Brazilian waterweed, has reduced habitat quantity and value for many native fishes. Water hyacinth forms floating mats that greatly reduce light penetration into the water column, which can significantly reduce primary productivity and available food for fish in the underlying water column. Brazilian waterweed grows along the margins of channels in dense stands that prohibit access by native juvenile fish to shallow water habitat. In addition, the thick cover of these two invasive plants provides excellent habitat for non-native ambush predators such as bass, which prey on native fish species. Studies indicate low abundance of native fish, such as Delta Smelt, Chinook Salmon, and Sacramento Splittail, in areas of the Delta where submerged aquatic vegetation infestations are thick (Grimaldo et al. 2004, 2012; Nobriga et al. 2005).

Invasive aquatic macrophytes are still equilibrating within the Delta and resulting habitat changes are ongoing, with negative impacts on habitats and food webs of native fish species (Toft et al. 2003; Grimaldo et al. 2009). Concerns about invasive aquatic macrophytes are centered on their ability to form large, dense growth that can clog waterways, block fish passage, increase water clarity, provide cover for predatory fish, and cause high biological oxygen demand. DWR is actively engaged in a program of aquatic weed control. Building on the state's existing herbicide treatment program, DWR targeted 200 acres of Delta Smelt habitat at Decker Island in the western Delta and the Cache Slough complex in the North Delta. Ongoing field studies are investigating the effect of herbicide treatment on Delta Smelt habitat (CNRA 2017).

Interagency Ecological Program Monitoring in the Delta

IEP is a consortium of California State and U.S. Federal agencies that guides and performs scientific research on the aquatic ecosystem of the Sacramento-San Joaquin Delta and San Francisco Bay. Beginning in 1970, the IEP has overseen a monitoring program that investigates the conditions of a number of ecosystem parameters, both biotic and abiotic in nature. Information gathered from these investigations, along with modeling and related research, is synthesized for use by the consortium agencies for decision-making purposes. DWR has contributed to the IEP for many years, both in terms of program governance (participating in and funding oversight and coordination, and helping to develop goals, strategies, and annual work plans) as well as performance or funding of the scientific activities, or both, of annual work plans. Table 4.4-2 highlights the 2019 IEP Work Plan activities that

DWR is either performing or funding that focus on Delta Smelt or provide incidental information to support management actions to improve Delta Smelt abundance, distribution, or habitat conditions. The name and description of each activity is taken directly from the "2019 IEP Work Plan Element Details" (IEP 2018).

Table 4.4-2. Interagency Ecological Program 2019 Work Plan Activities Performed or Funded by the California Department of Water Resources

Action	Description
Fall Midwater Trawl Survey	The Fall Midwater Trawl (FMWT) Survey provides long-term abundance trend information for age-0 Striped Bass, age-0 American Shad, Splittail, Threadfin Shad, Delta Smelt, and Longfin Smelt. These data will be used by California Department of Fish and Wildlife (CDFW) personnel in conjunction with other survey data to determine species status and to evaluate the success of various mitigation and restoration plans for fishes in the estuary. Delta Smelt data are used to calculate a recovery index as described in the Delta Smelt Biological Opinion (USFWS 2008) and by the U.S. Fish and Wildlife Service (USFWS) to set salvage limits for the Central Valley Project (CVP) and State Water Project (SWP).
Summer Townet Survey	The Summer Townet Survey (STN) samples throughout the summer with a towed, small mesh net from eastern San Pablo Bay throughout the Delta to monitor the annual abundance and distribution of juvenile fish in the upper estuary and evaluate factors affecting abundance. Annual Delta Smelt and Striped Bass indices are used to track long-term trends of relative abundance. Water quality profile and simultaneous zooplankton samples are collected as well. Data from this element was used to help determine the conservation status of Delta Smelt, Longfin Smelt, and Splittail.
Estuarine and Marine Fish Abundance and Distribution Survey	The primary objective of this element is to determine the effects of freshwater outflow and outflow related mechanisms on the abundance and distribution of estuarine and marine fishes and brachyuran crabs. The monthly midwater and otter trawling survey (since 1980) samples at 52 channel and shoal stations from South San Francisco Bay to the lower Sacramento and San Joaquin rivers, and tracks abundance and distribution trends of marine and estuarine fishes. Data are used to assess the status of marine and estuarine fishes in the estuary, as required by Water Right Decision 1641 (D-1641). (Note: This is part of the CDFW Bay Study.)
Bay Shrimp and Crab Abundance and Distribution Surveys	The primary objective of this element is to determine the effects of freshwater outflow and outflow related mechanisms on the abundance and distribution of caridean shrimp. The trawling survey described for 2019-2011 also includes the collection and processing of Caridean shrimp to track abundance and distribution trends of Bay and estuarine shrimp species. Data are used to assess the status of shrimp in the estuary.
Bay Salinity Monitoring	This element samples salinity and water temperature in San Francisco Bay. Data are used to better understand the hydrodynamics of the estuary and calibration of multi-dimensional flow and transport models. Understanding how these variables are distributed around the Bay leads to a better understanding of habitat types and fish distribution in the Bay. Time series of water temperature and specific conductance samples (salinity is calculated from conductivity and water temperature) are needed (1) to improve our understanding of the hydrodynamics of the estuary (e.g., gravitational circulation), (2) for calibration of multidimensional flow and transport models of the Bay, (3) to better understand the distribution of physiochemical habitat types throughout the Bay, and (4) to provide supporting data for numerous estuarine studies of the Bay and Delta.

Action	Description
Delta Flow Measurement Database Management	The Delta Flow Network consists of 35 flow and water quality monitoring stations located throughout the Sacramento-San Joaquin Delta; 11 of these stations are supported by IEP. Data from this network of stations are used by Delta managers and scientists to make real-time decisions and plan for future events, such as climate change, water operations, restoration projects, evaluations of fish transport, and migration issues. In addition, these data are used to calibrate and validate numerical models that are used to predict water levels, flow speeds, and spatial and temporal evolution of salinity in the Delta. The data collected at these stations are critical for understanding the circulation and mixing patterns in the complex and interconnected channels that comprise the Delta region. Understanding Delta hydrodynamics is imperative to understanding the impacts of proposed major infrastructure projects and the regulatory actions being taken to protect endangered species in the Delta.
20-mm Survey Delta Smelt	This element is a fine-mesh trawl survey that monitors larval and juvenile Delta Smelt and Longfin Smelt distribution throughout its historical spring range in the Sacramento-San Joaquin Delta and San Francisco Estuary. Zooplankton sampling and water quality sampling are conducted simultaneously. Sampling is conducted every 2 weeks from mid-March through mid-July at 35 to 40 stations from eastern San Pablo Bay through the Delta. The near-real-time sample processing enables distribution data to be used by agency managers in the Smelt Working Group to assess the risk of Delta Smelt and Longfin Smelt entrainment.
Juvenile Salmon Monitoring	This element will conduct weekly beach seining (year-round) within the lower Sacramento River and Delta, weekly seining in the lower San Joaquin River (January through June), and biweekly seining in San Francisco Bay and San Pablo Bay (November through June) to monitor the relative abundance and distribution of juvenile Chinook Salmon in unobstructed near-shore habitats. In addition, year-round surface trawling is conducted at Chipps Island and Sacramento to monitor juvenile Chinook Salmon abundance entering and exiting the Delta. Surface trawling at Mossdale is conducted from July to March to monitor the abundance and temporal distribution of juvenile Chinook Salmon entering the Delta. The surface trawling at Mossdale is conducted in cooperation with CDFW, which monitors at Mossdale from April to June.
Coleman National Fish Hatchery Late Fall-run Production Tagging	This element consists of coded-wire tagging of all Coleman National Fish Hatchery Late Fall-run production to ensure proper race identification during subsequent recovery of fish at Delta export facilities and in juvenile and adult sampling programs. Approximately 1,100,000 Late Fall-run Chinook Salmon will be marked and tagged each year. Recovery of tagged Late Fall-run Chinook Salmon is also part of the Spring-run Chinook Salmon recovery plan.
Mossdale Spring Trawl	This study is part of an overall effort to provide “near-time” information on the relative vulnerability of key fish species (primarily Chinook Salmon and steelhead) to water project operations. This supports California Department of Fish and Game’s (CDFG’s) Region 4 field work as well as collation and reporting of data from the Mossdale trawl-sampling program from April through June. Sampling results are made available within 48 hours via the Internet.
Environmental Monitoring Program	This element monitors water quality at 22 sites in San Pablo Bay, Suisun Bay, and the Delta in compliance with D-1641. In addition to basic water quality parameters, chlorophyll, phytoplankton, benthic, and zooplankton samples are collected. Continuous collection of water quality data for multiple parameters, including electrical conductivity or salinity, is telemetered to the California Data Exchange Network, and the data are available on a near real-time basis for day-to-day CVP and SWP operational decisions. Identification and enumeration of phytoplankton and benthic organisms, water quality constituents, and quality control samples should be available within 2 months of collection.
San Joaquin River Dissolved Oxygen Monitoring	DWR’s Bay-Delta Monitoring and Analysis Section has been monitoring dissolved oxygen (DO) levels in the Stockton Ship Channel (channel) during the late summer and fall since 1968. As low DO levels can have adverse impacts on fisheries and other beneficial uses of the waters within the Bay-Delta, the State Water Resources Control Board (SWRCB) established specific water quality objectives to protect these uses. This objective is established to protect Fall-run Chinook Salmon and applies to the lower San Joaquin River between Stockton and Turner Cut, which includes the eastern channel. Data are used to guide water project operations and barrier placement per the baseline objectives.

Action	Description
Central Valley Juvenile Salmon and Steelhead Monitoring (Knights Landing)	The data collected (since 1995) provide an early warning of when juvenile salmon emigrate from the Delta, and allows for real-time adaptive management of water operations. This sampling effort uses paired 8-foot rotary screw traps located near the town of Knights Landing. The season begins in October and continues through June of the following year. For salmonids specifically, data collection includes enumeration by life stage, race, fork lengths, and wet weight for assessing the condition factor of individual fish. A subsample of captured adipose fin-clipped (hatchery origin) Chinook Salmon are held for coded-wire tag reading to assess emigration rates of fish released from upstream hatcheries. In addition, a percentage of Fall-run Chinook Salmon are marked and recaptured as part of calculating passage. The daily catch is summarized and distributed by e-mail to agency representatives and water operations managers.
Upper Estuary Zooplankton Sampling	As a means of assessing trends in fish food resources, the Zooplankton Study has estimated the abundance of zooplankton taxa in the upper San Francisco Estuary since 1972, and it is part of a D-1641 mandate to monitor water quality and related parameters (see element #72). Sampling with three gear types occurs monthly at 22 stations located throughout San Pablo Bay, Suisun Marsh, Suisun Bay, and the Delta
Spring Kodiak Trawl	This program element provides detection of mature and maturing Delta Smelt from January through May. Improved detection of Delta Smelt will better inform water export facility operators of the potential to entrain adult Delta Smelt in subsequent weeks, as well as their offspring later in the year. Monthly Kodiak trawl sampling occurs from the Napa River and Carquinez Straight through the Delta. The data collected indicate the distribution and maturity status of adult Delta Smelt and the occurrence of spent female Delta Smelt, as an indication of the onset of larval recruitment in the Delta. Data are provided shortly after sampling to the Smelt Working Group and Water Operations Management Team.
University of California, Davis (UC Davis) Suisun Marsh fish Monitoring	The study (since 1979) monitors fish populations in Suisun Marsh, especially in response to modifications being made on the way water moves through the marsh. Monthly sampling is conducted within 21 sites among nine sloughs in Suisun Marsh, using a combination of otter trawls and beach seines. The objectives of the study are to understand the entire assemblage of fishes in the marsh by examining such factors as changes in species abundance and composition through time, fish use of various habitats within the marsh, and changes in fish assemblages in association with natural and anthropogenic change. This study informs management decisions and provides the key background information needed to determine the success of marsh restoration projects.
Smelt Larva Survey	This survey provides near real-time distribution data for Longfin Smelt (LFS) larvae in the Delta, Suisun Bay and Suisun Marsh. Data are used by agency managers to assess vulnerability of Longfin Smelt larvae to entrainment in South Delta export pumps. Sampling begins within the first 2 weeks in January and repeats every other week through the second week in March. The data are used to assist CDFW, USFWS, and the Smelt Working Group in assessing the risks of entrainment by the SWP and CVP and determining the Old and Middle River (OMR) levels designed to minimize take of juvenile LFS at these facilities.
Operation of Thermograph Stations	The U.S. Geological Survey (USGS) will maintain temperature stations at the San Joaquin River near Vernalis and the Sacramento River below Wilkens Slough near Grimes. Measurements are recorded at 15-minute intervals during the entire water year. The purpose is to provide continuous information on the temperature regime in the river to help evaluate effects on fisheries, amphibian, and other aspects of the aquatic ecosystem and to better understand the transition from cold water to warmwater regimes and how flow magnitude interacts to control the transition. A daily suspended sediment station also will be maintained at the San Joaquin River near Vernalis, and two bed material samples will be collected from this location annually. This is to provide data on the role of sediment loading in the Delta.

Action	Description
6-Year Steelhead Survival Survey	The program estimates survival and route entrainment of juvenile San Joaquin River steelhead during the spring under a range of river and Delta operation conditions. The objective of this program is to understand how survival and route entrainment of juvenile steelhead along the San Joaquin River and South Delta is related to regional hydrodynamics. The study was designed to use the results from the six-year steelhead telemetry study during 2011-2016 to evaluate juvenile steelhead route selection at channel divergences in the South Delta and along the mainstem San Joaquin River, and how these behaviors influence survival in specific reaches and through the Delta to Chipps Island.
Investigation of the Distribution and Abundance of Longfin Smelt in the San Francisco Estuary (SFE)	The overarching goal of these studies is to provide additional information about Longfin Smelt that is expected to improve management and protection of this species in the SFE. They aim to enhance our knowledge of the life history and ecology of Longfin Smelt, and to refine our understanding of the drivers of population distribution and abundance, including the relationship between freshwater outflow and the abundance of Longfin Smelt. A Technical Team is proposed as part of this work, and they will provide guidance and assistance for the proposed studies, review analyses and results, and assist in identifying refinements or additions to the proposed scope of investigations. Three components are being implemented in 2019: (1) sampling Bay tributaries for larvae, ripe adults and otolith chemistry baseline; (2) expansion of the Smelt Larva Survey (SLS) into Napa River and estimation of the Napa River contribution to upper estuary larva abundance; and (3) investigation of potential sampling bias in current FMWT and San Francisco Bay Study (Bay Study) surveys using Bay Study trawl data, such as examinations of the vertical and lateral distributions of LFS and the relationships between catch and Secchi depth, and catch and channel depth.
Juvenile Salmon Emigration Real-Time Monitoring	For this element, beach seining and surface trawling are conducted 3 days/week from October 1st to January 31st near Sacramento to detect the arrival of older juvenile Chinook Salmon entering the Delta. Monitoring data are used to inform Delta Cross Channel Gate closure decisions from October 1st to December 15th in order to minimize the diversion and mortality of emigrating juvenile Winter-run-sized Chinook Salmon. These data also were and will continue to be used to inform biological opinions and drought operations planning decisions.
Tidal Wetland Monitoring Pilot Study	The Fish Restoration Program Monitoring Team is tasked with monitoring fish and food web resources in restored tidal wetland sites. These restored sites are located in the Sacramento-San Joaquin Delta and Suisun Marsh pursuant to requirements in the 2008/2009 Biological Opinions for state and federal water project operations. In our initial pilot studies (conducted from July 2015 through June 2016), the primary goal was to determine which methods were reliable and effective for sampling fish and macroinvertebrates in tidal wetlands. The objective moving forward will be to obtain baseline monitoring data on existing and planned tidal wetlands, using the recommended gear types from previous pilot studies. In addition, we will evaluate the variability of the biotic community in and near wetlands to determine the most effective timing and replication of sampling for long-term monitoring. Understanding how invertebrate and fish communities change before and after restoration is essential to evaluating the benefits of tidal wetlands to native fish species.
Yolo Bypass Fish Monitoring Program	The objectives of this interdisciplinary monitoring effort are to: (1) collect baseline data on lower trophic levels (phytoplankton, zooplankton and aquatic insects), juvenile fish and adult fish, hydrology and physical conditions; (2) conduct pilot investigations of the temporal and seasonal patterns in chlorophyll-a concentrations, including whether high concentrations are exported from the Yolo Bypass during fall flow events after rice field drainage, and (3) investigate the possibility of manipulating bypass flows to benefit listed species such as Delta Smelt. The specific environmental conditions that trigger migrations and enhanced survival and growth of native fishes (especially salmon) have yet to be described in detail. In addition, the mechanisms through which lower trophic organisms reach higher abundance in the Yolo Bypass are not understood. This program will fill in these information gaps. The Yolo Bypass has been identified as a high restoration priority by the National Marine Fisheries Service (NMFS) and USFWS Biological Opinions for Delta Smelt, Winter-run and Spring-run Chinook Salmon, and by the Bay Delta Conservation Plan (BDCP). The Yolo Bypass Fish Monitoring Program informs the restoration actions that are mandated or recommended in these plans, and provides critical baseline data on bypass ecology.

Action	Description
Liberty Island Fish Survey	Liberty Island is a restoring wetland that provides important habitat for species of management concern, including Delta Smelt and Chinook Salmon. This element conducts beach seining every month, and larval and zooplankton trawls from February through July to provide baseline data, and serves as a reference for future restoration efforts at Liberty Island and in conjunction with BDCP.
Resident Fish Survey	This element conducts beach seining weekly from July through December within the lower San Joaquin River, and biweekly from July through October in San Francisco Bay and San Pablo Bay to monitor the abundance and distribution of resident fishes in unobstructed littoral habitats. This survey provides information on status and trends for fishes occurring within unobstructed littoral habitats.
Salmon Survival Studies	The objective of this task is to assess juvenile salmon survival in the South Delta and to determine the relative importance of factors influencing salmon survival as they move through the Delta. The results are used to inform several management groups (i.e., the Collaborative Adaptive Management Team's [CAMT's] Salmonid Scoping Team [SST] workgroup).
Estimation of Pelagic Fish Populations	This element will refine our design- and model-based estimates of the abundances of different life stages of Delta Smelt needed to assess the effectiveness of management actions on the population dynamics and the likelihood of population recovery. Previous work produced estimates for post-larvae, juveniles, sub-adults, and adults. This element will finalize and apply gear efficiency measures used to account for gear selectivity bias in catch data and consequently will standardize data across surveys, incorporate improved estimates of Bay-Delta water volumes that are needed to calculate abundances, formally compare the abundance estimates produced by two methods (design and model-based), extend our estimates to other life stages (e.g., larvae), and extend the estimates further back in time for life cycle modeling purposes (right now the model covers the period from 1990 to 2015).
Statistical Support Delta Smelt Life Cycle Model	The Delta Smelt Life Cycle Model (DSLCM) is a state-space model designed (1) to provide a quantitative, empirically based decision support tool for assessing the effects of management actions and environmental conditions on the population dynamics of Delta Smelt; (2) to suggest management actions; (3) to provide guidance and recommendations for future data needs and data collection procedures; and (4) to carry out Population Viability Analysis (PVA) to predict the long-term consequences of particular actions. The work this year will refine Delta Smelt Life Cycle Model(s) and assess data gaps, assess factors that may influence reproductive success and survival processes, and carry out a Population Viability Analysis to investigate the effects of potential recovery efforts.
Effects of Aquatic Macrophyte Control on Delta Smelt Habitat	California Department of Water Resources (DWR), State Parks, Division of Boating and Waterways, and CDFW will complete monitoring work that assesses the effect of herbicide treatment of invasive aquatic plants on aquatic habitat. Monitoring work includes the response of the vegetation, water quality, local hydrodynamics, the plankton, and the fish community to herbicide treatments. In 2019, this element will report the results of the multiyear monitoring program, providing new information on the impact of treatment on multiple aspects of habitat. This work will inform development of a management plan for macrophyte treatment in critical habitat areas for Delta Smelt.

Action	Description
Feasibility of Improving Juvenile Chinook Salmon Monitoring in the Upper San Francisco Estuary through Enhanced Delta Smelt Monitoring	This study aims to evaluate the extent to which the Enhanced Delta Smelt Monitoring Program (EDSM) can be leveraged to enhance the IEP salmon monitoring network and to synthesize data collected from IEP long-term monitoring programs related to juvenile salmon outmigration in the lower SFE. We propose a synthesis of juvenile Chinook Salmon data collected from various monitoring programs in the lower SFE to better understand the species' migration in the estuary and its behavioral diversity. Higher variability in juvenile size and timing during downstream migration to the ocean can help ensure that some portion of the salmon population survive well in a dynamic marine environment. We will conduct comparison of salmon catch data from two contrasting water years, 2017 and 2018, and would expect that wet year conditions will lead to higher variability in juvenile salmon size and timing in the lower estuary (i.e., higher life history diversity). We will incorporate data from other monitoring programs to fill any data gaps in EDSM data and for comparison purposes. As part of this effort, we will also note the limitations of the EDSM data, given that the program was designed to target Delta Smelt and not Chinook Salmon. Results from this synthesis effort will allow us to better understand juvenile salmon outmigration in the estuary and may help inform the development of future salmon monitoring programs.
Fish Diet and Condition	This study examines differences in the diet and condition of fishes with respect to species decline and provides field support (i.e., boats and operators) for related studies focused on contaminants, zooplankton and fish health indices. This study will examine the stomach contents of several fishes and zooplankton for changes in diet composition, feeding success and parasite load. Weight at length of fishes will be examined regionally to look for effects of diet, food availability and environmental conditions, such as specific conductance, water temperature, and water clarity. This study will inform understanding of pelagic organism decline and fall in low-salinity habitat.
Directed Field Collections	The Directed Field Collections element provides support for expanded field collections, enabling CDFW to provide other non-CDFW researchers access to boats and operators needed to sample the upper estuary. Access to this service, requires pre-proposal coordination with CDFW to ensure that the field time needed is possible and that IEP approves the subsequent proposal. This element was initiated during the Pelagic Organism Decline (POD) study period and was most recently associated with investigations for the Fall Low-Salinity Habitat Studies (FLaSH).
Yolo Bypass Productivity Export Studies	This study investigates the potential for flow pulses through the Yolo Bypass to trigger phytoplankton blooms in the lower estuary, such as those that occurred in 2011 and 2012. Primarily, we will examine the effects of fall rice field drainage flows, but we will also investigate the effects of routing water through the Yolo Bypass during other times of the year to produce food for listed species such as Delta Smelt. This study uses phytoplankton, zooplankton, nutrients, contaminants, and water quality sampling to answer questions about the mechanisms surrounding food production within the bypass and what aspects of the exported water trigger further production lower in the estuary. Due to the food-limited nature of the San Francisco Estuary, it is critical to understand the mechanisms resulting in successful production of beneficial algal blooms, which in turn support enhanced food resources for fish. Food limitation is one of the primary hypothesized causes of POD. This research has the potential to provide an efficient new management tool for improving the habitat and food resources for listed fish species, particularly during drought periods.
Estimating Effective Population Size and Long-Term Monitoring of Delta Smelt	The Effective Population Size Study will estimate the effective population size (Ne) of wild Delta Smelt, using genomic data from recently completed work from the authors' laboratory. The scope of this work includes two tasks: (1) reanalyzing archived Delta Smelt samples (dating back to the 2003 cohort), using Rapture sequencing; and (2) developing and implementing an ongoing genetic monitoring plan, using single-nucleotide polymorphisms (SNPs) for the wild Delta Smelt population. The results and analysis from each year will be compiled into an annual report for managers and into publications for the broader scientific community.

Action	Description
Delta Smelt Early Warning Studies: Application of the SmeltCam	This study will generate information that will contribute to a more complete understanding of Delta Smelt distribution in the water column and the processes driving Delta Smelt behavior and movements. Data collected will help to expand the utility and comparability of long-term IEP fish monitoring programs, data support for management of water project operations, and the continued research and development of non-lethal sampling methods for Delta Smelt and other fishes. In particular, this research will (1) estimate the vertical and lateral distribution of Delta Smelt in the water column in relation to physical and biological habitat features before and during upstream migration; (2) estimate a standardized spatial distribution of Delta Smelt with respect to tidal stage along the San Joaquin River corridor; and (3) advance the application and development of the SmeltCam through (a) improved species identification, (b) calibration of observations, and (c) assessment of indirect mortality.
Turbidity Transects (Boat-Based Turbidity)	The 2019-2020 Turbidity Transects element will obtain a fine resolution of turbidity in the Delta. As turbidity is a key environmental trigger in the USFWS and NMFS Biological Opinions for anadromous fish and Delta Smelt, this midchannel turbidity monitoring will be an important supplement to the existing continuous fixed-station water quality network in the Central Delta and the South Delta. This element assists in Delta Smelt assessments and water management decisions that minimize fish entrainment at state and federal South Delta pumping facilities. The Environmental Monitoring Program will conduct twice-weekly turbidity transects from December 2019 through March 2020, and will create a necessary "early warning" system for improved efficiency between state and federal water project operations and Delta Smelt trawl efforts.
Estimating Abundance of Juvenile Winter-run Chinook Salmon Entering and Exiting the Delta (SAIL)	This is a continuation of a 5-year project funded by DWR and CDFW and the Central Valley Project Improvement Act in 2017. The objective of the project is to improve estimates of population abundances for juvenile Fall-, Winter-, and Spring-run Chinook Salmon at Sacramento and Chipps Island by improving trawl efficiency estimates through the use of data from releases of coded-wire tags (CWTs) and acoustic tags (ATs) and by genetically sampling the trawl catch in 2018. The project will (1) develop statistical models for estimating trawl efficiencies from 2016-2018 data for paired AT-CWT releases of Winter-run and Fall-run Chinook Salmon; (2) use 2018 genetic sampling of trawl catch in combination with efficiency estimates to estimate population abundances of Fall-, Spring-, and Winter-run Chinook Salmon at Sacramento and Chipps Island in 2018; (3) implement trawl efficiency studies for multiple salmon runs in 2018, which are informed by the 2016 and 2017 results and implemented in coordination with hatcheries for inclusion of AT fish with existing CWT releases; and (4) combine trawl efficiencies with genetic samples of trawl catch to provide estimates of Fall-, Spring-, and Winter-run Chinook Salmon (with estimated precision) entering and exiting the Delta in 2018.
Comparative Predation Risk of Juvenile Chinook Salmon among River, Floodplain, and Wetland Rearing Habitats in the North Delta	This study will examine the relative predation on juvenile Chinook Salmon in the Yolo Bypass, a region of high restoration priority, to inform restoration design and management. It will also generate baseline data that can be used as a comparison for effects following restoration. This study will also refine and adapt stationary tethering methods so they can be used to evaluate relative predation risk within and among restored and altered habitats, such as the dead-end sloughs and tidal wetlands found throughout the North Delta.
Suisun Marsh Salinity Control Gate Study	The Suisun Marsh Salinity Control Gates (SMSCG), pending provision of the necessary permits, will be operated in Summer 2019 to reduce salinities in the Suisun Marsh to levels that are appropriate for Delta Smelt (DWR 2019d). The goal of this action is to open the Suisun Marsh area as viable rearing habitat to Delta Smelt during the summer period, which is currently a stressful period for Delta Smelt rearing because of high temperatures and a low food supply. This element includes evaluation of the 2018 pilot action, modeling to inform the potential benefit and water cost for a 2019 action, and monitoring and evaluation of the 2019 action.

Action	Description
Physiological and Behavioral Effects of Domestication on Delta Smelt	This program element aims to provide a better understanding of the effects of domestication on captive Delta Smelt by assessing the refuge population at the UC Davis Fish Conservation and Culture Laboratory (FCCL) in Byron, CA. Objectives of the study include characterizing domestication effects on hatchery Delta Smelt by synthesizing existing and historical datasets on growth and reproduction of fish at the FCCL since the start of the hatchery program; identifying the impacts of domestication on the physiological stress response of Delta Smelt following handling stress; and determining the effects of domestication index on individual and group swimming behavior, responses to predation, and responses within the context of climate change factors, including warming and increased salinity. This project will provide relevant and timely information for conservation managers and adaptive restoration strategies and will dovetail with the recommendations from the 2017 Delta Smelt Supplementation Workshop.

Notes:
ATs = acoustic tags
Bay Study = San Francisco Bay Study
BDCP = Bay Delta Conservation Plan
CAMT = Collaborative Adaptive Management Team
CDFW = California Department of Fish and Wildlife
channel = Stockton Ship Channel
CVP = Central Valley Project
CWTs = coded-wire tags
D-1641 = State Water Resources Control Board's Water Rights Decision 1641
CDFG = California Department of Fish and Game
DO = dissolved oxygen
DSLCM = Delta Smelt Life Cycle Model
DWR = California Department of Water Resources
EDSM = Enhanced Delta Smelt Monitoring Program
FCCL = Fish Conservation and Culture Laboratory
FLaSH = Fall Low-Salinity Habitat Studies
FMWT = Fall Midwater Trawl
IEP = Interagency Ecological Program
LFS = Longfin Smelt
NMFS = National Marine Fisheries Service
OMR = Old and Middle River
POD = Pelagic Organism Decline
PVA = Population Viability Analysis
SAIL = Salmon Entering and Exiting the Delta
SFE = San Francisco Estuary
SLS = Smelt Larva Survey
SMSCG = Suisun Marsh Salinity Control Gates
SNP = single-nucleotide polymorphism
SST = Salmonid Scoping Team
STN = Summer Townet Survey
SWP = State Water Project
SWRCB = State Water Resources Control Board
UC Davis = University of California, Davis
USFWS = U.S. Fish and Wildlife Service
USGS = U.S. Geological Survey

Rio Vista Estuarine Research Station and Fish Technology Center

DWR is overseeing the creation of the Rio Vista Estuarine Research Station and Fish Technology Center to coordinate and consolidate research and monitoring efforts in support of Delta Smelt management and to create facilities to house populations of smelt as a guard against extinction. DWR is working with other resource agencies and universities to determine the best strategy for developing a conservation hatchery program for Delta Smelt, which may lead to a future option to reintroduce cultured smelt into the wild to bolster the wild population until suitable habitat has been restored to aid in species recovery.

DWR published the final EIR along with the final Environmental Impact Statement (EIS) for the Rio Vista Estuarine Research Station in 2017. During 2018, USFWS and NMFS also released Biological Opinions (BiOps) for the project, and DWR certified the project as consistent with the Delta Stewardship Council's Delta Plan. Currently, DWR is working with USFWS and the Rio Vista Army Base to address federal funding needed for both the Rio Vista Estuarine Research Station and the Fish Technology Center. State funding has been secured for Rio Vista Estuarine Research Station.

4.4.1.5 YOLO BYPASS

The Yolo Bypass conveys flood flows from the Sacramento Valley, including the Sacramento River, Feather River, American River, Sutter Bypass, and westside tributaries.

The Yolo Bypass provides habitat for a wide variety of fish and aquatic species, including temporary migration corridors and juvenile rearing habitat for anadromous salmonids and other native and anadromous fishes. Species captured as adults and subsequently collected as YOY suggest that the Yolo Bypass provides spawning habitat for several species, including Sacramento Splittail, American Shad, Striped Bass, Threadfin Shad, Largemouth Bass, and Common Carp (Harrell and Sommer 2003; Sommer et al. 2014). The Yolo Bypass lacks a gravel substrate that would be suitable for supporting salmon spawning.

Focal fish species identified as potentially occurring in the Delta also could potentially occur in the Yolo Bypass.

Yolo Bypass Aquatic Habitat

Aquatic habitats in the Yolo Bypass include stream and slough channels for fish migration and when flooded, seasonal spawning habitat and productive rearing habitat (Sommer et al. 2001; CALFED 2000a, 2000b). During years when the Yolo Bypass is flooded, it serves as an important migratory route for juvenile Chinook Salmon and other native migratory and anadromous fishes moving downstream. During these times, it provides juvenile anadromous salmonids an alternative migration corridor to the lower Sacramento River (Sommer et al. 2003) and, sometimes, better rearing conditions than the adjacent Sacramento River channel (Sommer et al. 2001, 2005). When the floodplain is activated, juvenile salmon can rear for weeks to months in the Yolo Bypass floodplain before migrating to the estuary (Sommer et al. 2001). Research on the Yolo Bypass has found that juvenile salmon grow substantially faster in the Yolo Bypass floodplain than in the adjacent Sacramento River, primarily because of the greater availability of invertebrate prey in the floodplain (Sommer et al. 2001, 2005). When not flooded, the lower Yolo Bypass provides tidal habitat for young fish that enter from the lower Sacramento River via Cache Slough Complex—a network of tidal channels and flooded islands that includes Cache Slough, Lindsey Slough, Liberty Island, the Sacramento Deepwater Ship Channel, and the Yolo Bypass (McLain and Castillo; DWR unpublished data).

Sommer et al. (1997) demonstrated that the Yolo Bypass is one of the single most important habitats for Sacramento Splittail. Because the Yolo Bypass is dry during summer and fall, non-native species (e.g., predatory fishes) generally are not present year-round except in perennial water sources (Sommer et al. 2003). In addition to providing important fish habitat, winter and spring inundation of the Yolo Bypass supplies phytoplankton and detritus that may benefit aquatic organisms downstream in the brackish portion of the San Francisco Estuary (Sommer et al. 2004; Lehman et al. 2008a).

The benefit of seasonal inundation of the Yolo Bypass has been studied by DWR as part of the Delta Smelt Resiliency Strategy, which was developed by DWR and other state and federal resource agencies to boost both immediate- and near-term reproduction, growth rates, and survival of Delta Smelt (CNRA 2016; Mahardja et al. 2019). The Yolo Bypass has been identified as a significant source of phytoplankton and zooplankton biomass to the Delta in the winter and spring during floodplain inundation. However, little has been known about its contribution to the food web during the drier summer and fall months.

One action taken by DWR under the strategy is the implementation of food web enhancement projects in the Yolo Bypass. Under this action, DWR worked with farmers as well as irrigation and reclamation districts to direct water through the Yolo Bypass in the form of flow pulses during summer and fall (Frantzich et al. 2018). The first examination of off-season flow pulses occurred in 2016 when a flow pulse of 12,700 acre-feet (AF) was released over 2 weeks in the summer. The second examination occurred during 2018 when a 19,821 cfs flow occurred over 4 weeks in the fall. These flow pulses were followed in turn by a significant increase in phytoplankton biomass in the Cache Creek Complex and further downstream in the lower Sacramento River (CNRA 2017; DWR 2019c, 2019b). The increase in phytoplankton biomass was also found to enhance zooplankton growth and production, thereby increasing food supplies for Delta Smelt and other Delta fish species. During the second year of implementing flow pulses, a managed flow pulse was generated in the fall of 2018. The 2018 Fall North Delta Flow Action generated a flow pulse of 19,821 AF over 4 weeks, which while not coinciding with a wave of phytoplankton moving through the Yolo Bypass, did result in an export of higher densities of zooplankton into downstream habitats of lower Cache Slough and the Sacramento River at Rio Vista (DWR 2019c).

Studies will continue in 2019 on the issue of food web enhancement in the Yolo Bypass. Working with the Glenn Colusa Irrigation District, DWR will test the benefit of passing water through the Yolo Bypass to enhance Delta Smelt habitat in the North Delta region (DWR 2019c). DWR will alter the operation of the Knights Landing Outfall Gates and Wallace Weir to direct agricultural return flows, targeted at 27,000 AF, from the Colusa Basin Drain through Ridge Cut Slough and Wallace Weir into the Yolo Bypass for up to 4 weeks in late summer. This action is expected to generate a seasonal positive flow pulse through the Yolo Bypass Toe Drain, which is expected to benefit the food web in downstream areas for fishery resources. Monitoring of water quality, phytoplankton biomass, and zooplankton will be performed prior to, during, and after the flow pulse action at several locations in the system (DWR 2019a). DWR will also deploy cages of hatchery Delta Smelt in the Yolo Bypass Toe Drain and Sacramento River at Rio Vista to monitor growth and survival 4 weeks before and after the flow action (DWR 2019c, 2019d).

Fish Passage

The Fremont Weir is a major impediment to fish passage and a source of migratory delay and loss of adult Chinook Salmon, steelhead, and sturgeon (NMFS 2009a; Sommer et al. 2014). The Fremont Weir creates a migration barrier for a variety of species, although fish with strong jumping capabilities (such as salmonids) may be able to pass the weir at higher flows. In 2018, DWR implemented the Fremont Weir Adult Fish Passage Modification Project. The project replaced an old, undersized, inefficient fish ladder in the center of the weir with a wider and deeper gate structure. The gate structure is equipped with two Adaptive Resolution Imaging Sonar (ARIS) cameras that will aid in quantifying the structure's effectiveness, but the effectiveness of the structure under a range of flows is still under investigation.

Some adult Winter-run, Spring-run, and Fall-run Chinook Salmon and White Sturgeon migrate into the Yolo Bypass via the Toe Drain and Tule Canal when there is no flow into the floodplain over the Fremont Weir. Fyke trap monitoring by DWR has shown that adult salmon and steelhead migrate up the Toe Drain in autumn and winter regardless of whether the Fremont Weir spills (Harrell and Sommer 2003; Sommer et al. 2014). The Toe Drain does not extend to the Fremont Weir because the channel is fully or partially blocked by roads or other higher ground at several locations and fish are often unable to reach upstream spawning habitat in the Sacramento River and its tributaries (Harrell and Sommer 2003; Sommer et al. 2014). Other structures in the Yolo Bypass, such as the Lisbon Weir, and irrigation dams in the northern end of the Tule Canal may also impede upstream passage of adult anadromous fish (NMFS 2009a). Modifications to some of these structures were made as part of the Fremont Weir Adult Fish Passage Modification Project, and two agricultural road crossings were altered to improve fish passage.

In addition, sturgeon and salmonids attracted by high flows into the basin become concentrated behind the Fremont Weir, where they are subject to heavy illegal fishing pressure.

Stranding of juvenile salmonids and sturgeon has been reported in the Yolo Bypass in scoured areas behind the weir and in other areas as floodwaters recede (NMFS 2009a; Sommer et al. 2005). However, Sommer et al. (2005) found most juvenile salmon migrated off the floodplain as it drained.

DWR and Reclamation have been working on the Yolo Bypass Habitat Restoration (YBHR) program, which is developing and implementing six restoration actions in the Yolo Bypass, including removal of several fish passage barriers. Some of these actions are complete, or nearly complete, including the Wallace Weir Fish Rescue Facility Project and the Fremont Weir Adult Fish Passage Modification Project.

4.4.1.6 Suisun Marsh

Suisun Bay and Suisun Marsh are ecologically linked with the Central Delta, although with different tidal and salinity conditions than those found upstream. Suisun Bay and Suisun Marsh make up the largest expanse of remaining tidal marsh habitat within the greater Bay-Delta ecosystem and include Honker, Suisun, and Grizzly bays; Montezuma and Suisun sloughs; and numerous other smaller channels and sloughs.

Although the fish assemblages in Suisun Bay and Suisun Marsh can differ substantially from the fish assemblages in the Delta, all the species that use the Delta, including those of focal evaluation included in this DEIR (see Table 4.4-1), also use Suisun Bay and Suisun Marsh.

Suisun Marsh Aquatic Habitat

Suisun Marsh is a brackish-water marsh bordering the northern edge of Suisun Bay. Most of its marsh area consists of diked wetlands managed for waterfowl, and the rest of the acreage consists of tidally influenced sloughs and emergent tidal wetlands (Suisun Ecological Workgroup 2001). The central latitudinal location of Suisun Marsh within the San Francisco Estuary makes it an important rearing area for euryhaline freshwater, estuarine, and marine fishes. Many fish species that migrate or use Delta habitats are also found in the waters of Suisun Bay. Tides reach Suisun Bay and Suisun Marsh through the Carquinez Strait, and most freshwater flows enter at the southeast border of Suisun Marsh at the confluence of the Sacramento and San Joaquin rivers. The mixing of freshwater outflows from the Central Valley with saline tidal water in Suisun Bay and Suisun Marsh results in brackish water with strong salinity gradients, complex patterns of flow interactions, and generally the highest biomass productivity in the entire estuary (Siegel et al. 2010).

Flow, turbidity, and salinity are important factors influencing the location and abundance of zooplankton and small prey organisms used by Delta species (Kimmerer et al. 1998). The location where net current flowing inland along the bottom reverses direction and sinking particles are trapped in suspension is associated with the higher turbidity known as the estuarine turbidity maximum. Burau et al. (2000) reports that the estuarine turbidity maximum occurs near the Benicia Bridge and in Suisun Bay near Garnet Point on Ryer Island. Zooplanktonic organisms maintain position in this region of historically high productivity in the estuary through vertical movements (Kimmerer et al. 1998).

Salinity in the Suisun Marsh and Bay system is a major water quality characteristic that strongly influences physical and ecological processes. Many fish species native to Suisun Marsh require low salinities during the spawning and rearing periods (Suisun Ecological Workgroup 2001; Kimmerer 2004; Feyrer et al. 2007, 2010; Nobriga et al. 2008). The Suisun Marsh and Bay usually contain both the maximum estuarine salinity gradient and the low salinity zone. The overall estuarine salinity gradient trends from west (higher) to east (lower) in Suisun Bay and Suisun Marsh. The location of the low salinity zone gradient is influenced by outflow. Suisun Marsh also exhibits a persistent north-south salinity gradient. Despite low and seasonal flows, the surrounding watersheds have a significant water freshening effect because of the long residence times of freshwater inflows to the marsh, including discharges from the upper sloughs and wastewater effluent.

The Suisun Bay and Suisun Marsh system contains a wide variety of habitats such as marsh plains, tidal creeks, sloughs, channels, cuts, mudflats, and bays. These features and the complex hydrodynamics and water quality of the system have historically fostered significant biodiversity within Suisun tidal aquatic habitats, but these habitats, like the Delta, have also been significantly altered and degraded by human activities over the decades.

Categories of tidal aquatic waters include bays, major sloughs, minor sloughs, and the intertidal mudflats in those areas (Engle et al. 2010). These tidal waters total approximately 26,000 acres, with the various embayments totaling about 22,350 acres. Tidal slough habitat is composed of major and minor sloughs. Major sloughs of Suisun Marsh have a combined acreage of about 2,200 acres consisting of both shallow and deep channels. Minor sloughs are made up of shallow channel habitat and have a combined acreage of about 1,100 acres. Habitats in Suisun Marsh bays and sloughs support a diverse assemblage of aquatic species that typically use open-water tidal areas for breeding, foraging, rearing, or migrating.

Suisun Marsh Protection Plan

One of the first actions taken by DWR that focused on aquatic habitat in Suisun Marsh was participation in the development of the Suisun Marsh Protection Plan. The plan was prepared pursuant to the *Nejedly-Bagley-Z'berg Suisun Marsh Preservation Act of 1974*. Plan preparation and execution was overseen by the San Francisco Bay Conservation and Development Commission, which consists of representatives from multiple state, federal, and local agencies (including DWR as part of the California State Resources Agency); from nongovernmental organizations; and from nine counties (including Solano County). The basic purpose of the plan was to protect Suisun Marsh from developmental pressures while balancing the benefits of tidal wetland restoration with other benefits to salt marsh harvest mouse habitat, wetlands, public use, and upland habitat (Houghteling 1976). Included in the many findings of the plan was the need for projects designed to import or redistribute freshwater in Suisun Marsh for salinity control. The goal of freshwater redistribution in Suisun Marsh, while not tied directly in the plan to Delta Smelt, was designed to improve habitat conditions for aquatic resources, which included Delta Smelt.

Suisun Marsh Preservation Agreement

DWR began taking action to control salinity levels in Suisun Marsh in the 1980s. In response to concerns over water exports on Delta fish species, a joint state-federal planning group including DWR, formed to develop and implement a long-term comprehensive plan to restore ecological health and improve water management for beneficial uses of the Bay-Delta. This planning process eventually led to the development of the 1987 Suisun Marsh Preservation Agreement (SMPA), which was later revised in 2005 (USBR et al. 2005, 2015). The SMPA is a contractual agreement among several resource agencies, including DWR, and is intended to mitigate the salinity impacts in the marsh related to SWP and CVP operations as well as other upstream diversions. In the SMPA, DWR agreed to meet designated water salinity standards in the Suisun Marsh by constructing and operating water management facilities, including the Suisun Marsh Salinity Control Gates (SMSCG). DWR began operating the SMSCG in 1989 to block the salty flood tide from Grizzly Bay but allow passage of the freshwater ebb tide from the mouth of the Sacramento–San Joaquin Delta. Historically, the SMSCG have been operated only in the fall on an as-needed basis.

Under the 2015 SMPA, DWR also agreed to provide funding for four programs: (1) Water Manager; (2) Portable Pumps; (3) Individual Ownership Adaptive Management Habitat Plans; and (4) Drought Response. Finally, DWR agreed to participate in a monitoring program that includes stage and channel water electrical conductivity (EC) at a number of stations within Suisun Marsh and to participate in a review of the effectiveness of actions taken at the direction of the SMPA.

Suisun Marsh Habitat Management, Preservation, and Restoration Plan

In 2013, DWR participated in the development of the Suisun Marsh Habitat Management, Preservation, and Restoration Plan (USBR et al. 2013). This plan was intended to address issues previously recognized by the CALFED Bay-Delta Program and the 2005 Suisun Marsh Preservation Agreement. Its purpose was to preserve and enhance the quality and diversity of the Suisun Marsh aquatic and wildlife habitats and to assure retention of upland areas adjacent to Suisun Marsh in uses compatible with its protection. The plan is designed to meet four primary objectives: (1) restore 5,000 to 7,000 acres of tidal marsh while protecting and enhancing 40,000 to 50,000 acres of managed wetlands in the marsh; (2) maintain the heritage of waterfowl hunting and other recreational pursuits while increasing the local awareness of the ecological values of the marsh; (3) maintain and improve the marsh levee system; and (4) protect and improve water in the marsh, including estuarine, spawning, and migrating habitat for fish species and associated wildlife.

Delta Smelt Resiliency Strategy

In 2016, the California Natural Resources Agency (CNRA) released a Delta Smelt Resiliency Strategy, which was designed to boost both immediate- and near-term reproduction, growth rates, and survival of Delta Smelt (CNRA 2016). These goals are to be achieved by the implementation of 13 actions to be taken by the State that are aimed at creating better habitat, more food, and higher turbidity levels while simultaneously reducing the effects of weeds, predators, and harmful algal blooms. Four actions contained in the strategy that focus on Suisun Marsh are described below.

<u>Re-operation of Suisun Marsh Salinity Control Gates (SMSCG)</u> Under this action, DWR agreed to develop an adaptive management approach to the re-operation of the Suisun SMSCG during summer months to enhance the benefits to Delta Smelt associated with their operation. In 2017, DWR, developed an Adaptive Management Plan for re-operation of the SMSCG. DWR also initiated a feasibility study of the re-operation process, followed by a 2018 pilot study (GEI 2018). The pilot action involved the continuous operation of the SMSCG during August 2018, 2 months earlier than normal operation of the gates for waterfowl habitat management purposes. Before, during, and after the August 2018 Pilot SMSCG operation, DWR performed a broad sampling program at multiple locations throughout the Suisun Marsh region that involved water quality, phytoplankton, zooplankton, and bivalve data. These data, when added to the IEP monitoring results for 2018, advance the understanding of the relationship between SMSCG operation and abiotic and biotic conditions in Suisun Marsh.

<u>Roaring River Distribution System (RRDS) Food Production</u> Under this action, DWR agreed to install drain gates on the western end of the Roaring River Distribution System (RRDS) to drain food-rich water from the canal into Grizzly Bay, where other habitat conditions for Delta Smelt are beneficial. In order to fully develop the action in 2019, DWR is working with CDFW and San Francisco State University to develop a phytoplankton and zooplankton sampling program within the RRDS to better understand the distribution and abundance of the Delta Smelt food source at its east and west drains (Loboschefsky 2019) and to understand how to provide benefits to Delta Smelt while operating the RRDS to provide fresher water to managed wetlands.

<u>Coordinate Managed Wetland Flood Drain Operation in Suisun Marsh</u> Under this action, DWR agreed to coordinate with the Suisun Resource Conservation District to develop a plan to flood and drain wetlands into adjacent tidal sloughs and bays to augment food production for Delta Smelt. In 2018,

DWR funded a study of water quality and production in ponds within the Suisun Marsh managed wetlands (Phillips et al. 2019). The purpose of the study was to investigate the benefits of connectivity between wetlands and tidal sloughs compared to the historical practice of managing the wetlands for waterfowl and the sloughs for fish. The studies performed in the spring and fall of 2018 advanced DWR's understanding of this connectivity. The studies found that ponds and sloughs alternately serve as sources of primary production between the two seasons, whereas ponds appear to supply an important source of zooplankton for adjacent sloughs throughout both seasons.

Spawning Habitat Augmentation Based on past studies suggesting the importance of sandy shoals as Delta Smelt spawning substrate (Sommer and Mejia 2013), DWR agreed to assess the current availability of suitable spawning sandy shoal substrate in Suisun Marsh and Cache Slough, and to introduce sand if necessary. DWR began to compile data on the current status of different substrate throughout the Delta (CNRA 2017).

Fish Entrainment

Several facilities have been constructed by DWR and Reclamation to provide lower-salinity water to managed wetlands in the Suisun Marsh, including the RRDS, Morrow Island Distribution System, and Goodyear Slough Outfall. Other facilities constructed under the Suisun Marsh Preservation Agreement that could entrain fish include the Lower Joice Island and Cygnus Drain diversions.

The intake to the RRDS is screened to prevent entrainment of fish larger than approximately 1 inch (approximately 25 mm). DWR monitored fish entrainment from September 2004 through June 2006 at the Morrow Island Distribution System to evaluate entrainment losses at the facility. Monitoring took place over several months under various operational configurations and focused on Delta Smelt and salmonids. More than 20 species were identified during the sampling, but only two fish the size of Fall-run Chinook Salmon were observed, at the South Intake in 2006, and no Delta Smelt from entrained water were observed (Enos et al. 2007). The Goodyear Slough Outfall system is open for free fish movement except near the outfall when flap gates are closed during flood tides (USBR 2008). Conical fish screens have been installed on the Lower Joice Island diversion on Montezuma Slough.

Nearshore Pacific Ocean on the California Coast

Anadromous fish species use the Pacific Ocean as part of their life cycles. In addition, the Pacific Ocean supports the Southern Resident Killer Whale (*Orcinus orca*), which relies upon Chinook Salmon (e.g., Fall-run Chinook Salmon) as a major food source.

4.4.1.7 PACIFIC OCEAN HABITAT OF THE KILLER WHALE

The Pacific Ocean along the coast of California is included in this description of the affected environment because it provides habitat for the Southern Resident Killer Whale population.

Southern Resident Killer Whales are found primarily in the coastal waters offshore of British Columbia and Washington and Oregon in summer and fall (NMFS 2008). During winter, Southern Resident Killer Whales are sometimes found off the coast of central California and more frequently off the Washington coast (Hilborn et al. 2012).

The 2005 NMFS endangerment listing (70 FR 69903) for the Southern Resident Killer Whale DPS lists several factors that may be limiting the recovery of Killer Whales, including the quantity and quality of prey, accumulation of toxic contaminants, and sound and vessel disturbance. The Recovery Plan for Southern Resident Killer Whales (NMFS 2008) posits that reduced prey availability forces whales to spend more time foraging, which may lead to reduced reproductive rates and higher mortality rates. Reduced food availability may lead to mobilization of fat stores, which can release stored contaminants and adversely affect reproduction or immune function (NMFS 2008).

The Independent Science Panel reported that Southern Resident Killer Whales depend on Chinook Salmon as a critical food resource (Independent Science Panel and ESSA Technologies 2012). Hanson et al. (2010) analyzed tissues from predation events and feces to confirm that Chinook Salmon were the most frequent prey item for the Southern Resident Killer Whale in two regions of the whale's summer range off the coast of British Columbia and Washington State, representing more than 90% of the diet in July and August. Samples indicated that when Southern Resident Killer Whales are in inland waters from May through September, they consume Chinook Salmon stocks that originate from regions that include the Fraser River, Puget Sound, the Central British Columbia Coast, West and East Vancouver Island, and California's Central Valley(Hanson et al. 2010).

Significant changes in food availability for Southern Resident Killer Whales have occurred over the past 150 years, largely due to human impacts on prey species. Salmon abundance has been reduced over the entire range of the Southern Resident Killer Whales, from British Columbia to California. NMFS (2008) indicates that wild salmon have declined primarily due to degraded aquatic ecosystems, overharvesting, and production of fish in hatcheries. NMFS (2008) supports restoration efforts, including habitat, harvest, and hatchery management considerations, and continued use of existing NMFS authorities under the ESA and Magnuson-Stevens Fishery Conservation and Management Act to ensure an adequate prey base.

Central Valley streams produce Chinook Salmon that contribute to the diet of Southern Resident Killer Whales. The number of Central Valley Chinook Salmon that annually enter the ocean and survive to a size susceptible to predation by Southern Resident Killer Whales is not known.

4.4.2 Regulatory Environment and Compliance Requirements

4.4.2.1 Federal Plans, Policies, and Regulations

Federal Endangered Species Act

The ESA requires that both USFWS and NMFS maintain list of threatened and endangered species. A "endangered species" is defined as "…any species which is in danger of extinction throughout all or a significant portion of its range." A threatened species is defined as "…any species that is likely to become an Endangered Species within the foreseeable future throughout all or a significant portion of its range" (Title 16 U.S. Code [USC] Section 1532). Section 9 of the ESA makes it illegal to "take" (i.e., harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in such conduct) any endangered species of fish or wildlife, and regulations contain similar provisions for most threatened species of fish and wildlife (16 USC 1538). The ESA also requires the designation of "critical habitat" for listed species. "Critical habitat" is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential for the conservation of the species, and those features may require special management considerations or protection; and (2) specific areas outside the geographic area occupied by the species if the agency determines that the area itself is essential for conservation of the species (USFWS and NMFS 1998; NMFS 2009a).

Section 7 (a)(2) of the ESA requires all federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat. To ensure against jeopardy, each federal agency must consult with USFWS or NMFS, or both, if the federal agency determines that its action might affect listed species. NMFS jurisdiction under the ESA is limited to the protection of marine mammals, marine fish, and anadromous fish; all other species are within USFWS jurisdiction.

If an activity proposed by a federal agency would result in the take of a federally listed species, the consulting agency will issue a BiOp analyzing the impacts of the proposed action on listed species and an Incidental Take Statement if appropriate. The Incidental Take Statement typically requires various measures to avoid and minimize species take.

Where a federal agency is not authorizing, funding, or carrying out a project, take that is incidental to the lawful operation of a project may be permitted pursuant to Section 10(a) of the ESA through approval of a habitat conservation plan (HCP) and issuance of an incidental take permit.

Critical Habitat Designations

Critical habitat refers to areas designated by USFWS or NMFS for the conservation of their jurisdictional species listed as threatened or endangered under the Endangered Species Act of 1973. When a species is proposed for listing under the ESA, USFWS or NMFS considers whether there are certain areas essential to the conservation of the species. Critical habitat is defined in Section 3, Provision 5(A), of the ESA as follows.

> (a) The term "critical habitat" for a threatened or endangered species means–
>
> > (U) the specific areas within the geographical area occupied by a species at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and
>
> (b) (ii) specific areas outside the geographical area occupied by a species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential for the conservation of the species.

Delta Smelt critical habitat was designated on December 19, 1994 (59 FR 65256), and includes "areas of all water and all submerged lands below ordinary high water and the entire water column bounded by and constrained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the Delta." NMFS designated critical habitat for Winter-run

Chinook Salmon on June 16, 1993 (58 FR 33212). Critical habitat was delineated as the Sacramento River from Keswick Dam at RM 302 to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta (Delta), including Kimball Island, Winter Island, and Brown's Island; 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. In the Sacramento River, critical habitat includes the river water column and substrate and the adjacent riparian zone. Westward of Chipps Island, critical habitat includes the estuarine water column and essential foraging habitat and food resources used by Sacramento River Winter-run Chinook Salmon as part of their juvenile emigration or adult spawning migration.

Critical habitat was designated for Central Valley Spring-run Chinook Salmon on September 2, 2005 (70 FR 52488). Critical habitat for Central Valley Spring-run Chinook Salmon occurs in the Plan Area, and includes stream reaches such as those of the Feather and Yuba rivers; Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks; the main stem of the Sacramento River from Keswick Dam through the Delta; and portions of the network of channels in the northern Delta. Critical habitat includes the stream channels in these designated waters up to the ordinary high water line or bankfull elevation (elevation generally with a recurrence interval of 1 to 2 years).

Critical habitat was designated for steelhead in the Central Valley on September 2, 2005 (70 FR 41 52488). Critical habitat for Central Valley Steelhead occurs within the Plan Area, and includes the stream channels to the ordinary high water line within the designated stream reaches, such as those of the American, Feather, and Yuba rivers and the Deer, Mill, Battle, Antelope, and Clear creeks in the Sacramento River basin; the Calaveras, Mokelumne, Stanislaus, and Tuolumne rivers in the San Joaquin River basin; and the Sacramento and San Joaquin rivers and the entire Delta.

Critical habitat was designated for the southern DPS of North American Green Sturgeon on October 9, 2009 (74 FR 52345). The designation includes the stream channels and waterways in the Sacramento San Joaquin River Delta to the ordinary high water line. The designation also includes the mainstem Sacramento River upstream from the I Street Bridge to Keswick Dam and the Feather River upstream to the fish barrier dam adjacent to the Feather River Fish Hatchery; the Yuba River upstream to Daguerre Point Dam; the Sutter and Yolo bypasses; and the estuaries of the San Francisco Bay, Suisun Bay, and San Pablo Bay.

Endangered Species Act Consultation on Operation of the CVP and SWP

In 2008, Reclamation, in consultation with DWR, prepared a Biological Assessment on the continued long-term CVP and SWP operations. The Biological Assessment described how the Reclamation and DWR intended to operate the CVP and the SWP to divert, store, and convey water consistent with applicable law from 2008 through 2025 (USBR 2008).

U.S. Fish and Wildlife Service 2008 Biological Opinion

The 2008 USFWS Biological Opinion concurred with Reclamation's determination that the coordinated SWP and CVP operations were not likely to adversely affect listed species, with the exception of Delta

Smelt (USFWS 2008). USFWS concluded that the coordinated SWP and CVLP operations, as proposed, was likely to jeopardize the continued existence of the Delta Smelt and adversely modify Delta Smelt critical habitat. USFWS, in cooperation with Reclamation, developed a reasonable and prudent alternative (RPA) consisting of a number of components and actions to avoid the likelihood of jeopardizing the continued existence or the destruction or adverse modification of critical habitat for Delta Smelt. These actions include: (1) preventing and reducing entrainment of Delta Smelt at Jones and Banks pumping plants; (2) providing adequate habitat conditions that will allow the adult Delta Smelt to successfully migrate and spawn in the Bay-Delta; (3) providing adequate habitat conditions that will allow larvae and juvenile Delta Smelt to rear; and (4) providing suitable habitat conditions that will allow successful recruitment of juvenile Delta Smelt to adulthood. In addition, USFWS specified that it is essential to monitor Delta Smelt abundance and distribution through continued sampling programs through the IEP. The RPA reduced reverse flows in the OMR, channels leading to the State and federal diversions, when Delta Smelt are at increased risk of entrainment. Limiting reverse flows may reduce pump operations and can limit or delay deliveries of water to SWP and CVP contractors south of the Delta.

The SWP and CVP are currently operated in accordance with the terms and conditions of the 2008 USFWS BiOp.

National Marine Fisheries Service 2009 Biological Opinion and 2011 Amendments

The 2009 NMFS Biological Opinion (NMFS 2009a) concluded that the SWP and CVP operations were likely to jeopardize the continued existence of the species listed below:

- Sacramento River Winter-run Chinook Salmon
- Central Valley Spring-run Chinook Salmon
- Central Valley Steelhead
- Southern DPS of North American Green Sturgeon
- Southern Resident Killer Whale

The 2009 NMFS Biological Opinion (NMFS 2009a) also concluded that the proposed action was likely to destroy or adversely modify the designated critical habitats of Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Chinook Salmon, Central Valley Steelhead, and Green Sturgeon. The BiOp included RPAs designed to allow the SWP and CVP to continue operating without causing jeopardy to listed species and without adverse modification to designated critical habitat, provided the RPAs were implemented. In 2011, NMFS amended the 2009 RPA in response to recommendations provided in an Independent Review Panel report. The amendment modified the OMR triggers and updated the adaptive management provisions in the BiOp.

The SWP and CVP are currently operated in accordance with the RPA and terms and conditions of the NMFS 2009 BiOp. The actions included in the 2009 BiOp's RPA, as amended in 2011 to the proposed action are summarized below (NMFS 2009a).

- A new year-round temperature and Shasta Reservoir storage management program to minimize impacts on endangered Winter-run Chinook Salmon that spawn only in the Sacramento River, as well as long-term passage prescriptions at Shasta Dam and re-introduction of Winter-run Chinook Salmon to its native habitat in the McCloud River or the upper Sacramento River, or both

- Maintenance of current flow and water temperature conditions in Clear Creek
- Modified RBDD gate operations while an alternative diversion structure is being built; complete gate removal by 2012
- Short-term and long-term actions for improving juvenile rearing habitat in the lower Sacramento River and northern Delta
- Additional DCC gate closures to keep young fish out of artificial channels in the Delta and allow them to migrate safely toward the ocean
- New OMR reverse flow levels to limit the strength of reverse flows and reduce entrainment at the SWP and CVP facilities
- Use of additional technological measures at the SWP and CVP facilities to enhance screening and increase survival of fish
- Additional measures to improve survival of San Joaquin steelhead smolts, including increased San Joaquin River flows and export curtailments, and a new study of acoustic tagged fish in the San Joaquin River Basin to evaluate and refine these measures
- A new American River flow management standard, temperature management plan, additional technological fixes to temperature control structures, and, in the long-term, restoration of steelhead passage at Nimbus and Folsom Dams.
- A year-round minimum flow regime on the Stanislaus River necessary to minimize project impacts on each life stage of steelhead, including new springtime flows that will support rearing habitat formation and inundation and create pulses that allow salmon to migrate out successfully
- Development of hatchery genetic management plans to increase the diversity and therefore the resiliency of salmon to withstand a wide range of conditions.

Central Valley Project Improvement Act

The Reclamation Projects Authorization and Adjustment Act of 1992 (Public Law 102-575) includes Title 34, the Central Valley Project Improvement Act (CVPIA). The CVPIA amends the authorization of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes of the CVP having equal priority with irrigation and domestic uses of CVP water and elevates fish and wildlife enhancement to a level having equal purpose with power generation. Among the changes mandated by the CVPIA was dedication of 800 TAF of CVP yield annually to fish, wildlife, and habitat restoration. The Department of the Interior’s May 9, 2003 decision on implementation of Section 3406(b)(2) of CVPIA explains how Section 3406(b)(2) water will be dedicated and managed. Dedication of CVPIA 3406(b)(2) water occurs when Reclamation takes a fish and wildlife habitat restoration action based on recommendations of USFWS (and in consultation with NMFS and CDFW), pursuant to Section 3406 (b)(2). Water exports at the CVP pumping facilities have been reduced using (b)(2) water to decrease the risk of fish entrainment at the salvage facilities and also to augment river flows.

4.4.2.2 Collaborative Science and Adaptive Management Program

Since its inception in 2013, CSAMP has been focused on the management of CVP and SWP water project operations and how those operations affect listed fish species, particularly Delta Smelt and salmonids. CSAMP serves as a forum for communication, coordination and engagement on matters associated with the conservation of listed fish within the Sacramento San Joaquin Bay-Delta Estuary and the operations of the CVP and SWP. Information developed by CSAMP is intended to facilitate more effective management decisions, including regulatory decisions, but CSAMP does not directly engage in ongoing regulatory proceedings such as the Reinitiation of Consultation on the Coordinated Long-term Operation of the Central Valley Project and State Water Project (ROC) or the Water Quality Control Plan update.

In February 2017, the CSAMP Policy Group adopted the following updated purpose statement:

> (a) Work with a sense of urgency to collaboratively evaluate current hypotheses and management actions associated with protection and restoration of species of concern, current and future federal and state regulatory authorizations for the SWP and CVP, and other local and state management actions, to improve performance from both biological and water supply perspectives.

The CSAMP is structured as a four-tiered organization comprised of a Policy Group consisting of agency directors and top-level executives from the entities that created CSAMP. The Collaborative Adaptive Management Team (CAMT) is made up of managers and senior level scientists that serve at the direction of the Policy Group. Scoping Teams and Subcommittees are created on an as-needed basis to scope specific science studies or discuss study results. Investigators are contracted as needed to conduct studies. The original CAMT work plan included a number of key questions and possible investigative approaches related to Delta Smelt entrainment (Table 4.4-3), fall outflow and salmonid management actions, many of which are still relevant today.

Table 4.4-3. Key Questions and Possible Investigative Approaches to Address Entrainment Management as Part of the CAMT OMR/Entrainment Work Plan

Key Questions	Possible Investigative Approaches
What factors affect adult Delta Smelt entrainment during and after winter movements to spawning areas? a. How should winter “first flush” be defined for the purposes of identifying entrainment risk and managing take of Delta Smelt at the South Delta facilities? b. What habitat conditions (e.g., first flush, turbidity, water source, food, time of year) lead to adult Delta Smelt entering and occupying the central and South Delta.	Summarization of environmental and fish distribution/abundance (e.g., Fall Midwater Trawl [FMWT] Survey, Spring Kodiak Trawl [SKT]). Multivariate analyses and modeling (e.g., 3D particle tracking) to examine whether fall conditions affect winter distribution Completion of First Flush Study analyses. The Delta Conditions Team (DCT) is currently developing a scope of work to use turbidity modeling to examine various “first flush” conditions, expected entrainment risks, and potential preventative actions that could be taken to reduce entrainment, consistent with key question (a). the DCT could also conduct analyses to address key question (b).

Key Questions	Possible Investigative Approaches
What are the effects of entrainment on the population? a. What is the magnitude (e.g., percentage of population) of adult and larval entrainment across different years and environmental conditions? b. How do different levels of entrainment for adults and larvae affect population dynamics, abundance, and viability?	a. Application of different models (e.g., IBM, life history) to estimate proportional entrainment A direct approach to addressing question (a) has been proposed by Kimmerer 2008 as modified in 2011. This or a derivative approach should be explored as a means to directly estimate the proportional entrainment that has occurred in recent years. Apply to as much of the historical record as possible. b. Application of different models (e.g., IBM, life history, population viability analysis [PVA] to simulate effects on population dynamics, abundance, and variability.
How many adult Delta Smelt and larval/post-larval Delta Smelt are entrained by the water projects?	• Workshop of expert panel review • Testing of new field methodologies such as SmeltCAM • Gear efficiency and expanded trawling experiments • Evaluation of alternative models to estimate abundance, distribution, and entrainment
What conditions prior to movement to spawning areas affect adult Delta Smelt entrainment? • Is there a relationship between Delta Smelt distribution and habitat conditions (e.g., turbidity, X2, temperature, food) during fall and subsequent distribution (and associated entrainment risk) in winter?	• Summarization of environmental and fish distribution/abundance data (e.g., FMWT, SKT). • Multivariate analyses and modeling (e.g., 3D particle tracking) to examine whether fall conditions affect winter distribution. • Completion of Fish Flush Study analyses.
What factors affect larval and post-larval Delta Smelt entrainment? a. How does adult spawning distribution affect larval and post-larval entrainment? b. What conditions (e.g., first flush, spawning distribution, turbidity, water source, food, time of year) lead to larvae and post-larvae occupying the Central Delta and the South Delta?	• Summarization of environmental and fish distribution/abundance data. • Statistical analysis and modeling (e.g., 3D PTM) of effects of adult distribution (e.g., SKT) on larval (e.g., 20 mm) distributions. • Summarization of environmental and fish distribution/abundance data (e.g., 20 millimeter [mm]). Multivariate analyses/modeling to identify conditions promoting occupancy of the Central Delta and the South Delta.
What new information would inform future consideration of management actions to optimize water project operations while ensuring adequate entrainment protection for Delta Smelt? a. Can habitat conditions be managed during fall or early winter to prevent or mitigate significant entrainment events? b. Should habitat conditions (including OMR conditions) be more aggressively managed in some circumstances as a preventative measure during the upstream movement period (e.g., following first flush) to reduce subsequent entrainment?	• Synthesis of available information and study results by the Collaborative Adaptive Management Team (CAMT) Entrainment Team or a designated expert panel, or both. • Consultation with regulatory agencies and operators about the feasibility of different actions.

Notes:
3D = three dimensional
CAMT = Collaborative Adaptive Management Team
Delta Conditions Team (DCT
FMWT = Fall Midwater Trawl
IBM = Individual Based Model
mm = millimeter
OMR = Old and Middle River
PTM = Particle Tracking Model
PVA = population viability analysis
SKT = Spring Kodiak Trawl

4.4.2.3 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

The Magnuson-Stevens Fishery Conservation Management Act, as amended by the Sustainable Fisheries Act (Public Law 104 to 297), was enacted primarily to establish a management system for conserving and managing commercial fisheries within the 200-mile federal waters boundary of the United States. The act also requires that all federal agencies consult with NMFS on activities or proposed activities authorized, funded, or undertaken by that agency that may adversely affect essential fish habitat (EFH) of commercially managed marine and anadromous fish species. EFH includes specifically identified waters and substrate necessary for fish spawning, breeding, feeding, or growing to maturity. EFH also includes all habitats necessary to allow the production of commercially valuable aquatic species, to support a long-term sustainable fishery, and to contribute to a healthy ecosystem (16 USC 1802[10]).

The Pacific Fishery Management Council has designated the Delta, San Francisco Bay, and Suisun Bay as EFH to protect and enhance habitat for coastal marine fish and macroinvertebrate species that support commercial fisheries such as Pacific salmon. Because EFH only applies to commercial fisheries, this means that all Chinook Salmon habitats are included, but not steelhead habitat. There are three fishery management plans (for Pacific salmon, coastal pelagic, and groundfish species) issued by the Pacific Fishery Management Council that designate EFH within the Bay-Delta Estuary:

- Starry Flounder (*Platichthys stellatus*) Identified as Actively Managed in the Pacific Coast Groundfish Fishery Management Plan (Pacific Fishery Management Council 2016a)
- Pacific Sardine (*Sardinops sagax*) Identified as Actively Managed Species by the Coastal Pelagic Species Fishery Management Plan (Pacific Fishery Management Council 2019)
- Pacific Salmon Identified as an Actively Managed Species by the Pacific Coast Salmon Plan (Pacific Fishery Management Council 2016b)
- Northern Anchovy (*Engraulis mordax*) Managed as a Monitored Species by the Coastal Pelagic Species Fishery Management Plan and is subject to EFH consultation as a result.

Although coastal pelagic species EFH does not occur in the project area, the Plan Area is within the region identified as EFH for groundfish and Pacific salmon. Freshwater EFH for Pacific salmon (Sacramento River Winter-run, Central Valley Spring-run, and Central Valley Fall-run and Late Fall-run Chinook Salmon) includes waters currently or historically accessible to salmon within the Central Valley ecosystems, as described by Myers et al. (1998).

4.4.2.4 CLEAN WATER ACT

The Clean Water Act (CWA) is a comprehensive set of statutes aimed at restoring and maintaining the chemical, physical, and biological integrity of the nation’s waters. The CWA is the foundation of surface water quality protection in the United States Initial authority for the implementation and enforcement of the CWA rests with the EPA; however, this authority can be exercised by states with approved regulatory programs. In California, this authority is exercised by the State Water Board and the Regional Water Quality Control Boards (Regional Water Boards). The CWA contains a variety of regulatory and nonregulatory tools to significantly reduce direct pollutant discharges into waters of the

United States, to finance municipal wastewater treatment facilities, and to manage polluted runoff. These tools (e.g., Section 303[d] List of Impaired Waters and Section 404 permitting process) are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Clean Water Act Section 303(d)

Section 303(d) of the federal CWA requires states to identify water bodies that do not meet water quality standards and are not supporting their designated beneficial uses. These waters are placed on the Section 303(d) List of Impaired Waters. This list defines low-, medium-, and high-priority pollutants that require immediate attention by federal and state agencies. Placement on this list triggers development of a Total Maximum Daily Load (TMDL) Program for each water body and associated pollutant and stressor on the list. The Central Valley Regional Water Quality Control Board (Central Valley Water Board) is responsible for implementing the TMDL Program in California. Completed or ongoing TMDL programs in the Bay-Delta region include chlorpyrifos and diazinon, DO, mercury and methylmercury, pathogens, pesticides, organochlorine pesticides, salt and boron, and selenium.

Clean Water Act Section 401

Section 401 of the CWA specifies that states must certify that any activity subject to a permit issued by a federal agency (e.g., the U.S. Army Corps of Engineers [USACE]) meets all state water quality standards. In California, the State Water Resources Control Board (California Water Board) and the Regional Water Boards are responsible for certifying activities subject to any permit issued by USACE pursuant to Section 404 of the Clean Water Act or pursuant to Section 10 of the Rivers and Harbors Act of 1899.

4.4.3 State Plans, Policies, and Regulations

4.4.3.1 California Endangered Species Act

The California Endangered Species Act (CESA) (Fish and Game Code Sections 2050 to 2089) establishes various requirements and protections regarding species listed as threatened or endangered under state law. California's Fish and Game Commission is responsible for maintaining lists of threatened and endangered species under CESA. CESA prohibits the "take" of listed and candidate (petitioned to be listed) species (Fish and Game Code Section 2080). In accordance with Section 2081 of the California Fish and Game Code, a permit from CDFW is required for projects "that could result in the incidental take of a wildlife species state-listed as threatened or endangered". "Take" under California law means to "… hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch capture, or kill…" (Fish and Game Code Section 86). The state definition does not include "harm" or "harass," as the federal definition does. The measures required to minimize and fully mitigate the impacts of the authorized take must be roughly proportional in extent to the impact of the taking on the species, maintain the applicant's objectives to the greatest extent possible, and may be successfully implemented by the applicant (Title 14, Section 783.4 of the California Code of Regulations).

Longfin Smelt Incidental Take Permit

The San Francisco Bay/Sacramento-San Joaquin River Delta (Bay-Delta) population of Longfin Smelt was listed as threatened on June 26, 2009, under CESA. Various SWP facilities are located within the range of Longfin Smelt, which could affect the species. Accordingly, DWR applied for a CESA Incidental Take Permit (ITP) in 2008 requesting authorization under Section 2081(b) of CESA for incidental take of Longfin Smelt that could be entrained by SWP facilities. On February 23, 2009, CDFW issued DWR an ITP (Permit No. 2081-2009-001-03). The ITP covers incidental take of Longfin Smelt by ongoing operation of the SWP. The SWP's incidental take authorization of LFS expired on December 31, 2018. Prior to the expiration date, DWR requested a minor amendment to extend incidental take authorization to December 31, 2019 to allow preparation of an ITP Application for coverage of long-term operation of the SWP.

The SWP is currently operated in accordance with the 2009 Longfin Smelt ITP and 2018 minor amendment.

Consistency Determinations

In 2008, Reclamation, in consultation with DWR, prepared a Biological Assessment on the continued long-term CVP and SWP operations. Subsequently, USFWS and NMFS issued BiOps that concluded the coordinated long-term operation of the CVP and SWP, as proposed, would jeopardize the continued existence of Delta Smelt, Winter-run Chinook Salmon, and Spring-run Chinook Salmon (USFWS 2008; NMFS 2009). USFWS concluded that the coordinated SWP and CVLP operations, as proposed, was likely to jeopardize the continued existence of the Delta Smelt and adversely modify Delta Smelt critical habitat. USFWS and NMFS developed RPAs consisting of a number of components and actions to avoid the likelihood of jeopardizing the continued existence or the destruction or adverse modification of these species.

On June 17, 2009, the Director of CDFW received correspondence from the Director of DWR, requesting a determination that the USFWS Biological Opinion and its incidental take statement were consistent with CESA pursuant to Fish and Game Code Section 2080.1. On August 5, 2009 CDFW received a request from DWR to determine that the NMFS Biological Opinion, including the incidental take statement was consistent with CESA, such that no further take authorization was necessary. On July 16, 2009 CDFW issued a consistency determination with the 2008 USFWS Biological Opinion and on September 3, 2009 CDFW issued a consistency determination with the 2009 NMFS Biological Opinion.

The SWP is currently operated in accordance with the consistency determinations for the 2008 USFWS Biological Opinion and the 2009 NMFS 2009 Biological Opinion.

4.4.3.2 Sacramento–San Joaquin Delta Reform Act of 2009

In late 2009, the California Legislature enacted a package of related water bills that included the Sacramento–San Joaquin Delta Reform Act of 2009 (Delta Reform Act). One of the many objectives of the Delta Reform Act is to "[r]estore the Delta ecosystem, including its fisheries and wildlife, as the heart of a healthy estuary and wetland ecosystem."

4.4.3.3 Delta Stewardship Council Delta Plan

The Delta Stewardship Council (DSC) was created by Senate Bill (SB) 1X7, largely codified in the Sacramento-San Joaquin Delta Reform Act of 2019. Among other responsibilities, the bill gave the DSC jurisdiction to hear appeals of state and local agency certifications of consistency for certain land use projects in the Delta or Suisun Marsh that qualifies as “covered actions”. The DSC is composed of members who represent different parts of the state and offer diverse expertise in fields such as agriculture, science, the environment, and public service. Of the seven members, four are appointed by the governor, one each by the Senate and Assembly, and the seventh is the chair of the Delta Protection Commission. In addition, they are advised by a 10-member board of nationally and internationally renowned scientists.

The DSC is tasked with furthering the state’s coequal goals for the Delta through development of a Delta Plan (CA Water Code ~~§§~~ Sections 85300[a], 85302[a]). As defined in the California Water code, “coequal goal”s means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place” (CA Water Code Section~~§~~ 85054). The Delta Plan is a comprehensive, long-term management plan to further these goals for the Delta (CA Water Code Sections~~§§~~ 85059, 85300[a], 85302[a]).

The Delta Plan generally covers five topic areas and goals: increased water supply reliability, restoration of the Delta ecosystem, improved water quality, reduced risks of flooding in the Delta, and protection and enhancement of the Delta. The DSC does not propose constructing, owning, or operating any facilities related to these five topic areas. Rather, the Delta Plan sets forth regulatory policies and recommendations that seek to influence the actions, activities, and projects of cities and counties and State, federal, regional, and local agencies toward meeting the goals in the five topic areas.

The DSC unanimously approved the Delta Plan on May 16, 2013. Subsequently, its 14 regulatory policies were approved by the Office of Administrative Law, a state agency that ensures the regulations are clear, necessary, legally valid, and available to the public. The Delta Plan became effective with legally enforceable regulations on September 1, 2013, and has since been updated in April 2018. State and local agencies proposing covered actions that occur in whole or in part in the Delta or Suisun Marsh must file written certifications of consistency with the applicable Delta Plan policies before initiating implementation of such actions (CA Water Code Section~~§~~ 85225; CA Code Regs., Title 23 Section~~§~~ 5002). Any person may file an appeal with the DSC within 30 days, and the Council must hold a public hearing within 60 days and issue written findings granting or denying the appeal within an additional 60 days (CA Water Code Sections~~§§~~ 85225.10-85225.25). If the DSC grants an appeal, it must remand the certification to the action agency, and the agency may proceed with implementation only if it files a revised certification of consistency that addresses each of the DSC’s findings (CA Water Code Section~~§~~ 85225.25).

4.4.3.4 WATER QUALITY CONTROL PLANS

Water operations have changed substantially since the SWP and CVP were constructed. Operations were initially limited by physical capacity and available water. DWR and Reclamation's SWP and CVP operations changed significantly in 1978, with the issuance of the Water Quality Control Plan (WQCP) under the SWRCB Water Right Decision 1485 (D-1485). D-1485 imposed on the water rights for the CVP and SWP new terms and conditions that required DWR and Reclamation to meet certain standards for water quality protection for agricultural, municipal and industrial (M&I), and fish and wildlife purposes; incorporated a variety of Delta flow actions; and set salinity standards in the Delta while allowing the diversion of flows into the Delta during the winter and spring. Generally, during the time D-1485 was in effect, natural flows met water supply needs in normal and wetter years and reservoir releases generally served to meet export needs in drier years.

The D-1485 requirements applied jointly to both the SWP and CVP, requiring a joint understanding between the projects of how to share this new responsibility. To ensure SWP and CVP operations were coordinated, the COA was negotiated and approved by Congress in 1986, establishing terms and conditions by which DWR and Reclamation would coordinate SWP and CVP operations, respectively. The 1986 COA envisioned Delta salinity requirements but did not address export restrictions during excess conditions.

In 1992, the Central Valley Project Improvement Act (CVPIA) amended previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes having equal priority with irrigation and domestic water supply uses, and fish and wildlife enhancement as having an equal priority with power generation. The CVPIA included a number of other provisions that represented additional Congressional direction for CVP operations and overlaid a more complex statutory framework. These overlapping and sometimes competing requirements create challenges in how to address and balance the myriad of obligations Reclamation has in operating the CVP, and in how to coordinate with the SWP.

In 1995, the SWRCB issued an update to the WQCP for the Bay-Delta. In 1999 (revised in 2000) the SWRCB issued Water Right Decision 1641 (D-1641) to implement those elements of the 1995 WQCP that were to be implemented through water rights. The 1995 WQCP and D-1641 included a new export to total Delta inflow (E/I) ratio of 35% from February through June, which represented a significant change from D-1485. The 1995 WQCP and D-1641 also imposed Spring X2 requirements and pumping limitations based on San Joaquin River flow, which in combination with the E/I ratio, reduced the availability of "unstored" flow for the SWP and CVP.

On December 31, 2012, the State Water Resources Control Board (SWRCB) released a draft Substitute Environmental Document (SED) (2012 Draft SED) for the review and update of the San Joaquin River flow and southern Delta salinity objectives and associated program of implementation described in the 2006 Bay-Delta Water Quality Control Plan. After holding a public workshop and receiving public comments on the 2012 Draft SED in 2013, the State Water Board decided to recirculate the document. In September 2016, the State Water Board recirculated the draft SED, and after public review and comment, on December 12, 2018, through State Water Board Resolution No. 2018-0059, the State Water Board adopted the Bay-Delta Plan amendments establishing the lower San Joaquin River flow objectives and revised southern Delta salinity objectives. However, the SWRCB did not assign responsibility to any water right holders to meet these new and revised objectives. In addition, the amendments are being legally challenged and have not yet been implemented through a water rights decision. The SWRCB continues to work on proposed amendments for the Sacramento River, its tributaries and the Delta.

4.4.4 Regional and Local Plans, Policies, and Regulations

4.4.4.1 CALFED Bay-Delta Program

The CALFED Bay-Delta Program (CALFED)[5] was a collaborative effort of more than 20 federal and state agencies focusing on restoring the ecological health of the Bay-Delta while ensuring water quality improvements and water supply reliability to all users of the Bay-Delta water resources. The CALFED Bay-Delta Program included a range of balanced actions that are used in a comprehensive, multi-agency approach to managing Bay-Delta resources (CALFED Bay-Delta Program 2000a). The original objectives of the CALFED Bay-Delta Program are listed below:

- Provide good water quality for all beneficial uses.
- Improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species.
- Reduce the mismatch between Bay-Delta water supplies and current and projected beneficial uses dependent on the Bay-Delta system.
- Reduce the risk to land use and associated economic activities, water supply, infrastructure, and the ecosystem from catastrophic breaching of Delta levees.

The program objectives have been implemented among numerous CALFED elements since the CALFED Program Record of Decision was issued in 2000 (CALFED Bay Delta Program 2000b).

4.4.5 Regulatory Limitations on Operations of Delta Water Diversions

SWP and CVP operations are implemented in accordance with SWRCB water rights and water quality decisions, State and federal Endangered Species Act regulations and the CVPIA, including D-1641, the 2008 USFWS BiOp, the 2009 NMFS BiOp, and the SWP is operated in accordance with the 2009 Longfin Smelt ITP and 2009 consistency determinations issued by CDFW.

4.4.5.1 Decision 1641

The SWRCB adopted the 1995 Bay-Delta Plan on May 22, 1995. The plan became the basis of D-1641 (adopted December 29, 1999, and revised March 15, 2000). D-1641 amended certain terms and conditions of the SWP and CVP water rights to include flow and water quality objectives to ensure protection of beneficial uses in the Delta and Suisun Marsh. (SWRCB grants conditional changes to points of diversion for the CVP and SWP under SWRCB D-1641.) The requirements in D-1641 address

[5] As part of the Delta Reform Act of 2009, the Delta Stewardship Council has in effect taken on the CALFED mission.

the objectives for fish and wildlife protection, water supply water quality, and Suisun Marsh salinity. These objectives include specific Delta outflow requirements throughout the year, specific export limits 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, and fishery uses, and they vary throughout the year and by water year type.

The export to inflow ratio specified in D-1641 limited exports to 35% of total Delta inflow from February through June. The 35% E/I Ratio from February to June required in D-1641 was a substantial change from SWRCB Water Rights Decision 1485 (D-1485). D-1641 also specified a target location for X2 in the spring, from February through June, to maintain freshwater and estuarine conditions in the western Delta to protect aquatic life.

D-1641 also authorized the SWP and CVP to jointly use both the Jones and Banks pumping plants in the South Delta, with conditional limitations and required response coordination plans (referred to as the JPOD). Use of the JPOD is based on staged implementation and conditional requirements for each stage of implementation. In general, JPOD capabilities are used during specified periods or during certain Delta conditions to accomplish four basic CVP and SWP objectives, including: (1) increase San Luis Reservoir storage; (2) enhance annual CVP south-of-Delta water supplies; (3) facilitate water transfers; and (4) minimize entrainment of Delta fishes.

Joint Point of Diversion

D-1641 authorized the SWP and CVP to jointly use both Jones and Banks pumping plants in the South Delta, with conditional limitations and required response coordination plans (referred to as Joint Point of Diversion, or JPOD). Use of JPOD is based on staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in D-1641 are:

- Stage 1, for water service to a group of CVP water service contractors (Cross Valley contractors, San Joaquin Valley National Cemetery, and Musco Family Olive Company) and recovery of export reductions implemented to benefit fish;
- Stage 2, for any purpose authorized under the current CVP and SWP water right permits; and
- Stage 3, for any purpose authorized, up to the physical capacity of the diversion facilities.

In general, JPOD capabilities are used to accomplish four basic CVP and SWP objectives:

- When wintertime excess pumping capacity becomes available during Delta excess conditions and total CVP and SWP San Luis storage is not projected to fill before the spring pulse flow period, the project with the deficit in San Luis storage may elect to pursue use of JPOD capabilities.
- When summertime pumping capacity is available at Banks Pumping Plant and CVP reservoir conditions can support additional releases, the CVP may elect to use JPOD capabilities to enhance annual CVP south-of-Delta water supplies.
- When summertime pumping capacity is available at the Banks Pumping Plant or the Jones Pumping Plant to facilitate water transfers, JPOD may be used to further facilitate the water transfer.

- During certain coordinated CVP and SWP operations scenarios for fishery entrainment management, JPOD may be used to shift CVP and SWP exports to the facility with the least fishery entrainment impact while minimizing export at the facility with the most fishery entrainment impact.

Each JPOD stage has regulatory terms and conditions that must be satisfied to implement JPOD. All stages require a response plan (i.e., water level response plan) to ensure water elevations in the South Delta will not be lowered to the injury of local riparian water users and a response plan to ensure the water quality in the South Delta and the Central Delta will not be substantially degraded through operations of the JPOD to the injury of water users in the South Delta and the Central Delta. Stage 2 has an additional requirement to complete an operations plan (i.e., fisheries response plan) that will protect fish and wildlife and other legal users of water. Stage 3 has an additional requirement to protect water levels in the South Delta. All JPOD diversions under excess conditions in the Delta are junior to CCWD water right permits for the Los Vaqueros Project and must have an X2 location west of certain compliance locations consistent with the 1993 Los Vaqueros Biological Opinion for Delta Smelt.

Implementation of 2008 USFWS and 2009 NMFS Biological Opinions and CDFW Consistency Determinations

The 2008 USFWS and 2009 NMFS Biological Opinions and consistency determinations restrict CVP and SWP diversions to reduce reverse flows in the Old and Middle rivers. The 2008 USFWS BiOp includes criteria for fall Delta outflow. The 2009 NMFS BiOp includes criteria for a San Joaquin River I/E ratio.

2008 USFWS Biological Opinion OMR Criteria

The 2008 USFWS BiOp restricts South Delta pumping to preserve certain OMR flows as prescribed in three actions. Actions 1 and 2 are implemented for the protection of adult Delta Smelt migration and to minimize entrainment. These actions specify OMR criteria of -2,000, and range from -2,000 cfs to -5,000 cfs, respectively, potentially beginning on December 1, depending on conditions and recommendations from an interagency Smelt Working Group, and extending until a water temperature criterion is met or the onset of spawning is identified. Action 3 is implemented for the protection of larval and juvenile Delta Smelt after Actions 1 and 2 have concluded, when a water temperature criterion is met, or when spawning criteria are met. The actions will continue until June 30 or until a specific water temperature criterion is met. Action 3 specifies OMR criteria of −1,250 to −5,000 cfs, depending on conditions and recommendations from the Smelt Working Group.

2009 NMFS Biological Opinion OMR Criteria

The 2009 NMFS BiOp includes OMR criteria to protect juvenile salmonids during winter and spring emigration downstream into the San Joaquin River and to increase survival of salmonids and Green Sturgeon entering the San Joaquin River from Georgiana Slough and the lower Mokelumne River by reducing the potential for entrainment at the South Delta intakes. In 2011, NMFS amended the OMR criteria in response to recommendations provided in an Independent Review Panel report and updated the adaptive management provisions in the BiOp.

Actions for OMR criteria are implemented from January 1 through June 15 and reduces exports, as necessary, to limit negative flows to −2,500 to −5,000 cfs in the Old and Middle rivers, depending on the presence of salmonids. The reverse flow is managed within this range to reduce flows toward the pumps during periods of increased salmonid presence. The negative flow objective within the range is determined based on the decision tree shown in Table 4.4-4.

Table 4.4-4. 2009 NMFS Biological Opinion OMR Criteria

Date	Action Triggers	Action Responses
January 1–June 15	January 1 through June 15	−5,000 cfs
January 1–June 15 First Stage Trigger (increasing level of concern)	Daily SWP and CVP older juvenile loss density (fish per TAF): (1) is greater than incidental take limit divided by 2,000, with a minimum value of 2.5 fish per TAF; or (2) daily loss is greater than daily measured fish density divided by 12 TAF; or (3) Coleman National Fish Hatchery coded-wire-tag Late Fall-run or Livingston Stone National Fish Hatchery coded-wire-tag Winter-run cumulative loss greater than 0.5%; or (4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 12 TAF.	−3,500 to −5,000 cfs
January 1–June 15 Second Stage Trigger (analogous to high concern level)	Daily SWP and CVP older juvenile loss density (fish per TAF) is: (1) greater than incidental take limit divided by 1,000, with a minimum value of 2.5 fish per TAF; or (2) daily loss is greater than daily fish density divided by 8 TAF; or (3) Coleman National Fish Hatchery coded-wire-tag Late Fall-run or Livingston Stone National Fish Hatchery coded-wire-tag Winter-run cumulative loss greater than 0.5%; or (4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 8 TAF.	−2,500 to −5,000 cfs
End of Triggers	Continue action until June 15 or until average daily water temperature at Mossdale is greater than 72°F (22.2 °C) for 7 consecutive days (1 week), whichever is earlier.	No OMR restriction

Notes: °F = degrees Fahrenheit; cfs = cubic feet per second; CVP = Central Valley Project; OMR = Old and Middle River; SWP = State Water Project; TAF = thousand acre-feet

2009 NMFS Biological Opinion San Joaquin River I/E Ratio

The 2009 NMFS BiOp requires South Delta exports to be reduced during April and May to protect steelhead from emigrating from the lower San Joaquin River into the South Delta channels and intakes. The I/E ratio from April 1 through May 31 specifies that Reclamation is to operate New Melones Reservoir to maintain a specified flow schedule in the Stanislaus River at Goodwin and that the CVP and SWP pumps are operated to meet the ratios based upon a 14-day running average, as summarized in Table 4.4-5.

Table 4.4-5. 2009 NMFS Biological Opinion I/E Ratios

San Joaquin Valley Classification	San Joaquin River Flow at Vernalis (cfs): CVP/SWP Combined Export Ratio (cfs)
Critically dry	1:1
Dry	2:1
Below normal	3:1
Above normal	4:1
Wet	4:1
Vernalis flow equal to or greater than 21,750 cfs	Unrestricted exports until flood recedes below 21,750 cfs

Notes: cfs = cubic feet per second; CVP = Central Valley Project; NMFS = National Marine Fisheries Service; SWP = State Water Project

During multiple dry years, the ratio will be limited to 1:1 if additional criteria are met. In addition, implementation of the I/E ratio under all conditions would allow a minimum pumping rate of 1,500 cfs to meet public health and safety needs of communities that rely solely upon water diverted from the CVP and SWP pumping plants.

2008 USFWS Biological Opinion Fall X2 Criteria

The 2008 USFWS BiOp includes an additional Delta salinity requirement in September and October following wet and above-normal water years, which is often referred to as Fall X2. The salinity requirements is to maintain X2 at 74 kilometers from the Golden Gate Bridge during wet years and 81 kilometers from the bridge following above-normal water years based upon the Sacramento Basin 40-30-30 index described in D-1641. In November of such years, there is no specific X2 requirement. However, all inflow into SWP and CVP upstream reservoirs is required to be conveyed downstream to augment Delta outflow. If storage increases during November of these years, the increased storage volume is required to be released in December.

Coordinated Operation Agreement

The CVP and SWP are operated in a coordinated manner in accordance with Public Law 99-546 (October 27, 1986), which directs the Secretary of the Interior to execute and implement the Coordinated Operation Agreement (COA). The CVP and SWP are operated in coordination under the SWRCB decisions and water right orders related to the CVP's and SWP's water right permits and licenses to appropriate water by diverting to storage, by directly diverting to use, or by re-diverting releases from storage later in the year or in subsequent years.

In 2018, Reclamation and DWR executed a COA Addendum updating four elements of the COA: (1) in-basin uses; (2) export restrictions; (3) CVP use of Banks Pumping Plant of up to 195,000 AF per year; and (4) the periodic review. The updates are described further in Appendix B.

Obligations for In-Basin Uses

In-basin uses are defined in the COA as legal uses of water in the Sacramento Basin and Delta, including the water required under D-1485.

Balanced water conditions are defined in the COA as periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flows approximately equal the water supply needed to meet Sacramento Valley in-basin uses plus exports. Excess water conditions are periods when it is mutually agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses plus exports.

During excess water conditions, sufficient water is available to meet all beneficial needs, and the CVP and SWP are not required to make additional releases. In excess water conditions, water accounting is not required and some of the excess water is available to CVP water contractors, SWP water contractors, and users located upstream of the Delta. During excess conditions Reclamation and DWR export and store as much water as possible within their physical and contractual limits. However, during balanced water conditions, CVP and SWP share responsibility in meeting in-basin uses.

COA sharing percentages for meeting Sacramento Valley in-basin uses vary from 80% responsibility of the United States and 20% responsibility of the State of California in wet year types to 60% responsibility of the United States and 40% responsibility of the State of California in critical year types. In a dry or critical year following 2 dry or critical years, the United States and the State of California will meet to discuss additional changes to the percentage of water from the CVP and SWP that is allocated to meet in-basin use.

Accounting and Coordination of Operations

DWR and Reclamation coordinate daily to determine target Delta outflow for water quality, reservoir release levels necessary to meet in-basin demands, schedules for joint use of the San Luis Unit facilities, and use of each other's facilities for pumping and wheeling. During balanced water conditions, daily water accounting is maintained for the SWP and CVP obligations. This accounting allows for flexibility in operations and avoids the necessity of daily changes in reservoir releases that originate several days' travel time from the Delta.

4.4.6 Threshold of Significance

Thresholds of Significance represent the criteria that were used to identify whether an impact would be significant under CEQA. Appendix G of the CEQA Guidelines suggests the following evaluation criteria for biological resources. Based on Appendix G of the CEQA Guidelines, a project would be considered to have a significant impact if the project would:

- Have a substantial adverse impact, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service;
- Have a substantial adverse impact on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service;
- Have a substantial adverse impact on state or federally protected wetlands (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means;
- Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites;
- Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance;
- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

These significance criteria provided in Appendix G of the CEQA Guidelines do not provide quantitative thresholds against which project elements, actions or representations of hydrologic and hydrodynamic conditions (i.e., simulation model outputs) can be compared to identify potential impacts. Therefore, analyses have been developed based on the best available commercial and scientific information that evaluate known impact mechanisms and use observed species responses to changes in environmental conditions as indicators of impact. The results of individual analyses were used as impact indicators in conjunction with expert understanding of species responses to habitat perturbations to identify potential impacts of the Proposed Project on fish and aquatic resources.

Analyses have been developed based on an extensive review of fisheries literature and years of experience and research in the Delta and Central Valley. Impact determinations are based on consideration of all evaluated habitat parameters, as well as potential direct project impacts on individuals for all life stages of the evaluated species.

The Initial Study determined that the project would have no impact under several of the significance criteria provided in Appendix G of the CEQA Guidelines (see Appendix D), and those significance criteria are therefore not discussed further in this EIR. To further simplify understanding of the applicable significance criteria the applicable significance criteria were combined. Thus, for the purposes of this analysis, the Proposed Project would result in a significant impact on fish and aquatic resources if it would result in:

- A substantial adverse impact on any fish species of primary management concern, including species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by CDFW, NMFS, or USFWS.

Based on this threshold of significance, an impact is considered potentially significant if implementation of the Proposed Project would substantially adversely affect a species in consideration of all evaluated impact indicators for all life stages.

4.4.7 Impacts of the Proposed Project

4.4.7.1 General Analytical Approach

The impacts analysis is conducted by species and is broken into two main components that evaluate the impacts of (1) operations and maintenance and (2) environmental protective measures. These components are evaluated for direct project impacts on individuals and indirect impacts on individuals by assessing project impacts on habitat. Essential Fish Habitat and designated critical habitat are evaluated, as applicable for those species to which these regulatory designations apply.

Operations and maintenance components of the Proposed Project include all aspects of operating and maintaining the SWP. Components of the operations and maintenance (O&M) impacts analyses also include evaluating impacts of annual O&M activities included in the Proposed Project, such as installing and removing agricultural barriers and aquatic weed removal.

Following the analysis of potential impacts of O&M components of the Proposed Project, this section also analyzes the Environmental Protective Measures included in the Proposed Project to address and offset the impacts of the O&M components on listed species.

Each specific component of the Proposed Project is identified as an O&M component or environmental protective measure (see Chapter 3, “Project Description”), potential impact mechanism(s) are described, and the Proposed Project components are evaluated for each potentially affected species accordingly.

The impacts analyses evaluate potential impacts on life stages (for example, egg, alevin, fry, juvenile, adult) of each species based on species-specific conceptual models, if available. The impacts section is arranged by species, beginning with a summary of the relevant conceptual model, followed by consideration of the potential impacts of the Proposed Project by component. For example, within the Operations and Maintenance category, the impact of operations, which include OMR management and other individual operations-related actions, is addressed. Each species-specific analysis considers the exposure of each life stage to each Proposed Project component and focuses on the extent to which a Proposed Project component overlaps in time and location with the life stage. Potential direct and indirect impacts of exposure to the Proposed Project component on individuals of the species are then analyzed. This analysis is generally qualitative, although the potential impacts of flow-dependent actions are informed to the extent possible by simulating the operations using hydrologic and hydrodynamic models and is related to the conceptual model for the life stage transition being analyzed.

Assessment of direct impacts is based upon the likelihood of physical injury or mortality to individuals from SWP facilities and operations. It is not possible to predict the number of individuals that would be subject to such direct impacts. In general, predicting the number of individuals directly affected would be a density-dependent phenomenon (e.g., with more fish subject to direct impacts in years when the population is relatively high). Instead, the evaluation is conducted in a relative manner and assesses whether the direct impact is greater or lower under the Proposed Project, relative to the Existing Conditions scenario. Similarly, the assessment of indirect impacts on habitat is also evaluated in a relative manner.

4.4.7.2 Geographic Scope of the Analysis

As described in the introduction to Section 4.4, the geographic scope for evaluation of direct and indirect impacts of the Proposed Project is delineated by the following waters:

- Sacramento River from its confluence with the Feather River downstream to the legal Delta boundary at the I Street Bridge in the city of Sacramento
- Sacramento-San Joaquin Delta
- Suisun Marsh and Bay

The rationale for including these water bodies in the geographic area potentially affected by the Proposed Project and excluding other areas is provided in Appendix G.

4.4.7.3 Hydrologic and Hydrodynamic Modeling

The following fish and aquatic resources impact assessment relies on hydrologic and hydrodynamic modeling to provide a quantitative basis with which to assess the potential direct and indirect impacts of the Proposed Project scenario relative to the Existing Conditions scenario. Specifically, hydrologic and hydrodynamic modeling and post-processing applications were used to simulate operations expected to occur at SWP facilities and resulting aquatic habitat conditions (e.g., flow, velocity).

Model Uncertainty

The physical hydrologic and hydrodynamic models used in the analyses, although mathematically precise, should be viewed as having inherent uncertainty because of limitations in the theoretical basis of the model and the scope of the formulation and function for which the model is designed. In addition, the accuracy of the models is unknown and unquantifiable because of the planning-level nature under which the assumptions of the projected conditions have been established. Specifically, individual operational components of the Proposed Project are intended to be implemented in real time in ways that may not necessarily be directly compatible with CalSim II, the hydrologic simulation model used in these analyses. Therefore, assumptions regarding implementation of the Proposed Project components were used in the model to represent potential operations under the Proposed Project.

Nonetheless, physical hydrologic and hydrodynamic simulation models developed for planning and impact assessment purposes represent the best available information with which to conduct evaluations of proposed changes in SWP operations. Therefore, these models are used as analytical tools to identify potential changes in aquatic habitat variables (e.g., flows and water velocities), as well as inputs to species specific analytical tools, described in the analyses below. Detailed discussion of specific modeling tools, the modeling assumptions used, and the uncertainty associated with the models is provided in Appendix H.

Application of Model Output

The CalSim II model monthly simulation of an actual daily (or even hourly) operation of the CVP and SWP results in several limitations in the use of the model results. The model results must be used in a comparative manner, to reduce the effects of the use of monthly assumptions and other assumptions that are indicative of real-time operations but do not specifically match real-time observations.

As described above, model results are evaluated in a relative manner and are used for comparative purposes rather than for absolute predictions. The focus of the analyses is on differences in the results among comparative scenarios (e.g., simulated conditions under the Proposed Project scenario are compared to simulated conditions under the Existing Conditions scenario). All of the assumptions are the same for both the Proposed Project and Existing Conditions model simulations, except for the assumptions associated with the Proposed Project itself. Therefore, differences in the results of the model simulations represent changes in output parameters that could occur as a result of implementing the Proposed Project. Results from a single simulation may not necessarily correspond to actual system operations for a specific month or year, but are representative of general conditions and trends that could occur under the Proposed Project. Model results are best interpreted using various statistical measures such as long-term and water-year-type averages and probability of exceedance.

The CalSim II model contains several assumptions regarding the operation of the CVP and SWP system and uses a water balance approach to simulate those operations. The outputs are provided on a monthly time step. The model assumptions and water balance approach to modeling the large and complex CVP and SWP system may result in minor differences in simulations with the same assumptions under some limited circumstances. These minor differences require careful interpretation of CalSim II model results (e.g., using results in a comparative manner) to understand if the difference is a meaningful change or a limitation of the model. Therefore, for analytical purposes, if the quantitative differences in a CalSim model output parameter between the Existing Conditions and the Proposed Project model scenarios are 5% or less, the conditions between the scenarios are considered to be "similar." Differences in CalSim outputs of greater than 5% would not necessarily constitute a biological impact, but would be considered actual physical differences that could be expected to occur. These changes are factored in the species-specific analyses to identify potential biological effects. Detailed discussion of specific modeling tools, the modeling assumptions used, and the uncertainty associated with the models is provided in Appendix H.

Long-Term Average and Water Year Type Model Parameters

Long-term averages of the entire simulation period for all months, monthly averages, and averages by water year type are used as a measure of central tendency to identify overall differences between the Proposed Project and Existing Conditions modeling scenarios. These averages are not intended to identify each individual simulated monthly or daily difference in simulated parameters (e.g., monthly flow, daily velocity) between the Proposed Project and the Existing Conditions scenarios for a given parameter, but are intended to convey the long-term differences that are likely to occur and overall trends between scenarios. Where appropriate and applicable the variability in model output data sets is displayed by providing median and quartile statistics as well as confidence intervals around the mean.

Flow Exceedance Curves

Flow exceedance curves are used to illustrate the distribution of simulated model output parameters under the Proposed Project and Existing Conditions model scenarios. In general, flow exceedance curves represent the probability, as a percentage of time, that values would be met or exceeded at a specific location, during a certain time period. Therefore, exceedance curves demonstrate the cumulative probabilistic distribution of output parameters for each month at a given location under each model simulation. These cumulative probability distributions are generally used to show how often and by how much a modeled parameter under the Proposed Project scenario is above or below the Existing Conditions scenario.

Biological Models, Statistical Analyses, and Biological Inferences

Hydrologic model outputs from CalSim II and hydrodynamic outputs from DSM2 are used as inputs to various biological models and statistical analyses that are based on the most current available scientific information. These biological models and statistical analyses describe relationships between hydrologic and hydrodynamic parameters and species-specific responses. For example, evaluation of Chinook

Salmon smolt survival through the Delta is conducted using the DPM, which uses available time-series data and values taken from empirical studies or other sources to parameterize model relationships and inform uncertainty, thereby using the greatest amount of data available to dynamically simulate responses of smolt survival to changes in water management. Another example is the entrainment loss density (or salvage density) method used to evaluate entrainment using CalSim II outputs. The entrainment loss method is basically a description of differences in export flows weighted by historical monthly loss density. In addition, hydrologic and hydrodynamic model outputs are used to make more direct and simple inferences about potential project-related impacts on species or their habitat attributes (e.g., food availability, predation risk) based on observed responses to flow and hydrodynamic changes that are reported in available literature. Descriptions of the biological models used for quantitative analysis as well as selected detailed results are provided in Appendix E. CalSim II and DSM2, and their results, are provided in Appendix C.

Biological Model Uncertainty

Because these biological analyses are based on observed empirical data and relationships developed from those data, uncertainty exists in the relationships used in the models and, subsequently, in their results. This uncertainty is described in the model descriptions, provided in Appendix E, and in discussions regarding interpretation of the results in this section.

Identification of SWP Impacts

Quantitative and qualitative analyses attempt to account for the SWP portion of impacts by considering factors such as entrainment only at SWP facilities (e.g., entrainment into the CCF), but in some cases, such as effects based on Delta outflow, the analyses reflect SWP and CVP operations. Specifically, CalSim II and DSM2 simulations include operations of both the SWP and CVP because the models are simulating combined SWP and CVP operations. Therefore, many of the analyses would overestimate impacts of the SWP if model results were examined without consideration of the contribution of only the SWP to the modeled parameters (e.g., flow at Freeport).

Isolating the SWP contribution to hydrologic and hydrodynamic changes in the Delta was conducted based on the premise that under excess Delta conditions, the joint operations are typically governed by the exports at the SWP and CVP pumping facilities, and under balanced conditions, the SWP and CVP responsibility are defined in the COA. The COA identifies two types of balanced conditions, in-basin use (IBU) and unstored water for export (UWFE). In estimating the SWP proportion of impacts, the following principles were used:

- For months with IBU balanced conditions, the sharing ratio assigned to SWP in the COA is the SWP’s proportion of an impact.
- For months with UWFE balanced conditions and excess conditions, the proportion of exports at Banks Pumping Plant of the total exports at Banks and Jones pumping plants is the SWP’s proportion of an impact. All exports, including any water transfers at the Banks Pumping Plant, are used in this estimation.

These principles were applied to each month in the 82-year CalSim simulation period, and the SWP's proportions were identified for each month. Appendix H provides the percentage of combined SWP and CVP Delta water operations for which the SWP is responsible by month and water year type.

4.4.7.4 Species-Specific Impacts

Summary of Impacts by Species and Life Stage

Potential operations-related impacts were evaluated along with annual O&M activities and project Environmental Protective Measures for each species, and are summarized in Table 4.4-6. Detailed discussion and analyses of these impacts on each species are presented in the sections following Table 4.4-6.

Delta Smelt

Conceptual Model

The IEP MAST (2015) developed "a general life cycle conceptual model for the four Delta Smelt life stages (adults, eggs and larvae, juveniles, and subadults) that includes stationary landscape attributes and dynamic environmental drivers, habitat attributes, and Delta Smelt responses."

A life-stage transition in the December–May period addresses adults transitioning to eggs and larvae. Adult habitat attributes and environmental drivers potentially affected by the Proposed Project are primarily at risk of entrainment due to exports (a potential direct impact), as well as at risk of sediment/turbidity changes relating to predation (a potential indirect impact) and food availability (a potential indirect impact).

A life-stage transition in the March–June period address eggs and larvae transitioning to juveniles. Larvae habitat attributes and environmental drivers potentially affected by the Proposed Project are primarily food availability from food production and retention (a potential indirect impact), entrainment risk due to exports (a potential direct impact), and predation risk related to potential impacts on turbidity (a potential indirect impact).

A life-stage transition in the June–September period addresses juveniles transitioning to subadults. Juvenile habitat attributes and environmental drivers potentially affected by the Proposed Project are primarily food availability (a potential indirect impact), toxicity related to harmful algal blooms (a potential indirect impact), and predation risk related to potential impacts on turbidity (a potential indirect impact), and summer-fall habitat extent.

A life-stage transition in the September–December period addresses subadults transitioning to adults. Subadult habitat attributes and environmental drivers potentially affected by the Proposed Project are primarily food availability and predation risk related to potential impacts on turbidity (a potential indirect impact).

Operations-Related Impacts

Adults to Eggs and Larvae (December–May)

Predation

The IEP MAST (2015) conceptual model identifies predation risk as a habitat attribute affecting Delta Smelt egg survival, with flows interacting with erodible sediment supply to affect turbidity. In general, greater turbidity is thought to lower the risk of predation on Delta Smelt (Bennett 2005; Moyle et al. 2016). Large amounts of sediment enter the Delta from winter and spring storm runoff, with resuspension by tidal and wind action (Schoellhamer et al. 2014; Bever et al. 2018). Cloern et al. (2011) identified a relationship between suspended sediment in the Sacramento River at Rio Vista and flows in the Sacramento River at Freeport and through the Yolo Bypass. Simulated average monthly flows at Rio Vista during December through May were applied to the relationship developed by Cloern et al. (2011) to identify potential differences in predation risk based on differences in suspended sediment concentrations entering the Delta. Because simulated flows at Rio Vista under the Proposed Project and Existing Conditions scenarios generally are similar (Figure 4.4-10 to Figure 4.4-15), suspended sediment entering the Delta is not expected to be affected. Therefore, predation risk under the Proposed Project and Existing Conditions scenarios is expected to be similar.

Available estimates of sediment removal by the South Delta export facilities are low, i.e., ~2% of sediment entering the Delta at Freeport in 1999–2002 (Wright and Schoellhamer 2005). Given the limited expected difference in suspended sediment entering the Delta under the Proposed Project and Existing Conditions scenarios (as suggested by Rio Vista flows discussed above), as well as the small percentage of sediment that would be expected to be removed by the South Delta export facilities, the potential impact of the Proposed Project on turbidity generally would be expected to be low. Per the MAST conceptual model, high turbidity is correlated with low predation risk for Delta Smelt, as supported by mesocosm studies (Ferrari et al. 2014), which suggests that predation risk under both scenarios would be similar. However, there is uncertainty in this conclusion, given the complexity of sedimentation mechanisms in the Delta (Schoellhamer et al. 2012, their Figure 7) and the fact that quantitative analyses of the impacts of exports on predation risk and turbidity have not been conducted (IEP MAST 2015, p.52).

The potential impacts on Delta Smelt adult predation as a function of Rio Vista flows reflect combined SWP and CVP operations. During December–May, the SWP would be responsible for around 40% to 60% of Delta water operations under the Proposed Project, depending on water year type and month (see Appendix H).

Food Availability

Food availability is posited by the IEP MAST (2015) conceptual model to affect the probability of Delta Smelt adults spawning and transitioning to egg/larval production, and inundation of the Yolo Bypass could increase food web productivity and benefit growth and survival of Delta Smelt adults occurring downstream of the Yolo Bypass (DWR and Reclamation 2017, p.8-111 to p.8-112). Delta Smelt food sources and availability likely vary by region, and the proportion of Delta Smelt food availability

Table 4.4-6. Summary of Impacts and Conclusions Associated with Implementation of the Proposed Project along with Environmental Protective Measures and Other Actions to Offset Impacts Presented by Species and Life Stage

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Delta Smelt	Adult to Eggs and Larvae	Food Availability	Similar flow through the Yolo Bypass.	Figure 4.4-16 - Figure 4.4-21	Similar food production and input to the Delta under both scenarios. This is a combined State Water Project (SWP) and Central Valley Project (CVP) result.	Less than Significant	None Required
Delta Smelt	Adult to Eggs and Larvae	Predation	Similar Rio Vista Flows from December through May.	Figure 4.4-10 - Figure 4.4-15	Similar suspended sediment input to the Delta and low sediment removal from the Delta, and therefore there is a similar predation potential under both scenarios. This is a combined SWP and CVP result.	Less than Significant	None Required
Delta Smelt	Eggs and Larvae to Juveniles	Food Availability	Delta outflow from March through June is lower under the Proposed Project, and predicted *Eurytemora affinis* density is 2% to 4% lower under the Proposed Project.	Figure 4.4-22, Figure 4.4-23, Table 4.4-7	Food availability might be slightly reduced under the Proposed Project, but uncertainty is high. SWP responsibility for the impact is between approximately 40% to 60%.	Less than Significant	None Required
Delta Smelt	Eggs and Larvae to Juveniles	Predation	Similar Rio Vista Flows from December through May. South Delta exports are higher from March through May under the Proposed Project. Delta inflow from June through September is slightly lower under the Proposed Project.	Figure 4.4-10 - Figure 4.4-15, Figure 4.4-24, Figure 4.4-25	Similar predation potential associated with turbidity Potentially lower silverside cohort strength with high uncertainty, based on greater March–May South Delta exports. Potentially higher silverside cohort strength with high uncertainty, based on lower June–September Delta inflow. SWP contribution between approximately 40% to 60% during March – May. SWP responsibility for the June-September impact is between approximately between 20-50%.	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Food Availability	Delta outflow from July through September is similar most of the time (75% of the time) but is lower about 25% of the time, suggesting slightly lower predicted *Pseudodiaptomus forbesi* density. Similar QWEST under both scenarios in July and August. Higher (positive more often) QWEST in September under the Proposed Project.	Figure 4.4-27, Figure 4.4-28 – Figure 4.4-30	Slightly lower *P. forbesi* density under the Proposed Project as a result of lower Delta outflow some of the time. Analysis has high uncertainty. Similar *P. forbesi* subsidy to the low salinity zone (LSZ) from the San Joaquin River most of the time under both scenarios, but potentially slightly higher *P. forbesi* subsidy in September under the Proposed Project. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. This is a combined SWP and CVP result. SWP responsibility for the change in Delta Outflow and QWEST that could affect *P. forbesi* subsidy to the LSZ is between approximately 23-28% in wet and above-normal water year types (when X2 requirements are not in place under the Proposed Project).	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Predation	Similar Rio Vista Flows from December through May.	Figure 4.4-10 - Figure 4.4-15	Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and summer predation potential is unknown. However, wind and water temperature, which are drivers of predation, would be similar and therefore there is a similar predation potential under both scenarios. This is a combined SWP and CVP resul.t	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Harmful Algal Blooms	Similar probability of remaining below 1 foot per second (ft/sec) velocity Microcystis threshold at each of the 8 Delta locations.	Figure 4.4-31 – Figure 4.4-38	Identical nutrients and water temperatures because these factors that influence harmful algal blooms are not affected by Delta water operations. Similar potential for velocity conditions to affect harmful algal blooms under both scenarios. This is a combined SWP and CVP result.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat – Qualitative Discussion	N/A	N/A	Manage overlapping suitable habitat based on the latest conceptual model of suitable habitat for Delta Smelt in summer-fall using multiple tools including outflow augmentation, Suisun Marsh Salinity Control Gates (SMSCG) operation, and food actions. LSZ would tend to be further upstream following wet years, without detailed consideration of SMSCG operation. Evidence from 2018 SMSCG pilot action showed that Delta Smelt had access to suitable low-salinity habitat during the action.	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM) water year (WY) 2012 (salinity alone)	Limited benefits in the North Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation period. Reduced habitat area in Suisun Bay.	Figure 4.4-41	Modeled benefits are greater when gates are operated starting in August rather than June. Lower salinity in Suisun Marsh has the potential to increase habitat for Delta Smelt during the summer and fall.	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2012 (salinity, temperature, and turbidity)	Limited benefits overall in the North Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation.	Figure 4.4-42	Potentially beneficial overall because of improved Suisun Marsh Conditions.	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2017 (salinity alone)	Limited differences overall in the North Delta Arc or Cache to Montezuma Slough corridor. Changed conditions in Suisun Marsh extending beyond the SMSCG operation.	Figure 4.4-43	Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low-salinity habitat extent under the Proposed Project compared to Existing Conditions represented by historical 2017 conditions; potential negative effect under Proposed Project relative to implementation of X2 = 74 km in September/October.	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2017 (salinity, temperature, and turbidity)	Limited differences in the North Delta Arc or Cache to Montezuma Slough corridor. Changed conditions in Suisun Marsh extending beyond the SMSCG operation.	Figure 4.4-44	Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less habitat (low salinity and suitable Secchi depth and temperature) extent under the Proposed Project compared to Existing Conditions represented by historical 2017 conditions; potential negative effect under Proposed Project relative to implementation of X2 = 74 km in September/October.	Less than Significant	None Required
Delta Smelt	Subadults to Adults	Food Availability	Higher (positive more often) QWEST in September under the Proposed Project, although Delta outflow is lower.	Figure 4.4-28 – Figure 4.4-30	Potentially slightly higher *P. forbesi* subsidy in September under the Proposed Project based on net flow on the San-Joaquin River at Jersey Point (QWEST), but slightly lower based on Delta outflow. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. Overall density of calanoid copepods in the low salinity not shown to be related to Delta outflow (X2) by other analyses. This is a combined SWP and CVP result.	Less than Significant	None Required
Delta Smelt	Subadults to Adults	Predation	Similar Rio Vista Flows from December through May.	Figure 4.4-10 - Figure 4.4-15	Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and fall predation potential is unknown. Wind and water temperature, which are drivers of predation, would be similar. The low salinity zone would be further upstream under the Proposed Project in fall of wet years and further downstream under the Proposed Project in fall of above normal years, which potentially could give higher and lower predation risk under the Proposed Project, although there is uncertainty in this conclusion because of factors such as the influence of antecedent conditions on fall turbidity. This is a combined SWP and CVP result.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Delta Smelt	Subadults to Adults	Harmful Algal Blooms	Similar velocity conditions at 8 Delta locations. Similar probability of remaining below 1 ft/sec threshold at each of the 8 Delta locations.	Figure 4.4-31 – Figure 4.4-38	Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations. Similar potential for velocity conditions to affect harmful algal blooms under both scenarios. This is a combined SWP and CVP result.	Less than Significant	None Required
Delta Smelt	Entrainment	Consideration of Old and Middle River (OMR) Flows	During the March–June period of concern for larval and juvenile Delta Smelt entrainment risk, OMR flows would generally be lower (more negative) under the Proposed Project in April and May, but would be similar under both scenarios in March and June. During this period, flows under both scenarios would be at or less negative than the -5,000 cfs inflection point at which entrainment tends to sharply increase.	Figure 4.4-49 – Figure 4.4-53 Figure 4.4-50	Based on CalSim modeling estimated entrainment could increase for larvae/early juveniles (March – June) under the Proposed Project however there are number of measures that will keep entrainment risk at protective levels: • OMR flows during April and May under the Proposed Project are less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk. • Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts • Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles SWP responsibility for the impact is between approximately 30-60%.	Less than Significant	None Required
Delta Smelt	Entrainment	Particle Tracking Modeling	Delta Simulation Model II (DSM2) Particle Tracking Model (PTM) showed increases in Delta Smelt entrainment in April and May.	Table 4.4-8	Based on DSM2 PTM modeling estimated entrainment is appreciably greater under the Proposed Project in April and May. However there are number of measures that will keep entrainment risk at protective levels: • OMR flows during April and May under the Proposed Project are less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk. • Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts • Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles.	Less than Significant	None Required
Delta Smelt	All Life Stages	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window.	Less than Significant	None Required
Delta Smelt	All Life Stages	Annual O&M Activities	N/A	N/A	Annual O&M activities likely would have limited impacts on Delta Smelt because work windows and best management practices (BMPs) would be implemented. Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Delta Smelt	All Life Stages	Project Environmental Protective Measures including: • Clifton Court Forebay (CCF) predator relocation and aquatic weed control; • Skinner Fish Facility performance improvements; • Longfin Smelt Science Program; • Continue Studies to Establish a Delta Fish Hatchery; and • Conduct further Studies to Prepare for Delta Smelt Reintroduction from the Fish Conservation and Culture Laboratory (FCCL) (see Table 3-3)	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Delta Smelt reintroduction and Delta Fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics, and could increase options to improve Delta Smelt management. Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival	Less than Significant	None Required
Longfin Smelt	Population Abundance	Delta Outflow-Abundance	The results of the Nobriga and Rosenfield (2016) model application suggested that differences in the predicted fall midwater trawl abundance index between scenarios would be very small, with mean indices slightly lower under the Proposed Project and with some uncertainty, especially when considered in relation to the confidence intervals, as a result of high uncertainty in the outflow–abundance relationship.	Figure 4.4-55, Tables 4.4-9 – 4.4-10	Recruitment under the Proposed Project is modeled to slightly decrease under good survival (2% max difference) and poor survival (1% max difference) scenarios when confidence intervals are accounted for. The following measures should help reduce any potential small effects in real-time: • Increased measures to reduce entrainment losses for all Longfin Smelt life stages • A commitment to a Longfin Smelt Science program to understand mechanisms underlying flow-abundance relationships, and to identify and test additional options for Longfin Smelt management. • A commitment to support the Fish Culture Facility for Longfin Smelt culture for future study and adaptive management applications. This is a combined SWP and CVP result with the SWP responsibility of approximately 40% to 60%	Less than Significant	None Required
Longfin Smelt	Adult	Entrainment	Similar OMR flow from December February.	Figure 4.4-46 – Figure 4.4-48	Modeled entrainment under the Proposed Project is similar to the existing project. Other measures should reduce real-time entrainment risk, including: • OMR management Dec-Feb • OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt • Existing adult Longfin Smelt entrainment is less than 1% of the population (all years except 2008 @ 3%) SWP responsibility for slight differences in OMR is between approximately 40% to 60%	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Longfin Smelt	Larvae	Entrainment	DSM2-PTM results suggested that entrainment potential of Longfin Smelt larvae is similar between scenarios.	Table 4.4-12, Table 4.4-13	Modeled entrainment of larval Longfin Smelt does not increase under the Proposed Project. Other measures should reduce real-time entrainment risk, including: • OMR management Jan-Mar • OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt, shifting spawning seaward of interior Delta. • Adult Longfin Smelt presence as detected by the surveys and salvage suggests spawning is limited in interior Delta, which reduces subsequent larval entrainment risk. This is a combined SWP and CVP result	Less than Significant	None Required
Longfin Smelt	Juvenile	Salvage	Based on the Grimaldo et al. (2009) salvage-Old and Middle River flow regression, the potential exists for large relative increases in entrainment under the Proposed Project.	Figure 4.4-56, Figure 4.4.-57, Table 4.4-14, Table 4.4-15	Modeled juvenile Longfin Smelt salvage is increased under the Proposed Project. However, the following measures/considerations are expected to minimize entrainment: • OMR flows during April and May under the Proposed Project are less negative than the -5,000 cfs inflection point deemed protective of entrainment risk for Longfin Smelt and other ESA species. • Real-time OMR management, PTM models and CDFW Smelt Larval Survey (SLS) monitoring will be used to assess entrainment risk in real-time. • Increased first flush protection actions should lead to less movement and spawning in the interior Delta, subsequently decreasing entrainment risk of larvae and juveniles SWP responsibility for differences in OMR flows is between approximately 40-50%	Less than Significant	None Required
Longfin Smelt	All Life Stages	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window.	Less than Significant	None Required
Longfin Smelt	All Life Stages	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	None Required
Longfin Smelt	All Life Stages	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; • Skinner Fish Facility performance improvements; • Longfin Smelt Science Program; and • Continue Studies to Establish a Delta Fish Hatchery (see Table 3-3)	N/A	N/A	Longfin Smelt Science Program would improve understanding of Longfin Smelt ecology, population distribution, and abundance to better inform management decisions. Delta fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Winter-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of Salmon Entering and Exiting the Delta (SAIL) Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during most months of the immigration period	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flow conditions would likely result in similar habitat conditions including SAIL Conceptual Model habitat attributes of water temperature, dissolved oxygen concentrations, and other attributes that influence the timing, condition, and survival of adult Winter-run Chinook Salmon during their upstream migration. This is a combined SWP and CVP result	Less than Significant	None Required
Winter-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment	Changes in hydrodynamic conditions (velocity distributions) indicate that juvenile Winter-run Chinook Salmon entering the interior Delta from Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the corridors of the Old and Middle rivers may be more likely to become entrained under the Proposed Project if exports are greater at the time they are present. There is little difference during the main December-February period when Winter-run Chinook Salmon are most abundant in the Delta.	Figure 4.4-65, Figure 4.4-66	Although Chinook Salmon in the corridors of the Old and Middle rivers could become entrained more often under the Proposed Project, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin rivers indicate that probabilities of moving south from that point are similar. Thus, the Proposed Project would be unlikely to increase the proportion of winter run entering the corridors of the Old and Middle rivers. Coded wire tag data indicate that small fractions of juvenile Winter-run Chinook Salmon encounter the South Delta salvage facilities. Velocity changes that could occur in the spring and fall under the Proposed Project are less likely to affect Winter-run Chinook Salmon because most Winter-run Chinook Salmon are expected to have exited the Delta by April and May and are generally present in low abundance in September and November. This is a combined SWP and CVP result. Implementing OMR management, including factors such as cumulative loss thresholds, would limit entrainment of Winter-run Chinook Salmon that do enter the corridors of the Old and Middle rivers. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in the CCF, could reduce pre-screen losses, which could increase observed salvage. Skinner Fish Facility Improvements also have the potential to improve survival of salvaged Winter-run Chinook Salmon.	Less than Significant	None Required
Winter-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Winter-run Chinook Salmon at the SWP South Delta export facility would be similar between the scenarios.	Table 4.4-17	Entrainment loss would be similar under both scenarios, but the analysis is uncertain because it is not scaled by population size and there is uncertainty about the true racial identity of Chinook Salmon in salvage. The model does not include real-time management operations, which would reduce entrainment. The model does not include the genetic identity of salvaged Chinook Salmon, and some fish in historical salvage could be misidentified, which would artificially increase the estimated salvage in the analysis.	Less than Significant	None Required
Winter-run Chinook Salmon	Juvenile	Salvage based on Zeug and Cavallo (2014)	Winter-run Chinook Salmon salvage is similar under both scenarios. Median salvage of the juvenile population at the SWP was 0.149% under the Existing Conditions scenario and 0.140% under the Proposed Project scenario (≈ 0.01% lower under the Proposed Project). Median salvage at both the SWP and CVP combined was 0.353% under the Proposed Project scenario and 0.380% under the Existing Conditions scenario.	Figure 4.4-67, Figure 4.4-68	The maximum annual proportion of juvenile Winter-run Chinook Salmon production predicted to be salvaged is low (<1.2%) for both the Proposed Project and the Existing Conditions scenarios. Differences between scenarios in individual years were small (<0.5%). In addition, small differences in predicted salvage occurred in certain months and water year types. However, there was high overlap in interquartile ranges and the scenario with greater salvage was not consistent across these comparisons.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Winter-run Chinook Salmon	Outmigrant Survival	Delta Passage Model (DPM)	Across the 82-year simulation period, mean through-Delta survival was 0.1% greater for the Proposed Project. Survival followed water year-type for both scenarios, with the highest values in wet years and lowest values in critical years. Differences in individual model years were generally small (≤ 1.6%) as were differences within individual water year-types.	Figure 4.4-69, Figure 4.4-70	Through Delta survival of Winter-run Chinook Salmon was similar under both scenarios with some uncertainty. These results are similar to the those of the STARS analysis described below which does not include an export-survival function which is included in the DPM. Together, these results suggest changes in export operations under the Proposed Project had little influence on through-Delta survival of Winter-run Chinook Salmon. Uncertainty in the modeled result will be addressed by implementing cumulative loss thresholds as part of OMR management would limit entrainment. SWP responsibility for differences in Delta operations is between approximately 40% to 60%.	Less than Significant	None Required
Winter-run Chinook Salmon	Outmigrant Survival	Survival, Travel Time, and Routing Simulation (STARS)	Generally similar proportions of Winter-run Chinook Salmon entered the interior Delta via Georgiana Slough and the DCC, resulting in similar through-Delta survival under both scenarios except during November, when survival was predicted to be lower under the Proposed Project as a result of less river flow and greater Delta Cross Channel (DCC) opening as a result of model assumptions. However, abundance of Winter-run Chinook Salmon is generally low in November.	Figure 4.4-71	During most months of the outmigration period (October through June for this analysis), Winter-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the Central Delta and reduced survival could occur in November. However, abundance of Winter-run Chinook Salmon is generally low in November. This is a combined result. During November when the largest differences in routing occur, the SWP is responsible for approximately 50-60% of operations-related impacts, but note that the DCC is a CVP facility.	Less than Significant	None Required
Winter-run Chinook Salmon	Rearing Juveniles	Rearing Effects	Little difference in rearing habitat suggested by CalSim modeling of Freeport and Yolo Bypass flows.	N/A	Available tools are generally focused on rearing habitat as a function of Sacramento River and Yolo Bypass flows, which generally do not differ between the Proposed Project and Existing, and combined with results of other analyses suggest little potential for greater effects under Proposed Project compared to Existing. This is a combined result. SWP responsibility during winter-spring is generally 40-60%.	Less than Significant	None Required
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window and any entrainment counting toward cumulative loss thresholds.	Less than Significant	None Required
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	None Required
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival.	Less than Significant	None Required
Spring-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the January through June immigration period	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. SWP responsibility for ~~differences in OMR flows~~operations is between approximately 30-60%.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Spring-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	For juvenile Spring-run Chinook Salmon migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the corridors of the Old and Middle rivers during April and May suggest entrainment of fish entering Old River at HOR would be higher. For juvenile Spring-run Chinook Salmon originating from the Sacramento River, changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the corridors of the Old and Middle rivers in April and May are more likely to become entrained under the Proposed Project.	Figure 4.4-65, Figure 4-66, Table 4.4-72	Greater frequency of routing San Joaquin-origin Spring-run Chinook Salmon into Old River increases entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the South Delta including fish entrained into the facilities. This model found higher survival under the Proposed Project (see below) with uncertainty, but suggests survival would not be impaired for fish routed into Old River. For Sacramento River-origin Spring-run Chinook Salmon that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin rivers indicate that the probabilities of moving south from that point are similar. Thus, the Proposed Project would be unlikely to increase the proportion of Spring-run Chinook Salmon entering the corridors of the Old and Middle rivers. Coded-wire-tag data indicate that small fractions of juvenile Chinook Salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the corridors of the Old and Middle rivers, entrainment could increase in April and May. This is a combined SWP and CVP result. OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in the CCF, would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required
Spring-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Spring-run Chinook Salmon at the SWP South Delta export facility could be appreciably greater under the Proposed Project.	Table 4.4-18	Entrainment loss of Spring-run Chinook Salmon could be higher under the Proposed Project, but the analysis is uncertain and the model does not include genetic identity of salvaged Chinook Salmon or account for the total number of juveniles that could potentially be salvaged (data are not scaled). Coded-wire-tag studies indicate that small fractions of Sacramento River Chinook Salmon encounter the South Delta salvage facilities, so entrainment-related impacts on the ESU would be small. OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment. Actions to improve survival in the CCF including aquatic weed control and continued evaluation of predator reduction in the CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required
Spring-run Chinook Salmon	Outmigrant Survival	DPM	Across the 82-year simulation period, mean through-Delta survival was 0.6% lower under the Proposed Project. Differences in individual years were generally small (< 1.5%), with the largest difference occurring in the 1995 model year when survival under the Proposed Project was 1.6 % lower than under the Existing Conditions scenario.	Figure 4.4-73, Figure 4.4-74	Through Delta survival of Spring-run Chinook Salmon was similar under both scenarios with some uncertainty. The Delta Passage Model contains an export-survival relationship. Thus, higher exports in April and May did not results in substantial changes in through-Delta survival. Only a small fraction of Sacramento River-origin Spring-run Chinook Salmon enter the interior Delta, and most of the juvenile population is not exposed to the hydrodynamic effect of exports. This is a combined SWP and CVP result.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Spring-run Chinook Salmon	Outmigrant Survival	San Joaquin River Structured Decision Model (SDM)	Across the 82-year simulation period, through-Delta survival was low (< 4%) under both scenarios. Survival was higher under the Proposed Project for all years, but the magnitude of the difference between scenarios was variable in specific years. Survival was more similar between scenarios in drier year types relative to wetter year types.	Figure 4.4-75, Figure 4.4-76	Survival of San Joaquin River-origin Spring-run Chinook Salmon has the potential to be higher under the Proposed Project. Although exports will be higher under the Proposed Project in April and May, the SDM includes the latest acoustic tagging data from the CVP and South Delta. These data and the model suggest that volitional migration survival from the facilities north can be lower than entrainment at CVP and trucking to the west Delta. Thus, more fish being routed into Old River and higher exports lead to a higher survival under the Proposed Project. However, overall through-Delta survival for San Joaquin River-origin Chinook Salmon is low regardless of scenario (<4%).	Less than Significant	None Required
Spring-run Chinook Salmon	Outmigrant Survival	STARS	The STARS model results suggest little difference in predicted through-Delta survival of Spring-run Chinook Salmon between the scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December.	Figure 4.4-71	During most months of the outmigration period (November through May for this analysis) Spring-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the Delta and reduced survival could occur in November. Although the STARS model does not include an export-survival function, results generally followed those of the DPM which does. Only small fractions of Sacramento River Chinook Salmon encounter the South Delta facilities. as indicated by coded-wire-tag studies. This likely explains the minor effect of increased exports during April and May on total through-Delta survival. The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40–60%. depending on the month and water year type.	Less than Significant	None Required
Spring-run Chinook Salmon	Rearing Juveniles	Rearing Effects	Little difference in rearing habitat suggested by CalSim modeling of Freeport and Yolo Bypass flows.	N/A	Available tools are generally focused on rearing habitat as a function of Sacramento River and Yolo Bypass flows, which generally do not differ between the Proposed Project and Existing, and combined with results of other analyses suggest little potential for greater effects under Proposed Project compared to Existing. This is a combined result. SWP responsibility during winter-spring is generally 40-60%.	Less than Significant	None Required
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window.	Less than Significant	None Required
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project scenario.	Less than Significant	None Required
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Fall-run and Late Fall-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the July through December Fall-run Chinook Salmon and October through April Late Fall-run Chinook Salmon adult immigration periods. No SWP influence on DCC operations.	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flow conditions would likely result in similar habitat conditions along the Sacramento River, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. SWP responsibility for differences in Freeport flows is between approximately 20-60% during the Fall-run Chinook Salmon immigration period. SWP responsibility for differences in Freeport flows is between approximately 40% to 60% during the Late Fall-run Chinook Salmon immigration period. There is no difference in straying rates of Mokelumne River Fall-run Chinook Salmon because there is no SWP influence on DCC operations.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	For juvenile Fall-run Chinook Salmon migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the corridors of the Old and Middle rivers during April and May suggest entrainment of fish entering Old River at HOR would be higher. For juvenile Fall-run and Late Fall-run Chinook Salmon originating from the Sacramento River, changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the corridors of the Old and Middle rivers in April and May (primarily Fall-run) and November (Late Fall-run) are more likely to become entrained under the Proposed Project.	Figure 4-65, Figure 4.4-66. Figure 4.4-72, Figure 4.4-77, Figure 4.4-78	Greater frequency of routing San Joaquin-origin Fall-run Chinook Salmon into Old River increases entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the South Delta, including fish entrained into the facilities. This model found higher survival under the Proposed Project (see below) with uncertainty, but suggests survival would not be impaired for fish routed into Old River. For Sacramento River-origin Fall-run, and late Fall-run Chinook Salmon that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin rivers indicate that probabilities of moving south from that point are similar. Thus, the Proposed Project would be unlikely to increase the proportion of Fall-run and Late Fall-run Chinook Salmon entering the corridors of the Old and Middle rivers. Coded-wire-tag data indicate that small fractions of juvenile Chinook Salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the corridors of the Old and Middle rivers, entrainment could increase in April and May (Fall-run) or November (Late Fall-run). This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the period evaluated for San Joaquin River basin Fall-run Chinook Salmon is approximately 40% to 60%. OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in the CCF, would reduce pre-screen losses. Skinner Fish Facility Improvements would improve survival of salvaged fish.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Juvenile	Mokelumne River Fall-run Chinook Salmon Qualitative Discussion	N/A	N/A	Coded-wire-tag analysis suggests that very small percentages of Mokelumne River Fall-run Chinook Salmon would be expected to be entrained ranging from 0.4-0.6% of outmigrants	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Fall-run and Late Fall-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Fall-run Chinook Salmon at the SWP South Delta export facility could be appreciably greater under the Proposed Project. Entrainment loss of Late Fall-run Chinook Salmon is similar between scenarios.	Table 4.4-19, Table 4.4-20	Entrainment loss could be higher under the Proposed Project, but the analysis is uncertain and the model does not include genetic identity of salvaged Chinook Salmon. Small percentages of juvenile Sacramento River Fall-run and Late Fall-run Chinook Salmon are estimated to encounter the South Delta export facilities, so entrainment-related impacts on the ESU would be small. Entrainment losses are likely to be higher for San Joaquin River-origin Fall-run Chinook Salmon. However, the SDM model indicated higher survival under the Proposed Project due to poor volitional survival through Old River relative to salvage and trucking. OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in the CCF, would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	Delta Passage Model CV Fall-run and Late Fall-run Chinook Salmon	Across the 82-year simulation period, mean Fall-run Chinook Salmon through-Delta survival was 0.5% lower under the Proposed Project. Differences in individual years were generally small (< 1.5%). Across the 82-year simulation period, mean Late Fall-run Chinook Salmon through-Delta survival was 0.3% lower under the Proposed Project. Differences in individual years were generally small (< 1.0%).	Figure 4.4-79, Figure 4.4-80 Figure 4.4-81, Figure 4.4-82	Through Delta survival of Fall-run and Late Fall-run Chinook Salmon was similar under both scenarios with some uncertainty. These results were similar to those from the STARS model, which does not include an export-survival relationship like to DPM. This suggests changes to exports did not have a substantial effect on through-Delta survival. This is a combined SWP and CVP result.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	San Joaquin River SDM	Across the 82-year simulation period, through-Delta survival was low (< 4%) under both scenarios. Survival was higher under the Proposed Project for all years, but the magnitude of the difference between scenarios was variable. Survival was higher under the Proposed Project in all water year types.	Figure 4.4-83, Figure 4.4-84	Greater proportions of fish would be routed into Old River relative to the San Joaquin River under the Proposed Project, and exports will be higher in April and May when Fall-run Chinook Salmon are migrating. However, survival of San Joaquin River-origin Fall-run Chinook Salmon has the potential to be higher under the Proposed Project. The SDM uses the most recent survival data from acoustic-tagging studies in the South Delta and at the CVP. This indicates survival is higher for fish in Old River that are salvaged and trucked rather than volitional migration.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	STARS	The STARS model results suggest little difference in predicted through-Delta survival of Chinook Salmon between the scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December.	Figure 4.4-71	During most months of the outmigration period (January through June) Fall-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Late Fall-run Chinook Salmon could be exposed to increased routing into the Delta and reduced survival in November, although this is because of DCC operational assumptions related to Freeport flow. Small percentages of Sacramento River Fall-run Chinook Salmon and Late Fall-run Chinook Salmon encounter the South Delta salvage facilities, so entrainment-related impacts on the ESU likely would be small. This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 40% to 60%, depending on the month and water year type.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Fall-run and Late Fall-run Chinook Salmon	Rearing Juveniles	Rearing Effects	Little difference in rearing habitat suggested by CalSim modeling of Freeport and Yolo Bypass flows.	N/A	Available tools are generally focused on rearing habitat as a function of Sacramento River and Yolo Bypass flows, which generally do not differ between the Proposed Project and Existing, and combined with results of other analyses suggest little potential for greater effects under Proposed Project compared to Existing. This is a combined result. SWP responsibility during winter-spring is generally 40-60%.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
Central Valley Steelhead	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the July through March immigration period.	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. SWP responsibility for ~~differences in OMR flows~~operations is between approximately 20-60%.	Less than Significant	None Required
Central Valley Steelhead	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	For juvenile steelhead migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile fish approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the corridors of the Old and Middle rivers during April and May suggest entrainment of fish entering Old River at HOR would be higher. For juvenile steelhead originating from the Sacramento River, changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the corridors of the Old and Middle rivers in April and May are more likely to become entrained under the Proposed Project	Figure 4.4-65, Figure 4.4-66	Greater frequency of routing San Joaquin-origin steelhead into Old River increases entrainment risk for these fish, but whether this would translate into a population-level effect on survival is unknown. For Sacramento River-origin steelhead that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin rivers indicate that the probabilities of moving south from that point are similar. Thus, the Proposed Project would be unlikely to increase the proportion of steelhead entering the corridor of the Old and Middle rivers. For fish that do enter the corridor of the Old and Middle rivers, entrainment could increase in April and May. This is a combined SWP and CVP result. Implementing OMR management, including single-year and cumulative loss thresholds, would limit entrainment. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in the CCF, would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Central Valley Steelhead	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Central Valley Steelhead at the SWP South Delta export facility could be greater under the Proposed Project.	Table 4.4-21	Entrainment loss of steelhead could be higher under the Proposed Project, but the analysis is uncertain. Implementing OMR management, including single-year and cumulative loss thresholds, would limit entrainment. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in the CCF, would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required
Central Valley Steelhead	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window.	Less than Significant	None Required
Central Valley Steelhead	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	None Required
Central Valley Steelhead	All Life Stages Present in the Delta	Project Environmental Protective Measures, including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Delta Outflow	Similar under both scenarios.	Figure 4.4-85, Figure 4.4-86	Similar Delta outflow during most of the year would result in similar impacts under both scenarios. This is a combined SWP and CVP result. SWP responsibility for differences in Delta operations is between approximately 20-60%.	Less than Significant	None Required
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Annual O&M Activities	N/A	N/A	Annual O&M activities would not occur within the habitats occupied by Central California Coast Steelhead.	Less than Significant	None Required
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Project Environmental Protective Measures)	N/A	N/A	No project environmental protective measures occur in San Francisco Bay and San Pablo Bay, and no impacts on Central California Coast Steelhead would occur.	Less than Significant	None Required
Green Sturgeon	Immigrating Adults and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.	Figure 4.4-58 Figure 4.4-63, Table 4.4-16	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in 2 non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on Green Sturgeon habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required
Green Sturgeon	Juvenile	Daily Salvage Loss Density	Green Sturgeon salvage is low and is similar under both scenarios.	Table 4.4-22	Green Sturgeon salvage would be expected to be similar under both scenarios.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Green Sturgeon	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under Proposed Project's expanded July-November water transfer window but entrainment is limited and would be kept below protective level from NMFS ROC LTO BiOp.	Less than Significant	None Required
Green Sturgeon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	None Required
Green Sturgeon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
White Sturgeon	Immigrating Adults and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions and during April and May.	Figure 4.4-58 Figure 4.4-63, Table 4.4-16	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in 2 non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on White Sturgeon habitat attributes. Reductions in Delta outflow in April/May have the potential to reduce year-class strength based on observed correlations, although there is uncertainty in the mechanism and differences would be expected to be small relative to variability in estimates that may reflect hydrological conditions as opposed to operations. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%, and for Delta outflow in April/May is approximately 40-50%.	Less than Significant	None Required
White Sturgeon	Juvenile	Daily Salvage Loss Density	White Sturgeon salvage is low and is similar under both scenarios.	Table 4.4-23	White Sturgeon salvage is low and is similar under both scenarios.	Less than Significant	None Required
White Sturgeon	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under Proposed Project's expanded July-November water transfer window but entrainment is low and so any effects expected to be limited.	Less than Significant	None Required
White Sturgeon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	None Required
White Sturgeon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Pacific Lamprey and River Lamprey	Immigrating Adults, Ammocoetes, and Migrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.	Figure 4.4-58 Figure 4.4-63, Table 4.4-16	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in 2 non-consecutive months) to result in substantial long-term impacts on lamprey habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required
Pacific Lamprey and River Lamprey	Juvenile	Daily Salvage Loss Density	Lamprey salvage is similar under both scenarios in wet and above-normal water years, but is higher under the Proposed Project in below-normal, dry, and critical water years.	Table 4.4-24	Lamprey salvage is similar under both scenarios in wet and above-normal water years, but is higher under the Proposed Project in below-normal, dry, and critical water years. Real-time OMR management for other listed species, particularly first flush protections for Delta Smelt, may incidentally limit lamprey salvage. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in the CCF, could limit pre-screen loss. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Expansion of the water transfer window to include July to November would have limited potential to increase lamprey salvage based on historical patterns in salvage density.	Less than Significant	None Required
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Annual operations and maintenance (O&M) Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	None Required
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
Native Minnows	Native Minnow Residence	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in 2 non-consecutive months) to result in substantial long-term impacts on resident native minnow habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required
Native Minnows	Splittail Spawning	Flow Analysis	Similar flow conditions at Freeport during the native minnow spawning periods.	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flows would not result in substantial long-term impacts on native minnow spawning habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 30-60%.	Less than Significant	None Required

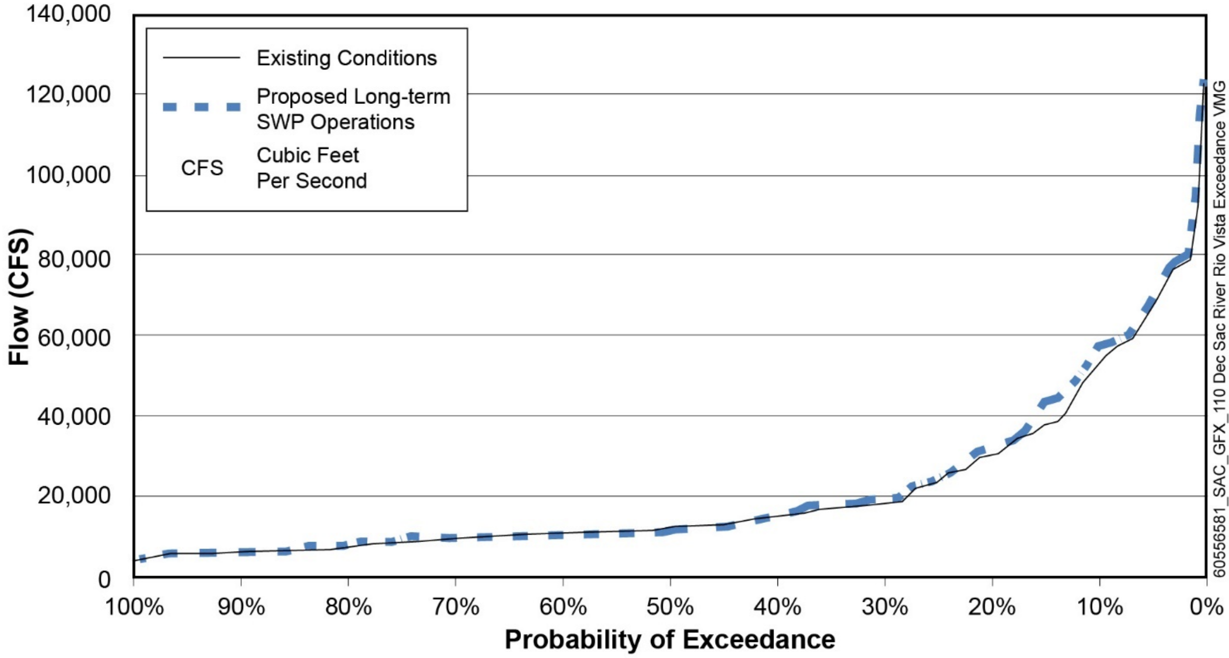
Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Native Minnows	Hardhead Spawning	Flow Analysis	Similar flow conditions at Freeport during the native minnow spawning periods.	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flows would not result in substantial long-term impacts on native minnow spawning habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 30-60%.	Less than Significant	None Required
Native Minnows	Central California Roach Spawning	Flow Analysis	Similar flow conditions at Freeport during the native minnow spawning periods.	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flows would not result in substantial long-term impacts on native minnow spawning habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 30-60%.	Less than Significant	None Required
Native Minnows	Juvenile	Splittail Salvage Loss Density	Appreciable increases in entrainment of Sacramento Splittail could occur under the Proposed Project.	Table 4.4-25	Although salvage could be higher under the Proposed Project, the main driver of Sacramento Splittail population dynamics appears to be inundation of floodplain habitat, such as the Yolo Bypass, which would not change. Sacramento Splittail may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in the Proposed Project that would be implemented to protect listed salmonids and smelts. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in the CCF, would reduce pre-screen losses. Skinner Fish Facility improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required
Native Minnows	Juvenile	Hardhead Salvage Loss Density	Hardhead salvage is similar under both scenarios and is low.	Table 4.4-26	Similar and low salvage loss would not be expected to substantially affect Hardhead.	Less than Significant	None Required
Native Minnows	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under Proposed Project's expanded July-November water transfer window for Splittail (but not Hardhead), but entrainment is not a driver of population dynamics and so any effects expected to be limited.	Less than Significant	None Required
Native Minnows	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	None Required
Native Minnows	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
Striped Bass	Immigrating and Spawning Adults, Rearing and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, particularly during the immigration, spawning, and larvae dispersal period (April through June). Less Delta outflow (greater fall X2) in fall following wet years; greater fall outflow (lower fall X2) in fall following above-normal years.	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on Striped Bass. Differences in young-of-the-year abundance as a result of differences in fall Delta outflow/X2 may result in potentially limited population-level impacts because of density dependence later in the life cycle. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Striped Bass	Juvenile Entrainment	Entrainment Loss Density	Similar salvage of juvenile Striped Bass under both scenarios.	Table 4.4-27	Similar and low salvage loss would not be expected to substantially affect Striped Bass. Potential for greater entrainment loss of early life stages (eggs/larvae) during spring may be limited by ancillary protection for listed salmonids and smelts, with limited population-level impacts because of density dependence later in the life cycle.	Less than Significant	None Required
Striped Bass	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under expanded July-November water transfer window, but limited population-level impacts because of density dependence later in the life cycle.	Less than Significant	None Required
Striped Bass	All Life Stages Present in the Delta	Annual O&M Activities l	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	None Required
Striped Bass	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
American Shad	Immigrating and Spawning Adults	Flow Analysis	Similar flow conditions at Freeport during most months of the year, particularly during the immigration, spawning, and larvae dispersal period (April through June)	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on American Shad. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required
American Shad	Juvenile Entrainment	Entrainment Loss Density	Similar salvage of juvenile American Shad under the both scenarios during most years, with higher salvage occurring under the Proposed Project scenario during critical water years.	Table 4.4-28	Similar salvage loss would not be expected to result in substantial impacts on American Shad under the Proposed Project scenario. Loss of earlier life stages may be limited because most early rearing is upstream of the Delta, and there may be ancillary protection from OMR management for listed fish in the spring.	Less than Significant	None Required
American Shad	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under expanded July-November water transfer window, but limited because of upstream rearing and low spatial overlap with south Delta.	Less than Significant	None Required
American Shad	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	None Required
American Shad	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Non-Native Freshwater Bass	Resident Adults and Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, except during September and November when flows are lower under the Proposed Project scenario. Reductions occur during higher flow conditions	Figure 4.4-58 - Figure 4.4-63, Table 4.4-16	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in 2 non-consecutive months) to result in substantial long-term impacts on resident non-native freshwater bass habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required
Non-Native Freshwater Bass	Juvenile Entrainment	Entrainment Loss Density	The salvage-density method suggested the potential for entrainment of Largemouth Bass to moderately increase under the Proposed Project scenario, particularly in intermediate water years. Similar salvage of juvenile Spotted Bass and Smallmouth Bass would occur under both scenarios.	Table 4.4-28, Table 4.4-29 Table 4.4-30	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project scenario.	Less than Significant	None Required
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under expanded July-November water transfer window, but limited effect because main period of entrainment of main species (Largemouth Bass) is in summer (i.e., outside the expanded period).	Less than Significant	None Required
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	None Required
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (See Table 3-3)	N/A	N/A	Because impacts on Fall-run and Late Fall-run Chinook Salmon are less than significant, impacts on killer whales resulting from prey reductions would be minimal.	Less than Significant	None Required
Killer Whale	All Life Stages	Food Source Discussion	See model results for Fall-run and Late Fall-run Chinook Salmon.	See exhibits for Fall-run and Late Fall-run Chinook Salmon.	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project scenario.	Less Than Significant	None Required

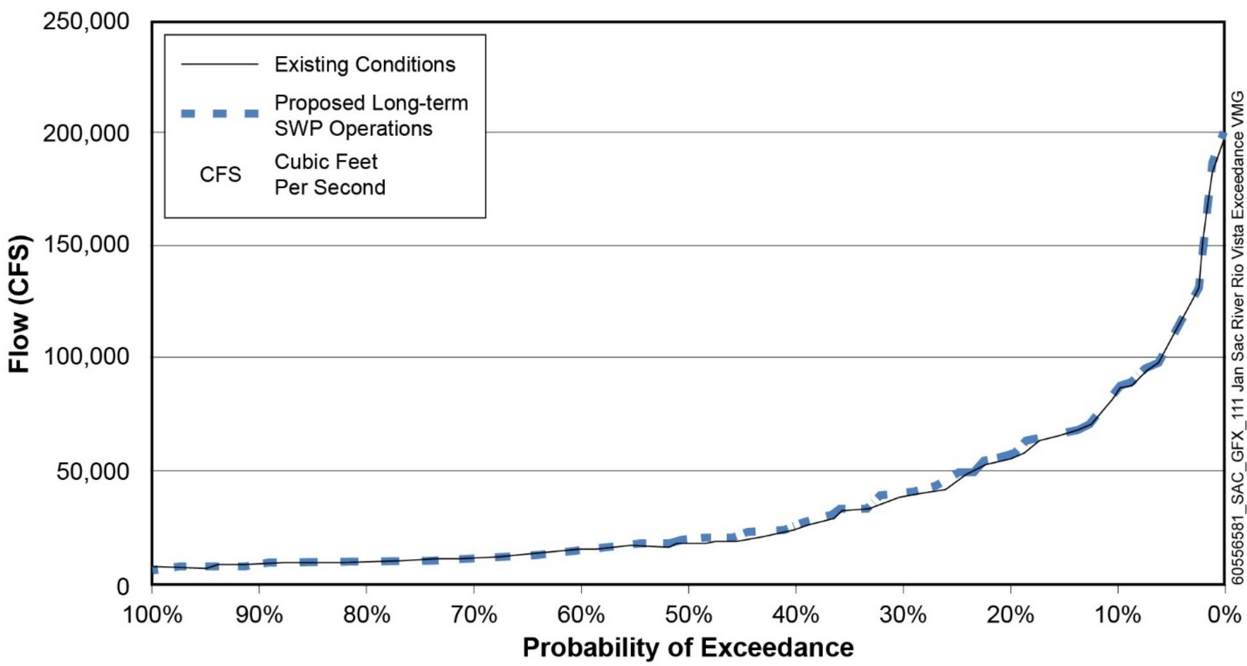
Notes:
BMPs = best management practices
CCF = Clifton Court Forebay
CVP = Central Valley Project
DSM2 = Delta Simulation Model II
FCCL = Fish Conservation and Culture Laboratory
ft/sec = foot per second
HOR = Head of Old River
LSZ = low salinity zone
N/A = not applicable
O&M = operations and maintenance
PTM = Particle Tracking Model
QUEST = Net flow on the San-Joaquin River at Jersey Point
SAIL = Salmon Entering and Exiting the Delta
SCHISM = Semi-implicit Cross-scale Hydroscience Integrated System Model
SMSCG = Suisun Marsh Salinity Control Gates
STARS = Survival, Travel Time, and Routing Simulation
SWP = State Water Project
WY = water year
X2 = Delta outflow

originating in the Yolo Bypass is unclear. Therefore, the analysis of Yolo Bypass inundation and resulting impacts on food availability for Delta Smelt is uncertain. Nonetheless, modeling suggests that there would be little difference in flow through the Yolo Bypass between the Proposed Project and Existing Conditions scenarios (Figure 4.4-16 to Figure 4.4-21), suggesting that food availability would also be similar.



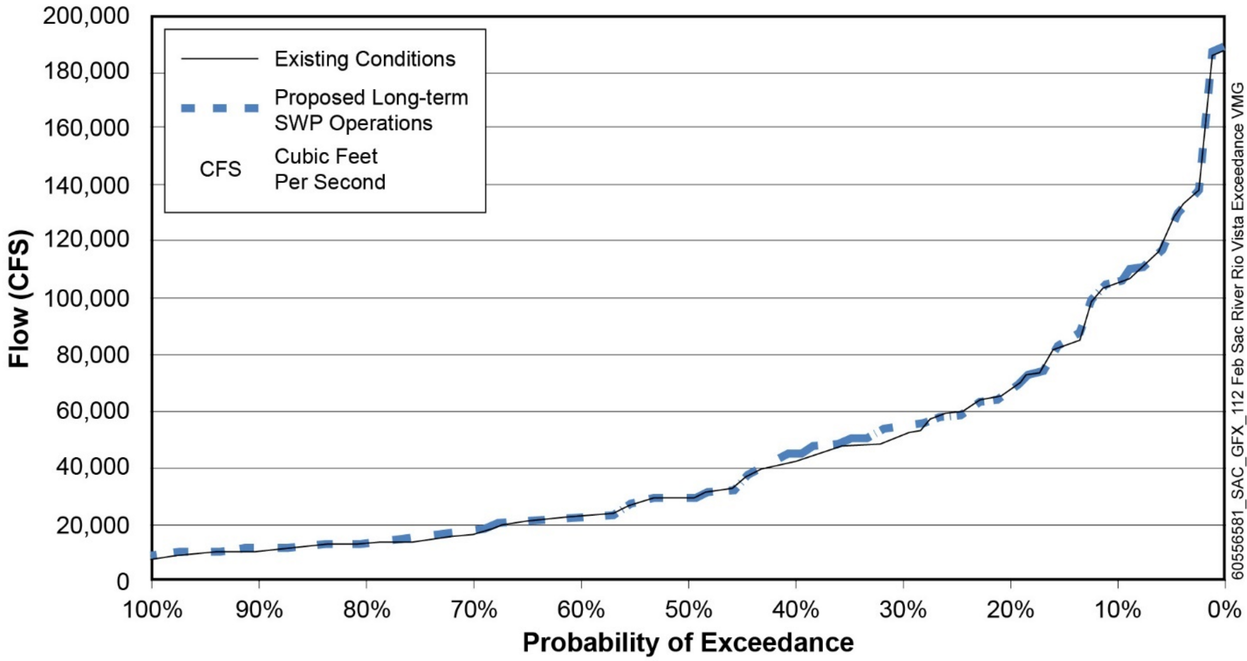
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4.4-10. Mean Modeled Sacramento River Flow at Rio Vista, December



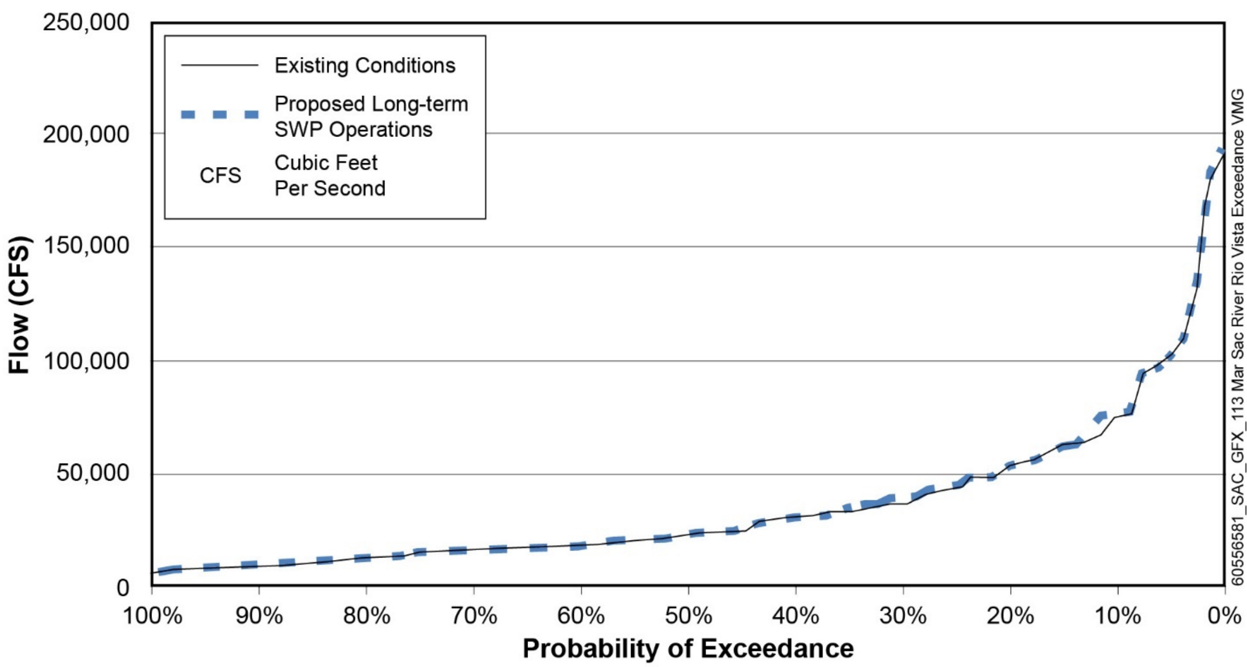
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4.4-11. Mean Modeled Sacramento River Flow at Rio Vista, January



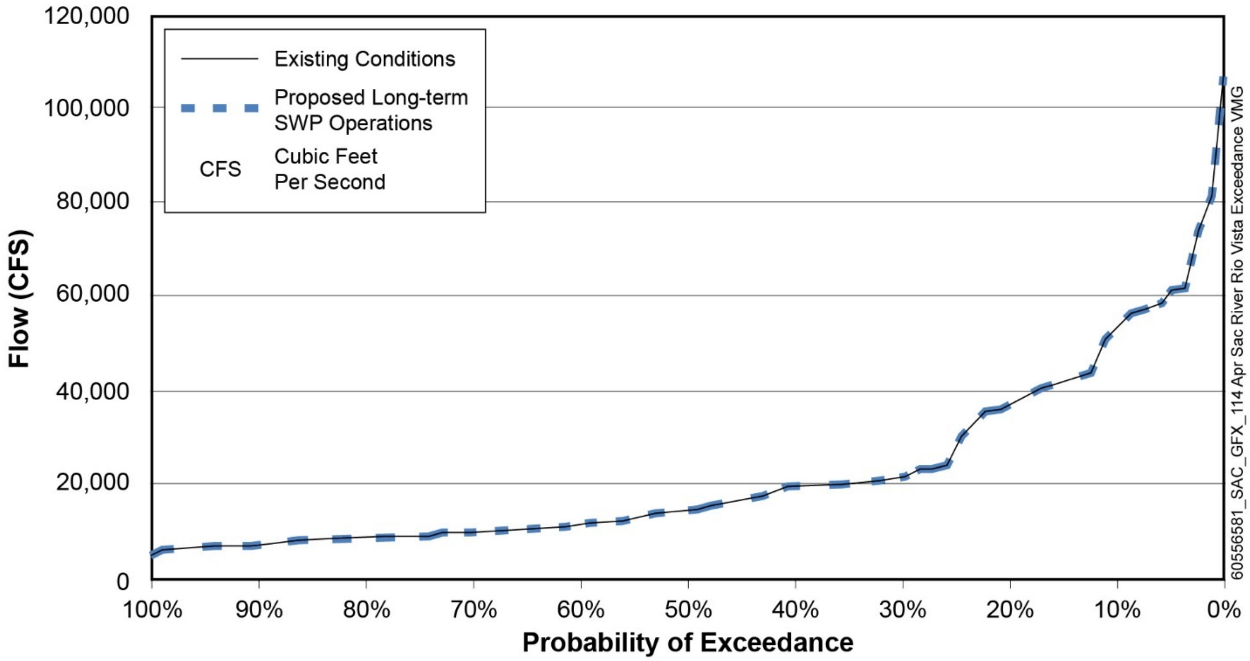
Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4.4-12. Mean Modeled Sacramento River Flow at Rio Vista, February



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4.4-13. Mean Modeled Sacramento River Flow at Rio Vista, March



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4.4-14. Mean Modeled Sacramento River Flow at Rio Vista, April

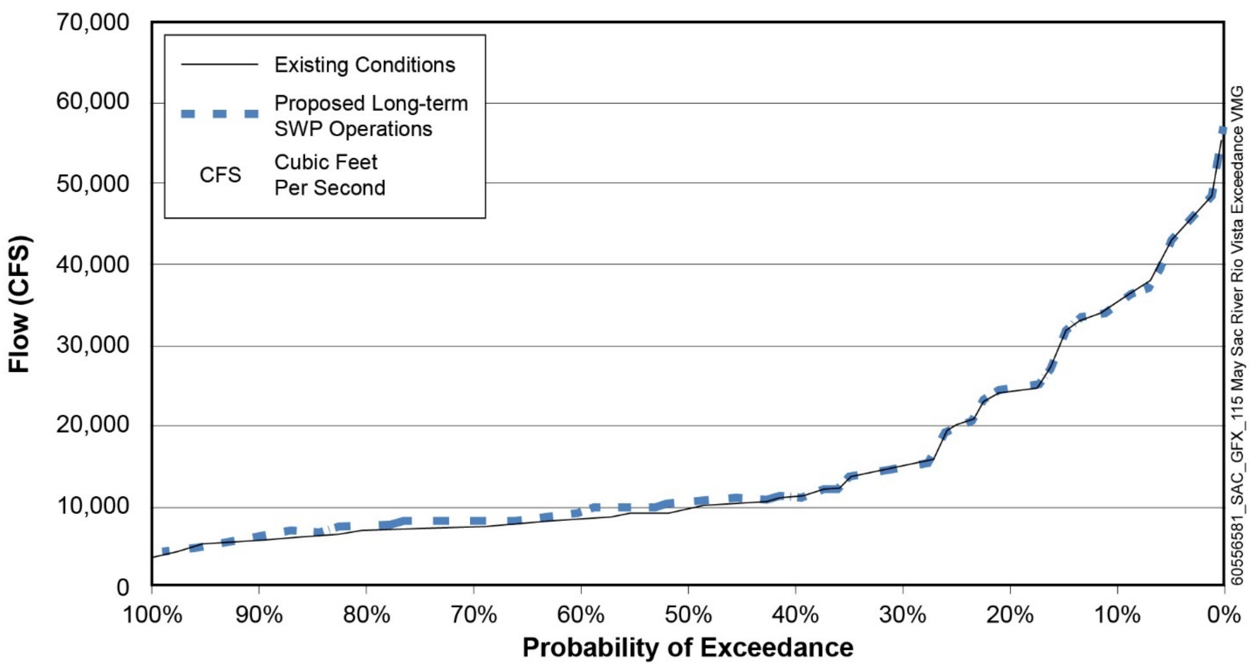


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Figure 4.4-15. Mean Modeled Sacramento River Flow at Rio Vista, May

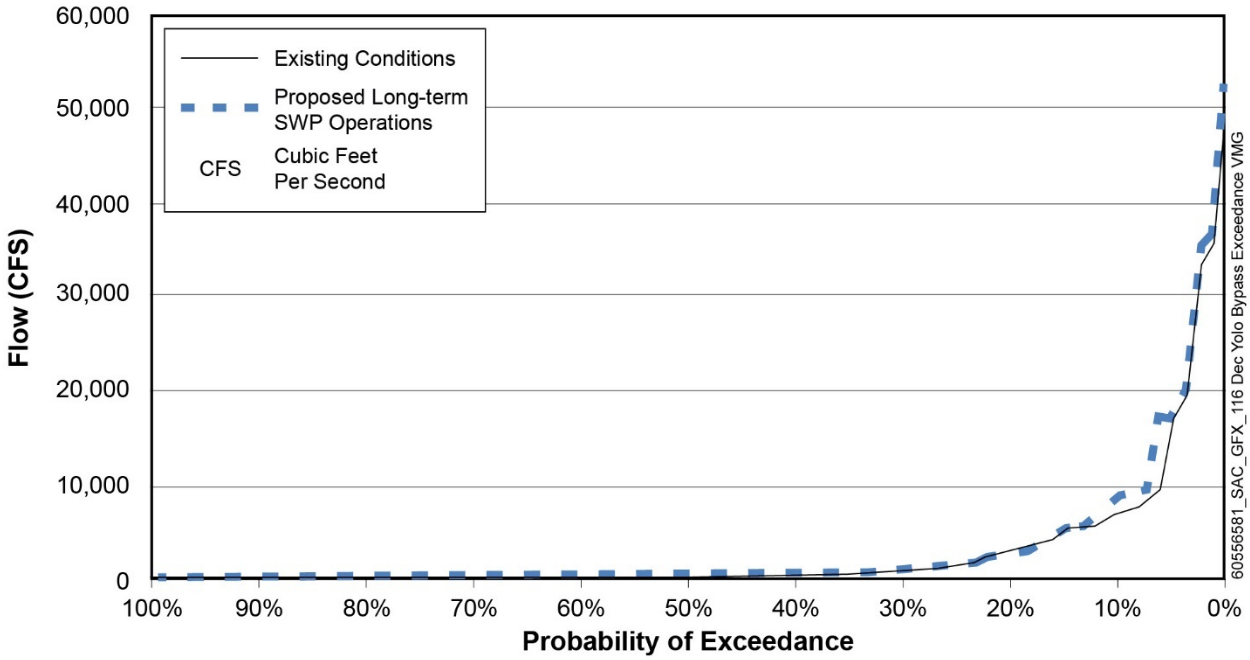

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Figure 4.4-16. Mean Modeled Flow Through Yolo Bypass, December

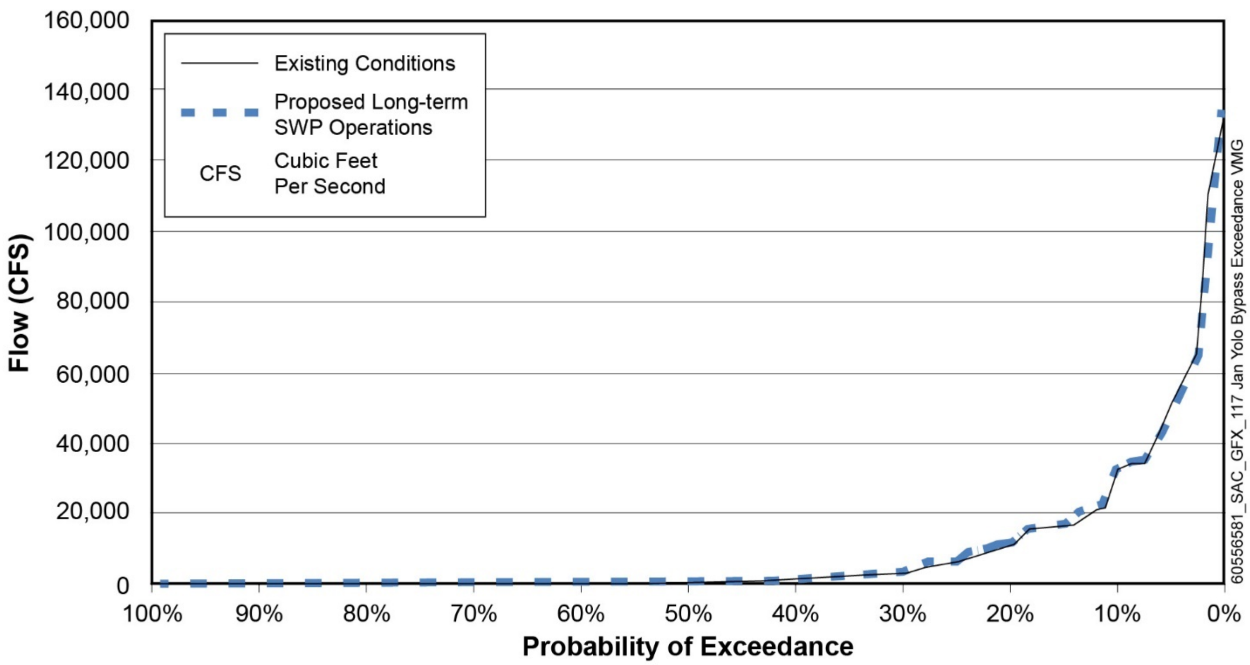

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Figure 4.4-17. Mean Modeled Flow Through Yolo Bypass, January

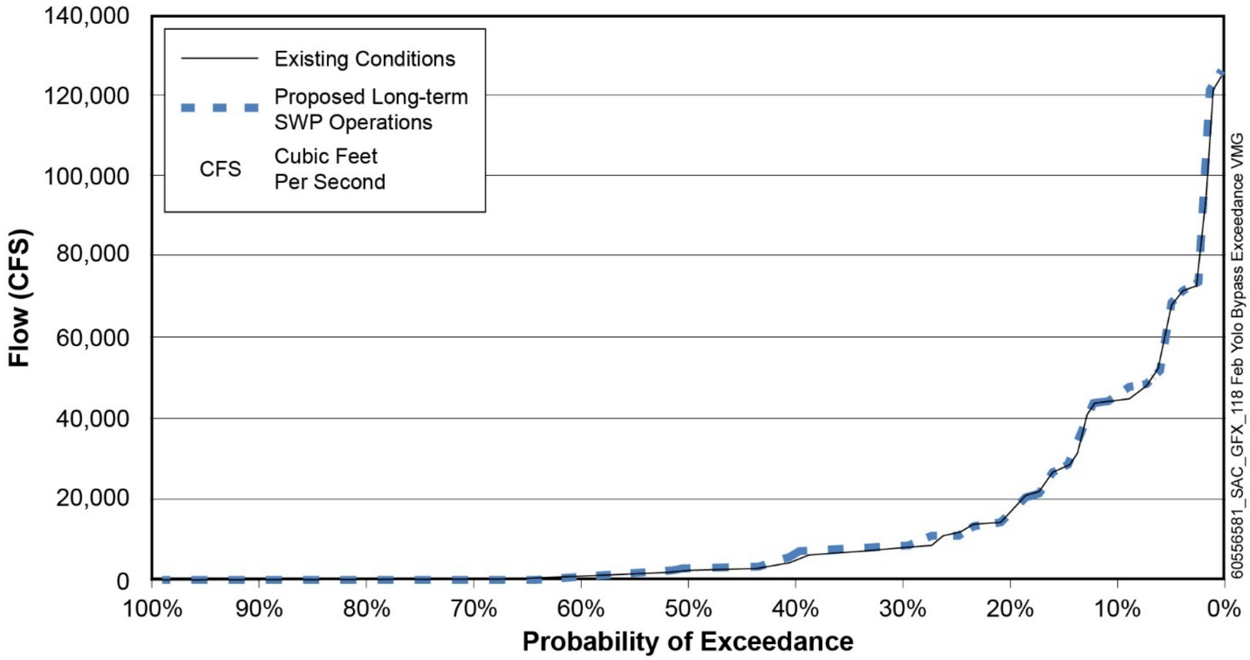

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Figure 4.4-18. Mean Modeled Flow Through Yolo Bypass, February

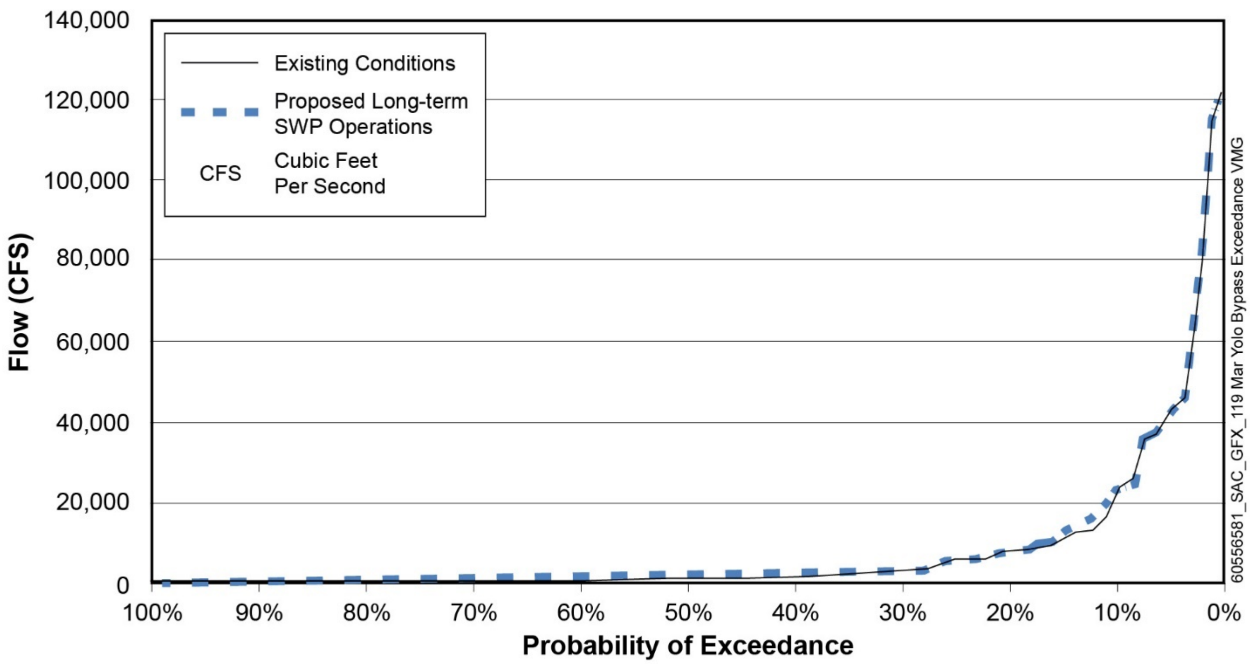

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Figure 4.4-19. Mean Modeled Flow Through Yolo Bypass, March

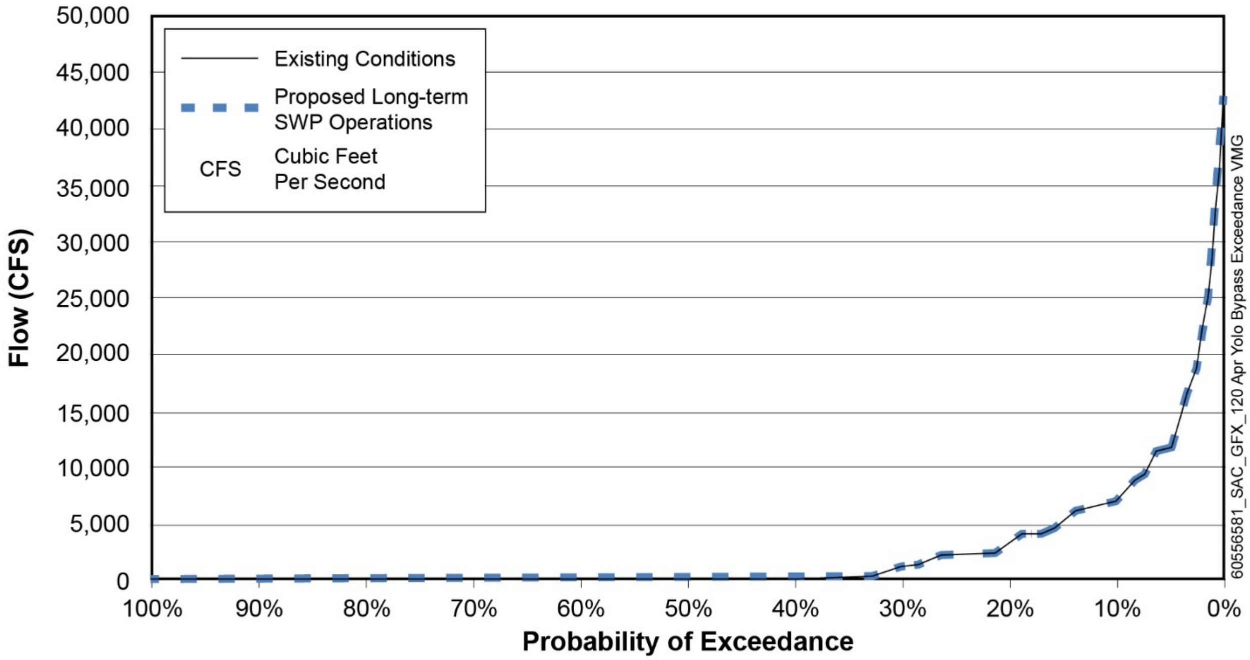

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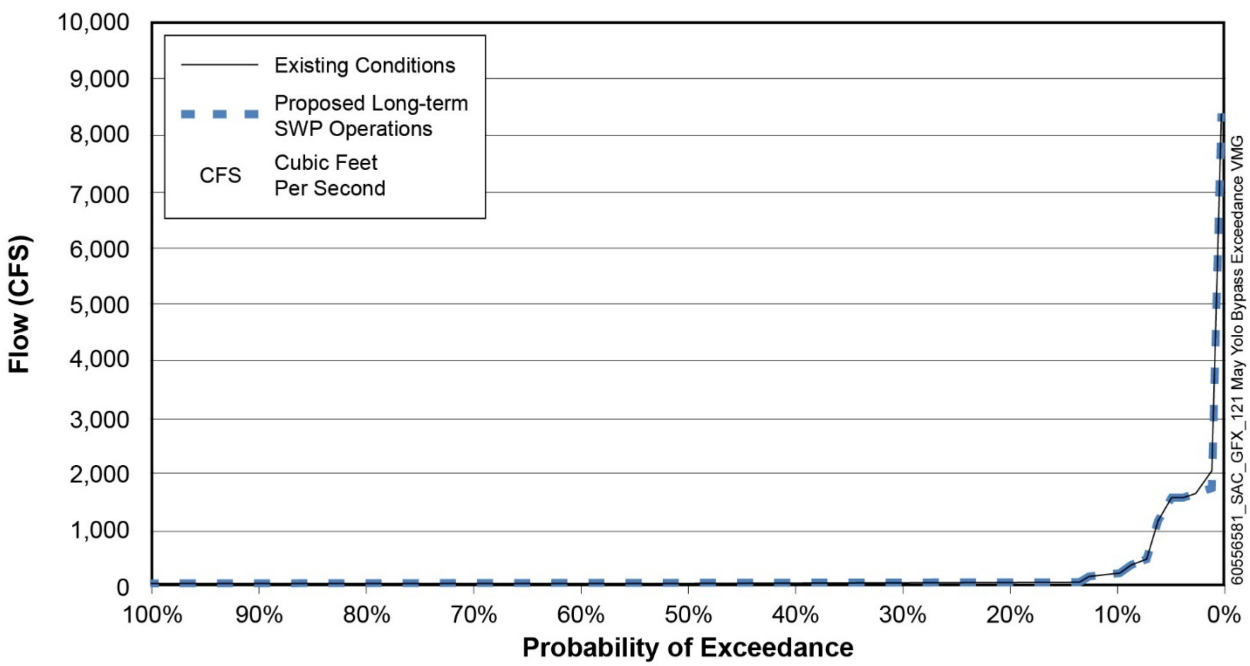
Figure 4.4-20. Mean Modeled Flow Through Yolo Bypass, April



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

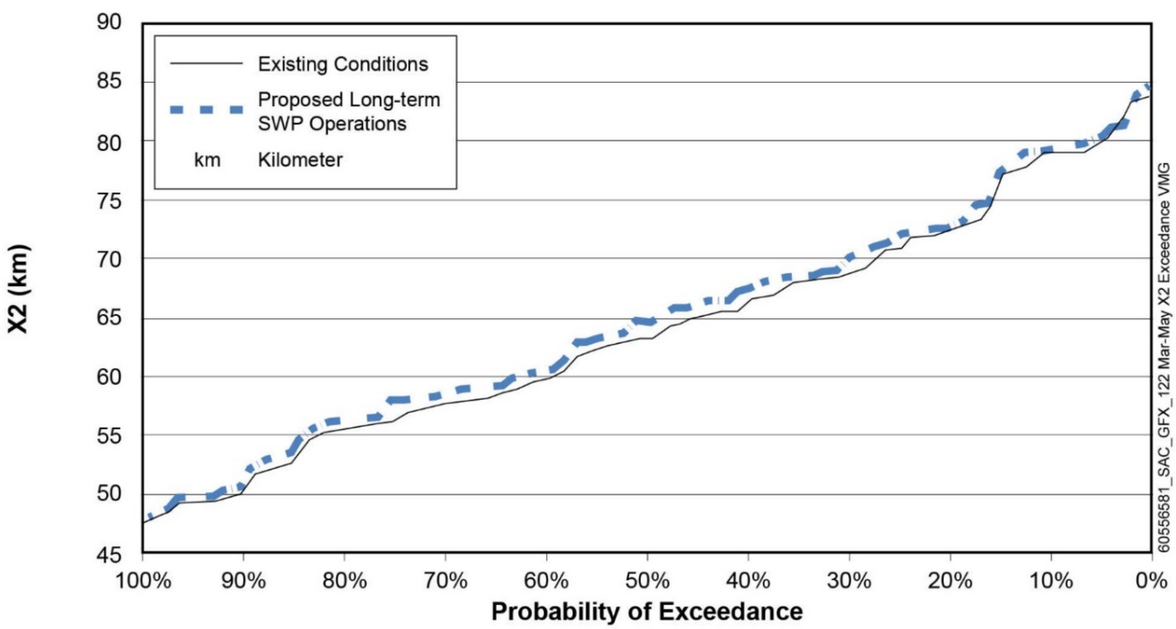
Figure 4.4-21. Mean Modeled Flow Through Yolo Bypass, May

Eggs and Larvae to Juveniles (March–June)

Food Availability

The IEP MAST (2015) conceptual model suggests that South Delta exports could affect food availability for larval Delta Smelt. The mechanism for the impacts of South Delta exports on food availability could be related to the hydrodynamic impacts of Delta outflow because a positive correlation between the density of the important Delta Smelt larval and juvenile zooplankton prey *Eurytemora affinis* in the low salinity zone and Delta outflow (as indexed by X2) during the spring (March–May; Kimmerer 2002, Greenwood 2018). As shown in Figure 4.4-22, simulated Delta outflow is lower under the Proposed Project than under the Existing Conditions scenario in April and May, and X2 would be greater (i.e., farther upstream). Therefore, food availability for larval Delta Smelt in April and May could be lower under the Proposed Project scenario.

To illustrate the magnitude of the potential impact, a regression of March–May X2 versus *E. affinis* density in the low salinity zone was used to compare the Existing Conditions and Proposed Project scenarios (see the methods description provided in Appendix E). This analysis suggested that there is appreciable uncertainty in the predictions of *E. affinis* density as a function of X2, with 95% prediction intervals spanning several orders of magnitude (Figure 4.4-23). The difference between the Proposed Project and Existing Conditions scenarios in mean estimates of *E. affinis* was small, approximately 2% to 4% (Table 4.4-7). Overall, although this suggests that while there may be the potential for *E. affinis* density in the low salinity zone to be less under the Proposed Project scenario than under the Existing Conditions scenario, this is uncertain and the predicted mean difference is small.



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4.4-22. Mean Modeled X2, March–May

Table 4.4-7. Mean Annual Predicted *Eurytemora affinis* Density in the Low Salinity Zone under the Proposed Project and Existing Conditions Modeling Scenarios, and Differences between the Scenarios Expressed as a Numerical Difference and Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
Wet	204	198	-5 (-3%)
Above Normal	177	171	-6 (-3%)
Below Normal	136	131	-5 (-4%)
Dry	112	109	-3 (-3%)
Critical	82	80	-1 (-2%)

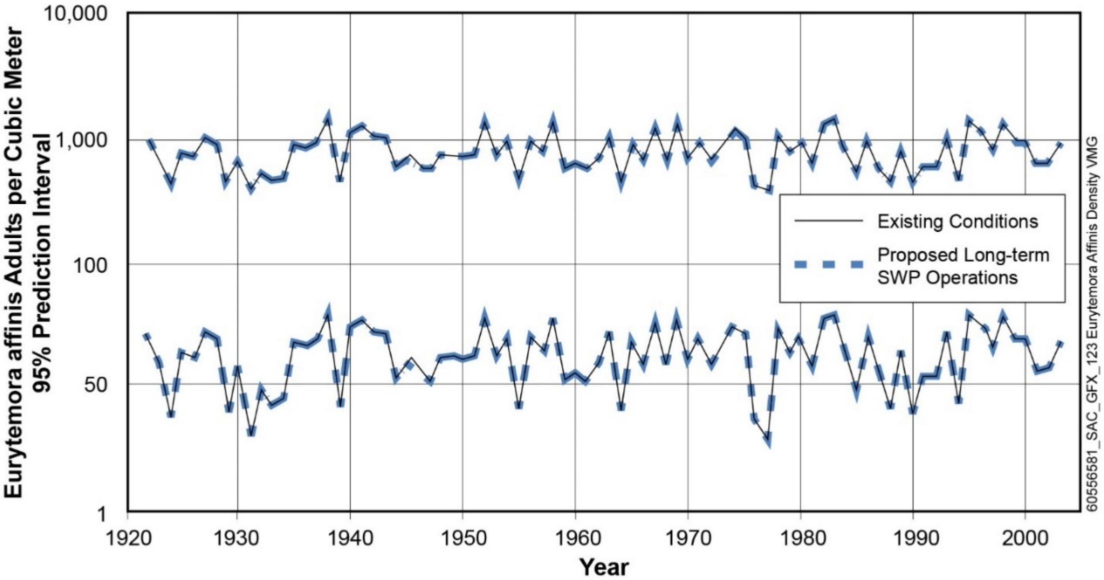


Figure 4.4-23. ***Eurytemora affinis*** **Density in the Low-Salinity Zone 95% Prediction Interval, for the 1922-2003 Modeled Period**

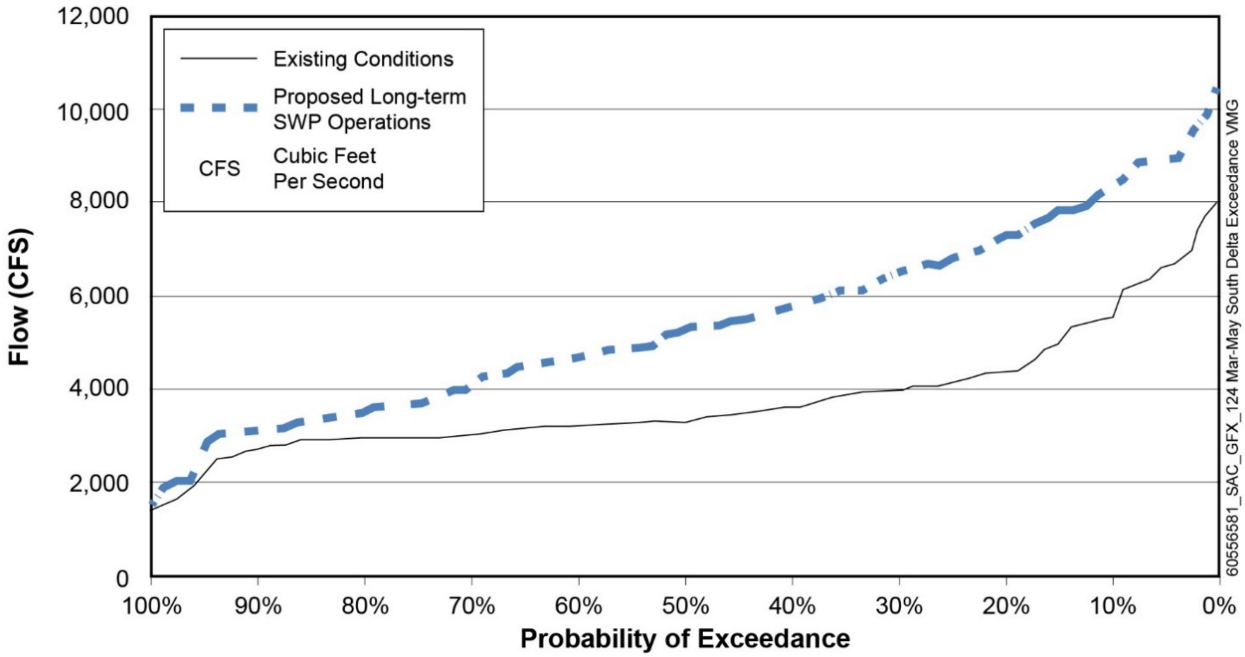
These potential impacts on *E. affinis* as a function of X2 reflect combined SWP and CVP operations from March through May, the period of potential impacts on *E. affinis*. The SWP would be responsible for around 40% to 60% of Delta water operations under the Proposed Project, depending on water year type and month (see Appendix H).

Predation

The IEP MAST conceptual model (2015) suggests that the probability of egg/larval Delta Smelt surviving to juveniles is influenced by predation risk, which may involve different factors such as turbidity, water temperature, and predators (silversides). SWP operations have limited potential to affect water temperature in the Delta (Wagner et al. 2011), and as discussed for adult Delta Smelt, turbidity would be similar under the Proposed Project and Existing Conditions scenarios (although this conclusion is uncertain because of the complexity of sedimentation mechanisms in the Delta), so predation risk associated with these factors would be expected to be similar under both the Proposed Project and Existing Conditions scenarios.

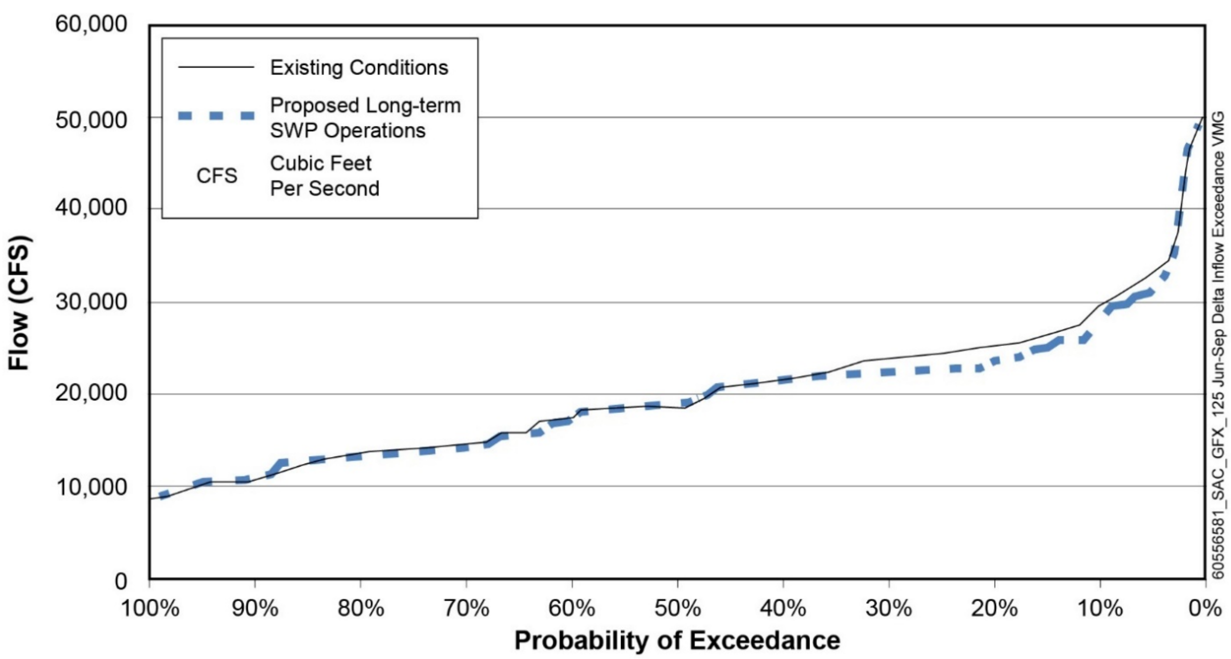
Detection of predation on Delta Smelt embryos and larvae is rare, which reduces the certainty of any conclusions of analyses of predation, although silversides have been found with Delta Smelt in their guts during the larval period (Schreier et al. 2016). Evaluation of silversides is conducted using multivariate relationships identified by Mahardja et al. (2016) that showed summer (June–September) Delta inflow and spring (March–May) South Delta exports had the strongest correlations with silverside cohort strength. Both relationships were negative. Mahardja et al. (2016, p.12) cautioned that the relationships are not meant to imply causality, given that the mechanisms could not be identified, and that further investigation is merited. Nonetheless, March-May South Delta exports under the Proposed Project scenario are higher than under the Existing Conditions scenario (Figure 4.4-24), which could correlate with lower silverside cohort strength under the Proposed Project. However, June-September Delta inflow under the Proposed Project scenario is similar or slightly lower than under the Existing

Conditions scenario (Figure 4.4-25), which could correlate with similar or somewhat higher silverside cohort strength. Because simulated exports and inflow suggest opposing impacts on silverside cohort strength under the Proposed Project as well as the uncertainty in the strength of the relationships, it is uncertain what the net impact of these changes would be.



Source: <ITP_PP_0819.dss>, <2020D09EDV.dss>.

Figure 4.4-24. Mean Modeled South Delta Exports, March–May



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>.

Note: Delta inflow is represented by flow at Sacramento River at Freeport + through Yolo Bypass + Mokelumne River + San Joaquin River at Vernalis.

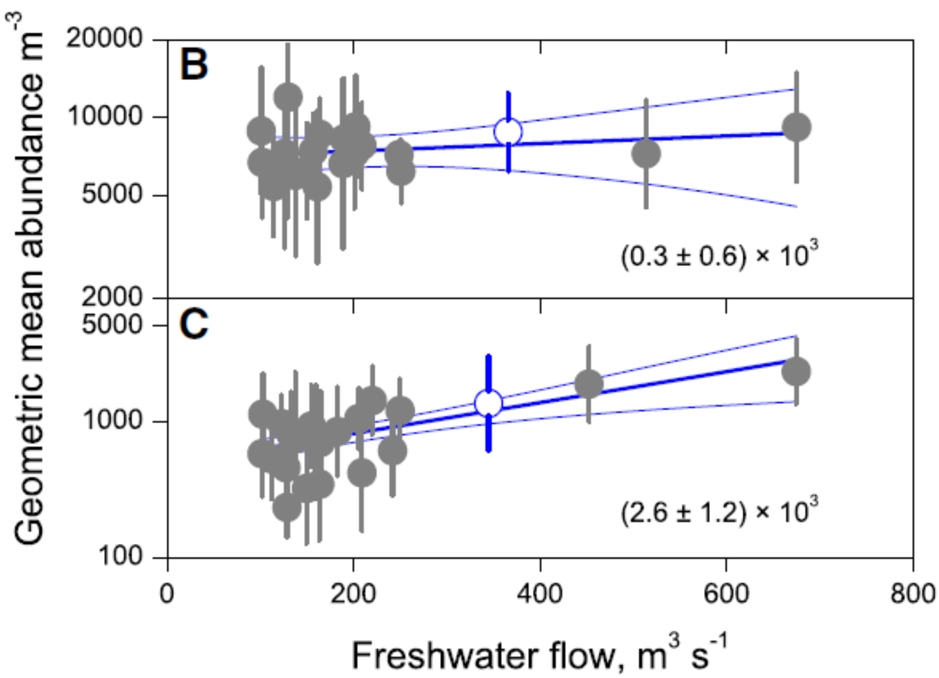
Figure 4.4-25. Mean Modeled Delta Inflow, June–September

The potential impacts on silversides and, therefore, Delta Smelt larval predation as a function of Delta inflow and South Delta exports reflect combined SWP and CVP operations. During the March–May period, which is the period of potential impacts on silversides from South Delta exports, the SWP would be responsible for around 40% to 60% of Delta water operations under the Proposed Project, depending on water year type and month, whereas from June through September, the period correlated with potential inflow impacts on silversides, the SWP would be responsible for approximately 20% to 50% of Delta water operations (see Appendix H).

<u>**Juveniles to Subadults (June–September)**</u>

Food Availability

The IEP MAST (2015) conceptual model describes food availability and quality as key components of the June through September transition probability of juvenile Delta Smelt to subadulthood through growth and survival of individuals. Freshwater inflows influence the subsidy of the Delta Smelt zooplankton prey *Pseudodiaptomus forbesi* to the low salinity zone from the freshwater Delta (Kimmerer et al. 2018, Figure 4.4-26), and these potential negative impacts are possibly of particular importance on the San Joaquin River side of the Delta, given the high density of *P. forbesi* in the region (Kimmerer et al. 2019).

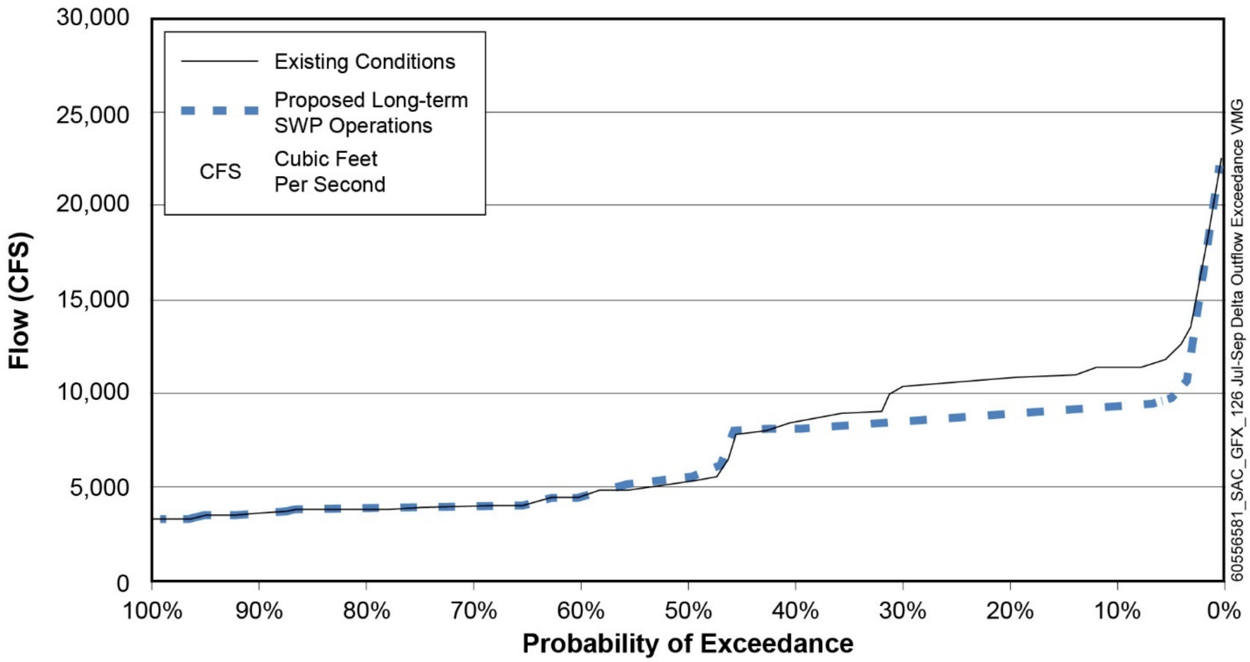


Source: Kimmerer et al. (2018).

Note: Error bars are 95% confidence limits based on all samples from the selected stations, and points for 2011 are shown as open circles. Lines with error bounds are from least-squares models of log of abundance versus flow, weighted by the inverse of variance. Values are slopes with 95% confidence intervals; only the slope for the low salinity zone stations was statistically significant.

Figure 4.4-26. July–September Geometric Mean Abundance of *Pseudodiaptomus forbesi* Copepodites and Adults for 1994–2016 in (B) Freshwater Stations (Salinity < 0.5) and (C) Low Salinity Zone Stations (Salinity 0.5–5), Excluding Suisun Marsh and the Central to Eastern Delta

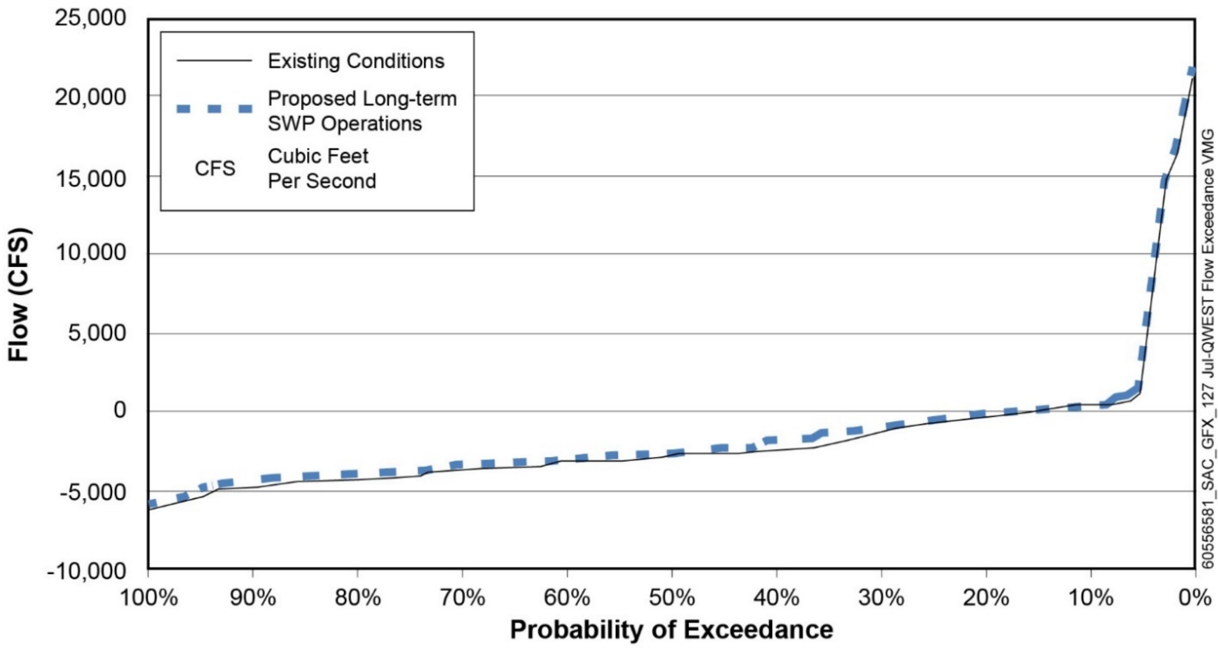
South Delta exports may entrain *P. forbesi* (USFWS 2008, p.228; Kimmerer et al. 2019), resulting in a positive correlation between the July to September Delta outflow and *P. forbesi* density in the low salinity zone (Kimmerer et al. 2018) (as shown in panel C in Figure 4.4-26). July to September Delta outflow generally would be similar for the Proposed Project and Existing Conditions scenarios, except for differences attributable to the inclusion of fall X2 criteria (beginning in September) under the Existing Conditions scenario, which would result in an approximately 2,000-cfs difference between scenarios at ~5% to 30% exceedance (~10,500–11,500 cfs for the Existing Conditions scenario and ~8,500–9,500 cfs for the Proposed Project scenario; Figure 4.4-27). Such differences, amounting to 50 cumecs—the unit used by Kimmerer et al. (2018) in Figure 4.4-26—would be predicted to result in a *P. forbesi* density that is lower under the Proposed Project scenario than under the Existing Conditions scenario, although statistical uncertainty in the relationship is indicated by the 95% confidence interval on the regression (as shown in Panel B in Figure 4.4-26).



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

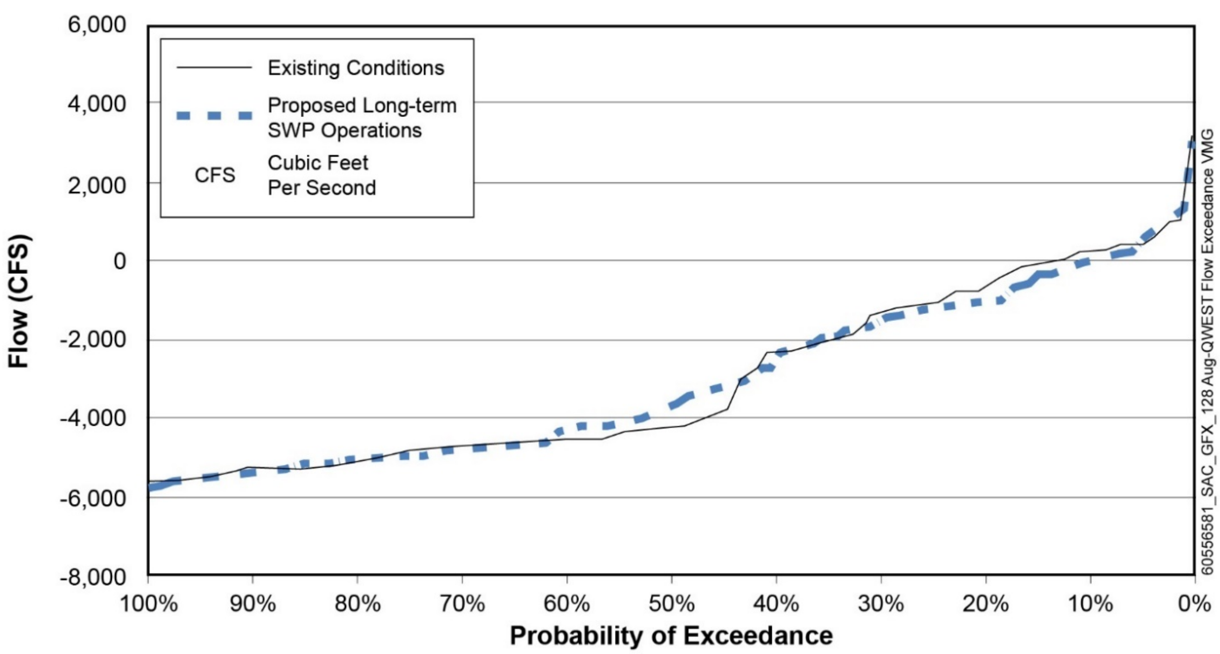
Figure 4.4-27. Mean Modeled Delta Outflow, July–September

Given the suggested importance of the San Joaquin River side of the Delta for spatial subsidy of *P. forbesi* to the low salinity zone and modeled losses of *P. forbesi* to entrainment by the South Delta export facilities (Kimmerer et al. 2019), modeled flows in the lower San Joaquin River (QWEST) were evaluated as an indicator of downstream *P. forbesi* subsidy potential from the lower San Joaquin River to the low salinity zone. Based on the assumption that net positive QWEST provides an indicator of downstream *P. forbesi* subsidy potential from the lower San Joaquin River to the low salinity zone, results of the QWEST evaluation suggest that the potential for subsidy of *P. forbesi* to the low salinity zone may be similar under the Proposed Project and Existing Conditions scenarios in July and August, which have a similar percentage of negative QWEST under both scenarios (Figure 4.4-28 and Figure 4.4-29). In September the percentage of years with positive QWEST was somewhat greater (~20%) under the Proposed Project scenario compared to the Existing Conditions scenario (~10%) (Figure 4.4-30). Uncertainty exists regarding the extent to which changes in the food subsidy to the low salinity zone would be of consequence should these even occur as a result of lower San Joaquin River flow differences, given the high rate of grazing in the low salinity zone (Kayfetz and Kimmerer 2017; Kimmerer et al. 2019) and the distribution of an appreciable portion of Delta Smelt upstream of the low salinity zone (i.e., an average of 23% [range 2% to 47%] during the 2005–2014 period [Bush 2017]). Nonetheless, QWEST typically would be negative under both the Proposed Project and Existing Conditions scenarios, indicating the potential downstream subsidy of *P. forbesi* would be very limited regardless of scenario.



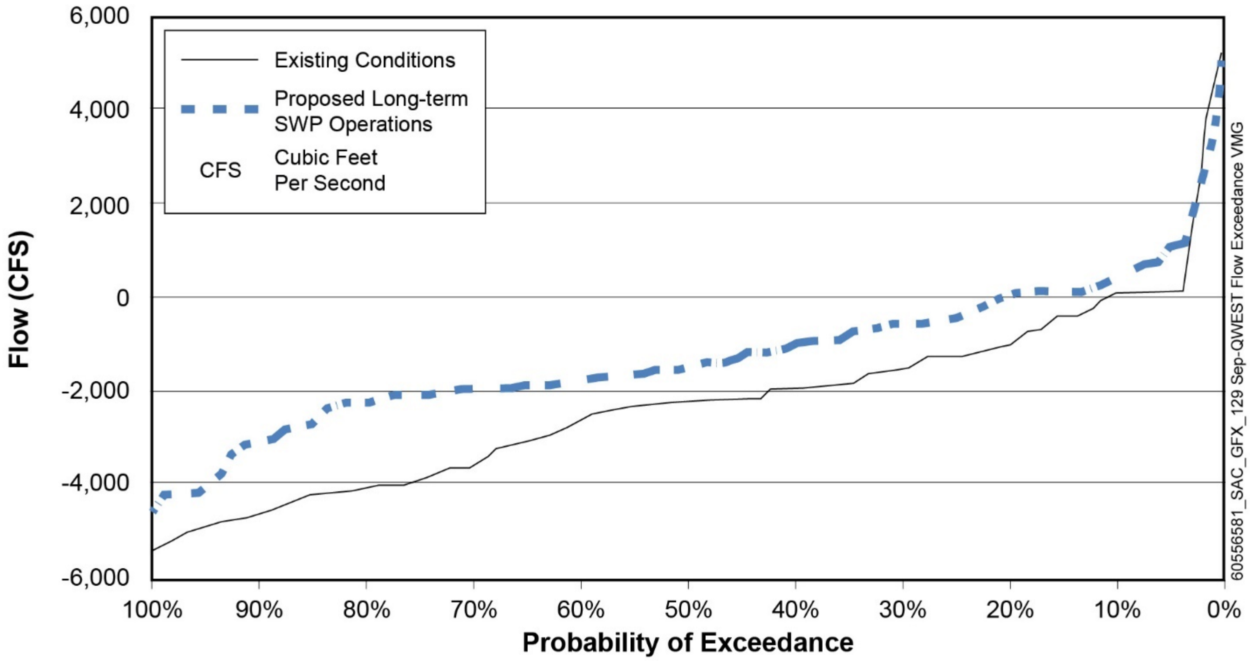
Source: <ITP_PP _0819.dss> and <2020D09EDV.dss>

Figure 4.4-28. Mean Modeled QWEST Flow, July



Source: <ITP_PP_0819.dss> and <2020D09EDV.dss>

Figure 4.4-29. Mean Modeled QWEST Flow, August



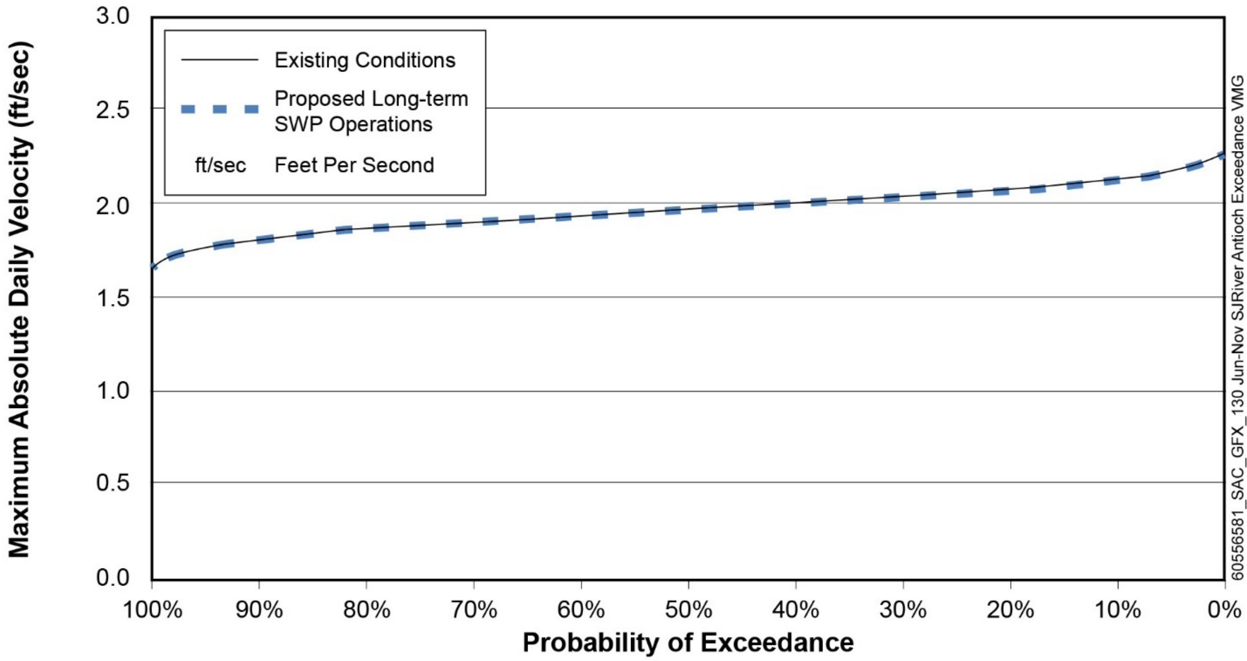
Source: <ITP_PP _0819.dss> and <2020D09EDV.dss>

Figure 4.4-30. Mean Modeled QWEST Flow, September

The potential impacts on the *P. forbesi* food subsidy, as indicated by Delta outflow and QWEST analyses, reflect combined SWP and CVP operations. During September, the main month of potential impacts on *P. forbesi* subsidy to the low salinity zone, the SWP would be responsible for an average of approximately 23% to 28% of Delta water operations in the wet and above-normal years for which fall X2 requirements would not be included in the Proposed Project (see Appendix H).

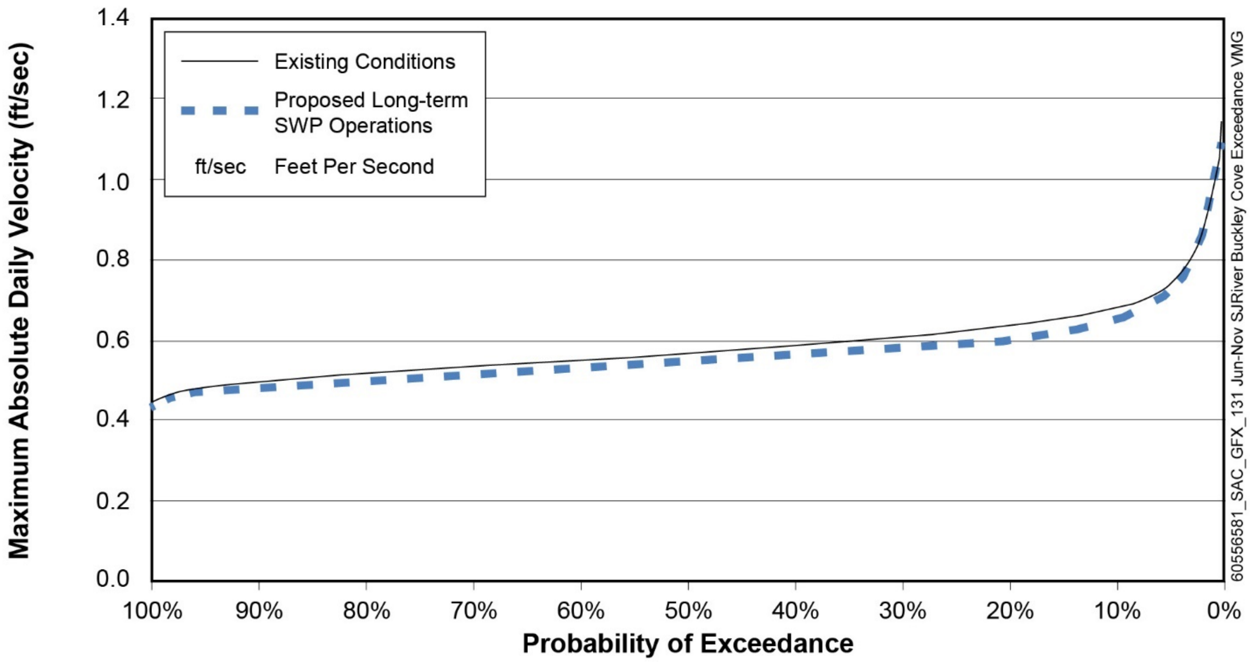
Harmful Algal Blooms

The IEP MAST (2015) conceptual model posits a linkage between various factors (nutrients, summer hydrology, and air temperature) and toxicity from harmful algal blooms to Delta Smelt and their prey. Based on this conceptual model (see also additional discussion in IEP MAST 2015, p.85-86), differences in flows could influence harmful algal blooms (Lehman et al. 2018); operations would not be expected to affect nutrients or temperature. A previous analysis by RBI (2017) focused on an analysis of maximum daily absolute velocity to assess exceedance of a 1 foot per second (ft/s) threshold, above which turbulent mixing may disrupt *Microcystis* blooms. The same analysis was applied using results from DSM2-HYDRO modeling. The DSM2-HYDRO results suggested that there would be little difference between Proposed Project and Existing Conditions scenarios in velocity conditions in the central and South Delta during summer and fall (June through November), as shown in Figures 4.4-31 through 4.4-38. In addition, the DSM2-HYDRO results suggest little difference, if any, in the probability of exceeding the 1-ft/s velocity threshold. These results also suggest little difference between the Proposed Project and Existing Conditions scenarios in the potential for velocity conditions affecting harmful algal blooms.



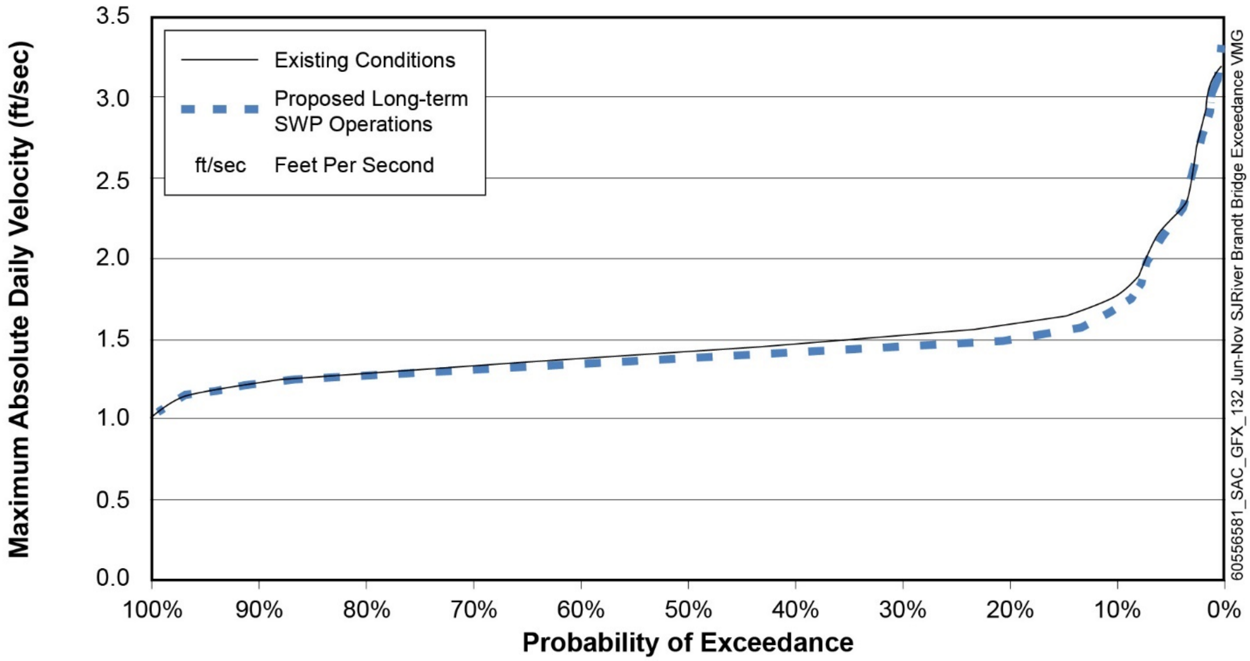
Source: <marin_absDmax.dss>

Figure 4.4-31. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Antioch, June–November



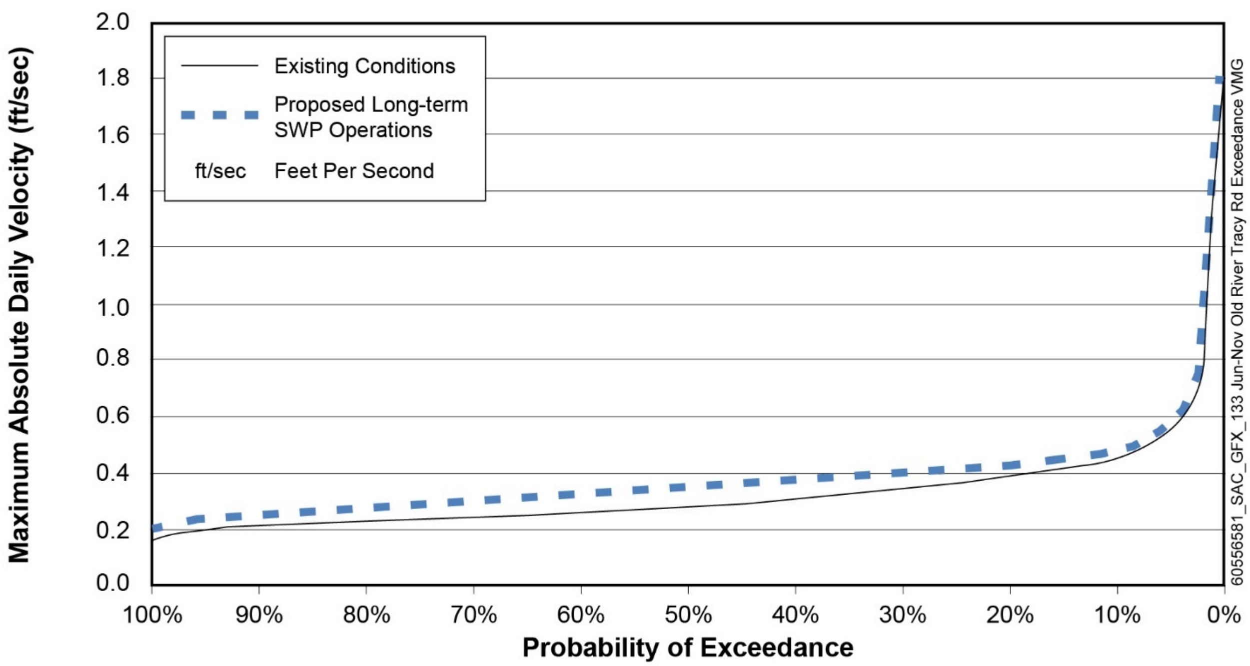
Source: <marin_absDmax.dss>

Figure 4.4-32. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Buckley Cove, June–November



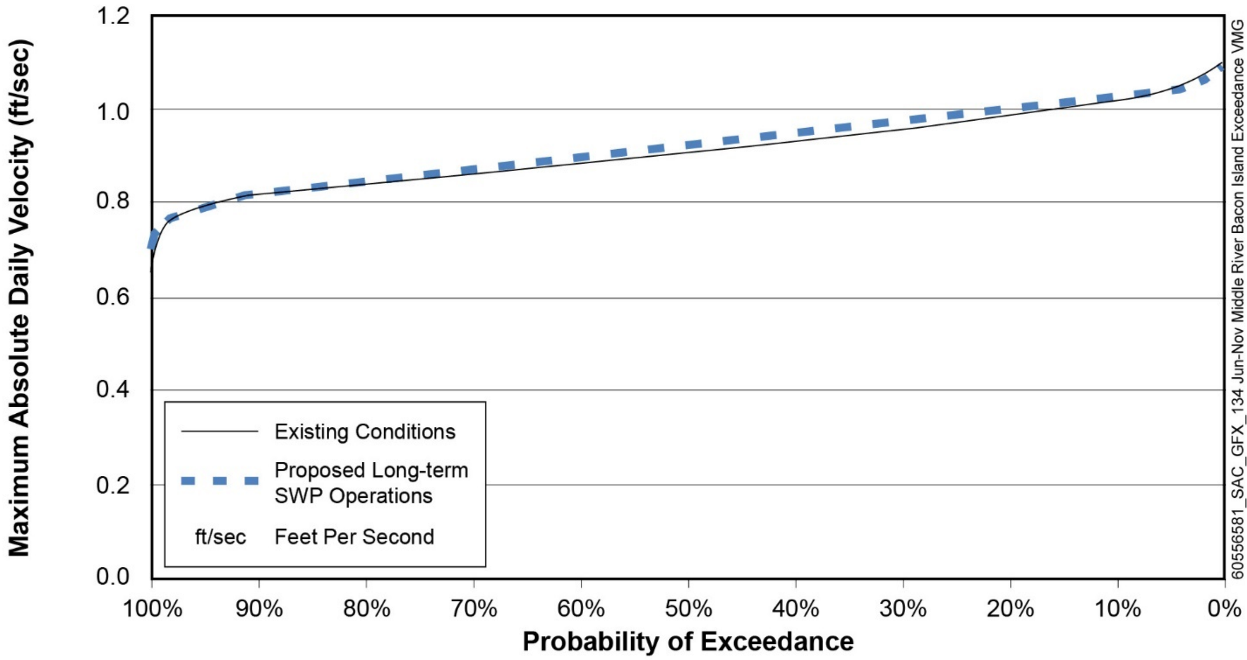
Source: <marin_absDmax.dss>

Figure 4.4-33. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Brandt Bridge, June–November



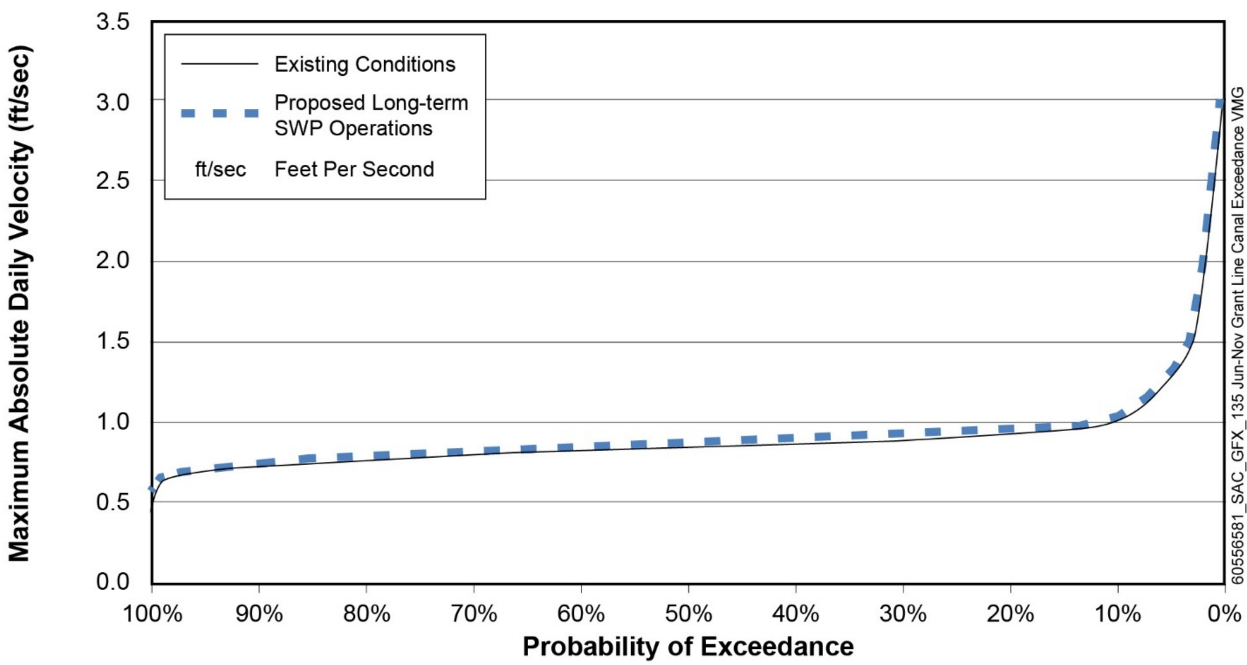
Source: <marin_absDmax.dss>

Figure 4.4-34. Modeled Maximum Absolute Daily Velocity in Old River at Tracy Road, June–November



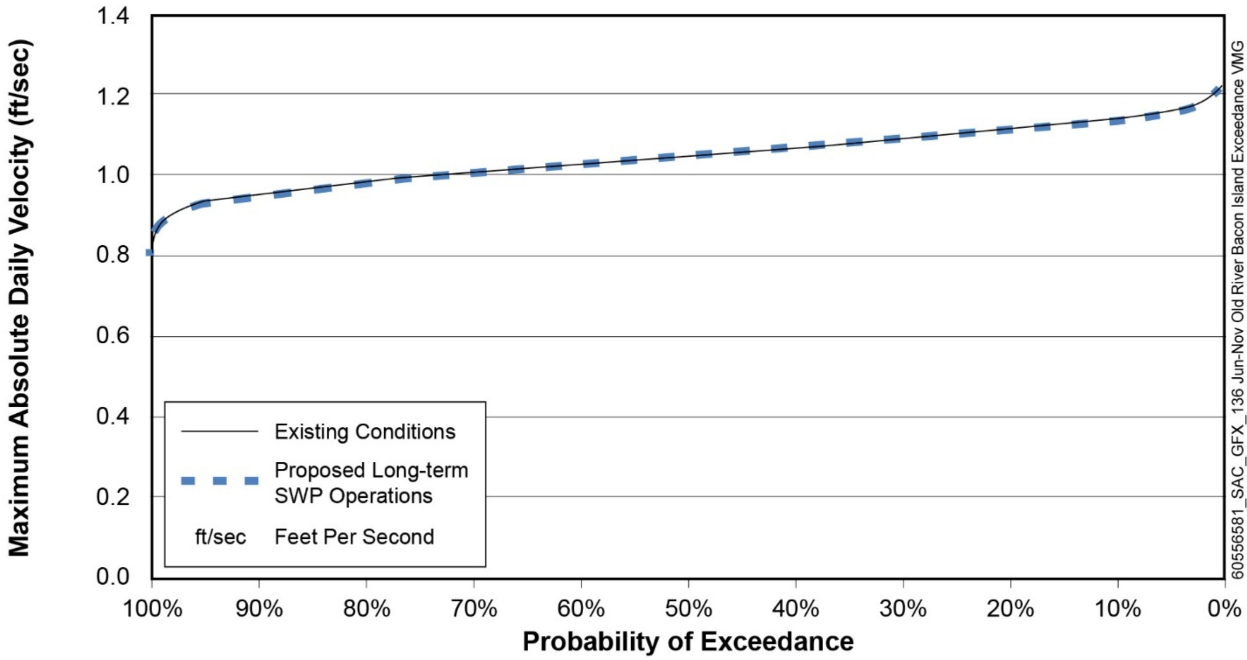
Source: <marin_absDmax.dss>

Figure 4.4-35. Modeled Maximum Absolute Daily Velocity in Middle River at Bacon Island, June–November



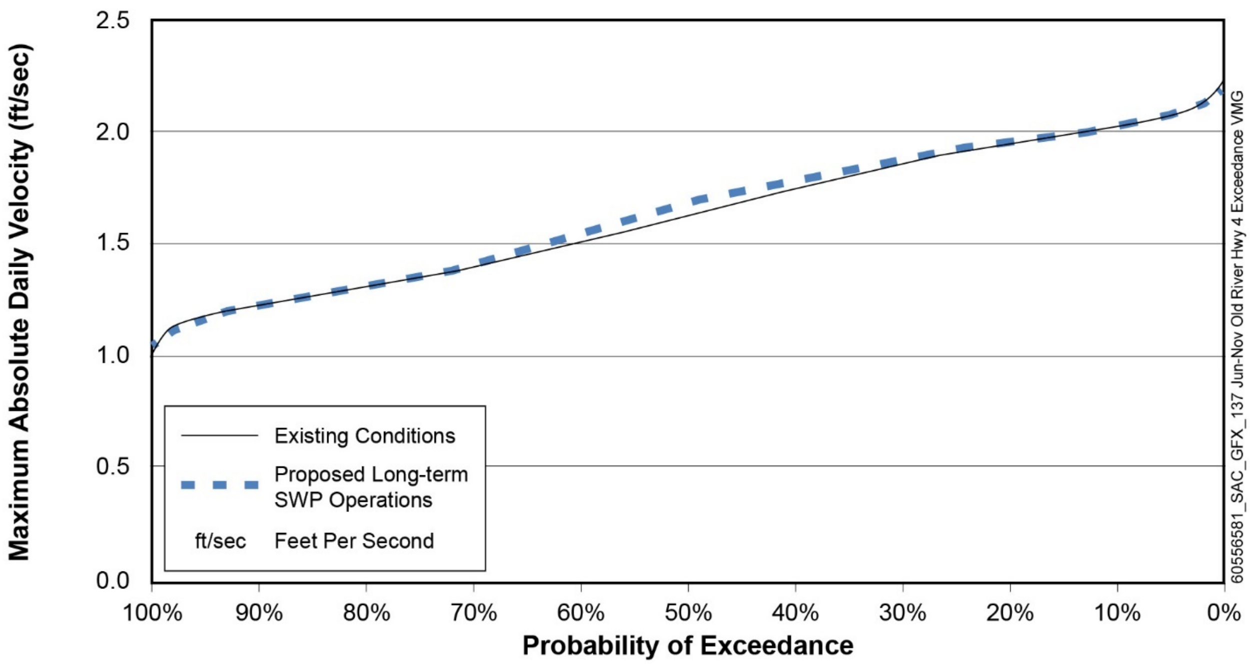
Source: <marin_absDmax.dss>

Figure 4.4-36. Modeled Maximum Absolute Daily Velocity in Grant Line Canal Downstream of Temporary Barrier, June–November



Source: <marin_absDmax.dss>

Figure 4.4-37. Modeled Maximum Absolute Daily Velocity in Old River at Bacon Island, June–November



Source: <marin_absDmax.dss>

Figure 4.4-38. Modeled Maximum Absolute Daily Velocity in Old River at Highway 4, June–November

The potential impacts on harmful algal blooms as a function of velocity at various Delta locations reflect combined SWP and CVP operations. During the June-November period, the SWP would be responsible for approximately 20% to 60% of Delta water operations under the Proposed Project, depending on water year type and month (see Appendix H).

Predation

The IEP MAST (2015) conceptual model posits that predation risk for juvenile Delta Smelt is a function of predators, turbidity, and water temperature. As previously discussed for larval Delta Smelt, water temperature in the Delta under the Proposed Project would be similar to the Existing Conditions scenario because operations have little influence on Delta water temperatures. Bever et al. (2018) reported that wind was a strong driver of turbidity, which is not affected by the Proposed Project and would be identical under both the Proposed Project and Existing Conditions scenarios.

As discussed above for adult Delta Smelt, differences in winter and spring Rio Vista flow and sediment delivery, together with only small amounts of sediment lost to entrainment, suggest that similar turbidity would occur under the Proposed Project and Existing Conditions scenarios during the winter-spring period. Although sediment input would be similar, the relationship between sediment input during winter and spring and the summer predation potential of juvenile Delta Smelt is unknown. However, wind and water temperature, which are drivers of predation, would be similar. Therefore, predation risk also would be similar.

Summer-Fall Habitat

Qualitative Analysis

The IEP MAST (2015) conceptual model posits that Delta Smelt abundance, survival, and growth are affected by the size and location of the low salinity zone during fall, with IEP MAST (2015, p.142) concluding: “The limited amount of available data provides some evidence in support of this hypothesis, but additional years of data and investigations are needed.” Others have found that low salinity zone habitat may not be a predictor of Delta Smelt survival (ICF 2017). Related to this, an additional argument in support of summer-fall habitat actions potentially being of importance to Delta Smelt is that having a broader distribution provides “bet-hedging” against the effects of environmental stressors. For example, if a species’ distribution is too constrained, its extinction risk is elevated as compared to a broader distribution. Hence, habitat actions that help support a broad distribution can have long-term population benefits. Note that this logic is somewhat different than the goal of maximizing habitat area

The Proposed Project includes structured decision-making to implement the Delta Smelt Summer-Fall Habitat Action, which is intended to improve Delta Smelt food supply and habitat, thereby contributing to the recruitment, growth, and survival of the species. Whereas current management, as represented by the Existing Conditions scenario, focuses on USFWS (2008) SWP/CVP BiOp fall criteria (i.e., X2 in September–October ≤ 74 km following wet years and ≤ 81 km following above-normal years, with provisions to extend these requirements into November or December if specific conditions are met), the Proposed Project scenario includes the potential for X2 ≤ 80 km in September–October of wet and above-normal years. Based solely on consideration of X2 and the typical distribution of the low salinity zone, this would tend to give a smaller area of low-salinity habitat under the Proposed Project scenario in wet years and somewhat larger area of low-salinity habitat under the Proposed Project scenario in above-normal years, relative to the Existing Conditions scenario. However, the Proposed Project scenario also includes potential additional operation of the SMSCG, relative to the Existing Conditions scenario, for up to 60 days in June through October of above-normal, below-normal, and wet years.

Evidence from a pilot 2018 application of the SMSCG action suggests that the Delta Smelt Summer-Fall Habitat Action would provide habitat benefits for Delta Smelt. The SMSCG were operated during August 2018 and it was found that a small number of Delta Smelt were observed in Suisun Marsh and therefore had access to additional relatively productive habitat; better water quality conditions (lower salinity and higher turbidity) occurred, relative to the period before the gates were operated; and the benefits extended well beyond the period of gate operations (Sommer et al. 2018). Thus, the proposed SMSCG action potentially increases Delta Smelt habitat suitability in an area with relatively high food availability and growth potential, as reflected by Delta Smelt individual-level responses, such as stomach fullness generally being higher in Suisun Marsh than other areas of the Delta Smelt range (Hammock et al. 2015). The 2018 pilot implementation of the SMSCG action illustrated that the action could provide salinity conditions in Suisun Marsh for Delta Smelt during below-normal years that were similar or better than in those observed in wet years (Sommer et al. 2018). The SMSCG action would have the potential to affect a sizable proportion of the Delta Smelt population (e.g., an average of 77% of Delta Smelt in the low salinity zone as observed in recent years [Bush 2017], with approximately 20% of juvenile Delta Smelt in Suisun Marsh as indicated by EDSM surveys during the 2018 pilot action, albeit with considerable uncertainty because of the overall low numbers caught in surveys).

As noted in the project description, additional Delta outflow to support the above Summer-Fall actions could come from export reductions, increased reservoir releases, or some combination of the two. From the perspective of summer-fall Delta Smelt habitat, the expected source of the outflow changes will not matter. For either operational approach, habitat area, habitat quality, and resulting geographic distribution should be similar.

In addition to X2 management and SMSCG operations, the Proposed Project summer-fall habitat actions included in the Proposed Project potentially include food enhancement actions such as those found in the Delta Smelt Resiliency Strategy (North Delta Food Subsidies and Colusa Basin Drain project, and Suisun Marsh Food Subsidies [Roaring River distribution system reoperation]). Augmentation of flow from the Colusa Basin drain during summer/early fall as part of the Delta Smelt Summer-Fall Habitat Action could increase transfer of food web materials to the North Delta, thereby potentially increasing food availability for juvenile Delta Smelt. An average of 23% of Delta Smelt surviving to adulthood are resident in the Cache Slough Complex/Sacramento Deepwater Ship Channel region throughout their lives, whereas the remainder either migrate to the low salinity zone or are resident there (Bush 2017). The proportion of the population resident in the North Delta would be most likely to benefit from the North Delta food subsidies action. A pilot implementation of this action in 2016 found that primary production in the North Delta increased as a result of the action (Frantzich et al. 2018), with enhanced zooplankton growth and egg production (California Natural Resources Agency 2017). Reclamation (2018:2) suggested that a chlorophyll concentration of 10 µg/l of chlorophyll, as achieved in 2016 for a number of days during the action, could support relatively high zooplankton production (Müller-Solger et al. 2002) without adversely affecting water quality (e.g., dissolved oxygen concentration). Analyses are underway to determine the potential effectiveness of a 2018 pilot implementation of the action, but preliminary information suggests that chlorophyll concentration above 10 µg/l was limited in duration in the Yolo Bypass and there was no increase at

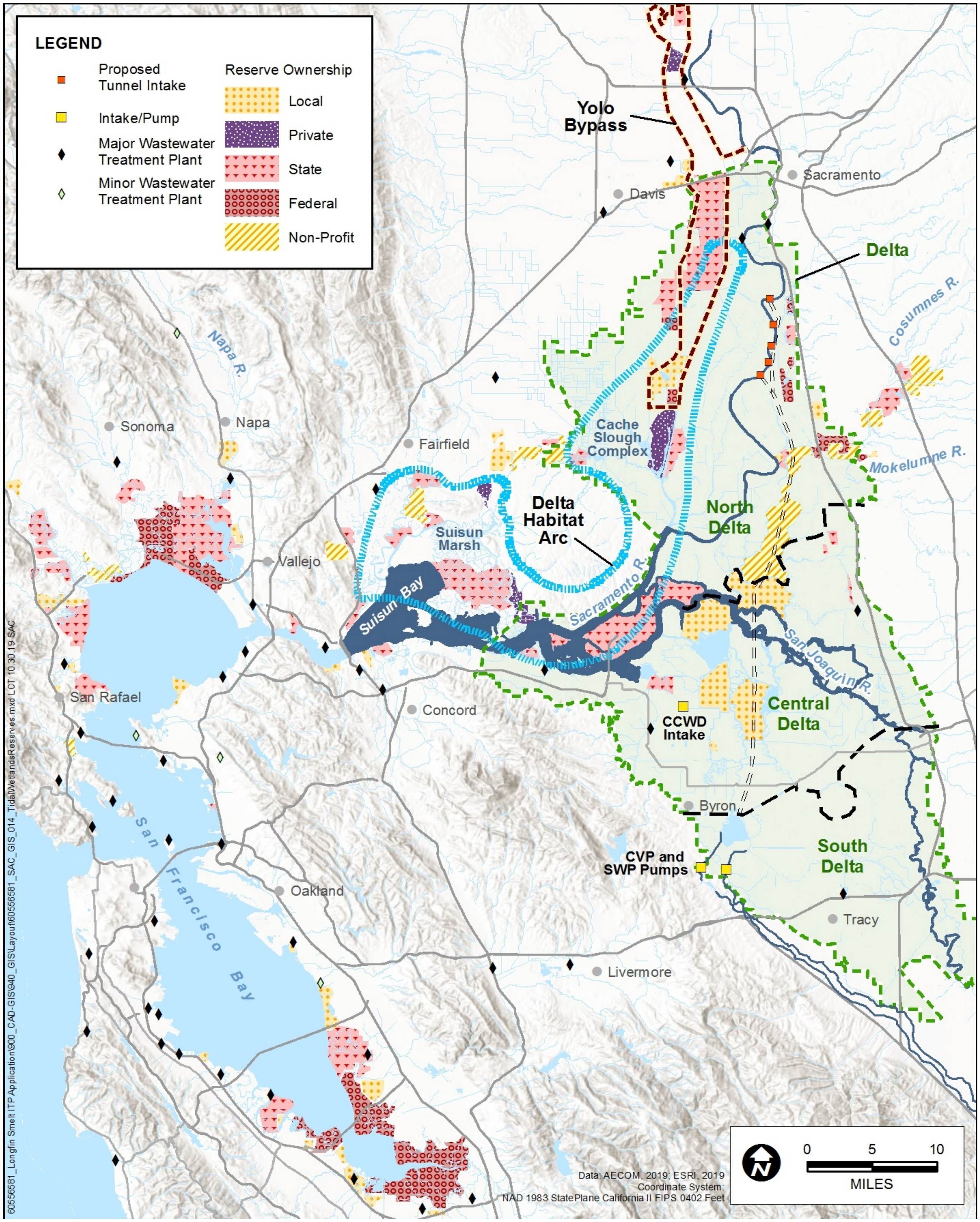
Rio Vista. Nonetheless, the 2018 action still showed downstream transport of chlorophyll in the Cache Slough Complex, a primary habitat area for Delta Smelt (DWR unpublished data).

SCHISM Analysis

To illustrate the potential impacts of SMSCG operations and September and October X2 operations proposed for consideration as part of the Delta Smelt Summer-Fall Habitat Action, a hindcasting analysis based on historical conditions in 2012 (a representative below-normal water year) and 2017 (a representative wet water year) was undertaken using the SCHISM model, which is described in more detail in Appendix D. In each year, a base scenario simulated historical conditions; in 2017, an additional scenario with X2 of 74 km in September–October was run to provide a further point of comparison for context.

Two potential Proposed Project summer-fall habitat action scenarios were simulated for 2012. One scenario included 60-day SMSCG operations commencing on June 14, and the other scenario included 60-day SMSCG operations commencing on August 15. The mean area of low salinity (≤ 6 psu) was calculated for each day. In consideration of the importance of the North Delta arc of habitat for Delta Smelt (Hobbs et al. 2017; Figure 4.4-39), results were calculated for several generalized geographic regions: the North Delta arc, a corridor of channels from Cache Slough to Montezuma Slough, Suisun Marsh, and Suisun Bay (Figure 4.4-40). In addition to a summary of results considering salinity alone, a second analysis overlaid salinity with interpolated data for water temperature from various monitoring stations and turbidity (Secchi depth) from summer townet and fall midwater trawl surveys (ftp://ftp.wildlife.ca.gov/TownetFallMidwaterTrawl/). For each day, the average area of habitat meeting three criteria (salinity ≤ 6; temperature < 25C; Secchi depth >0.5 m [Bever et al. 2016]) was summarized. Appendix D provides additional details regarding the methods and results of the SCHISM modeling and analysis.

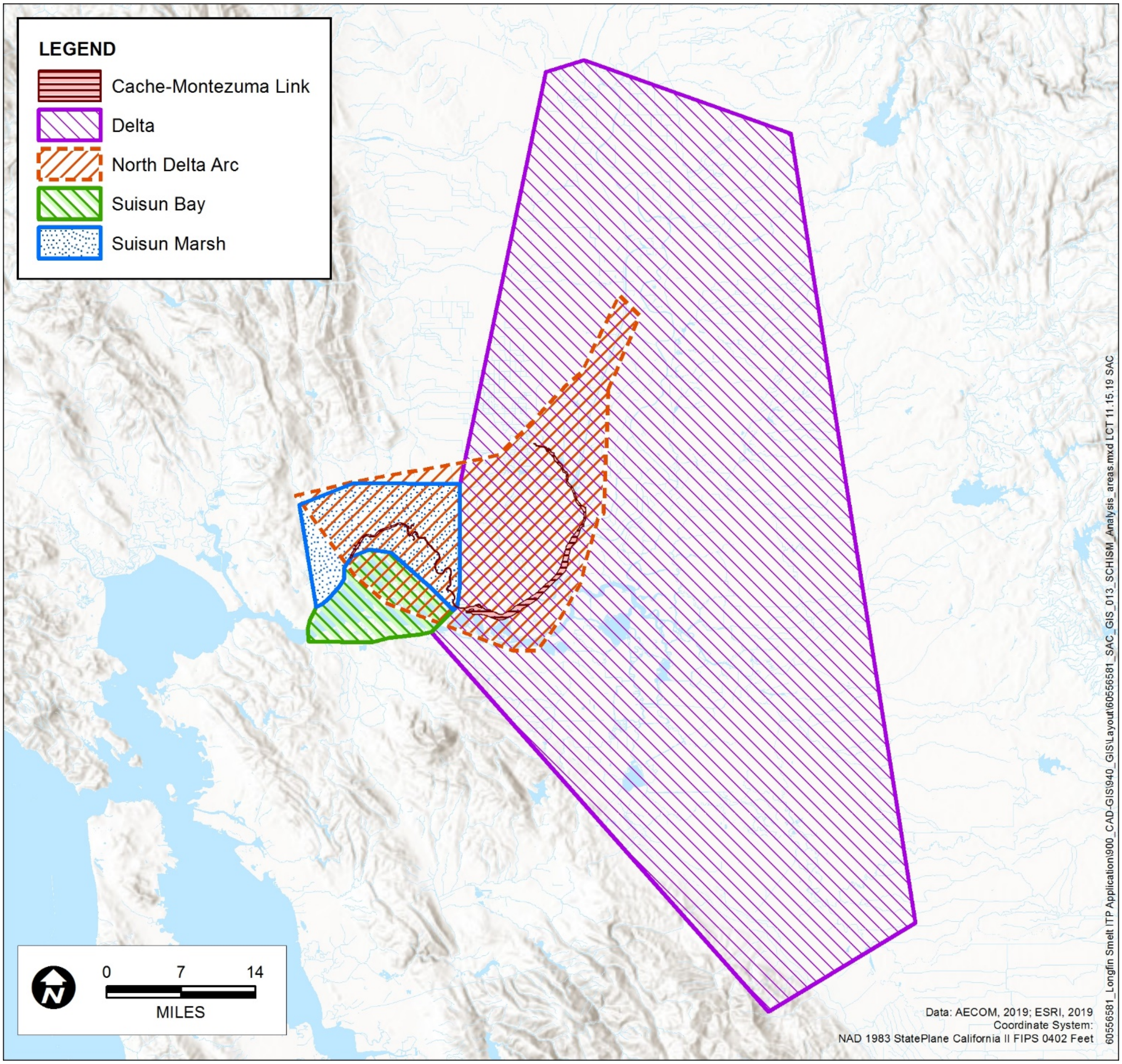
The 2012 SCHISM results illustrated that operation of the SMSCG would have yielded a greater extent of low-salinity habitat if undertaken for 60 days commencing on August 15 rather than June 14 (Figure 4.4-41). In general, D-1641 agricultural water quality standards are sufficient to protect low-salinity habitat in Suisun Marsh until August 15, when the standards no longer apply. At the scale of the overall North Delta arc or the Cache to Montezuma corridor, differences in low-salinity area between scenarios as a result of SMSCG operations would be expected to be modest (Figure 4.4-41). The greatest differences would occur within Suisun Marsh, for which SMSCG operations commencing on August 15 would be expected to result in appreciably greater extent of low-salinity habitat from August 15 through October 15, extending somewhat to the November–December time frame. Operation of the SMSCG in this manner would be expected to result in a reduction in the extent of low-salinity habitat in Suisun Bay (including Grizzly Bay) relative to the scenario without SMSCG operation (Figure 4.4-41). The extent to which this reduction in Suisun Bay habitat could affect Delta Smelt would depend on the distribution of the species. However, sampling during the 2018 SMSCG action suggested a greater presence of Delta Smelt in Suisun Marsh than Suisun Bay (Figure 4.4-45), which may indicate greater potential for a positive rather than a negative impact of habitat changes resulting from the SMSCG operation, particularly considering that Suisun Marsh provides habitat in which Delta Smelt generally have appreciably better conditions than in Suisun Bay (Hammock et al. 2015).



Source: Adapted from Hobbs et al. 2017

Note: "Proposed tunnel" represents previously considered facilities as part of Bay Delta Conservation Plan/California WaterFix planning process.

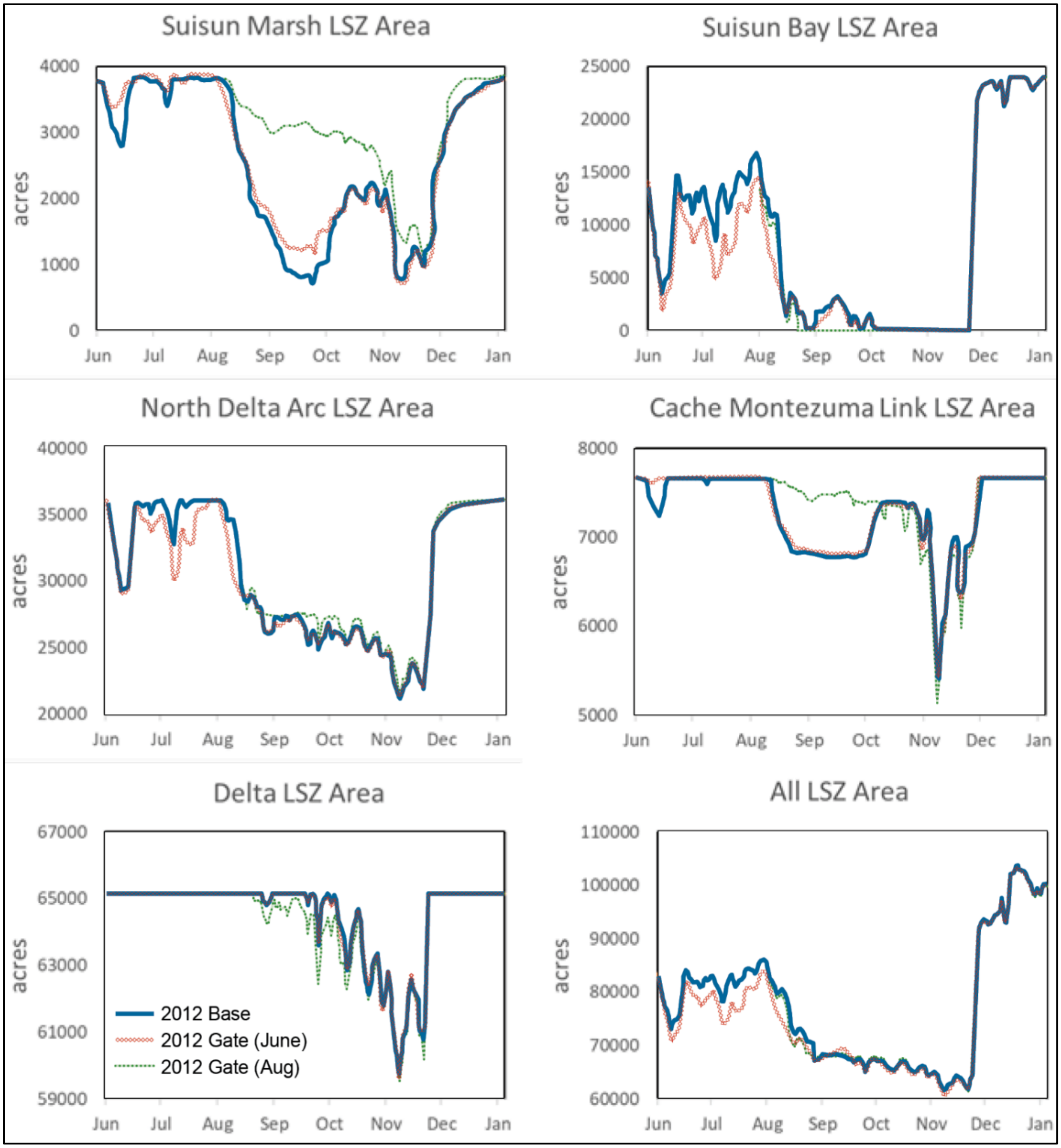
Figure 4.4-39. Tidal Wetland Reserve Ownership by Entity, including the North Delta Arc (Arc of Habitat outlined in blue), Islands in the Central Delta (yellow) and Lands in the Napa–Sonoma Marsh, Petaluma River in the North Bay and Salt Ponds in South Bay (pink hues)



Source: Appendix D

Figure 4.4-40. Regions Used in SCHISM Analysis

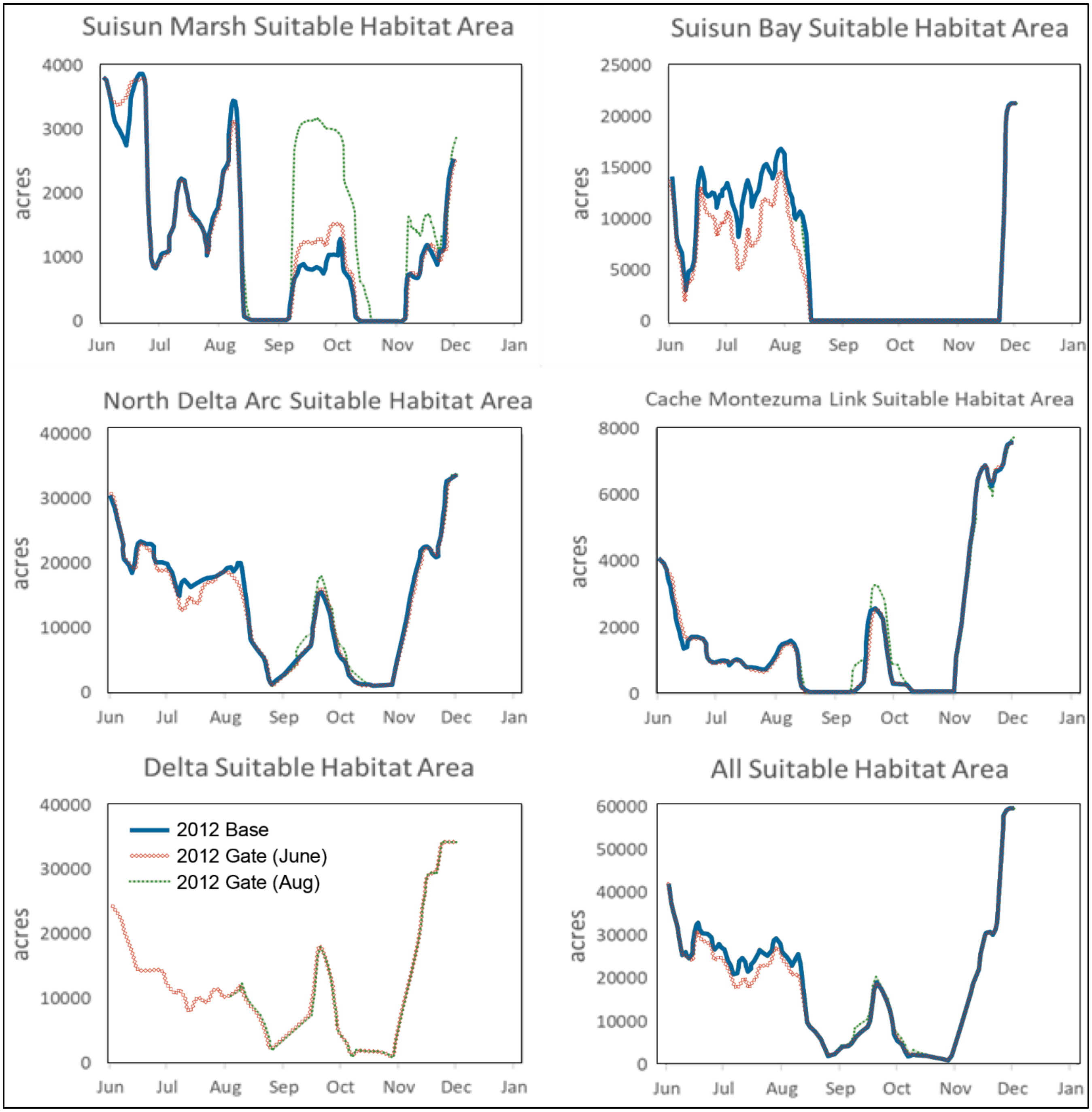
Considering temperature and turbidity (water clarity) in addition to salinity and focusing on the SMSCG operations commencing in August generally suggested a similar overall pattern to salinity alone, with respect to modest differences between scenarios at the scale of the North Delta arc or the Cache to Montezuma link corridor, and with greater differences in Suisun Marsh; however, there was not less habitat meeting all three criteria in Suisun Bay. Notably different from the analysis considering salinity alone was that the area meeting the salinity, temperature, and Secchi depth criteria dropped to zero on a number of occasions, which reflected Secchi depth increasing slightly above the 0.5-meter threshold selected for analysis; the results, provided in Appendix D, are sensitive to a threshold-based approach of defining habitat criteria, particularly in Suisun Bay and Suisun Marsh.



Note: "2012 Base" = historical 2012 operations; "2012 Gate (Jun)" = SMSCG operations for 60 days commencing June 14; "2012 Gate (Aug)" = SMSCG operations for 60 days commencing August 15. The "All LSZ Area" represents the combination of the Delta + Suisun Marsh + Suisun Bay areas

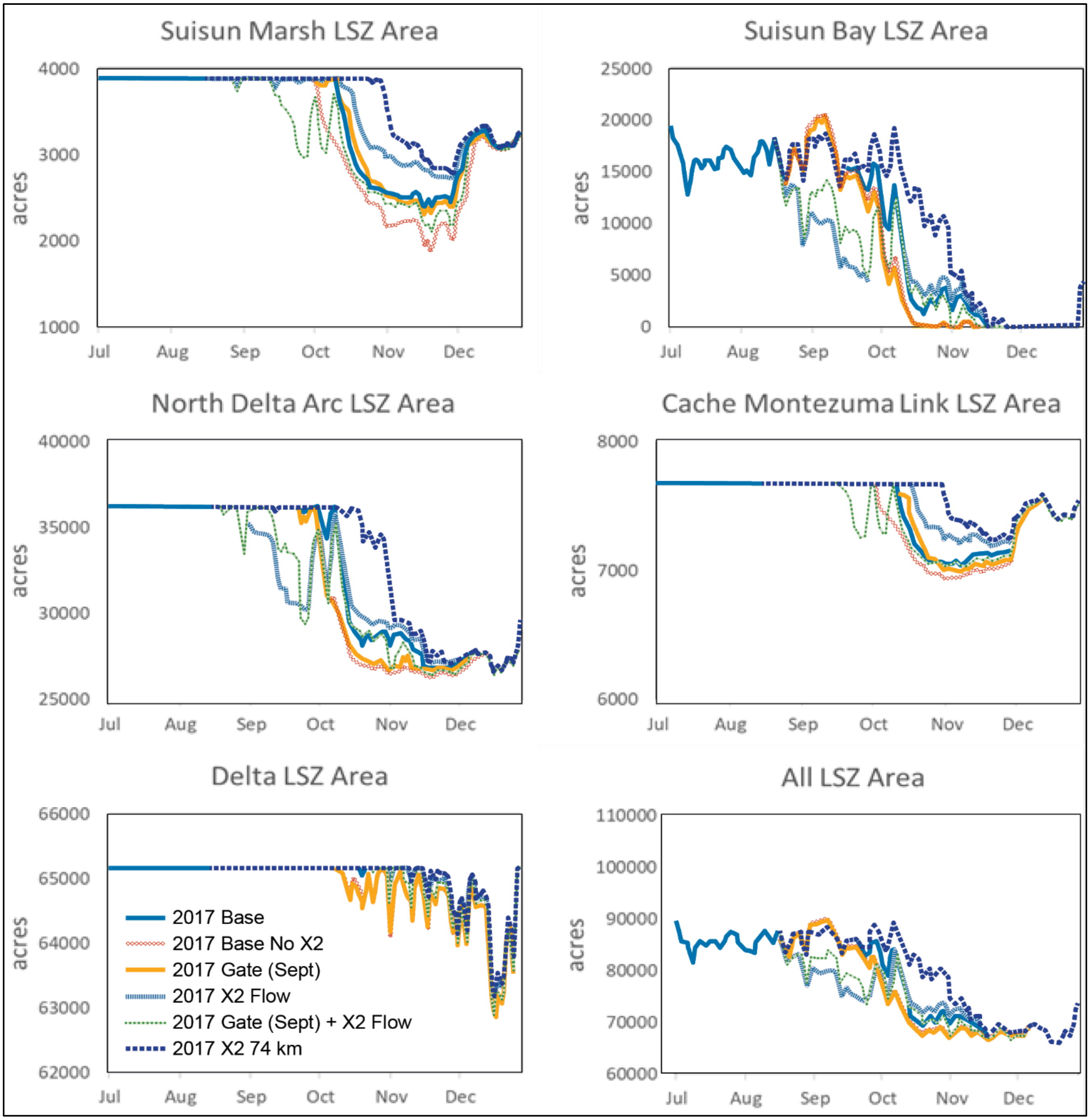
Figure 4.4-41. Area of Low-Salinity Habitat (≤6), June 2012–January 2013 Resulting from SCHISM Simulations

The SCHISM analysis for 2017 considered both SMSCG operations (commencing September 1) as well as operations to maintain X2 at 80 km in September and October as a representation of Proposed Project operations. The relatively wet conditions in 2017 led to low-salinity habitat throughout much of the simulated area until October/November, after which time there was a residual impact of the combination of SMSCG operations and maintaining X2 of 80 km in November (Figure 4.4-43). This suggests the potential for the Proposed Project scenario to increase the area of low salinity relative to



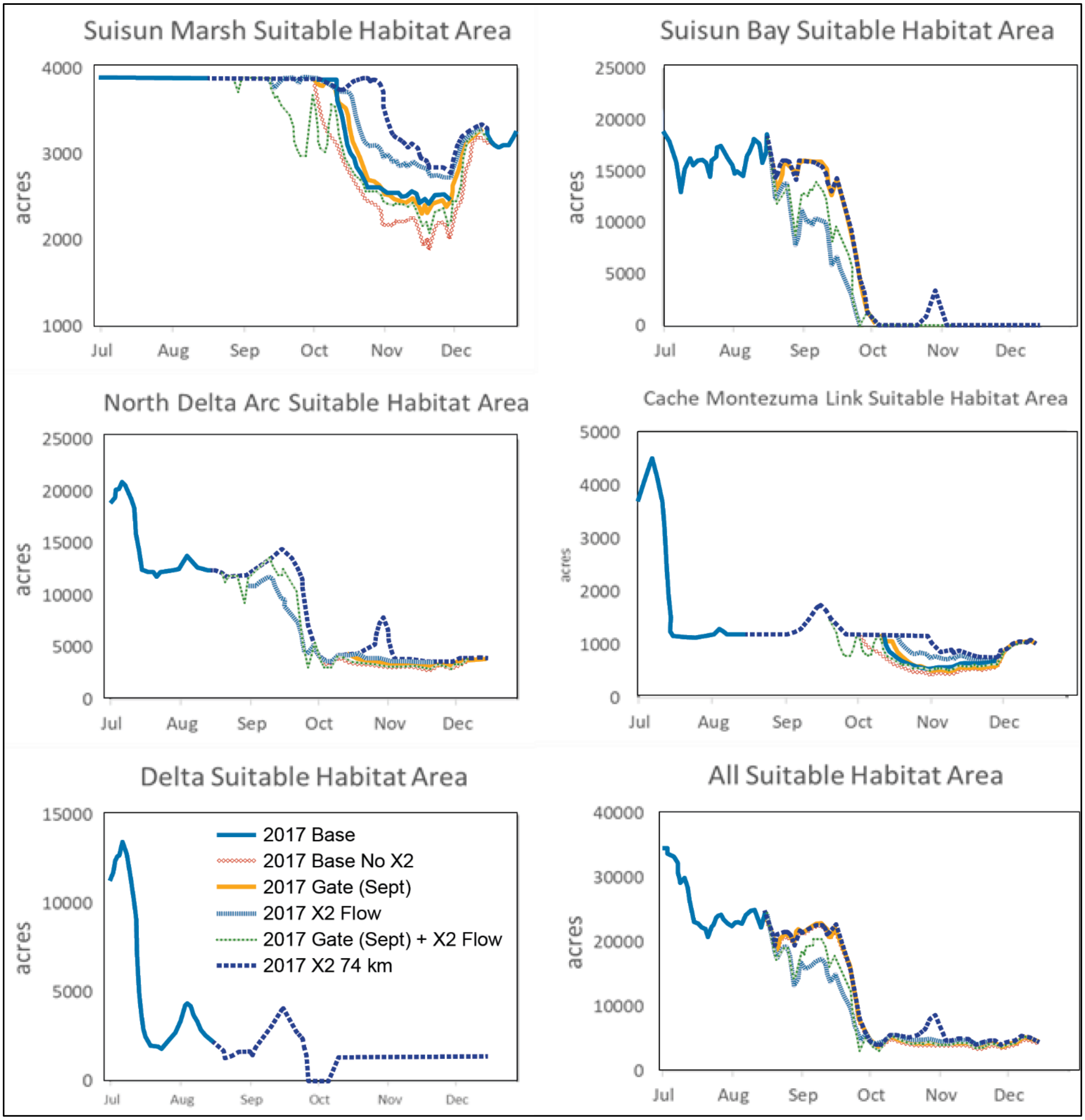
Note: "2012 Base" = historical 2012 operations; "2012 Gate (Jun)" = SMSCG operations for 60 days commencing June 14; "2012 Gate (Aug)" = SMSCG operations for 60 days commencing August 15. The "All Suitable Habitat Area" represents the combination of the Delta + Suisun Marsh + Suisun Bay areas.

Figure 4.4-42. Area of Habitat with Salinity ≤ 6, Temperature < 25C, and Secchi Depth >0.5 m, June–December 2012 Resulting from SCHISM Simulation



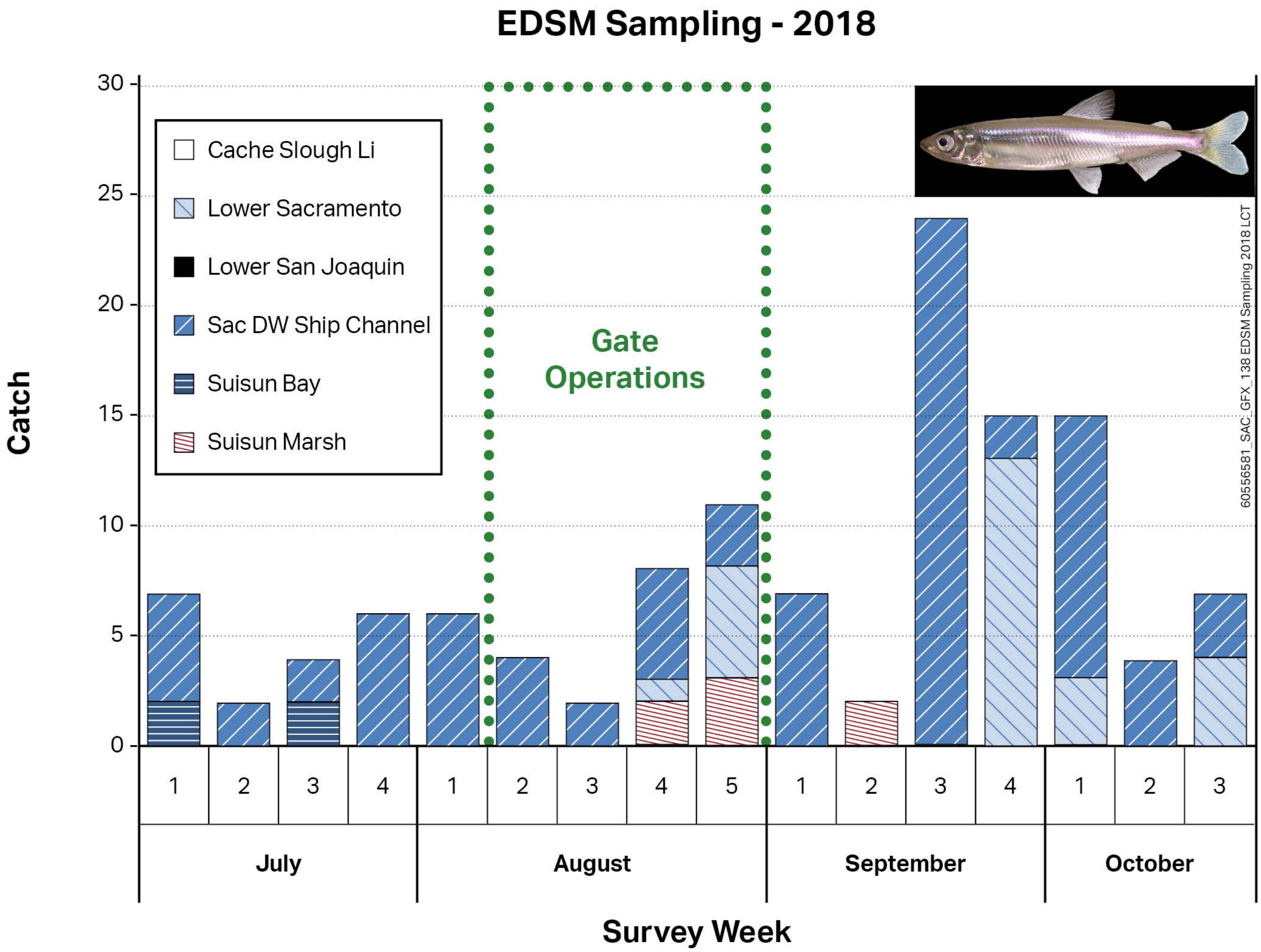
Note: "2017 Base" = historical 2017 operations; "2017 Base No X2" = historical 2017 operations without additional outflow to meet fall X2 requirements; "2017 Gate (Sep)" = SMSCG operations for 60 days commencing September 1; "2017 X2 80km" = operations to achieve X2 of 80 km in September and October; "2017 Gate (Sep) + X2 80km" = gate operations and flow to achieve X2 of 80 km as for the prior two scenarios; 2017 X2 74km = operations to achieve X2 of 74 km in September and October. The "All LSZ Area" represents the combination of the Delta + Suisun Marsh + Suisun Bay areas.

Figure 4.4-43. Area of Low Salinity Habitat (≤6), June 2017–January 2018 Resulting from SCHISM Simulations



Note: "2017 Base" = historical 2017 operations; "2017 Base No X2" = historical 2017 operations without additional outflow to meet fall X2 requirements; "2017 Gate (Sep)" = SMSCG operations for 60 days commencing September 1; "2017 X2 80km" = operations to achieve X2 of 80 km in September and October; "2017 Gate (Sep) + X2 80km" = gate operations and flow to achieve X2 of 80 km as for the prior two scenarios; 2017 X2 74km = operations to achieve X2 of 74 km in September and October. The "All LSZ Suitable Habitat Area" represents the combination of the Delta + Suisun Marsh + Suisun Bay areas.

Figure 4.4-44. Area of Habitat with Salinity ≤ 6, Temperature < 25C, and Secchi Depth >0.5 m, June–December 2017 Resulting from SCHISM Simulations



Source: Adapted from Sommer et al. 2018

Figure 4.4-45. Catch of Delta Smelt by the Enhanced Delta Smelt Monitoring Program During the 2018 Pilot Suisun Marsh Salinity Control Gates Action

the Existing Conditions scenario if Existing Conditions operations were similar to those undertaken historically in 2017, with the increase being greatest in Suisun Marsh and modest at the larger scale of the North Delta arc, a pattern also evident when considering the results from the combination of salinity, temperature, and water clarity (Figure 4.4-44). Additional considerations are provided in Appendix D, but overall, the modeling does not suggest that the extent of low-salinity habitat for Delta Smelt would be lower under the Proposed Project scenario than under the Existing Conditions scenario as historically operated in 2017. However, had the historical 2017 operations been adaptively managed to instead achieve X2 of 74 km in September and October, there would have been a generally greater extent of low salinity habitat and habitat meeting the low salinity, Secchi depth, and water temperature criteria than under the Proposed Project (Figures 4.4-43 and 4.4-44).

Operations-related impacts on the size and location of the low salinity reflect combined SWP and CVP operations. Operation of the SMSCG is the responsibility of SWP. During the June to October period of the Delta Smelt Summer-Fall Habitat Action, the SWP's responsibility for water operations would be

~30% to 40% in June, ~20% to 40% in July and August, ~20% to 50% in September, and ~40% to 50% in October (see Appendix H).

Subadults to Adults (September–December)

Food Availability

As discussed for juvenile Delta Smelt, seasonal South Delta export operations have the potential to affect Delta Smelt food availability through changes in *P. forbesi* subsidy to the low salinity zone rearing habitat occupied by most Delta Smelt reaching adulthood, as illustrated for September (Figure 4.4-30).

Although the FLaSH investigations predicted that Delta Smelt food availability (as represented by calanoid copepods) in the fall low salinity zone would be greater with lower X2 (i.e., higher outflow)(Brown et al. 2014, p.25), this was not found to be the case either for the post-*Potamocorbula amurensis* invasion period (1988–2015/2016; Figures 5.16-27, 5.16-28, 5.16-29, 5.16-30, 5.16-31, and 5.16-32 in Reclamation 2019) or for the period following onset of the Pelagic Organism Decline (2003–2015/2016; ICF 2017, p.78–82). Therefore, as described for juvenile Delta Smelt, there is a potential positive impact on *P. forbesi* transport to the low salinity zone under the Proposed Project in September, relative to the Existing Conditions scenario, but not for overall calanoid copepod density in the low salinity zone based on previous analyses related to X2 (ICF 2017, p. 78-82).

The potential impacts of the Proposed Project on the *P. forbesi* food subsidy, as indicated by Delta outflow and QWEST analyses, reflect combined SWP and CVP operations. During September, the main month of potential impact on *P. forbesi* subsidy to the low salinity zone, the SWP would be responsible for an average of approximately 23% to 28% of Delta water operations in the wet and above-normal years for which fall X2 requirements would not be included in the Proposed Project (see Appendix H).

Harmful Algal Blooms

As discussed for juvenile Delta Smelt, application of the threshold velocity approach from RBI (2017) with DSM2-HYDRO modeling results suggests that there would be little difference in velocity conditions between the Proposed Project and Existing Conditions scenarios in the Central Delta and South Delta during summer-fall (June–November; Figure 4.4-31 through Figure 4.4-38), which also suggests little difference between scenarios in the potential for velocity conditions affecting harmful algal blooms.

The potential impacts on harmful algal blooms as a function of velocity at various Delta locations reflect combined SWP and CVP operations. During the June-November period, the SWP would be responsible for around 20% to 60% of Delta water operations under the Proposed Project, depending on water year type and month (see Appendix H).

Predation

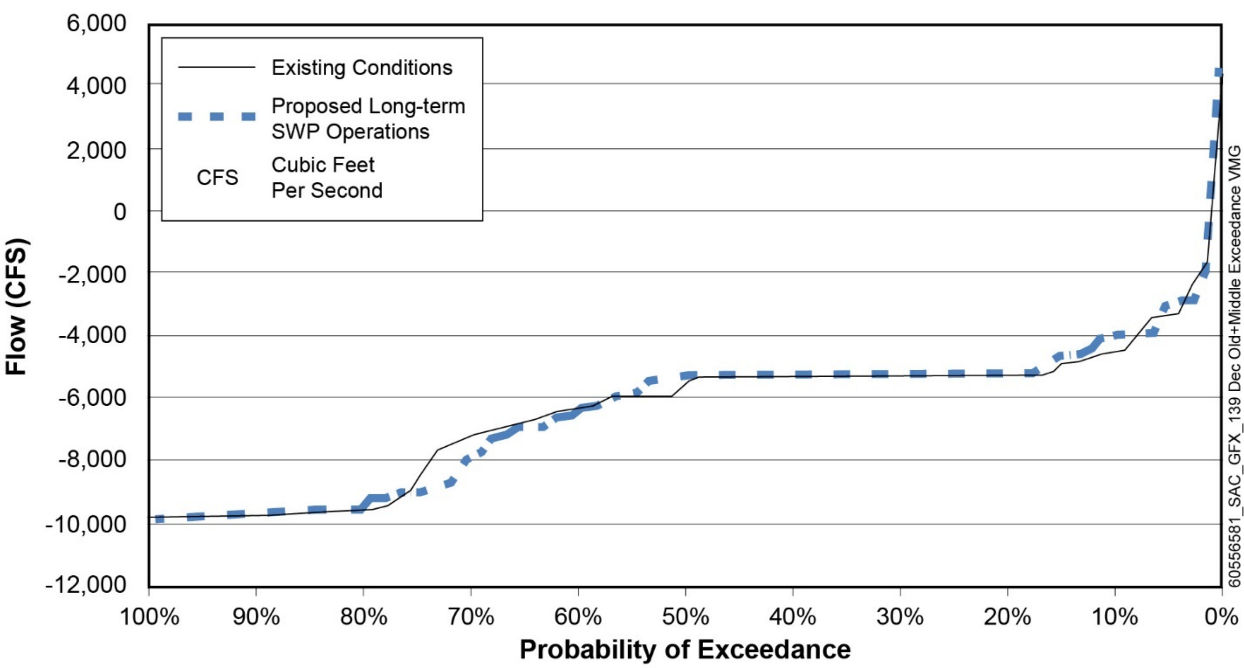
Similar to other Delta Smelt life stages, sediment supply during the winter and spring would be similar under the Proposed Project and Existing Conditions scenarios, so the potential impact on sediment resuspension during the fall subadult period would be expected to be similar for both scenarios. In addition, as previously described for other life stages of Delta Smelt, water temperature and wind-related resuspension of sediment would not be expected to be affected by operations under the Proposed Project. With greater (more upstream) X2 under the Proposed Project in the fall relative to

Existing Conditions in September/October of wet water years, the low salinity zone potentially could overlap areas with greater water clarity (i.e., lower turbidity; ICF 2017, p.105-115) that are less likely to have wind-wave sediment resuspension (IEP MAST 2015, p.50), which could then translate into greater predation risk based on the negative correlation between predation risk and turbidity. In above normal water years, the more downstream low salinity zone under the Proposed Project (i.e., X2 of 80 km in September/October vs. X2 of 81 km under Existing) could slightly reduce predation risk under the PP. The extent to which observed negative correlations between fall X2 and water clarity in the low salinity zone are the result of antecedent conditions (i.e., sediment supply during high-flow months) is uncertain (ICF 2017, p.106). Therefore, predation risk under the Proposed Project scenario would be expected to be greater or less than the Existing Conditions scenario, depending on water year type, although this is uncertain.

<u>**Entrainment**</u>

Consideration of OMR Flows

OMR flows are an important indicator of Delta Smelt entrainment risk (Grimaldo et al. 2009, 2017b). During the main period of adult entrainment risk (December–March; USFWS 2008), the Proposed Project scenario is expected to have generally similar OMR flows to the Existing Conditions scenario (Figure 4.4-46 through Figure 4.4-49), suggesting that adult entrainment risk considering only OMR flows would be similar between the Proposed Project and Existing Conditions scenarios. As described in the project description, the first flush protection action would be triggered more often under the Proposed Project, than under existing operating criteria (Figure 4.4-50), thereby potentially providing additional entrainment risk protection under the Proposed Project (the first flush protection is not represented in the CalSim modeling). Other factors such as turbidity are also important influences on



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4.4-46. Mean Modeled Old and Middle River Flow, December

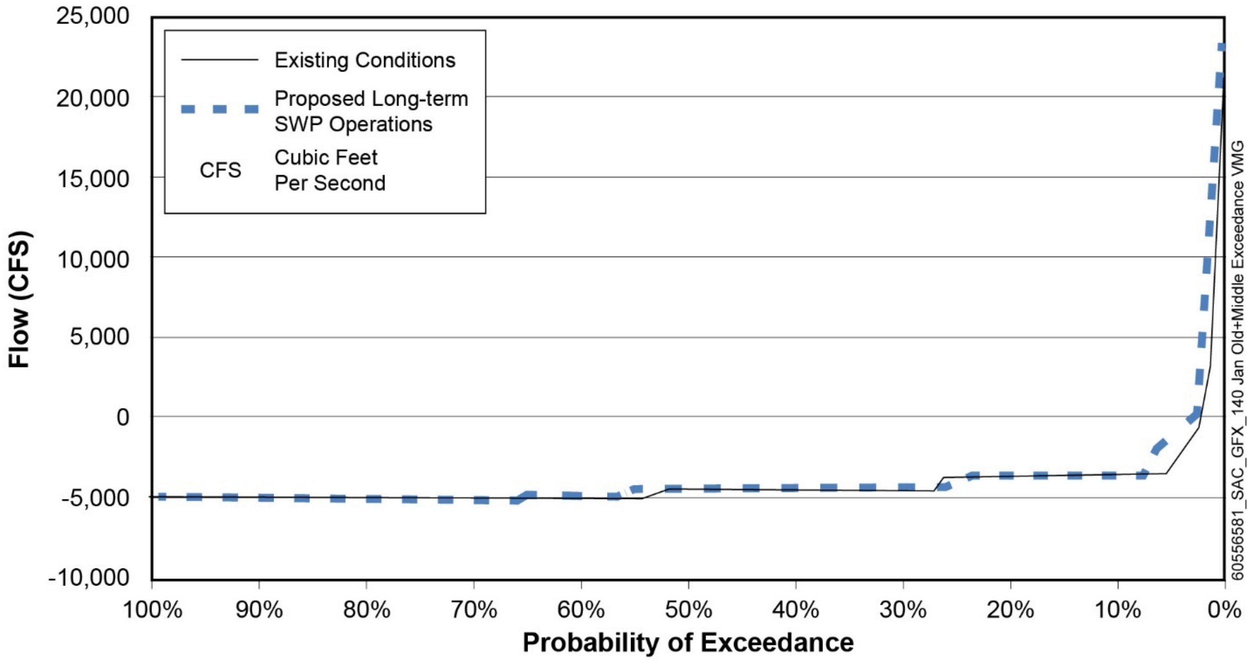


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Figure 4.4-47. Mean Modeled Old and Middle River Flow, January

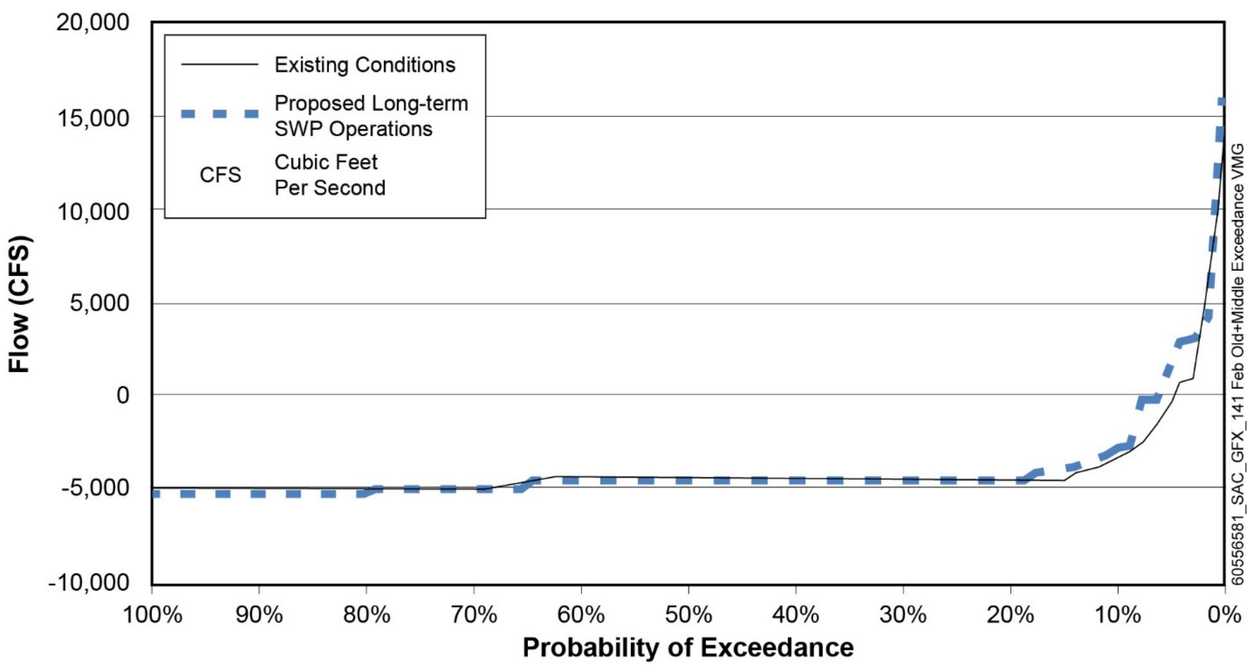

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Figure 4.4-48. Mean Modeled Old and Middle River Flow, February

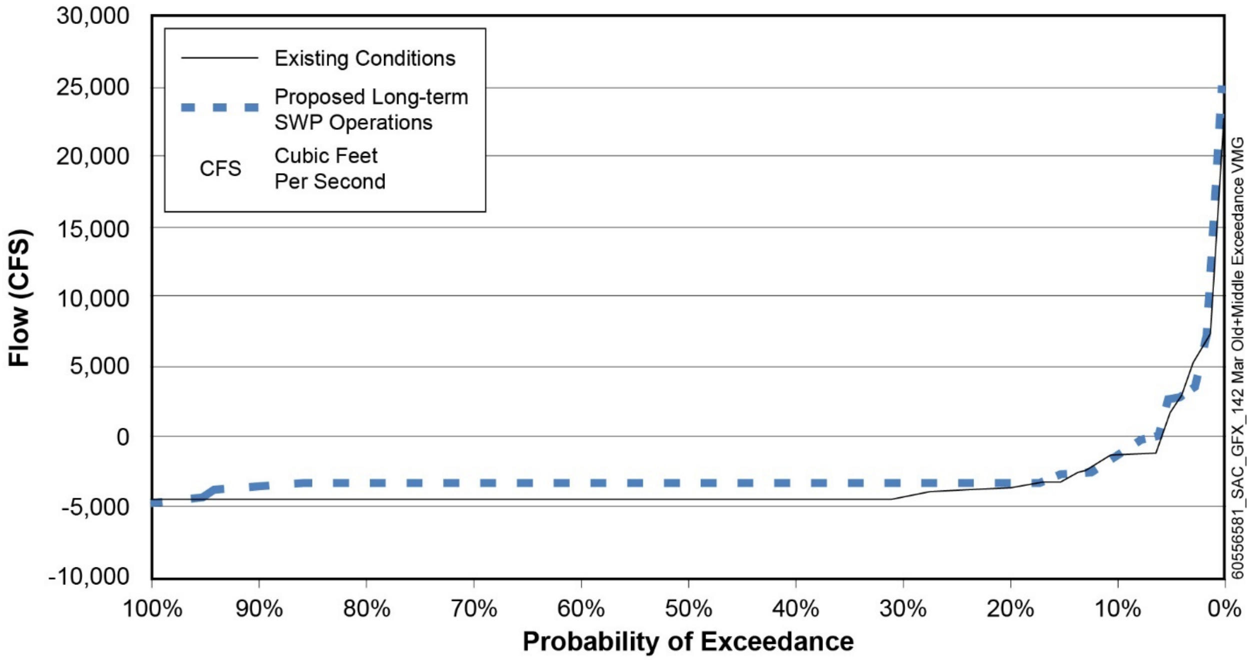

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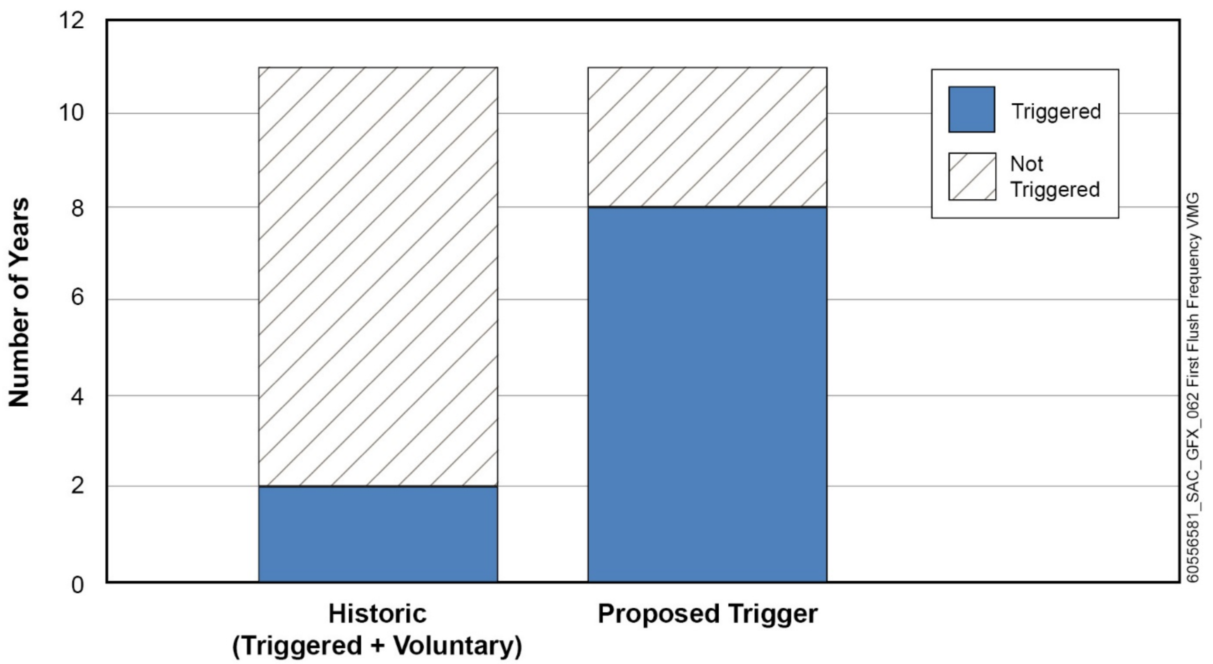
Figure 4.4-49. Mean Modeled Old and Middle River Flow, March



Source: <PP _OMR_Actions_8-6-19.pptx>

Figure 4.4-50. Number of Years During 2009–2019 That First Flush Action Was Triggered Historically or Would Have Been Triggered under Proposed Project

entrainment risk but also are not directly modeled in CalSim. Although assumptions about the "turbidity bridge"[6] avoidance actions are included in the CalSim modeling, the modeling cannot

[6] A turbidity bridge is an area of high turbidity water spanning the Central Delta to the South Delta, with increased turbidity being associated with increased risk of South Delta entrainment (Grimaldo et al. 2009).

simulate real-time decision-making that would limit entrainment risk. OMR management included in the Proposed Project to protect adult Delta Smelt would be expected to result in low levels of entrainment loss similar to those achieved during the implementation of the USFWS (2008) BiOp.

During the March–June period of concern for larval and juvenile Delta Smelt entrainment risk, OMR flows would tend to be more negative under the Proposed Project scenario compared to the Existing Conditions scenario in April and May, but similar in March and June (Figure 4.4-49, Figure 4.4-51 through Figure 4.4-53). Flows in both scenarios would be above the -5,000 cfs inflection point at which entrainment tends to sharply increase (Grimaldo et al. 2017b). As part of real-time operational decision-making OMR management, DWR will use results produced by CDFW and USFWS approved life cycle models along with real-time monitoring of the spatial distribution of Delta Smelt to manage the annual entrainment levels of larval and juvenile Delta Smelt. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment such as OMR flows. On or after March 15 of each year, if QWEST is negative and larval or juvenile Delta Smelt are detected within the corridors of the Old and Middle rivers based on real-time sampling of spawning adults or YOY life stages, DWR (in coordination with Reclamation) will run hydrodynamic models and forecasts of entrainment to estimate the percentage of larval and juvenile Delta Smelt that could be entrained; DWR will manage exports, as necessary, to limit entrainment to be protective based on the modeled recruitment levels. Such OMR management is not reflected in the CalSim modeling. The real-time management would be intended to limit entrainment risk to low levels similar to the levels achieved following implementation of the USFWS (2008) BiOp, during which time loss of juvenile Delta Smelt was within authorized incidental take limits.

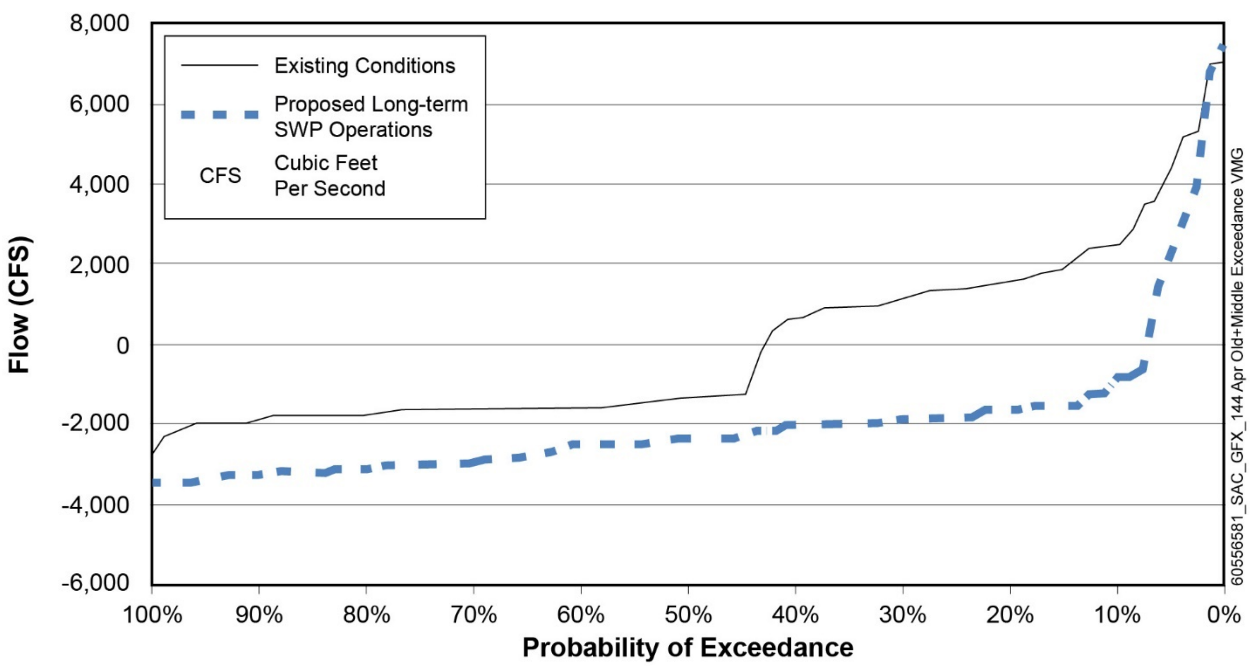


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Figure 4.4-51. Mean Modeled Old and Middle River Flow, April

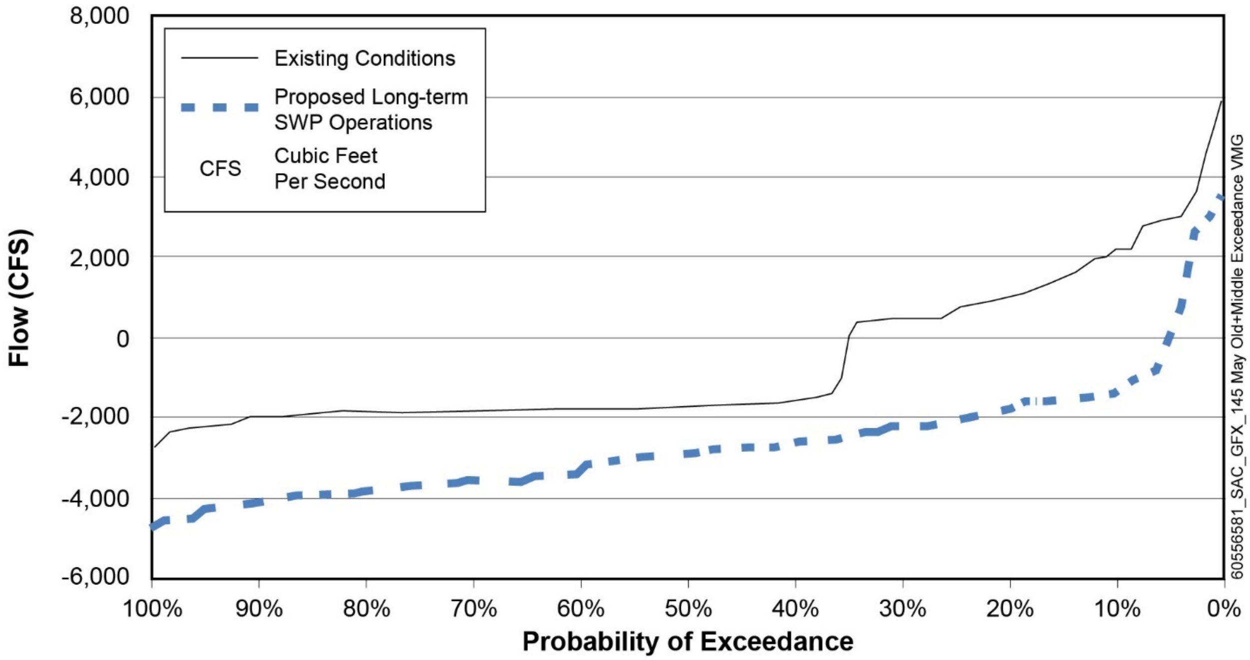

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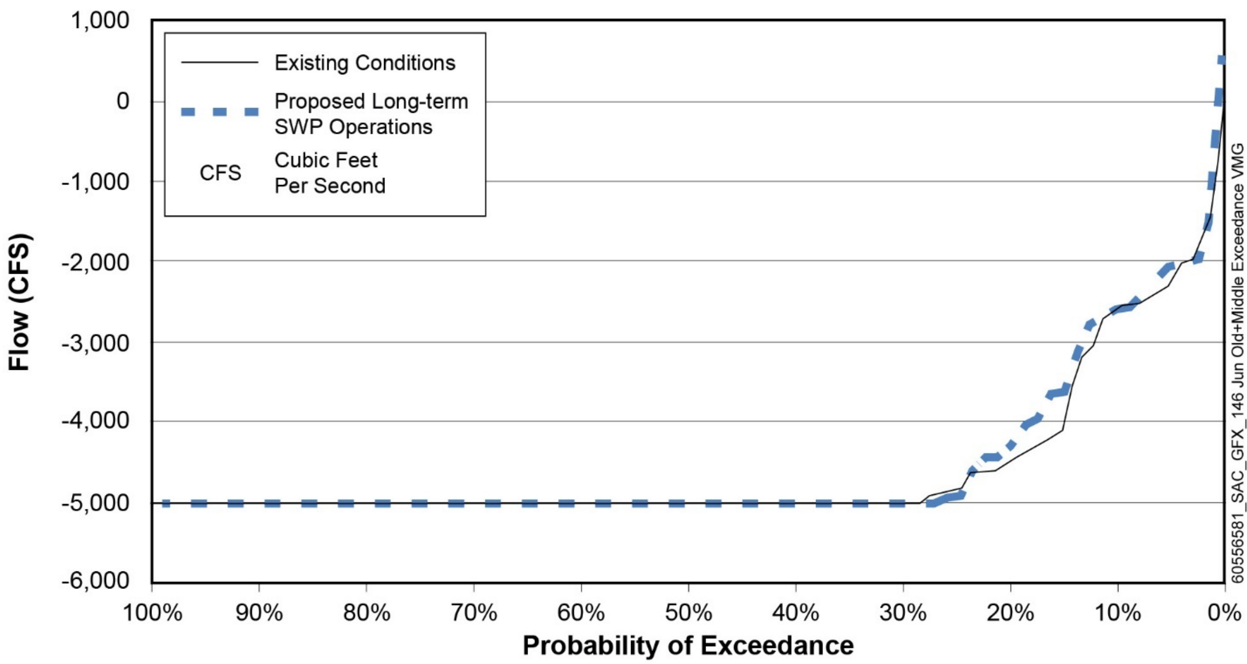
Figure 4.4-52. Mean Modeled Old and Middle River Flow, May



Source: <DWR_ITP_Trend_Reporting_rev18cy_DV4_CALSIM_20190821__Existing_PP.xlsm>

Figure 4.4-53. Mean Modeled Old and Middle River Flow, June

The impacts on OMR flows depend on combined SWP and CVP operations. However, during the March–June period, which is the period of larval and early juvenile Delta Smelt entrainment concern, the SWP generally is responsible for approximately 30% to 60% of Delta water operations, depending on water year type and month (see Appendix H).

Particle Tracking Modeling Analysis

DSM2-PTM was used in the impacts analysis to illustrate potential differences in the percentage of entrainment of Delta Smelt larvae by SWP facilities (Clifton Court Forebay and the NBA Barker Slough Pumping Plant) under the Proposed Project and Existing Conditions scenarios. Detailed information regarding the method is provided in Appendix E. This approach assumed that the susceptibility of Delta Smelt larvae can be represented by entrainment of passive particles, based on existing literature (Kimmerer 2008, 2011). Results of the PTM simulations do not represent the actual entrainment of larval Delta Smelt that could occur under the Proposed Project and Existing Conditions scenarios, but rather should be viewed as a comparative indicator of the relative risk of larval entrainment under the scenarios, without consideration of the real-time risk management measures included in the Proposed Project.

The DSM2-PTM analysis suggested the potential for appreciable increases in larval and early juvenile Delta Smelt entrainment at the CCF during April and May under the Proposed Project scenario compared to the Existing Conditions scenario (Table 4.4-8), which is a result of differences in OMR flows during this time period (see the “Consideration of OMR Flows” section above). DSM2-PTM does not include real-time operational decision-making, modeling, and OMR management, which would be used by DWR to minimize entrainment under the Proposed Project. As part of real-time operational decision-making OMR management, DWR will use results produced by CDFW and USFWS approved life cycle models along with real-time monitoring of the spatial distribution of Delta Smelt to manage the annual entrainment levels of larval and juvenile Delta Smelt. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment, such as OMR flows. On or after March 15 of each year, if QWEST is negative and larval or juvenile Delta Smelt are detected within the corridors of the Old and Middle rivers based on real-time sampling of spawning adults or YOY life stages, DWR (in coordination with Reclamation) will run hydrodynamic models and forecasts of entrainment to estimate the percentage of larval and juvenile Delta Smelt that could be entrained and will manage exports, as necessary, to limit entrainment to be protective based on the modeled recruitment levels. Actual management of larval and juvenile Delta Smelt entrainment during implementation of the USFWS (2008), which the Existing Conditions modeling scenario represents, limited entrainment well below authorized protective take limits. Although the Proposed Project modeling suggests an increase in entrainment relative to the Existing Conditions scenario, entrainment would be expected to be maintained at protective levels.

The DSM2-PTM results suggested that there would be little difference in the potential for entrainment of Delta Smelt at the Barker Slough Pumping Plant under the Proposed Project and Existing Conditions scenarios (Table 4.4-8). No differences in operational criteria of the Barker Slough Pumping Plant are included in the Proposed Project relative to the Existing Conditions scenario, and the potential for entrainment also would be limited by the incidental take limit from USFWS ROC on LTO Biological Opinion.

Table 4.4-8. Percentage of Particles Entrained Over 30 Days into Clifton Court Forebay and Barker Slough Pumping Plant – Table 4.4-8 a and Table 4.4-8 b

Table 4.4-8 a. Percentage of Particles Entrained Over 30 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
March	Wet	3.28	2.92	-0.36 (-11%)
March	Above Normal	3.66	3.15	-0.51 (-14%)
March	Below Normal	9.63	8.05	-1.58 (-16%)
March	Dry	10.53	9.15	-1.38 (-13%)
March	Critical	7.74	8.16	0.42 (5%)
April	Wet	0.75	2.50	1.75 (235%)
April	Above Normal	1.69	5.05	3.36 (199%)
April	Below Normal	3.36	9.04	5.68 (169%)
April	Dry	3.48	6.85	3.37 (97%)
April	Critical	3.32	4.35	1.03 (31%)
May	Wet	1.31	4.90	3.59 (274%)
May	Above Normal	2.61	10.29	7.69 (295%)
May	Below Normal	2.47	10.39	7.92 (321%)
May	Dry	3.46	7.39	3.93 (114%)
May	Critical	3.25	4.11	0.85 (26%)
June	Wet	9.20	9.42	0.22 (2%)
June	Above Normal	8.48	8.73	0.25 (3%)
June	Below Normal	9.49	9.52	0.03 (0%)
June	Dry	10.26	10.24	-0.01 (0%)
June	Critical	6.09	6.20	0.11 (2%)

Table 4.4-8 b. Percentage of Particles Entrained Over 30 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
March	Wet	0.08	0.09	0.00 (4%)
March	Above Normal	0.06	0.06	0.00 (-2%)
March	Below Normal	0.11	0.11	0.00 (2%)
March	Dry	0.05	0.04	0.00 (-4%)
March	Critical	0.02	0.03	0.01 (40%)
April	Wet	0.08	0.07	0.00 (-4%)
April	Above Normal	0.17	0.16	-0.01 (-6%)
April	Below Normal	0.07	0.07	0.00 (-1%)
April	Dry	0.18	0.18	0.00 (0%)
April	Critical	0.07	0.06	-0.01 (-14%)
May	Wet	0.09	0.09	0.00 (1%)
May	Above Normal	0.15	0.15	0.00 (-2%)
May	Below Normal	0.21	0.20	-0.02 (-8%)
May	Dry	0.15	0.12	-0.03 (-17%)
May	Critical	0.04	0.03	-0.01 (-26%)
June	Wet	0.13	0.13	0.00 (0%)
June	Above Normal	0.32	0.31	-0.01 (-2%)
June	Below Normal	0.26	0.26	0.00 (-1%)
June	Dry	0.20	0.19	-0.01 (-5%)
June	Critical	0.02	0.02	0.00 (-5%)

Source: ptm_fate_results_30day_Mar-Jun_qa_ITP_EX_20191030.dat; ptm_fate_results_30day_Mar-Jun_qa_ITP_PP_20191030.dat

Water Transfers

Expansion of the water transfer window to include July to November would be unlikely to affect Delta Smelt, given that the species is mostly downstream of the Delta, although upstream migrating adults could overlap the window if first flushes occur prior to December. This is unlikely given that the main period of potential entrainment is the December–March period (USFWS 2008).

Annual O&M Activities-Related Impacts

Annual O&M activities that could potentially affect Delta Smelt include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. These activities likely would have limited impacts on Delta Smelt when they are implemented because existing permit conditions such as work windows and best management practices (BMPs) to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.

Project Environmental Protective Measure-related Impacts

Environmental Protective Measures (see Table 3-3) that could potentially affect Delta Smelt include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

- Delta Smelt Reintroduction Studies
- Continue studies to establish a Delta fish Conservation Hatchery

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish. Delta fish hatchery studies and Delta Smelt reintroduction studies could improve understanding of Delta Smelt culture practices, population genetic structure, and genetic management needs for future reintroduction.

Overall, these Environmental Protective Measures could reduce operations-related impacts on Delta Smelt, potentially improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Delta Smelt

Delta Smelt inhabit areas of the Delta that could be affected by the Proposed Project throughout their life cycle including transitions from: (1) adults to eggs and larvae from December to March; (2) eggs and larvae from March to June; (3) juveniles to subadults from June to September; and (4) subadults to adults from September to December. Potential operations-related changes to food availability, predation, harmful algal blooms, and summer-fall habitat that could affect Delta Smelt were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures.

The analyses conducted for each life stage of Delta Smelt, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of Delta Smelt are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on Delta Smelt, relative to the Existing Conditions scenario, and are considered **Less than Significant.**

Longfin Smelt

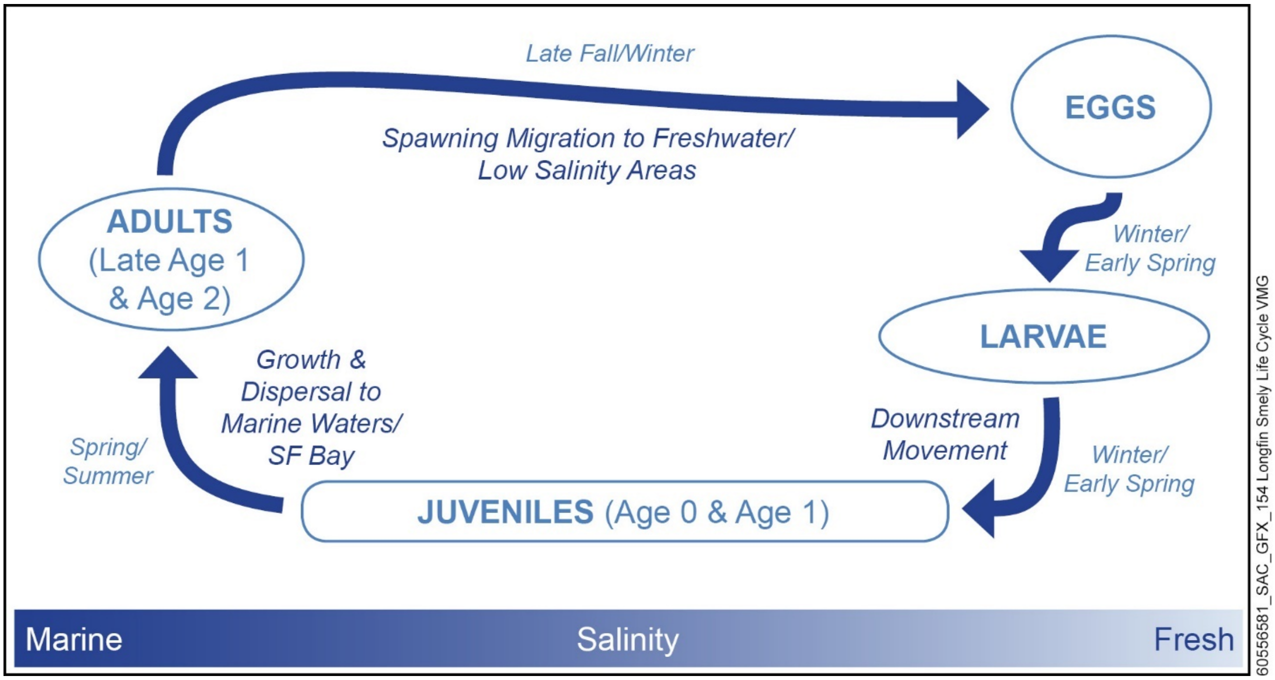
Conceptual Model

A recent published conceptual model describing the life stage transitions and factors affecting each life stage transition is not yet available for use in this analysis. The most recent conceptual model submitted for the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) (Rosenfield 2010) and recent studies and emerging information regarding Longfin Smelt life history and habitat use information is used to inform the analyses conducted to evaluate potential impacts of the Proposed Project.

During the late summer and early fall, adult Longfin Smelt are more common throughout San Francisco Bay rather than farther upstream (Rosenfield and Baxter 2007). During the fall and early winter spawning period, adult Longfin Smelt are commonly found in San Francisco Bay tributaries and marshes (Hobbs et al. 2015) and Suisun Marsh and Bay, as well as the Sacramento-San Joaquin Delta during drier years (Rosenfield and Baxter 2007; Grimaldo et al. 2017a; Lewis et al. 2019). After spawning, adults are widely distributed in San Francisco Bay, associated tributaries, and Suisun Bay through the late spring. By early summer, most sub-adult and adult Longfin Smelt are observed in San Francisco Bay and some percentage is believed to move to the coastal ocean (Rosenfield and Baxter 2007).

Emerging research and synthesis of the CDFW's 1980s Bay Larval Survey shows that Longfin Smelt larvae are widely distributed through the San Francisco Estuary (SFE) based on precipitation and river inflows from the Delta and Bay area tributaries. Researchers are increasingly recognizing that spawning and incubation is more widespread than previously believed (Hobbs et al. 2010; Grimaldo et al. 2017a; Parker et al. 2017; Lewis et al. 2019). Until recently, Longfin Smelt spawning was believed to occur almost exclusively in tidal freshwater areas such as the lower Sacramento River (Rosenfield 2010). During wetter years newly hatched larvae have been found in San Francisco Bay and adjacent tributaries and marshes, including the Napa River, Petaluma River, Sonoma Marsh, Hamilton Marsh, and other smaller marshes of the South Bay (Grimaldo et al. 2017a; Lewis et al. 2019). Recent analyses by Grimaldo et al. (2017a) show that the proportional abundance and relative density of newly hatched larvae generally is higher in Suisun Bay compared to other regions of the SFE during drier years and higher in San Pablo Bay during wetter years. The regional distributions of newly hatched yolk-sac larvae (newly emerged larvae less than 7 days old) and post-yolk-sac larvae are similar. For the Delta, Merz et al. (2013) showed that larvae tend to be sampled considerably more frequently in the Cache Slough and Sacramento Deep Water Ship Channel area, as well as the lower Sacramento and San Joaquin rivers and their confluence, than in the east and South Delta or locations farther upstream the Sacramento and San Joaquin rivers.

Juvenile Longfin Smelt are widely distributed through the SFE (MacWilliams et al. 2016; Rosenfield and Baxter 2007). In recent years, juvenile Longfin Smelt have been observed in relatively high densities in South Bay, Napa River, San Pablo Bay, Suisun Bay, and Central Bay (Parker et al. 2017; Grimaldo et al. 2017). As with larvae, the general distribution of juveniles tends to move farther upstream or out of the San Francisco estuary during drier years. Figure 4.4-54 presents the Longfin Smelt Life Cycle.



Source: Adapted from DWR 2009

Figure 4.4-54. Longfin Smelt Life Cycle with Life Stage Box Width Indicating General Salinity Range

Operations-related Impacts

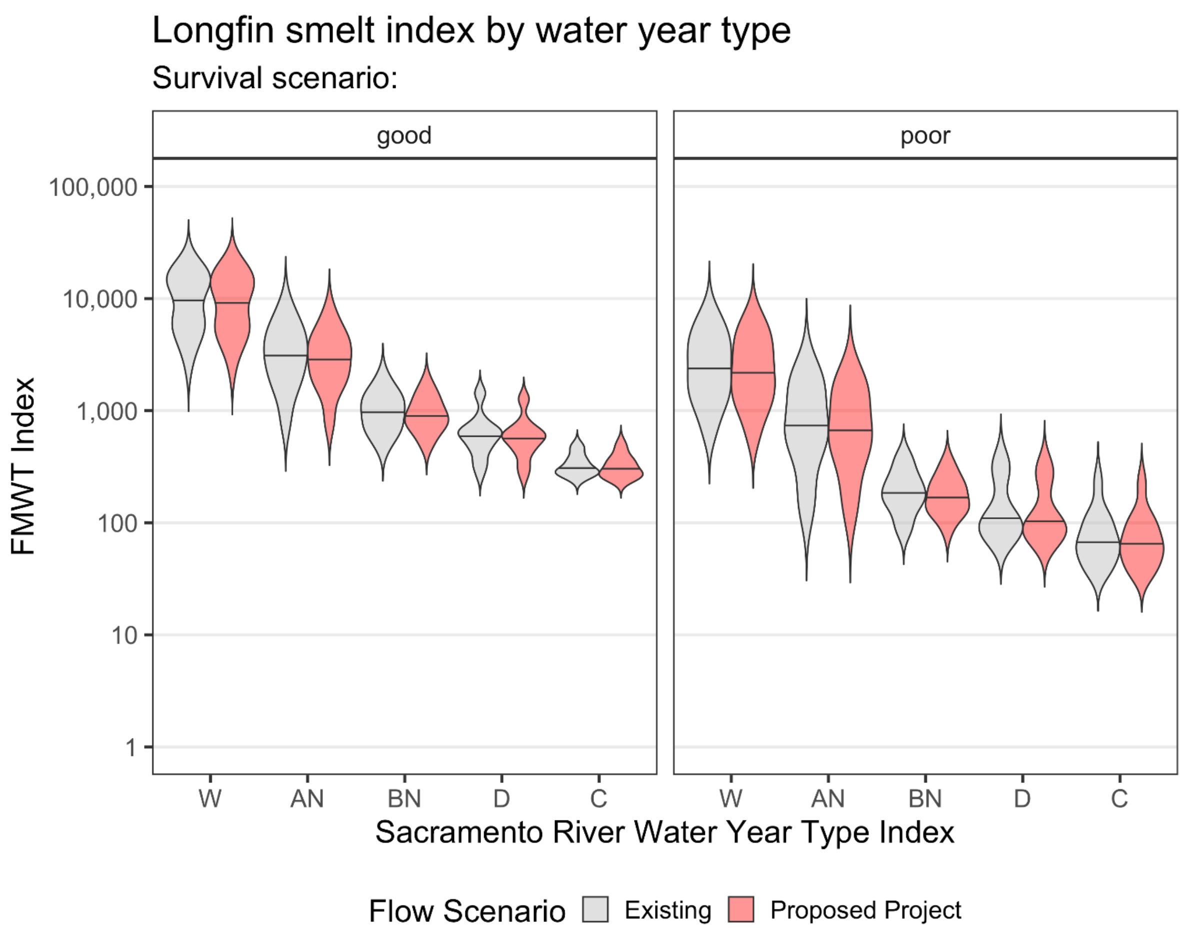
Delta Outflow-Abundance

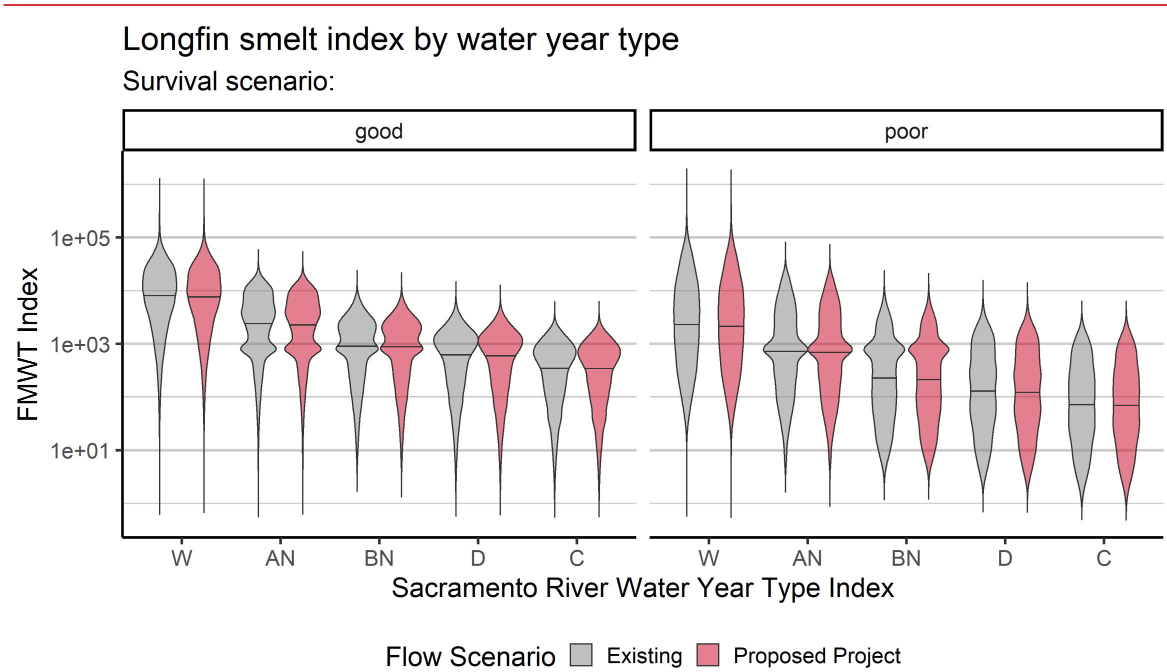
For Longfin Smelt, focus on estuarine flow has centered on the positive relationship found between winter and spring outflow and juvenile abundance during the fall (Rosenfield and Baxter 2007; Kimmerer et al. 2009). Specifically, as X2 (the position of the 2 ppt near-bottom salinity isohaline from the Golden Gate Bridge; see Jassby et al. [1995]) shifts downstream during the winter and spring, the abundance index of Longfin Smelt in the following FMWT survey increases (Kimmerer 2002a; Kimmerer et al. 2009). The mechanisms underlying this relationship are poorly understood; however, the significant X2-abundance relationship suggests that higher outflow (lower X2) or conditions associated with wetter hydrological conditions produce conditions that enhance recruitment to juvenile life stages. Hypotheses about underlying mechanisms to this X2-abundance relationship include transport of larval Longfin Smelt out of the Delta to downstream rearing habitats (Moyle 2002; Rosenfield and Baxter 2007); increased extent of rearing habitat as X2 moves seaward (Kimmerer et al. 2009); retention of larvae in suitable rearing habitats (Kimmerer et al. 2009); increased food abundance under higher flows (CDFG 2009); and reduced clam grazing impacts on primary and secondary production (CDFG 2009). With respect to habitat size for early life stages, new information indicates that the distribution of spawning and early life stages may be broader than previously thought, including areas with salinity 2–12 (Grimaldo et al. 2017a). It has also been recognized that abundance of adults (spawners) is an important factor driving Longfin Smelt population dynamics (Baxter et al. 2010), with recent studies examining this link in detail (Maunder et al. 2015; Nobriga and Rosenfield 2016). A state-space modeling study by Maunder et al. (2015) found that multiple factors (flow, ammonium concentration, and water temperature) and density dependence influenced the survival of Longfin Smelt (represented by Bay Study abundance indices during 1980–2009). However, the flow terms included in their best models are not affected by the Proposed Project: Sacramento River October–July unimpaired runoff and Napa River runoff.

Aside from the Maunder et al. (2015) model, which is not useful for the present impacts analysis because it does not include flow terms that could be influenced by the Proposed Project, a recently published Longfin Smelt population dynamics modeling study is that of Nobriga and Rosenfield (2016), which examined various formulations of a Ricker (1954) stock-recruitment model to simulate fall midwater trawl indices through time. They found that December-May Delta outflow had a positive association with recruits per spawner and that juvenile recruitment from age 0 to age 2 was density-dependent (lower survival with greater numbers of juveniles), but cautioned that the density-dependence in the model may be too strong[7]. It should also be noted that analyses relying on surveys such as the fall midwater trawl index do not fully encompass the range of Longfin Smelt and do not reflect potential changes in catchability over time because of factors such as increased water clarity and gear avoidance (Latour 2016) that are the subject of ongoing investigations. Nonetheless, the model may represent the best available option for assessing potential impacts of the Proposed Project. The model described by Nobriga and Rosenfield (2016) was used to compare the Proposed Project scenario to the Existing Conditions scenario, using Delta outflow outputs from CalSim; additional detail on the method is provided in Appendix E.

The results of the Nobriga and Rosenfield (2016) model application suggested that differences in predicted fall midwater trawl abundance index between the Proposed Project and Existing Conditions scenarios would be very small, relative to the variability in the predicted values, which spans several orders of magnitude (Figure 4.4-55; Tables 4.4-9 and 4.4-10). Thus whereas the percentage difference in median index for the poor (post-1991) juvenile survival scenario, for example, ranges from 4% to 11% less under the Proposed Project scenario, there is only a 0% to 2% difference when accounting for the high signal to noise ratio (i.e., when divided by the Existing 95% confidence interval) (Table 4.4-10). Specifically, the simulation results showed that the variability in FMWT index predictions within each scenario was considerably greater than the differences between the scenarios. This variability reflects the uncertainty in parameter estimates, which results in uncertainty in the extent to which operations-related differences in Delta outflow could affect Longfin Smelt. Specifically, variability in Delta outflow associated with overall hydrologic conditions (i.e., different water year types) is substantially larger than the minor differences in Delta outflow associated with changes in SWP operations. As described previously, Maunder et al. (2015) found that general hydrological conditions in the Sacramento River watershed and Napa River were a better explanation of population dynamics than Delta outflow.

[7] Comments on the DEIR suggested that a form of stock-recruitment function other than the Ricker method used by Nobriga and Rosenfield (2016) would be appropriate for exploration, such as the Beverton-Holt method. As noted in Appendix E, the Beverton-Holt method was explored for the FEIR but was found to be a poorer fit to the empirical data than the Ricker method, so the Ricker method consistent with Nobriga and Rosenfield (2016) was retained.





Note: Median is indicated by the horizontal line.
FMWT = Fall Midwater Trawl

Figure 4.4-55. Violin Plots of Predicted Longfin Smelt Fall Midwater Trawl Index by Water Year Type

Table 4.4-9. Predicted Median Longfin Smelt Fall Midwater Trawl Index Averaged by Water Year Type, Based on Nobriga and Rosenfield (2016) Assuming Good (Pre-1991) Juvenile Survival

Water Year Type	Existing (95% Confidence Interval)	Proposed Project (95% Confidence Interval)	Proposed Project vs. Existing[1]	Proposed Project vs. Existing [2]
Wet	10,617 (273–47,140)~~11,372 (271-46,328)~~	10,252 (264–45,489)~~10,945 (268-44,593)~~	-365 (-4%) ~~-428 (-4%)~~	-365 (-1%)~~-428 (-1%)~~
Above Normal	3,587 (94–11,888) ~~3,799 (92-11,441)~~	3,245 (84–10,857) ~~3,444 (83-10,530)~~	-342 (-11%)~~-355 (-10%)~~	-342 (-2%)~~-355 (-2%)~~
Below Normal	1,047 (25–4,289) ~~1,141 (25-4,204)~~	974 (23–4,053) ~~1,059 (23-3,962)~~	-73 (-7%) ~~-81 (-8%)~~	-73 (-1%)~~-81 (-1%)~~
Dry	653 (18–2,557) ~~697 (17-2,508)~~	613 (17–2,435) ~~656 (16-2,395)~~	-40 (-7%) ~~-40 (-6%)~~	-40 (-1%)~~-40 (-1%)~~
Critical	331 (9–1,664) ~~357 (9-1,634)~~	324 (9–1,629) ~~350 (9-1,593)~~	-7 (-2%)~~-7 (-2%)~~	-7 (0%)~~-7 (0%)~~

Notes: [1] Difference is absolute difference between median estimates, with values in parentheses representing % difference in median.
[2] Difference is absolute difference between median estimates, with values in parentheses representing mean % difference based on difference between Proposed Project and Existing in each year, divided by the Existing 95% confidence interval, which is an indicator of signal to noise. Specifically, the value represents the percentage of the median change in relation to the 95% confidence intervals of the abundance estimates.

Table 4.4-10. Predicted Median Longfin Smelt Fall Midwater Trawl Index Averaged by Water Year Type, Based on Nobriga and Rosenfield (2016) Assuming Poor (Post-1991) Juvenile Survival

Water Year Type	Existing (95% Confidence Interval)	Proposed Project (95% Confidence Interval)	Proposed Project vs. Existing[1]	Proposed Project vs. Existing [2]
Wet	2,954 (89–55,750)~~2,916 (86-54,509)~~	2,758 (85–53,051)~~2,729 (82-51,692)~~	-196 (-7%)~~-187 (-7%)~~	-196 (-1%)~~-187 (-1%)~~
Above Normal	954 (38–12,399) ~~948 (37-11,658)~~	856 (34–11,436) ~~851 (33-10,654)~~	-98 (-11%)~~-97 (-11%)~~	-98 (-1%)~~-97 (-1%)~~
Below Normal	203 (9–4,305) ~~197 (9-3,963)~~	184 (8–4,024) ~~179 (8-3,707)~~	-19 (-10%)~~-18 (-10%)~~	-19 (0%)~~-18 (0%)~~
Dry	154 (6–2,494) ~~152 (6-2,333)~~	142 (6–2,378) ~~141 (6-2,215)~~	-12 (-8%) ~~-11 (-8%)~~	-12 (0%) ~~-11 (0%)~~
Critical	83 (3–1,494)~~83 (3-1,398)~~	80 (3–1,467) ~~80 (3-1,374)~~	-3 (-4%) ~~-3 (-4%)~~	-3 (0%) ~~-3 (0%)~~

Notes: [1] Difference is absolute difference between median estimates, with values in parentheses representing % difference in median.
[2] Difference is absolute difference between median estimates, with values in parentheses representing mean % difference based on difference between Proposed Project and Existing in each year, divided by the Existing 95% confidence interval, which is an indicator of signal to noise. Specifically, the value represents the percentage of the median change in relation to the 95% confidence intervals of the abundance estimates.

Investigations funded under the Longfin Smelt Science Program will continue to provide additional information regarding potential mechanisms behind the correlation between flow and Longfin Smelt abundance indices, and allow for a better understanding of Longfin Smelt distribution and abundance, which would be used to improve management actions.

The analysis based on the Nobriga and Rosenfield (2016) model application includes consideration of December–May Delta outflow, which depends on combined SWP and CVP operations. During this time period, the SWP is responsible for ~40% to 60% of Delta water operations, depending on month and water year type (see Appendix H).

Adult Entrainment

There is the potential for adult Longfin Smelt entrainment to occur under the Proposed Project, although take of adults is very limited relative to other life stages. Grimaldo et al. (2009) found that adult Longfin Smelt salvage at the South Delta export facilities was significantly negatively related to mean December–February OMR flows, but not to X2 (or other variables that were examined). As previously noted for Delta Smelt, modeling indicates there would be expected to be little difference between the Proposed Project and Existing Conditions scenarios in OMR flows during this period (Figures 4.4-46, 4.4-47, and 4.4-48). However, the Proposed Project includes OMR management from December 1 through February 28, when additional real-time consideration of adult Longfin Smelt entrainment risk will be undertaken by DWR in association with CDFW and WOMT, to provide protection for adult Longfin Smelt. During the December–February period, SWP responsibility for Delta water operations is ~40% to 60%, depending on water year type (see Appendix H).

Particle Tracking Modeling (Larval Entrainment)

Larval Longfin Smelt entrainment by water diversions in the Delta, including into the Clifton Court Forebay and the Barker Slough Pumping Plant, could occur under the Proposed Project and winter (January–March) is of particular concern. A DSM2-PTM analysis was undertaken that followed the methods provided in Appendix E. Staff observations from preliminary Longfin Smelt culture efforts at the UC Davis Fish Conservation and Culture Laboratory have suggested that larvae may not be buoyant in freshwater, but field studies found that they are buoyant in brackish water (Bennet et al. 2002; S. Acuña, pers. comm.), which may add some uncertainty to the results from PTM analysis. Analysis of surface and neutrally buoyant particles provides information on two plausible behaviors, recognizing that the estimates are only order-of-magnitude comparisons that are best used in a relative fashion to compare different operational scenarios.

The DSM2-PTM results suggested that there would be relatively minor differences in the potential for entrainment of Longfin Smelt larvae between the Proposed Project and Existing Conditions scenarios (Tables 4.4-11 and 4.4-12). Differences suggested by the PTM results would be expected to lower when the Proposed Project is implemented because real-time operational measures are included in the Proposed Project that would manage OMR flows for the protection of Longfin Smelt. Although the estimates of entrainment are intended to primarily be used comparatively, the weightings applied in the modeling are intended to represent a realistic distribution of larvae in the Delta and downstream and as such may provide some perspective on the magnitude of larval population loss, i.e., generally in the low single-digit percentage (Table 4.4-11). Note that these estimates may overestimate entrainment loss because the Smelt Larval Survey providing the weighting for particle starting distributions does not sample the full extent of downstream areas where the species is occurring (see Appendix E).

Table 4.4-11. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into Clifton Court Forebay and Barker Slough Pumping Plant, and Passing Chipps Island. Table 4.4-11 a – Table 4.4-11 c

Table 4.4-11 a. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.78	0.77	-0.01 (-1%)
January	Above Normal	1.21	1.23	0.02 (2%)
January	Below Normal	1.96	2.01	0.06 (3%)
January	Dry	2.59	2.93	0.34 (13%)
January	Critical	2.56	2.75	0.19 (7%)
February	Wet	0.53	0.51	-0.02 (-4%)
February	Above Normal	0.91	0.86	-0.06 (-6%)
February	Below Normal	1.28	1.29	0.01 (1%)
February	Dry	1.81	1.92	0.11 (6%)
February	Critical	2.19	2.25	0.05 (2%)
March	Wet	0.57	0.42	-0.15 (-26%)
March	Above Normal	0.71	0.52	-0.19 (-27%)
March	Below Normal	1.18	0.92	-0.26 (-22%)
March	Dry	1.32	1.09	-0.24 (-18%)
March	Critical	1.17	1.42	0.25 (22%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat~~ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20190901.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_Proposed Project.dat~~

Table 4.4-11 b. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.20	0.20	0.00 (-2%)
January	Above Normal	0.21	0.21	-0.01 (-3%)
January	Below Normal	0.23	0.23	-0.01 (-3%)
January	Dry	0.25	0.26	0.00 (1%)
January	Critical	0.21	0.20	-0.01 (-3%)
February	Wet	0.20	0.20	0.00 (1%)
February	Above Normal	0.21	0.20	-0.01 (-4%)
February	Below Normal	0.21	0.21	-0.01 (-3%)
February	Dry	0.17	0.16	0.00 (-3%)
February	Critical	0.14	0.14	0.00 (2%)
March	Wet	0.18	0.18	0.00 (1%)
March	Above Normal	0.18	0.18	-0.01 (-5%)
March	Below Normal	0.23	0.23	0.00 (-1%)
March	Dry	0.17	0.16	-0.01 (-5%)
March	Critical	0.09	0.10	0.01 (13%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat

Table 4.4-11 c. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days Passing Chipps Island

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	46.31	46.44	0.12 (0%)
January	Above Normal	42.91	43.06	0.15 (0%)
January	Below Normal	38.53	38.74	0.20 (1%)
January	Dry	33.50	32.78	-0.72 (-2%)
January	Critical	30.95	30.15	-0.80 (-3%)
February	Wet	46.41	46.50	0.08 (0%)
February	Above Normal	45.04	45.31	0.26 (1%)
February	Below Normal	41.77	41.89	0.12 (0%)
February	Dry	37.96	37.77	-0.19 (-1%)
February	Critical	33.06	33.14	0.08 (0%)
March	Wet	46.52	46.72	0.20 (0%)
March	Above Normal	45.67	46.02	0.34 (1%)
March	Below Normal	43.76	44.34	0.59 (1%)
March	Dry	41.59	42.22	0.64 (2%)
March	Critical	38.80	38.03	-0.77 (-2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_20191030.dat~~ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20190901.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_Proposed Project.dat~~

Table 4.4-12. Percentage of Surface-Oriented Particles Entrained Over 45 Days into Clifton Court Forebay and Barker Slough Pumping Plant, and Passing Chipps Island. Table 4.4-12 a – Table 4.4-12 c

Table 4.4-12 a. Percentage of Surface-Oriented Particles Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	3.73~~3.72~~	3.67~~3.66~~	-0.06 (-2%)~~-0.06 (-2%)~~
January	Above Normal	6.30~~6.29~~	6.16~~6.14~~	-0.14 (-2%)~~-0.15 (-2%)~~
January	Below Normal	9.84~~9.84~~	10.06~~10.05~~	0.22 (2%)~~0.20 (2%)~~
January	Dry	10.76~~10.75~~	11.40~~11.40~~	0.64 (6%)~~0.64 (6%)~~
January	Critical	10.01~~10.01~~	10.60~~10.60~~	0.59 (6%)~~0.59 (6%)~~
February	Wet	2.55~~2.55~~	2.34~~2.33~~	-0.21 (-8%)~~-0.22 (-9%)~~
February	Above Normal	4.91~~4.90~~	4.44~~4.43~~	-0.47 (-10%)~~-0.47 (-10%)~~
February	Below Normal	7.27~~7.27~~	6.67~~6.66~~	-0.60 (-8%)~~-0.61 (-8%)~~
February	Dry	9.02~~9.02~~	8.78~~8.77~~	-0.25 (-3%)~~-0.25 (-3%)~~
February	Critical	8.89~~8.89~~	9.09~~9.08~~	0.20 (2%)~~0.20 (2%)~~
March	Wet	2.52~~2.52~~	2.62~~2.61~~	0.09 (4%)~~0.09 (3%)~~
March	Above Normal	3.26~~3.25~~	3.17~~3.16~~	-0.09 (-3%)~~-0.09 (-3%)~~
March	Below Normal	6.18~~6.18~~	7.03~~7.03~~	0.85 (14%)~~0.85 (14%)~~
March	Dry	6.76~~6.76~~	7.45~~7.45~~	0.69 (10%)~~0.69 (10%)~~
March	Critical	5.87~~5.87~~	7.04~~7.04~~	1.17 (20%)~~1.17 (20%)~~

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat ~~ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_Proposed Project_BHV.dat~~

Table 4.4-12 b. Percentage of Surface-Oriented Particles Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	0.24~~0.76~~	0.24~~0.34~~	0.00 (-2%)~~-0.42 (-55%)~~
January	Above Normal	0.33~~0.79~~	0.31~~0.31~~	-0.02 (-5%)~~-0.48 (-61%)~~
January	Below Normal	0.39~~0.78~~	0.38~~0.38~~	-0.01 (-3%)~~-0.40 (-51%)~~
January	Dry	0.34~~0.94~~	0.35~~0.50~~	0.01 (2%)~~-0.44 (-47%)~~
January	Critical	0.21~~0.47~~	0.22~~0.22~~	0.01 (5%)~~-0.26 (-54%)~~
February	Wet	0.22~~0.44~~	0.22~~0.43~~	0.00 (-1%)~~0.00 (-1%)~~
February	Above Normal	0.30~~1.21~~	0.29~~0.52~~	-0.01 (-3%)~~-0.69 (-57%)~~
February	Below Normal	0.33~~0.71~~	0.32~~0.32~~	-0.01 (-3%)~~-0.39 (-55%)~~
February	Dry	0.08~~0.39~~	0.09~~0.09~~	0.00 (2%)~~-0.31 (-78%)~~
February	Critical	0.04~~0.27~~	0.06~~0.29~~	0.02 (52%)~~0.02 (7%)~~
March	Wet	0.29~~0.71~~	0.28~~0.28~~	-0.01 (-2%)~~-0.43 (-61%)~~
March	Above Normal	0.34~~1.46~~	0.33~~0.56~~	-0.01 (-3%)~~-0.90 (-62%)~~
March	Below Normal	0.54~~0.54~~	0.54~~0.54~~	0.00 (0%)~~0.00 (0%)~~
March	Dry	0.14~~0.75~~	0.12~~0.12~~	-0.01 (-8%)~~-0.62 (-83%)~~
March	Critical	0.03~~0.95~~	0.02~~0.02~~	-0.01 (-20%)~~-0.93 (-97%)~~

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat
~~ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_Proposed Project_BHV.dat~~

Table 4.4-12 c. Percentage of Surface-Oriented Particles Entrained Over 45 Days Passing Chipps Island

Month	Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
January	Wet	35.13~~34.84~~	35.53~~34.81~~	0.40 (1%)~~-0.03 (0%)~~
January	Above Normal	22.86~~22.48~~	23.34~~22.48~~	0.48 (2%)~~0.00 (0%)~~
January	Below Normal	7.16~~7.15~~	8.03~~7.91~~	0.87 (12%)~~0.76 (11%)~~
January	Dry	2.31~~2.23~~	2.25~~2.18~~	-0.07 (-3%)~~-0.05 (-2%)~~
January	Critical	0.29~~0.29~~	0.36~~0.35~~	0.06 (22%)~~0.06 (22%)~~
February	Wet	38.29~~38.11~~	38.77~~37.51~~	0.48 (1%)~~-0.60 (-2%)~~
February	Above Normal	28.59~~28.03~~	29.15~~28.68~~	0.56 (2%)~~0.65 (2%)~~
February	Below Normal	16.96~~16.93~~	18.03~~17.62~~	1.08 (6%)~~0.69 (4%)~~
February	Dry	6.13~~6.12~~	6.15~~5.92~~	0.02 (0%)~~-0.20 (-3%)~~
February	Critical	1.08~~1.08~~	1.10~~1.08~~	0.02 (2%)~~0.00 (0%)~~
March	Wet	34.93~~34.52~~	35.48~~34.65~~	0.54 (2%)~~0.12 (0%)~~
March	Above Normal	29.32~~28.72~~	30.73~~30.09~~	1.41 (5%)~~1.37 (5%)~~
March	Below Normal	9.72~~9.72~~	10.83~~10.83~~	1.10 (11%)~~1.10 (11%)~~
March	Dry	4.65~~4.61~~	5.40~~5.33~~	0.75 (16%)~~0.72 (16%)~~
March	Critical	1.60~~1.59~~	1.54~~1.53~~	-0.06 (-4%)~~-0.06 (-4%)~~

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV_20191030.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_PP_BHV_20191030.dat
~~ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_Proposed Project_BHV.dat~~

No differences in operational criteria for the Barker Slough Pumping Plant are included in the Proposed Project, and the DSM2-PTM results suggested little potential for difference in entrainment potential between the two scenarios for neutrally buoyant and surface-oriented particles (Tables 4.4-12 and 4.4-

13)~~ and greater entrainment potential under the Proposed Project scenario for surface-oriented particles (Table 4.4-13)~~. However, the modeling does not reflect real-time operational adjustments that would be made if Longfin Smelt larvae were observed at SLS Station 716, i.e., 7-day average diversions of no more than 50 cfs at the Barker Slough Pumping Plant in dry and critical years. Further, as described in the California WaterFix ITP Application (ICF International 2016b), estimated annual entrainment of larval and early juvenile Longfin Smelt < 25 mm at the NBA for 1995-2004 was 0 to 0.4%, indicating low levels of entrainment would occur under the Proposed Project and would be generally similar in magnitude to the levels under the Existing Conditions scenario.

Additional discussion of methods and the uncertainty associated with these analyses is provided in Appendix E.

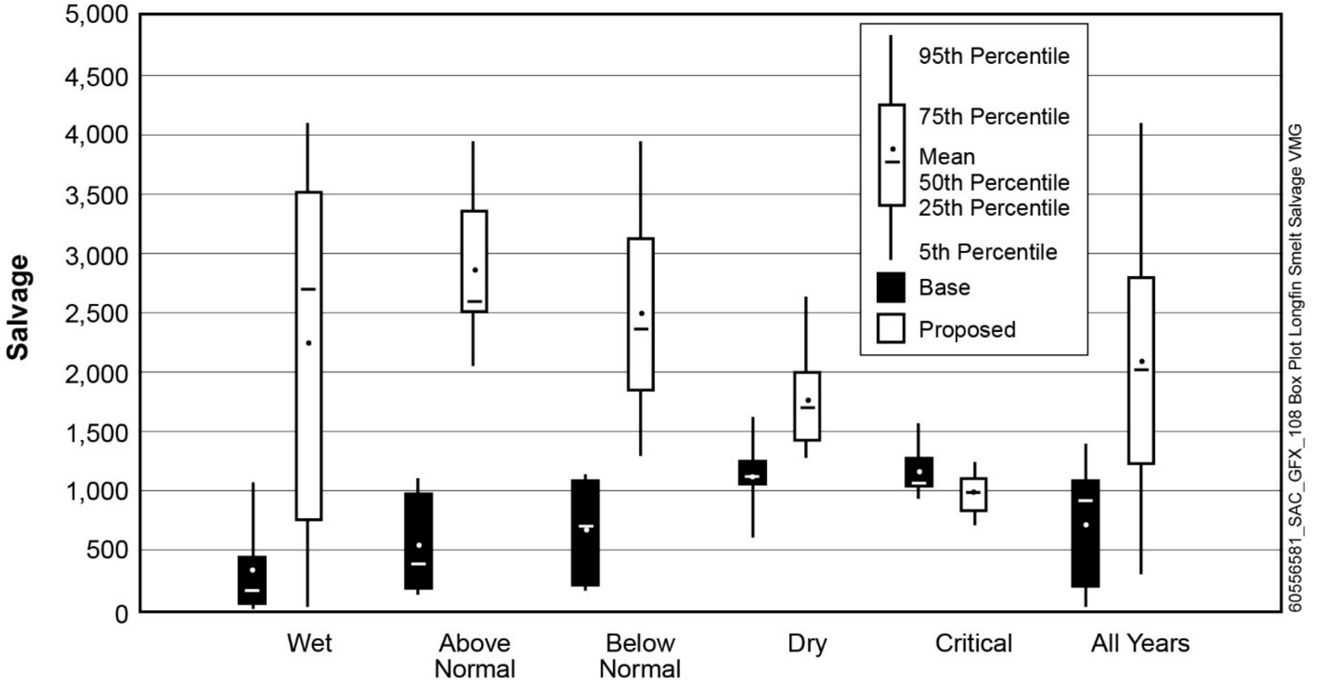
Salvage Old and Middle River Regression

Grimaldo et al. (2009) found that juvenile Longfin Smelt salvage principally occurred in April–May, and was significantly negatively related to mean April–May OMR flow (and was not related to other factors such as X2). For this impacts analysis, an evaluation of potential differences in entrainment between the Proposed Project and Existing Conditions scenarios was evaluated by recreating and applying the Grimaldo et al. (2009) relationship between salvage and OMR flows (see Appendix E).

The analysis based on the Grimaldo et al. (2009) salvage-OMR flow regression suggested the potential for very large relative increases in entrainment under the Proposed Project scenario compared to the Existing Conditions scenario with considerable uncertainty around the predictive estimates (Figure 4.4-56 and Figure 4.4-57; Table 4.4-13). However, these results do not reflect real-time operational adjustments that would be undertaken for Longfin Smelt or other species, which would be expected to reduce the difference in entrainment between the Existing Conditions scenario and the Proposed Project. Further, entrainment of juvenile Longfin Smelt is likely to represent a low percentage of the overall juvenile Longfin Smelt population because management of entrainment is estimated to have resulted in a very small percentage of the juvenile population being entrained in recent years (2009 onwards) under the operations regime that is represented by the Existing Conditions modeling scenario (Table 4.4-14). Specifically, Longfin Smelt entrainment loss under the Proposed Project likely represents a low percentage of the overall juvenile Longfin Smelt population because the species is widely distributed in the San Francisco Bay and its tributaries including the Napa and Petaluma rivers, and South Bay tributaries.

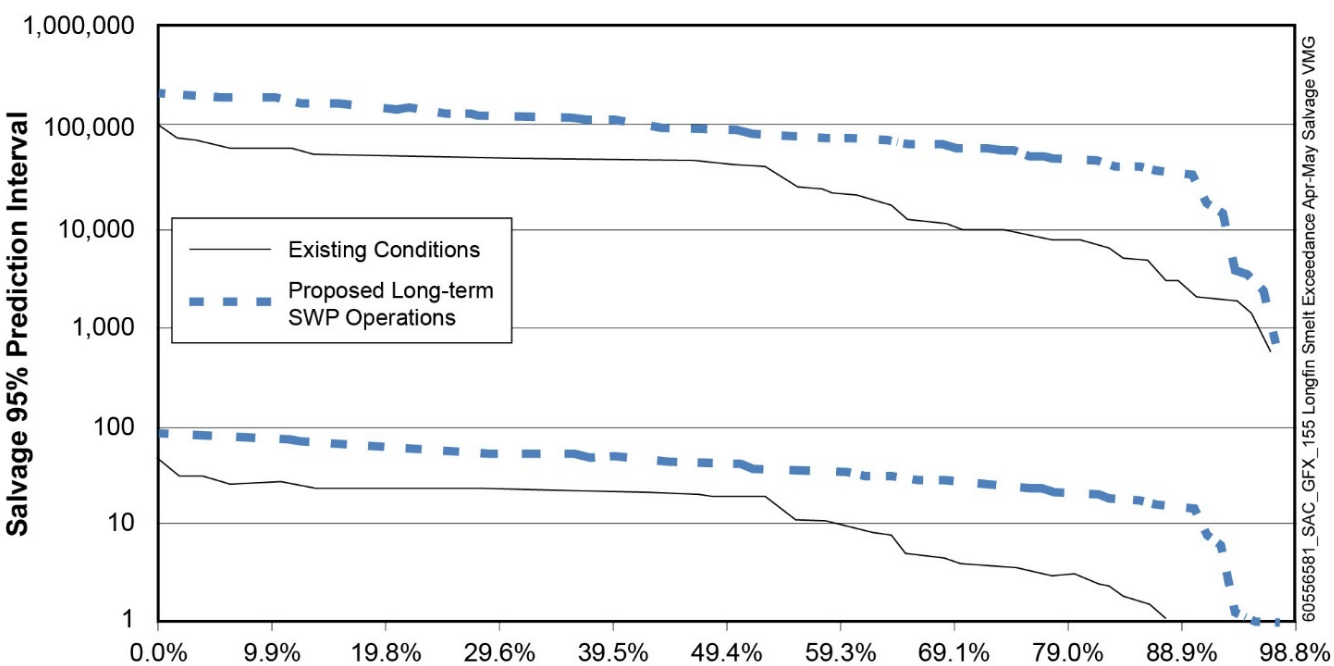
Table 4.4-13. Mean Annual Longfin Smelt April–May Salvage, from the Regression including Mean Old and Middle River Flows (Grimaldo et al. 2009), Grouped by Water Year Type

Water Year Type	Existing	Proposed Project	Proposed Project vs. Existing
Wet	333	2,251	1,918 (576%)
Above Normal	551	2,863	2,311 (419%)
Below Normal	670	2,494	1,824 (272%)
Dry	1,130	1,761	631 (56%)
Critical	1,171	991	-180 (-15%)



Note: Plot only includes mean responses and does not consider model uncertainty.

Figure 4.4-56. Box Plot of Longfin Smelt April–May Salvage, from the Regression Including Mean Old and Middle River Flows (Grimaldo et al. 2009), Grouped by Water Year Type



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown. Zero estimates are converted to 1 in this plot to allow plotting on a log scale.

Figure 4.4-57. Exceedance Plot of Longfin Smelt April–May Salvage, from the Regression Including Mean Old and Middle River Flows

Table 4.4-14. Juvenile Longfin Smelt: Estimated Entrainment Loss Relative to Population Size, SWP South Delta Export Facility, 1995-2015

Water Year	Entrainment Loss	Population Abundance Mean	Population Abundance Lower 95% Confidence Limit	Population Abundance Upper 95% Confidence Limit	Entrainment Loss as % of Population Abundance Mean	Entrainment Loss as % of Population Abundance Lower 95% Confidence Limit	Entrainment Loss as % of Population Abundance Upper 95% Confidence Limit
1995	690	28,533,241	646,582	83,446,706	0.00%	0.00%	0.11%
1996	1,888	55,551,678	2,952,507	160,930,326	0.00%	0.00%	0.06%
1997	14,941	53,124,330	27,786,879	81,514,564	0.03%	0.02%	0.05%
1998	12,870	67,816,816	430,480	201,955,221	0.02%	0.01%	2.99%
1999	13,662	105,680,968	23,624,089	227,525,445	0.01%	0.01%	0.06%
2000	28,136	155,878,920	29,659,827	397,513,090	0.02%	0.01%	0.09%
2001	44,701	14,788,919	6,268,759	27,156,527	0.30%	0.16%	0.71%
2002	1,106,614	34,788,791	16,739,707	57,544,906	3.18%	1.92%	6.61%
2003	10,252	12,690,736	2,456,744	31,824,070	0.08%	0.03%	0.42%
2004	4,101	11,953,747	3,049,485	25,527,635	0.03%	0.02%	0.13%
2005	3,593	20,103,627	3,154,146	53,010,040	0.02%	0.01%	0.11%
2006	0	95,376,388	835,562	280,036,933	0.00%	0.00%	0.00%
2007	1,218	3,401,228	1,296,730	6,933,677	0.04%	0.02%	0.09%
2008	22,036	23,211,998	9,640,306	41,680,217	0.09%	0.05%	0.23%
2009	447	14,105,134	4,450,357	28,046,192	0.00%	0.00%	0.01%
2010	81	11,153,903	3,420,542	21,828,717	0.00%	0.00%	0.00%
2011	0	26,490,436	3,961,703	60,752,372	0.00%	0.00%	0.00%
2012	57,693	9,952,855	3,415,564	18,849,797	0.58%	0.31%	1.69%
2013	13,297	81,399,104	22,474,351	193,721,641	0.02%	0.01%	0.06%
2014	650	5,885,151	2,546,574	10,333,427	0.01%	0.01%	0.03%
2015	2,071	1,105,156	128,317	2,788,331	0.19%	0.07%	1.61%

Source: Entrainment loss estimated from observed juvenile salvage with CDFG (2009) loss multiplier (20.3) applied. Population abundance estimates from ICF International (2016b).

This entrainment loss is considered less than significant because of real-time OMR management actions that are expected to minimize entrainment losses and because entrainment losses would occur to a small percentage of the Longfin Smelt population.

The analysis of potential salvage-related impacts on Longfin Smelt from differences in April–May OMR flows reflect combined SWP and CVP operations. During April–May, the SWP would be responsible for around 40% to 50% of Delta water operations under the Proposed Project, depending on water year type and month (see Appendix H).

Water Transfers

Expansion of the water transfer window to include July to November would be expected to have limited effects on Longfin Smelt, given that upstream migrating adults have very little entrainment during these months (Grimaldo et al. 2009).

Annual O&M Activities-related Impacts

Annual O&M activities that could potentially affect Longfin Smelt include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. These activities likely would have limited impacts on Longfin Smelt when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.

Project Environmental Protective Measure-related Impacts

Environmental Protective Measures that could potentially affect Longfin Smelt include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival
- Continue studies to establish a Delta fish Conservation Hatchery
- Longfin Smelt Science Program including
  - Studies to better understand the Longfin Smelt population distribution and abundance in the San Francisco Bay and Delta

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and

various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish. The Longfin Smelt Science program is specifically intended improve the scientific understanding of Longfin Smelt to allow for better management of the species and its habitat.

Overall, these Environmental Protective Measures could minimize operations-related impacts on Longfin Smelt, improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Longfin Smelt

Longfin Smelt are relatively widely distributed in the San Francisco Bay, San Pablo Bay, Suisun Bay, and tributaries, but also inhabit areas of the Delta that could be affected by the Proposed Project throughout their life cycle. Potential operations-related changes to Longfin Smelt abundance, larval entrainment, and juvenile and adult salvage were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures

The analyses conducted for each life stage of Longfin Smelt, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of Longfin Smelt are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on Longfin Smelt, relative to the Existing Conditions scenario, and are considered **Less than Significant.**

Winter-run Chinook Salmon

Conceptual Model

Adult Winter-run Chinook Salmon first enter the San Francisco Bay Estuary from the Pacific Ocean starting in November and December, and continue to migrate through the Delta into late spring (May/June) or early summer (July). Winter-run Chinook Salmon juveniles rear and emigrate from the Sacramento River in the reach from the confluence with the Feather River through the Delta from October through May (NMFS 2009, p.80; NMFS 2017, p.67).

The Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) conceptual models describe life stage transitions of Winter-run Chinook Salmon. SAIL life stage transitions include egg and alevin mortality, egg to fry emergence, juvenile rearing to outmigrating, adult migration, and adult holding. The SAIL conceptual model used in the evaluation of immigrating adult Winter-run Chinook Salmon and the Bay-Delta to Upper River conceptual model (Figure 4.4-2, above) is the only model used to evaluate impacts on this life stage because the only riverine reach of the Sacramento River with the potential to be affected by SWP operations is the reach that extends from the confluence of the Feather River to the Delta. Adult migration attributes included in the SAIL conceptual model that are potentially affected by operations under the Proposed Project include water temperature, DO, and other habitat attributes that influence the timing, condition, and survival of adult Winter-run Chinook

Salmon during their upstream migration and holding in the middle and upper Sacramento River. Simulated flows in the Sacramento River at Freeport are evaluated as an indicator of potential changes in the reach that could result from implementation of the Proposed Project. Changes that could potentially occur to the SAIL conceptual model habitat attributes are then evaluated qualitatively based on the differences in simulated flows that could occur between the Proposed Project and Existing Conditions modeling scenarios.

The SAIL conceptual models used in the evaluation of outmigrating juvenile Winter-run Chinook Salmon are the Middle River conceptual model (Figure 4.4-1, above) and the Bay-Delta conceptual model (Figure 4.4-7, above). Middle Sacramento River rearing to outmigrating juvenile attributes with the potential to be affected by SWP operations include: dilution (e.g., toxicity and contaminants), water temperatures (which also affect DO, food availability, predation, pathogens, and disease), river stage and flow velocity (which affect habitat connectivity, bioenergetics, food availability, and predation), entrainment and stranding risk, and potentially cues that stimulate outmigration.

Evaluation of the Proposed Project's impacts on many of these habitat attributes is not feasible because site-specific and Delta-wide relationships between hydrodynamic conditions and many of the habitat attributes do not exist. In addition, interaction between SWP operations and other anthropogenic activities in the lower Sacramento River and Delta (e.g., agricultural practices, stormwater management, waterfowl management) and their effect on aquatic habitat is complex. Therefore, the tidal estuary and bay juvenile rearing and migration habitat attributes relevant the Proposed Project and readily evaluated include outmigration cues and entrainment risk. With regard to these habitat attributes, routing into the Delta and at distributary junctions in the Delta can influence survival of outmigrating juvenile salmonids and also influence their potential exposure to entrainment at the SWP export facilities in the South Delta. Routing at distributary junctions is affected by the proportion of flow entering each junction, which in turn, may be affected by SWP exports if sufficiently close to the South Delta export facilities or by riverine flow entering the Delta from upstream reservoirs. These conceptual model attributes are addressed by the quantitative evaluations and qualitative discussions described for the Outmigrant Survival and Entrainment analyses conducted using the DPM, STARS, juvenile salvage density, and salmonid junction entry analyses described below.

Operations-Related Impacts

Immigrating Adults

As described in the SAIL Adult Migration from Bay-Delta to Upper River conceptual model, adult Winter-run Chinook Salmon use the lower Sacramento River between the Delta and the confluence with the Feather River as a migration corridor. These immigrating adults can be present from November through July. During this period, changes in simulated average monthly flows at Freeport under the Proposed Project, relative to the Existing Conditions scenario are generally relatively small (see Figure 4.4-58, Figures 4.4-59 through 4.4-63, and Table 4.4-15). In fact, because of the water balance nature of CalSim, the monthly timestep, and generalized operations assumptions in the model, simulated differences in flow of about 1% to 2% may not represent actual flow changes that could potentially occur as SWP facilities are operated (see Section 4.1.4.1 CalSim II for discussion of model limitations). Therefore, flows at Freeport are considered similar under the Proposed Project and Existing Conditions scenarios during most months of the year.

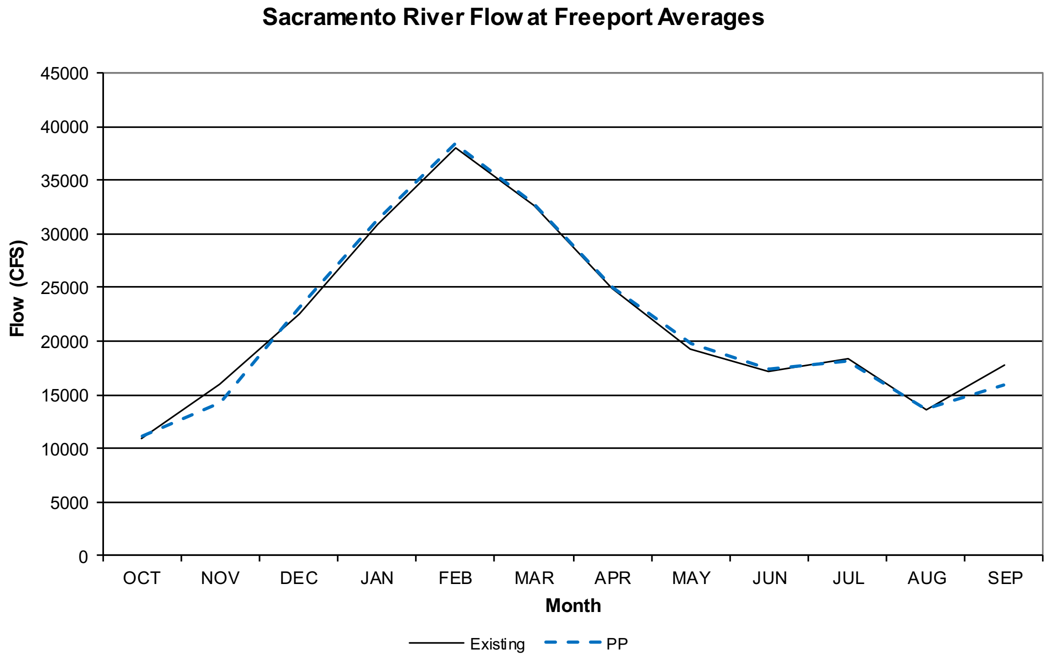


Figure 4.4-58. Simulated Average Monthly Flows in the Sacramento River at Freeport under the Proposed Project and Existing Conditions Modeling Scenarios

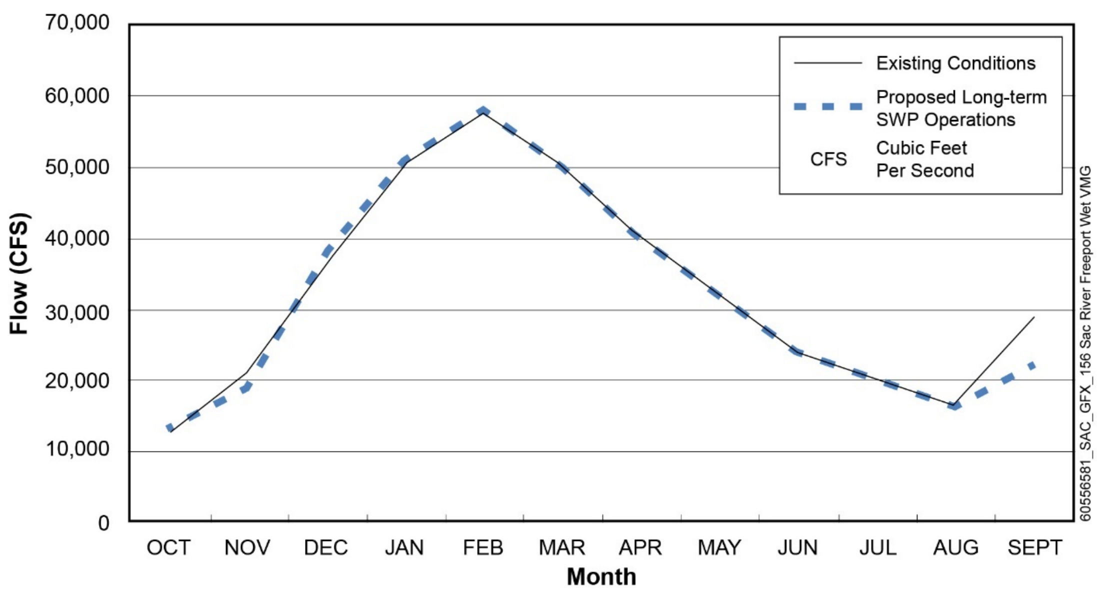


Figure 4.4-59. CalSim-Modeled Mean Sacramento River Flow at Freeport by Month, Wet Years

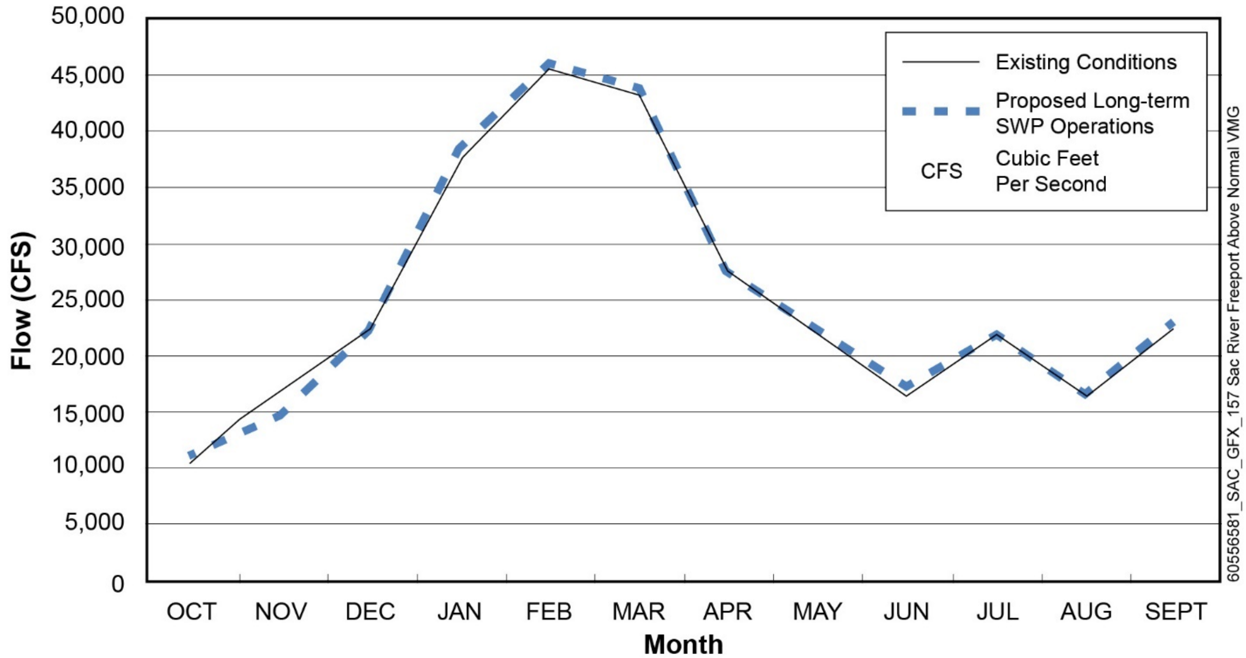


Figure 4.4-60. CalSim-Modeled Mean Sacramento River Flow at Freeport by Month, Above Normal Years

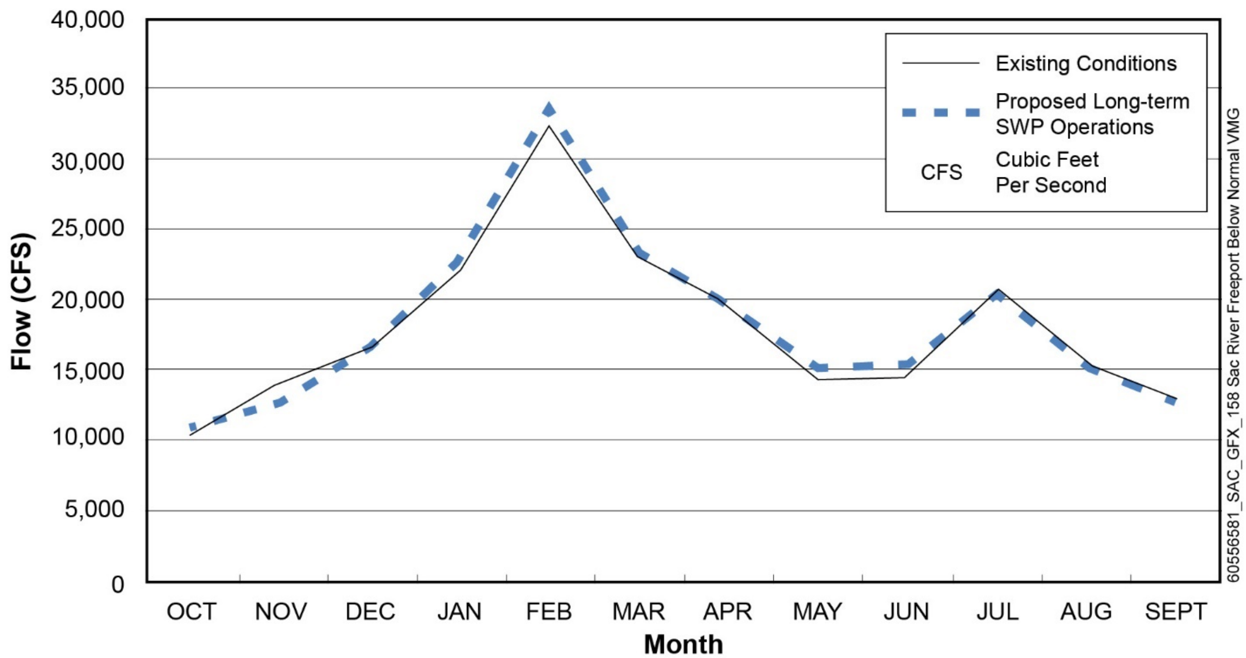


Figure 4.4-61. CalSim-Modeled Mean Sacramento River Flow at Freeport by Month, Below Normal Years

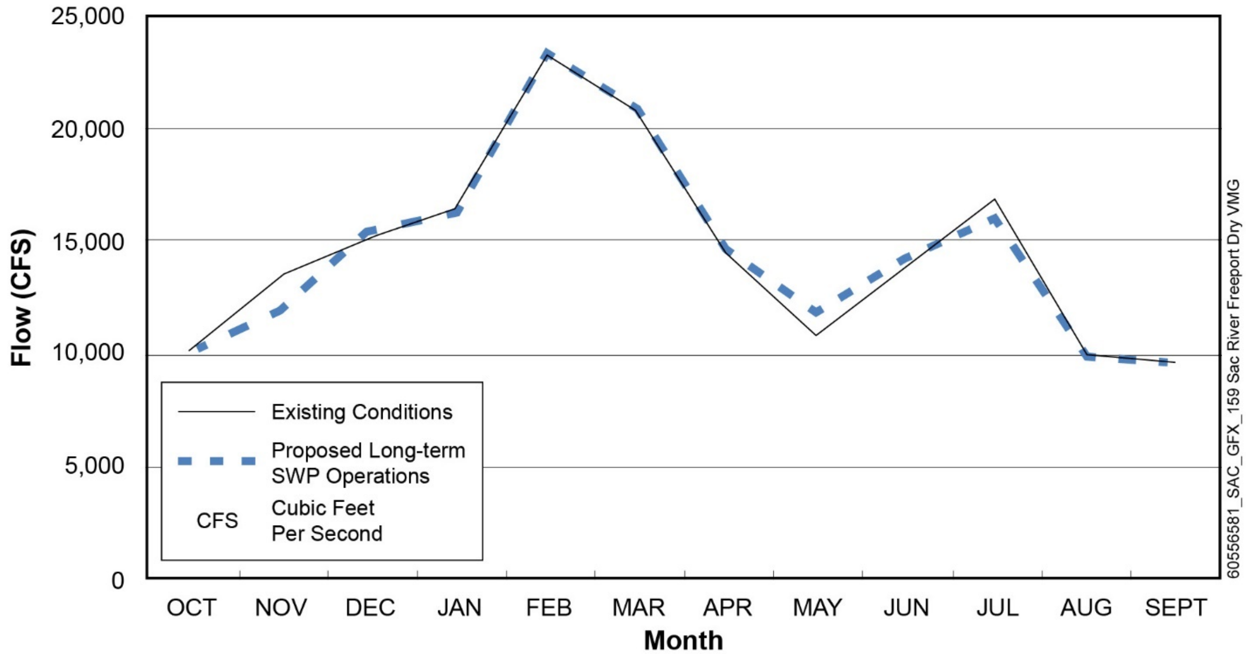


Figure 4.4-62. CalSim-Modeled Mean Sacramento River Flow at Freeport by Month, Dry Years

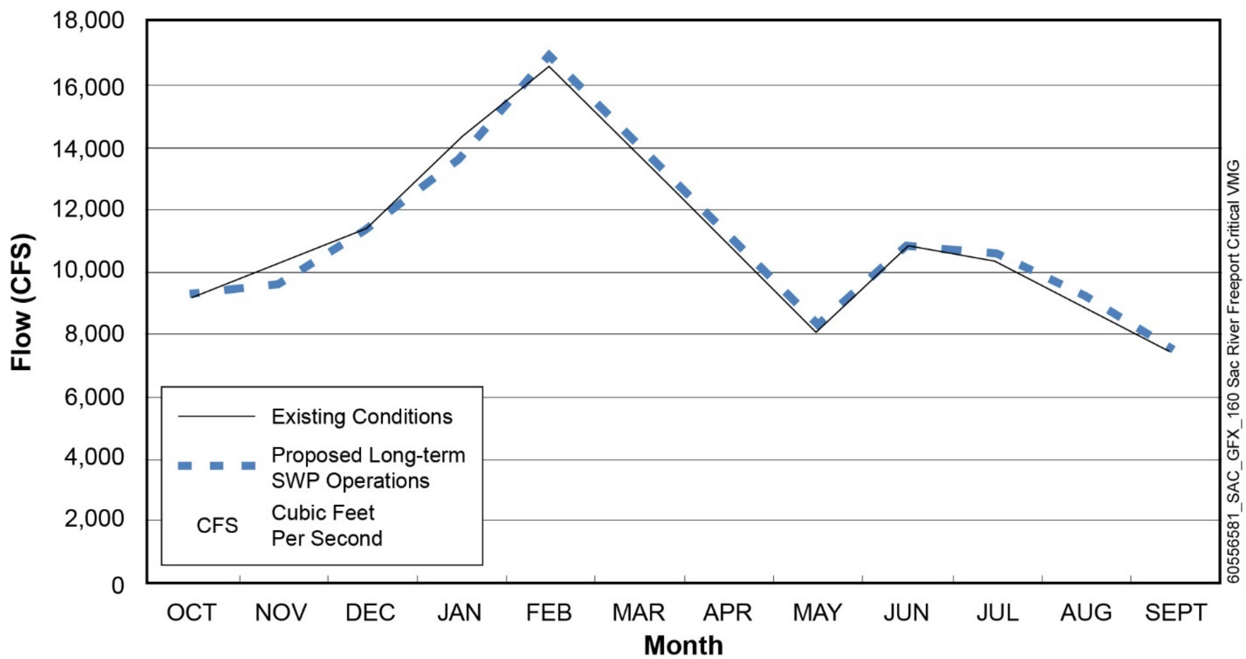


Figure 4.4-63. CalSim-Modeled Mean Sacramento River Flow at Freeport by Month, Critical Years

Table 4.4-15. Simulated Average Monthly Flows (cfs) at Freeport under the Proposed Project and Existing Conditions Modeling Scenarios, and the Difference and Percentage Difference (Proposed Project Existing Conditions = Difference

Month	Existing	Proposed Project	Difference	Percent Difference
January	30820	31210	390	1.3
February	37978	38462	484	1.3
March	32595	32897	302	0.9
April	24891	24958	67	0.3
May	19312	19719	407	2.1
June	17132	17441	309	1.8
July	18361	18162	-199	-1.1
August	13660	13655	-5	0.0
September	17819	15851	-1968	-11.0
October	10902	11184	282	2.6
November	16017	14330	-1687	-10.5
December	22564	23129	565	2.5

Because flows are generally similar under the Proposed Project and Existing Conditions scenarios, it is expected that habitat attributes such as water temperature, dissolved oxygen concentrations, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.3 feet (Table 1-2-1, Appendix C), which would not likely reduce migration opportunities for adult Winter-run Chinook Salmon. In addition, larger differences in flow between the Proposed Project and Existing Conditions scenarios that occur during November suggest little potential for differences in rates of straying of adult Winter-run Chinook Salmon between the Proposed Project and Existing Conditions scenarios. Specifically, other salmonids in the same genus (i.e., closely related to Chinook Salmon) such as adult Sockeye Salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989). Under the assumption that Sockeye Salmon responses to changes in olfactory cues are similar to those of Winter-Run Chinook Salmon, potential impacts of the Proposed Project on immigrating adult Winter-run Chinook Salmon in the Sacramento River are expected to be similar to those under the Existing Conditions scenario. Evidence from the Bay-Delta suggests that straying rates of Sacramento River basin hatchery-origin Chinook Salmon were very low (<1%) during the period from 1979 through 2007 (Marston et al. 2012), indicating that even across a wide range of differences in flow, straying is very low.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on immigrating adult Winter-run Chinook Salmon; the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the November–July Winter-run Chinook Salmon adult immigration period is approximately 20% to 60%, depending on month and water year type (see Appendix H).

Delta Hydrodynamic Analysis

Velocity Assessment

Hydrodynamic changes associated with river inflows and South Delta exports have been suggested to adversely affect juvenile Chinook Salmon in two distinct ways: (1) "near-field" mortality associated with entrainment to the export facilities, and (2) "far-field" mortality resulting from altered hydrodynamics. Near-field and entrainment effects associated with proposed seasonal operations are discussed separately for each salmonid in the Entrainment Loss Density analyses, and in the Winter-run Chinook Salmon Salvage analysis.

A foundation for assessing far-field hydrodynamic effects has been provided by work of the Collaborative Adaptive Management Team's (CAMT) Salmonid Scoping Team (SST). The SST completed a thorough review of this subject and defined a driver-linkage-outcome (DLO) framework for specifying how water project operations (the "driver") can influence juvenile salmonid behavior (the "linkage") and potentially cause changes in survival or routing (the "outcome"). The SST concluded altered "Channel Velocity" and altered "Flow Direction" were the only two hydrodynamic mechanisms by which exports and river inflows could affect juvenile salmonids in the Delta. Figure 4.4-64 provides a simplified conceptual model of the DLO defined by the CAMT SST.

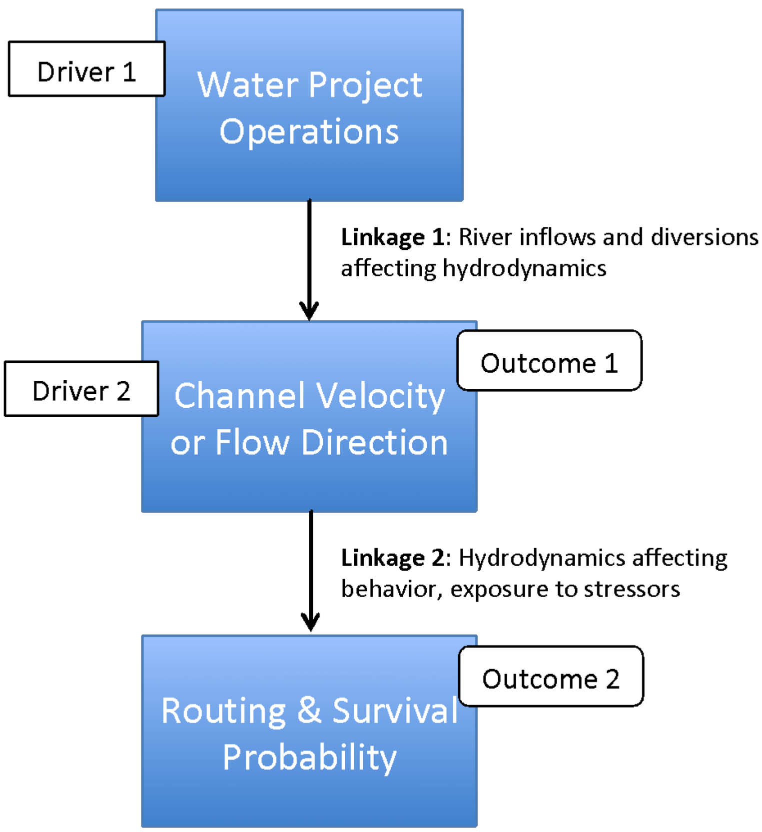
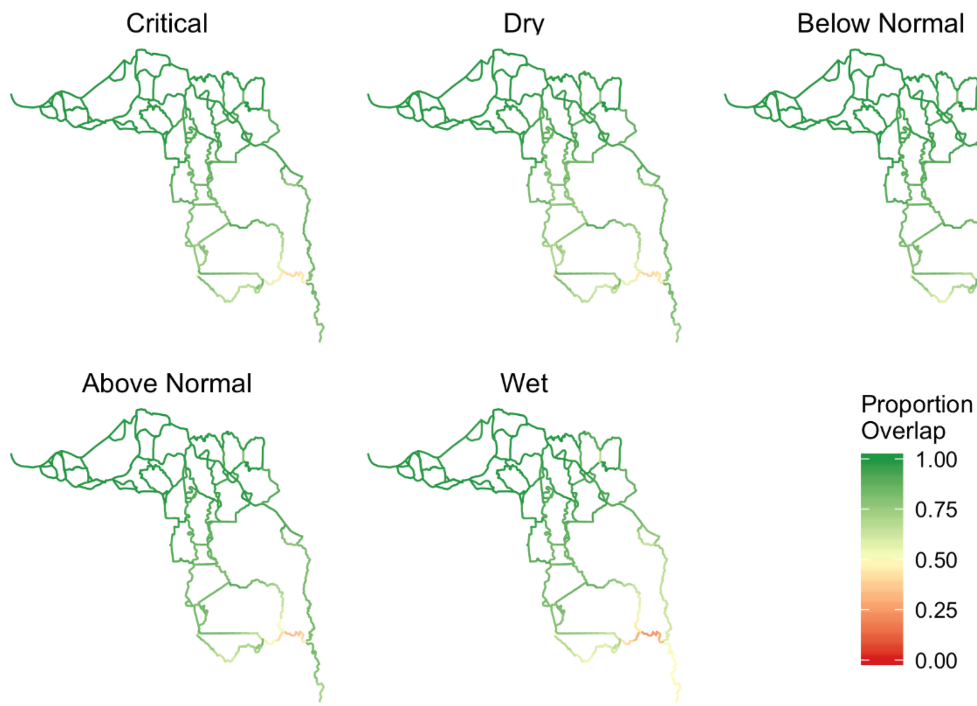


Figure 4.4-64. Conceptual Model for Far-field Effects of Water Project Operations on Juvenile Salmonids in the Delta. This CM is a Simplified Version of the Information Provided by the CAMT SST.

To assess potential hydrodynamic impacts, hourly DSM2 HYDRO outputs were used to identify Delta channels exhibiting velocity changes under the Proposed Project and Existing Conditions scenarios. The analysis is stratified by water year type and by the three seasons when juvenile salmonids are present in the Delta (fall, winter, and spring). CalSim modeling indicates that inflows to the Delta from the Sacramento and San Joaquin rivers generally would not be appreciably different under the Proposed Project and Existing Conditions scenarios. In the Delta, the largest hydrodynamic differences between the Proposed Project and the Existing Conditions scenarios that may influence juvenile salmonids occur in the South Delta and result from changes to spring export rates and the HORB.

Between September and November, velocities in the Central Delta (between Highway 4 and north to the San Joaquin River mainstem) are generally similar between the Proposed Project and Existing Conditions scenarios (Figure 4.4-65). The largest velocity changes are apparent near the HOR. Under the Proposed Project, no barrier is in place at this location and, therefore more water is flowing into eastern Old and Middle rivers, increasing velocities in these channels. Velocities in the mainstem San Joaquin River both upstream and downstream of the HOR exhibit few differences in critical, dry, below-normal, and above-normal water years. In wet water years, the absence of the HORB causes moderately increased velocities upstream and slightly decreased velocities downstream of the HOR under the Proposed Project. Exports proposed for fall months (particularly November) lead to slight velocity changes in the South Delta near the export facilities. Flows in the South Delta are tidal (i.e., bidirectional), and velocity changes in this region reflect both slightly stronger negative velocities and slightly weaker positive velocities.

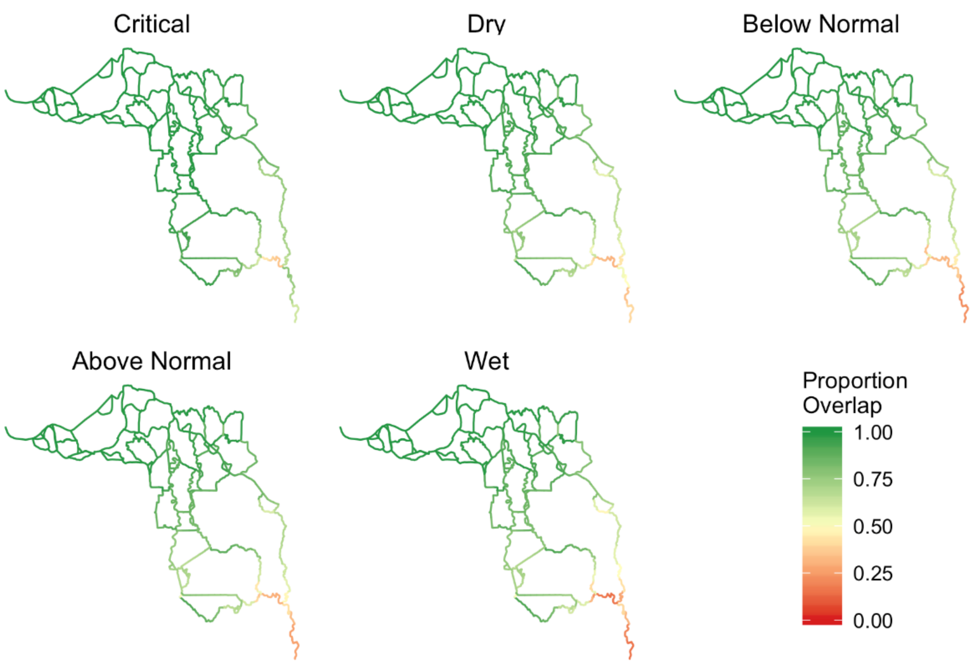


Map colors depict the proportion of overlap in velocity-frequency distribution with these contrasting export rates. Green indicates velocities are very similar (high overlap), while orange indicates large velocity differences (low overlap). More information on the source of these data and an interactive Shiny application is available at https://fishsciences.shinyapps.io/delta-hydrodynamics/. The Shiny application allows the user to select and view hydrodynamic conditions resulting from a variety of operating conditions and for a variety of hydrodynamic metrics.

Figure 4.4-65. Overlap in Delta Water Velocities, September-November, with the Proposed Project vs. Existing Condition

Between December and February, exports between the Proposed Project and Existing Conditions scenarios are similar and the HORB is not installed. Velocities throughout the South and Central Delta are largely unchanged in winter months between the Proposed Project and the Existing Conditions scenarios.

Between March and May, velocities in the Central Delta (between Hwy 4 and north to the San Joaquin River mainstem) are generally similar between the Proposed Project and Existing Conditions scenarios (Figure 4.4-66). The largest velocity changes are apparent near the HOR. Under the Proposed Project scenario, no barrier is in place at this location and, therefore, more water would flow into eastern Old and Middle rivers, increasing velocities in these channels. Velocities in the mainstem San Joaquin River both upstream and downstream of the HOR exhibit increasing differences with wetter water year types. These differences are due to the absence of the HORB under the Proposed Project. The lack of HORB causes moderate to large increases in velocities upstream of the HOR, and slight to moderately decreased velocities downstream of HOR. These impacts occur because the presence of the HORB creates hydraulic head that slows upstream velocities and this impact is stronger with higher San Joaquin River flows. Exports proposed for spring months (particularly April and May) lead to some velocity changes in the South Delta near the export intake facilities. Minimal differences are apparent in critically dry years, but slight to moderate velocity differences occurred in the Old and Middle rivers immediately north of the export facilities during wetter water year types. Velocity changes associated with spring exports under the Proposed Project do not appear to extend into the Central Delta. Flows in the South and Central Delta are tidal (i.e., bidirectional), and export-related velocity changes observed in these regions reflect both slightly stronger negative velocities and slightly weaker positive velocities.



Map colors depict the proportion of overlap in velocity-frequency distribution with these contrasting export rates. Green indicates velocities are very similar (high overlap), while orange indicates large velocity differences (low overlap). More information on the source of these data and an interactive Shiny application is available at https://fishsciences.shinyapps.io/delta-hydrodynamics/. The Shiny application allows the user to select and view hydrodynamic conditions resulting from a variety of operating conditions and for a variety of hydrodynamic metrics.

Figure 4.4-66. Overlap in Delta Water Velocities March-May with the Proposed Project vs. Existing Condition

Delta hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the September through May period evaluated above is approximately 20% to 60%, depending on the month and water year type (see Appendix H).

Hydrodynamic Impacts on Winter-run Chinook Salmon

Coded-wire-tagging and acoustic-tagging studies suggest relatively few juvenile Chinook Salmon entering the Delta from the North will be exposed to velocity changes observed in the South Delta under the Proposed Project (e.g., less than 1% of coded-wire-tagged fish were found in salvage) (Zeug and Cavallo 2014). Fish passing through the DCC or Georgiana Slough and continuing to migrate westward in the mainstem San Joaquin River will experience no velocity changes likely to influence their survival or behavior. Fish that move southward enough in the corridors of the Old and Middle rivers to reach areas of altered velocities may be more likely to continue moving toward the export facilities and become vulnerable to entrainment. However, velocity changes that could occur in the spring and fall are not likely to affect Winter-run Chinook Salmon because most Winter-run Chinook Salmon are expected to have exited the Delta by April and May and are not generally present in the region in September and November.

<u>**Entrainment**</u>

Entrainment Loss Density

To provide perspective on potential differences in entrainment loss of Winter-run Chinook Salmon juveniles between the Proposed Project and Existing Conditions scenarios, the salvage-density method was used (Appendix E). Note that this method is based on length-at-date classification of Chinook Salmon race, and therefore the determination of race in historical salvage is uncertain. Therefore, all months are evaluated in this analysis but only those Chinook Salmon that were reported as Winter-run Chinook Salmon based on their length at the time of salvage were included in the weighting and subsequent reporting of Winter-run Chinook Salmon loss density.

The estimates of entrainment loss obtained from the salvage-density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim-modeled differences in South Delta exports between the evaluated scenarios. Therefore, the results are basically a description of differences in export flows weighted by monthly loss density. Historical loss density numbers provide some perspective on the absolute numbers of fish being entrained, but are a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected[8]. Although the emphasis is consideration of the relative difference between scenarios, it is important to appreciate that the modeling is limited in its representation of real-time adjustments to operations in order to minimize impacts on listed fishes, so that differences between scenarios are likely to be less

[8] The loss density estimates reflect the regulatory accepted multipliers for estimating loss as a function of observed salvage; it is acknowledged herein that loss is likely to vary from the regulatory multipliers, for example, as illustrated by historical and recent studies of pre-screen loss in Clifton Court Forebay (Gingras 1997; Miranda 2019), but it is assumed that loss density provides a reasonable depiction of seasonal patterns in entrainment from which to weight modeled exports for comparison of the Existing Conditions and Proposed Project scenarios.

than suggested by the method. Specifically, CalSim II modeling does not include OMR management based on cumulative loss thresholds for Winter-run Chinook Salmon, which would limit entrainment.

The salvage-density method suggested that entrainment loss of juvenile Winter-run Chinook Salmon at the SWP South Delta export facility would be similar between the Proposed Project and Existing Conditions scenarios (Table 4.4-16). These results occur because most Winter-run Chinook Salmon entrainment largely occurs prior to the April–May period when the largest difference in simulated South Delta exports occurs between the scenarios. It should be noted that the analysis herein is based on size-at-date criteria, and does not reflect potential errors in Chinook Salmon race identification based on these criteria (Harvey et al. 2014). It is expected that the latest information (e.g., genetic assignment) would be used as it becomes available, to limit potential entrainment loss of Winter-run Chinook Salmon. In addition, the risk assessment-based approach for OMR flow management included in the Proposed Project (i.e., cumulative and single-year loss thresholds, which, if met, restrict OMR flows and require DWR to coordinate with CDFW to manage OMR flows), would be expected to limit entrainment loss for Winter-run Chinook Salmon juveniles to no more than the protective levels required by the NMFS ROC on LTO Biological Opinion. These protective low levels would continue the low levels of entrainment (i.e., less than ~1% of genetically identified Winter-run Chinook Salmon juveniles entering the Delta), that occurred as a result of the NMFS (2009) BiOp criteria implementation (see, for example, Islam et al. 2018).

Winter-run Chinook Salmon Salvage (Based on Zeug and Cavallo 2014)

A predictive model of Winter-run Chinook Salmon salvage was developed based on a study of 178 release groups of Winter-run Chinook Salmon from the Livingston Stone hatchery by Zeug and Cavallo (2014). The predictive salvage model was run for the Existing Conditions and the Proposed Project scenarios using export and flow data from the DSM2 model. Additional discussion of the method is provided in Appendix E. Results were compared between the two scenarios and summarized on an annual basis, and for each month Winter-run Chinook Salmon occur in the Delta by water year type.

Across the 82-year DSM2 simulation period, salvage of juvenile Winter-run Chinook Salmon was predicted to be less than 0.02% of the total juvenile population for both scenarios. Median salvage was slightly lower under the Proposed Project scenario relative to the Existing Conditions scenario over the entire modeling period (0.0119% and 0.0121%, respectively). Despite the trend of lower median salvage under the Proposed Project scenario across all years, there was variation in which scenario produced lower salvage in individual years (Figure 4.4-67).

Median predicted salvage was higher under the Proposed Project scenario in some months of some water year types, and was higher under the Existing Conditions scenario in some months of some water year types (Figure 4.4-68). In most months of all water year types, considerable overlap in the interquartile ranges occurred. The highest median salvage for both scenarios occurred in wet water years, but salvage did not exceed 0.25% in any month (Figure 4.4-68). The lowest salvage for both scenarios occurred in critical water years. Overall, in most months, salvage of Winter-run Chinook Salmon is similar for the Proposed Project and Existing Conditions scenarios. However, notable

Table 4.4-16. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-16 a – Table 4.4-16 f

Table 4.4-16 a. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2,397	624	1,846	126	11	0	0	0	0	0	0	377
Proposed Project	2,284	639	1,594	323	29	0	0	0	0	0	0	379

Table 4.4-16 b. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	4,613	1,710	1,076	25	0	0	0	0	0	0	0	760
Proposed Project	4,661	1,631	841	94	0	0	0	0	0	0	0	773

Table 4.4-16 c. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,272	1,209	1,447	0	0	0	0	0	0	0	0	68
Proposed Project	1,354	1,247	1,198	81	42	0	0	0	0	0	0	70

Table 4.4-16 d. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	531	990	2,039	44	0	0	0	0	0	0	0	354
Proposed Project	578	1,034	1,650	104	0	0	0	0	0	0	0	380

Table 4.4-16 e. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	386	697	436	39	7	0	0	0	0	0	0	243
Proposed Project	429	704	467	56	9	0	0	0	0	0	0	216

Table 4.4-16 f. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	5,381	8,184	4,031	3,958	1,809
Proposed Project	5,247	8,001	3,993	3,746	1,882
Proposed Project vs. Existing	-134 (-2%)	-183 (-2%)	-38 (-1%)	-212 (-5%)	73 (4%)

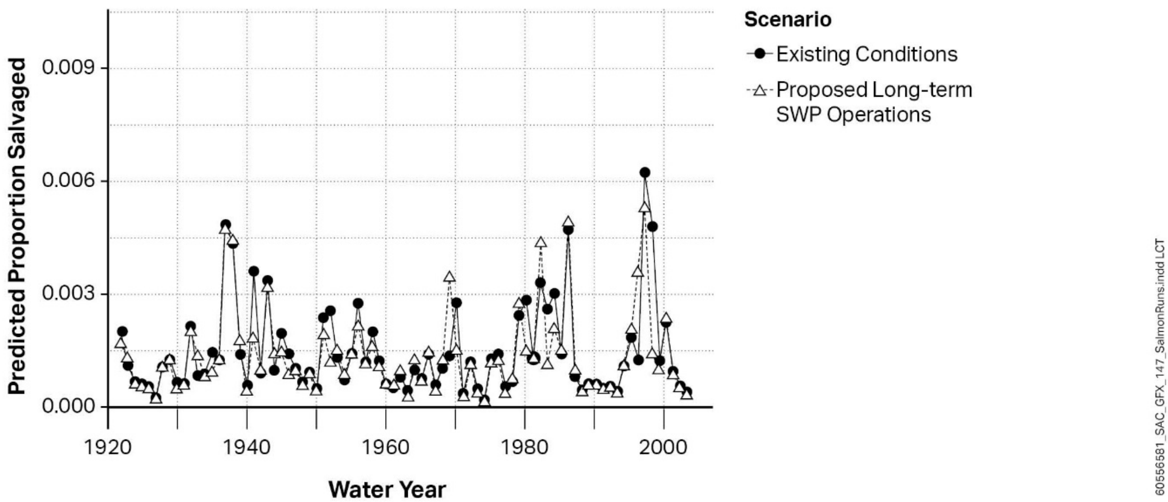
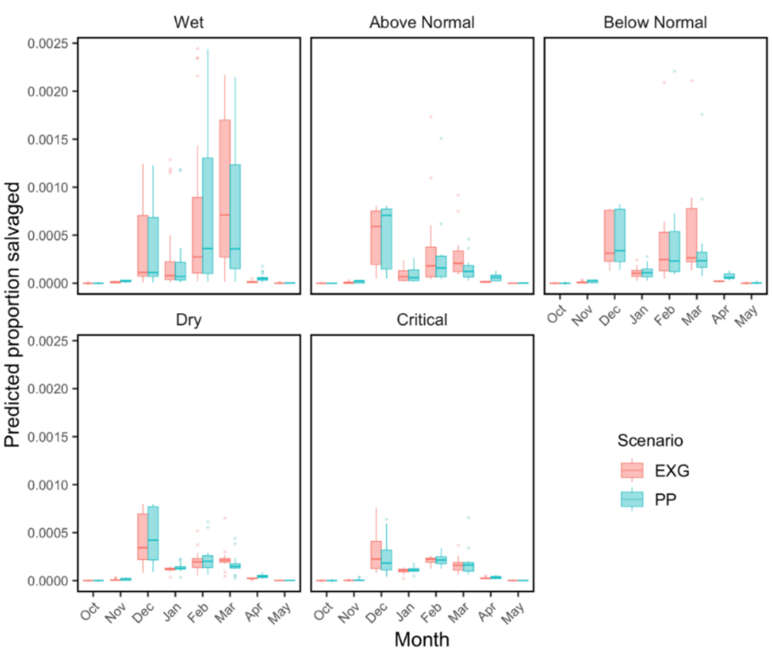


Figure 4.4-67. Predicted Proportion of Juvenile Winter-run Chinook Salmon Salvage at the SWP under the Existing Conditions and the Proposed Project Scenarios across the 82-Year DSM2 Simulation Period



Note: The horizontal line is the median value, the box defines the interquartile range, and vertical lines define the minimum and maximum values. Single points are outliers.

Figure 4.4-68. Box and Whisker Plots of Predicted Proportion of Juvenile Winter-run Chinook Salmon Salvaged at the Skinner Delta Fish Protective Facility of the State Water Project as a Function of SWP Exports and Sacramento River Flow for Existing Conditions and Proposed Project Scenarios

differences in predicted salvage occur in some months of some water years. For example, in February and March of wet, above-normal, and below-normal water years salvage is expected to be lower under the Proposed Project and in December of dry water years salvage is expected to be higher under the Proposed Project (Figure 4.4-68). Further, the underlying DSM2 modeling does not reflect real-time operational decision-making, modeling, and OMR management that would occur under the Proposed Project. These real-time operations and risk assessment-based OMR management, including cumulative and single-year loss thresholds would be expected to limit entrainment (and thus, salvage) to protective levels.

The analysis of potential salvage-related impacts on Winter-run Chinook Salmon from differences in October–May OMR flows reflect combined SWP and CVP operations. The SWP responsibility for Delta water operations during the October-May period evaluated above is approximately 40% to 60%, depending on the month and water year type (see Appendix H).

__Outmigrant Survival__

Delta Passage Model

The DPM integrates operational impacts of the Existing Conditions and Proposed Project scenarios that could influence through-Delta survival of migrating juvenile Chinook Salmon smolts, including Sacramento River Winter-run Chinook Salmon. Functions included in the DPM include reach-specific flow-survival and flow travel-time relationships, flow-routing relationships, and export-survival relationships. Uncertainty in the quantitative relationships included in the DPM were integrated into the analysis, using Monte Carlo techniques. One hundred iterations of the model were run for each scenario in which distributions for each parameter were resampled for each iteration. Model output reported here is annual through-Delta survival in the 82-year CalSim period and through-Delta survival aggregated by water year-type. Additional details of the method are provided in Appendix E.

Across the 82-year simulation period, mean through-Delta survival was 0.1% greater for the Proposed Project scenario (28.4%, 95% CI 20.6-24.0) relative to the Existing Conditions scenario (28.3%, 95% CI 27.1-29.5). Survival was greater under the Existing Conditions scenario for 33 of the 82 years and greater under the Proposed Project scenario in 49 years (Figure 4.4-69). Differences in individual years were generally small (< 1%), with the largest difference occurring in the 1957 model year when survival under the Proposed Project scenario was 1.3 % higher than under the Existing Conditions scenario. Confidence intervals for through-Delta survival overlapped between scenarios in all years.

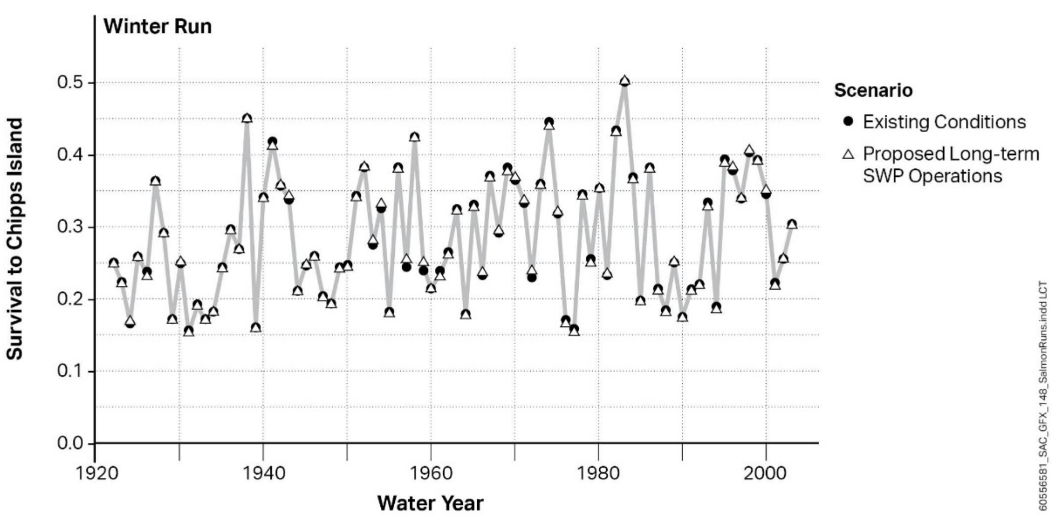


Figure 4.4-69. Mean Estimates of Winter-run Chinook Salmon Through-Delta Survival with 95% Confidence Intervals for the Proposed Project and the Existing Conditions in Each Simulation Year

For both scenarios, mean survival rates tracked water year type with the highest value in wet years and the lowest value in critical years (Figure 4.4-70). In each water year-type, mean survival was slightly higher under the Proposed Project scenario relative to the Existing Conditions scenario. However, 95% confidence intervals overlapped substantially between survival estimates. The largest difference between scenarios occurred in below-normal years when mean survival under the Proposed Project scenario was 0.22% higher than the Existing Conditions scenario. The smallest difference occurred in critical water years when mean survival under the Proposed Project was 0.004% higher than the Existing Conditions scenario (Figure 4.4-70).

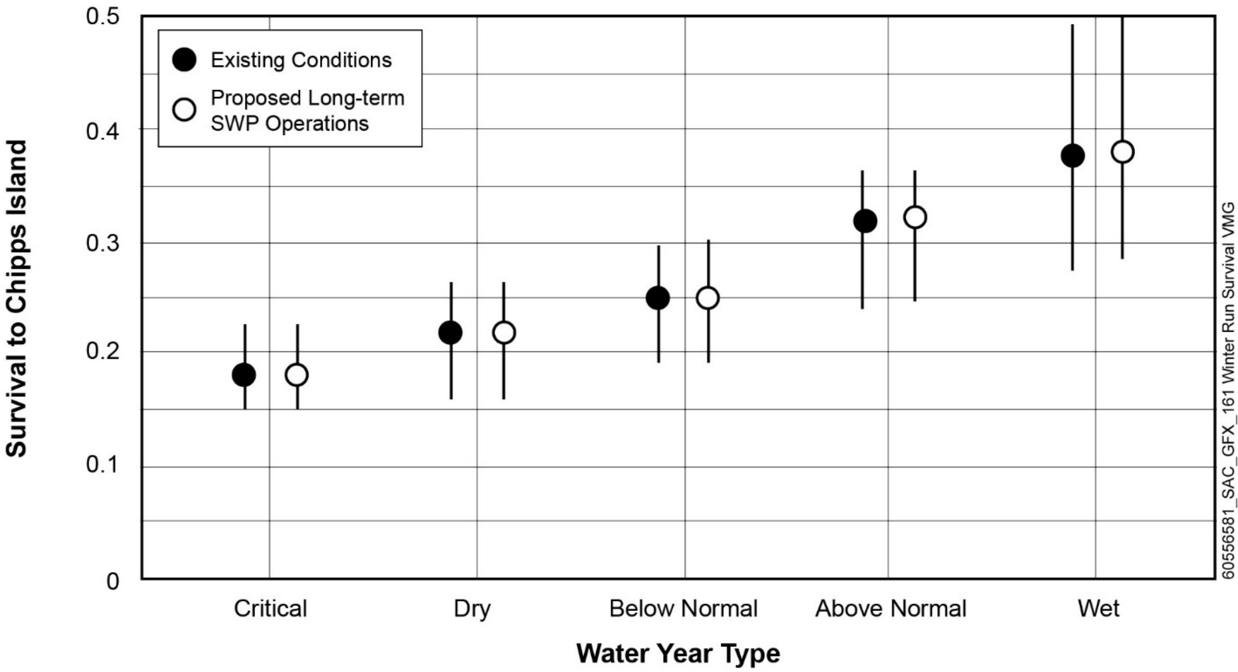


Figure 4.4-70. Mean Through-Delta Survival with 95% Confidence Intervals for Juvenile Winter-run Chinook Salmon under the Proposed Project and the Existing Conditions. Values were summarized by water year-type over the 82-year CalSim period

Through-Delta survival impacts as represented by the DPM include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the main winter-spring (~December–April) period of Winter-run Chinook Salmon entry into the Delta is approximately 40% to 60% (see Appendix H).

STARS

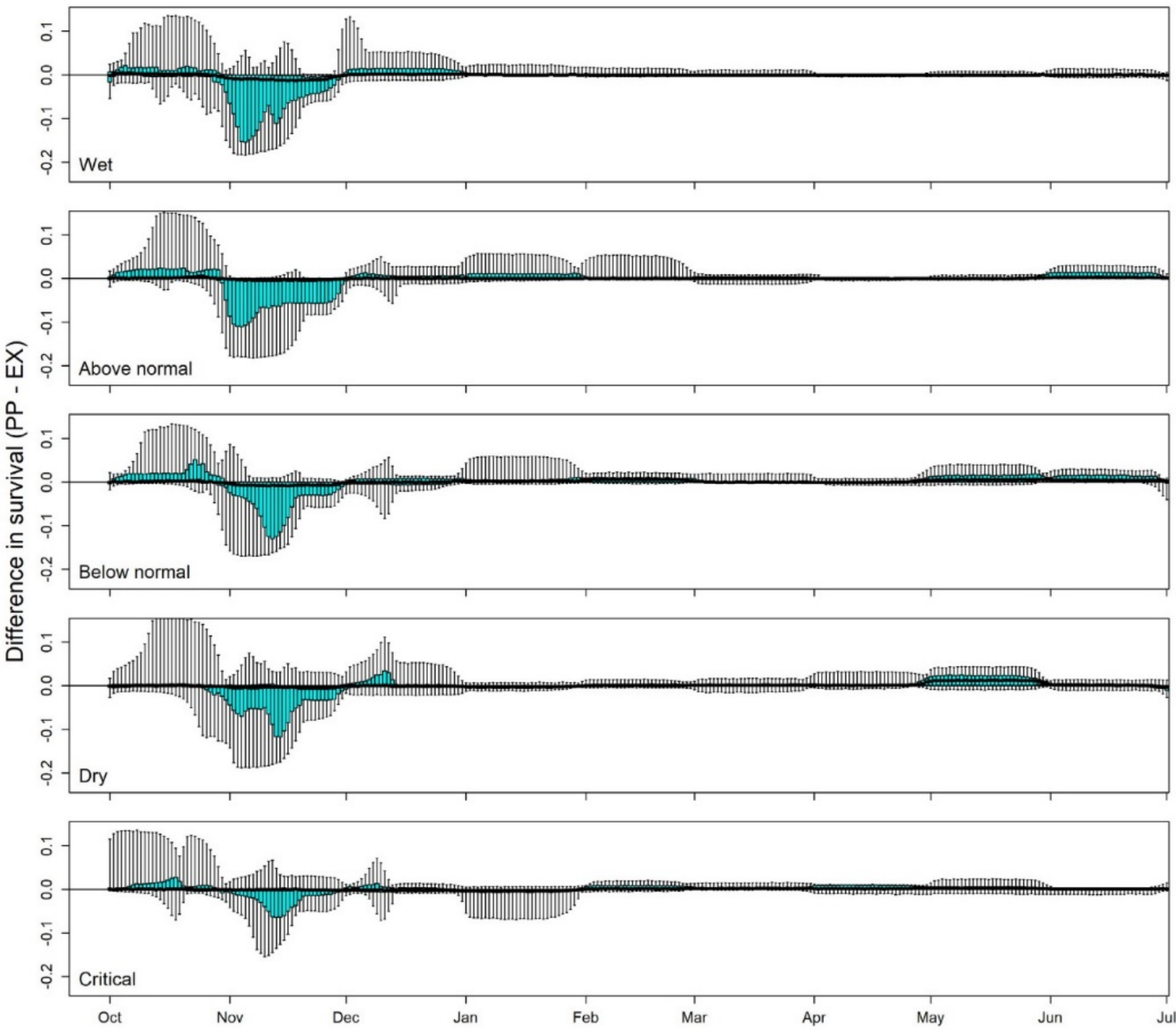
The Survival, Travel Time, And Routing Simulation Model (STARS; Perry et al. 2018) was used to provide perspective on potential differences in the routing to the interior Delta of juvenile Chinook Salmon between the Proposed Project and Existing Conditions scenarios. The model simulated migration routing using CalSim modeled flows (82-year time series) and DCC gate operations to assess differences between the two scenarios in entrainment to the interior Delta of juvenile Chinook Salmon from October-June. However, the analyses of the STARS model results for Winter-run Chinook Salmon considered the months of October through May based on the time period when they could potentially rear and emigrate from the Delta (NMFS 2009, p.80; NMFS 2017, p.67).

The parameters on which the model is based were derived from a Bayesian mark-recapture model that jointly estimated reach-specific travel time, migration routing, and survival of juvenile Chinook Salmon. The model is designed to predict survival of a cohort of fish that experience variable daily river flows as they migrate through the Delta from the Sacramento River. The STARS model provides causal inference (flow affects routing and travel time which ultimately affects survival) based on studies conducted on Late Fall-run Chinook Salmon and the results contain some degree of uncertainty that comes with making predictions on out-of-sample conditions (i.e., predictions for Winter-run Chinook Salmon entering the Delta at different sizes and during different time periods). A complete description of the STARS model, limitations and assumptions, and the results of this analysis are provided in Appendix E (see Attachment 1, "Using the STARS Model to Evaluate the Effects of the Proposed Project on Juvenile Salmon Survival, Travel Time, and Migration Routing for the Long-Term Operation of the State Water Project Incidental Take Permit Application and CEQA Compliance").

Although the STARS model addresses potential impacts associated with routing and travel time, the discussion focuses on differences in survival because the survival calculations integrate flow-survival relationships, travel time, and routing of fish into different parts of the Delta with varying survival estimates. Past studies have shown a negative correlation between routing to the interior Delta and survival of juvenile Chinook Salmon (Perry et al. 2013; Perry et al. 2014; Perry et al. 2015).

Perry et al. (2018) determined that median travel time was related to the inflow in all reaches of the Delta. In contrast, survival was strongly related to inflow in only three of eight reaches. In the three reaches that exhibited strong inflow-survival relationships, river flows transitioned from tidally influenced, bidirectional flow at low net inflow to unidirectional downstream flow as net inflows increased and tidal forcing was dampened. Thus, these three reaches caused route-specific survival through the Delta to increase with flow, yet fish that entered the interior Delta through Georgiana Slough or the DCC experienced lower route-specific survival than other migration routes. In addition, Perry et al. (2018) identified that the proportion of fish entering the interior Delta increased as (1) inflows decreased below about 25,000 cfs and (2) when the DCC gate was opened. These mechanisms increase the proportion of fish experiencing low-survival migration routes, thereby further reducing overall survival through the Delta. Because the STARS model incorporates the effect of river flow and DCC gate operation on juvenile Chinook Salmon survival, travel time, and migration routing, the analysis can be used to identify mechanisms by which SWP operations affect overall survival through the Delta. One limitation, however, is that the statistical model of Perry et al. (2018) did not include South Delta exports. Thus, the modeling results presented herein are insensitive to any difference in exports between the scenarios being considered.

The STARS analyses provided in Appendix E were conducted for the October–June period. The analyses revealed that, overall, there generally was little difference in predicted survival between the Proposed Project and Existing Conditions scenarios (Figure 4.4-71). The exception generally was in November, for which survival under the Proposed Project scenario was typically lower than under the Existing Conditions scenario. This likely reflected differences in inflow to the Delta as a result of the Proposed Project scenario not including the fall X2 action. The fall X2 action was included in the Existing Conditions scenario, resulting in lower Freeport flow and therefore greater frequency of opening of the



Note: Each boxplot represents the distribution of median survival differences among the 82 years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

Figure 4.4-71. Daily Boxplots of Median Differences in Median Through-Delta Survival between the Proposed Project (PP) and Existing Conditions (EX) Scenarios by Water Year Type

DCC (assumed to be open at flow <25,000 cfs). Although the fall X2 action applies in wet and above-normal water year types, the difference between the Proposed Project and Existing Conditions scenarios in November survival was apparent in all water year types because November is part of the subsequent water year, for which the water year type would vary irrespective of the prior water year type.

The STARS model results suggest little difference in predicted through-Delta survival of Winter-run Chinook Salmon between the Proposed Project and Existing Conditions scenarios, except for juveniles migrating before December. Given that most individuals appear to migrate into the Delta with early winter flow pulses (del Rosario et al. 2013) that may coincide with closure of the DCC, this may limit the potential for some of the early outmigrating juvenile Winter-run Chinook Salmon to find their way to the South Delta and potentially be entrained at the SWP export facility. Historically, a relatively low proportion of juvenile Winter-run Chinook Salmon are salvaged (Zeug and Cavallo 2014). Therefore, the differences between the Existing Conditions and Proposed Project scenarios in outmigrant survival, as influenced by routing (entrainment into the interior Delta) and travel time, are not considered a substantial impact on the outmigrating Winter-run Chinook Salmon population.

The analysis of through Delta survival, routing, and timing as represented by the STARS model reflect combined SWP and CVP operations. The SWP responsibility for Delta water operations during November when differences in survival were most pronounced is approximately 50% to 60% depending on the water year type (see Appendix H).

Additional discussion of methods, results, and uncertainty associated with the STARS analyses is provided in Appendix E.

Rearing Effects

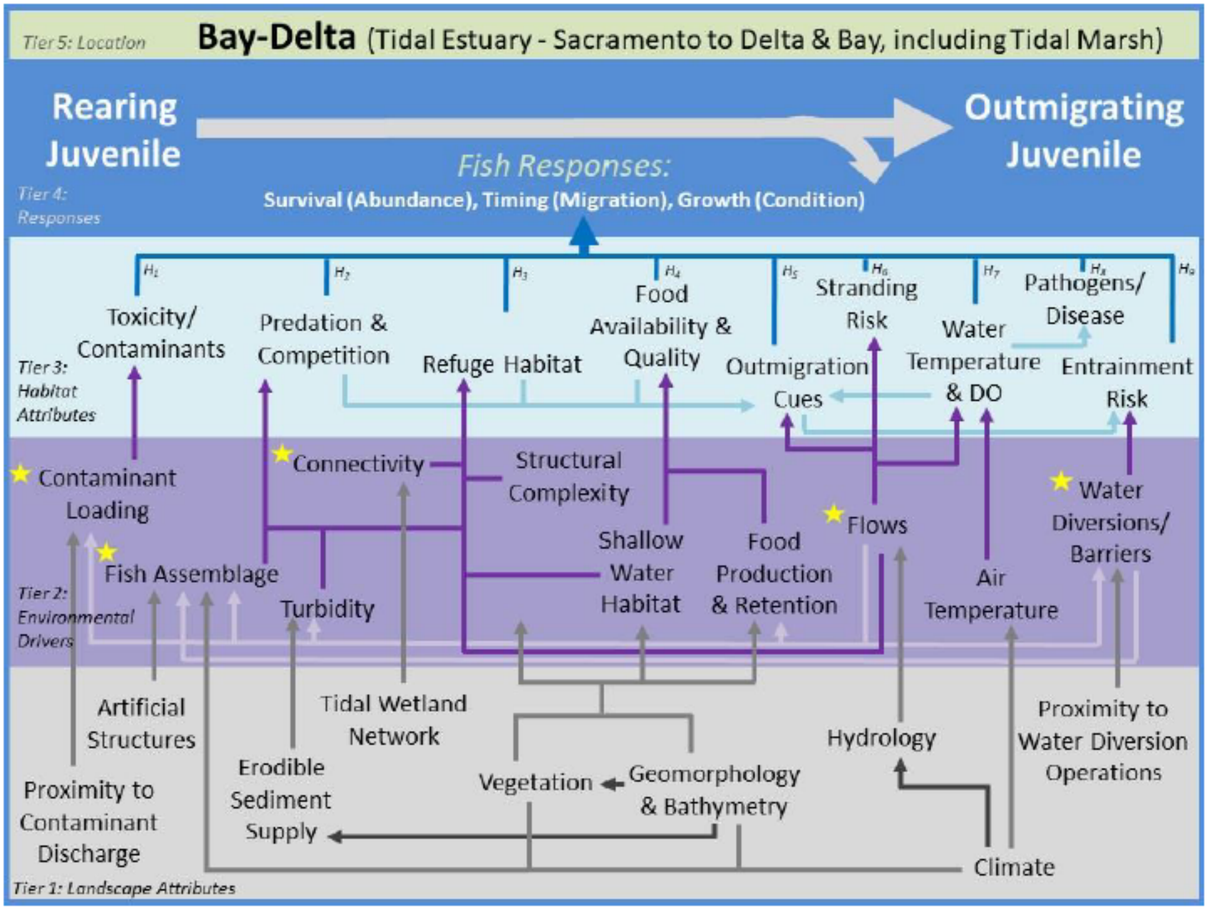
Background for Juvenile Salmonid Rearing Delta

The ITP Application for the Proposed Project (p.2-21) noted that "Although the Delta was historically used for rearing, it appears that Winter-run Chinook Salmon now use the Delta primarily as a migration corridor to Suisun Bay and Marsh (Hassrick, pers. comm)." This statement was based primarily on relatively short residence times within the Delta for acoustically tagged juvenile Winter-run Chinook Salmon of 80-127 mm (Hassrick et al. 2014, Hassrick et al. 2016). However, there is some uncertainty with respect to rearing in the Delta: for example, Phillis et al. (2018) estimated from isotopic evidence that around 6–20% of returning Winter-run Chinook Salmon adults had reared in the Delta. Moreover, del Rosario et al. (2013) looked at apparent migration rates of winter-run sized fish at different points in the system and concluded that there was evidence of substantial Delta rearing, perhaps 1-3 months.

Based on this evidence, a recent conceptual model for the rearing to migrating life stage of Winter-run Chinook Salmon in the Bay-Delta hypothesizes that changes in flow could interact with shallow water habitat availability in the Bay-Delta to affect the availability of refuge habitat and survival (Figure 4.4-72). As noted by the authors of this conceptual model, information regarding Winter-run Chinook Salmon use of Delta habitats is limited because of routine sampling limitations (Windell et al. 2017, p.19).

Previous Analyses of Rearing Habitat

The California WaterFix (CWF) project included analyses that can be used to inform the effects analysis of the Proposed Project. These analyses included an assessment of reduction in juvenile salmonid rearing habitat at restored wetland and riparian benches in the north Delta as a result of diversions by the proposed north Delta intakes (see methods in ICF International 2016, Appendix 5.D, beginning p.5-268). The analysis found that the estimated reduction in water level (stage) in the Sacramento River from the proposed diversions could give somewhat reduced access to riparian bench habitats, which are at relatively higher elevations, but would be expected to give little difference in access to wetland benches, which are at relatively lower elevations (ICF International 2016, p.5-179 to p.5-184).



Source: Windell et al. (2017). Note: Hypotheses referenced by the “H-number” are identified in the Windell et al. (2017) conceptual model 4 narrative. Management actions are denoted by stars and are described in Table 1 of Windell et al. (2017).

Figure 4.4-72. Conceptual Model of Drivers Affecting the Transition of Sacramento River Winter-Run Chinook Salmon from Rearing Juvenile to Outmigrating Juvenile in the Bay-Delta.

The National Marine Fisheries Service Winter-Run Chinook Salmon Life Cycle Model (WRLCM) was also used to assess potential CWF effects (NMFS 2017). This model addresses Delta rearing habitat capacity through consideration of channel type (high quality: blind channels; low quality: mainstem river, distributaries, open water), cover (high quality: vegetated; low quality: not vegetated), and water depth (high quality: >0.2 meters, ≤ 1.5 meters; low quality: ≤ 0.2 meters, >1.5 meters) (Hendrix et al. 2014). The model did not suggest that changes in Delta rearing capacity would have appreciable effects on the species: for example, a sensitivity analysis of an additional 11,000 acres of restored tidal habitat in the Delta, with resulting increase in habitat capacity, gave little difference in cohort replacement rate (NMFS 2017, p.807–810). As noted by NMFS (2017, p.810), “…the proposed Delta habitat restoration did not improve the cohort replacement rate under this scenario because the current low abundance of the winter-run population is not limited by Delta rearing habitat. As the population abundance increases because of recovery action implementation (such as newly reintroduced populations in Battle Creek and upper Sacramento River – above Shasta Reservoir) the availability of additional tidal Delta rearing habitats will become more important for the species.”

Results of the WRLCM for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and the State Water Project found limited effects of the Proposed Action (PA) compared to the Current Operations Scenario (COS; NMFS 2019). Although there have been refinements to the model since the CWF analysis, the method of assessing habitat capacity in the Delta remains the same (see NMFS 2019, Appendix A). Overall this suggested limited potential for effects of changes in rearing habitat within the Delta as a result of differences in operations between the PA and COS scenarios.

Implications for Proposed Project Operational Effects

The analyses of rearing habitat (bench inundation and WRLCM rearing habitat capacity) described above are largely driven by Sacramento River flow into the Delta. This suggests that a qualitative assessment of differences in Freeport flow for the Proposed Project relative to Existing Conditions provides an indication of potential changes to juvenile salmonid rearing habitat as a result of differences in operations. CalSim modeling results for Freeport flow generally suggest little difference between Proposed Project and Existing during the winter-spring juvenile salmonid rearing period (Appendix C, Attachment 2-2, Table 1-1, and Figures 1-1 through 1-6). Some reductions in rearing habitat could occur under the Proposed Project during late fall (November) as a result of lower Freeport flow, which is caused by the Proposed Project not including the USFWS (2008) fall X2 action flows. However, based on results of the WRLCM model for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and the State Water Project, such differences would be expected to have limited population-level effects on juvenile Winter-run Chinook Salmon (NMFS 2019).

Rearing habitat availability for juvenile salmonids in the Delta is also affected by Yolo Bypass inundation (e.g., Takata et al. 2017). Based on modeled operations, there would be minimal differences in Yolo Bypass flows between the Proposed Project and Existing scenarios (Appendix C, Attachment 2-2, Table 3-1, and Figures 3-1 through 3-6). In addition, construction of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project is anticipated to be completed by December 2022, which will contribute to minimizing and mitigating potential Proposed Project effects.

Water Transfers

Expansion of the water transfer window to include July to November would be expected to have limited overlap with Winter-run Chinook Salmon occurrence in the Delta, given that most individuals appear to migrate into the Delta with early winter flow pulses (del Rosario et al. 2013). The potential for greater South Delta entrainment would exist for juvenile Winter-run Chinook Salmon occurring during the water transfer window, but this would be expected to be limited and any entrainment loss would count toward cumulative thresholds, which would protect the species throughout the entire winter/early spring entrainment risk period.

Annual O&M Activities-related Impacts

Annual O&M activities that could potentially affect Winter-run Chinook Salmon include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal

- Clifton Court Forebay maintenance including
    - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. These activities likely would have limited impacts on Winter-run Chinook Salmon when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project scenario.

Project Environmental Protective Measure-Related Impacts

Environmental Protective Measures that could potentially affect Winter-run Chinook Salmon include:

- Clifton Court Forebay actions to reduce predation including
    - Continued evaluation of predator relocation studies
    - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
    - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
    - Continued refinement and improvement of the fish sampling and hauling procedures
    - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are expected to minimize operations-related impacts on Winter-run Chinook Salmon, improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Winter-run Chinook Salmon

Winter-run Chinook Salmon inhabit areas of the Delta that could be affected by the Proposed Project during the adult migration and juvenile rearing to outmigrating portions of their life cycle as identified in the SAIL conceptual model. Potential operations-related changes to migration and rearing habitat attributes, outmigrant survival, entrainment into the Delta from the Sacramento River, and entrainment at SWP facilities were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures.

The analyses conducted for each life stage of Winter-run Chinook Salmon, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of Winter-run Chinook Salmon are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on Winter-run Chinook Salmon, relative to the Existing Conditions scenario, and are considered **Less than Significant.**

Spring-run Chinook Salmon

Conceptual Model

The SAIL conceptual model was prepared especially for Sacramento River Winter-run Chinook Salmon, but the cause and impacts relationships it diagrams generally apply to the Spring-run Chinook Salmon population in Sacramento River. Therefore, the analysis of changes in flows in the reach of the Sacramento River from the Feather River Confluence to the Delta and the potential impacts on adult Spring-run Chinook Salmon will be discussed in a similar manner as described for Winter-run Chinook Salmon. In addition, evaluation of juvenile habitat attributes potentially affected by the Proposed Project are evaluated in a similar manner to those described for Winter-run Chinook Salmon. The differences in the analyses between Winter-run Chinook Salmon and Spring-run Chinook Salmon are primarily associated with the differences in life stage timing.

Adult Spring-run Chinook Salmon enter the San Francisco Bay Estuary from the ocean in January to late February and continue to be present in the Delta through June.

Spring-run Chinook Salmon 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. They use the reach of the Sacramento River from the confluence with the Feather River to the Delta as rearing habitat and a migratory corridor to the Delta. The majority of Spring-run-sized juveniles occur at Knights Landing from November through May, with two separate peak occurrences: December and March through April (NMFS 2017, p.71).

Operations-Related Impacts

<u>**Immigrating Adults**</u>

Adult Spring-run Chinook Salmon use the lower Sacramento River between the Delta and the confluence with the Feather River as a migration corridor. These immigrating adults can be present from January through June. During this period, changes in simulated average monthly flows at Freeport under the Proposed Project, relative to the Existing Conditions scenario, are generally relatively small (see Figure 4.4-58, Figures 4.4-59 through 4.4-63, and Table 4.4-15) and flows at Freeport are considered similar under the Proposed Project and Existing Conditions scenarios during most months of the year. In addition, the SWP is responsible for between approximately 30% to 60% of Delta water operations, depending on month and water year type.

Because flows are generally similar under the Proposed Project and Existing Conditions scenarios, it is expected that habitat attributes such as water temperature, dissolved oxygen concentrations, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is less than 1 foot (Appendix C, Table 1-2-1), which would not likely reduce migration opportunities. In addition, little potential for differences in rates of straying exist for adult Spring-run Chinook Salmon between the Proposed Project and Existing Conditions scenarios. Specifically, other salmonids in the same genus (i.e., closely related to Chinook Salmon) such as adult Sockeye Salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989). Under the assumption that Sockeye Salmon responses to changes in olfactory cues are similar to those of Spring-Run Chinook Salmon, potential impacts of the Proposed Project on immigrating adult Spring-run Chinook Salmon in the Sacramento River are expected to be similar to those under the Existing Conditions scenario. Evidence from the Bay-Delta suggests that straying rates of Sacramento River basin hatchery-origin Chinook Salmon were very low (<1%) during 1979-2007 (Marston et al. 2012), indicating that even across a wide range of differences in flow, straying is very low.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on immigrating adult Spring-run Chinook Salmon the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the January-June Spring-run Chinook Salmon adult immigration period is approximately 30% to 60% depending on month and water year type (see Appendix H).

Delta Hydrodynamic Assessment and Salmonid Junction Entry

In considering changes in flow proportion impacts, it is important to consider when juvenile salmon of various races may be present in the Delta. Juvenile Spring-run Chinook Salmon are present in the Delta between November and early June with a peak in April. Coded wire tagging and acoustic tagging studies suggest few juvenile Chinook Salmon entering the Delta from the Sacramento River would be exposed to velocity changes observed in the South Delta under the Proposed Project scenario (e.g., Zeug and Cavallo 2014). Juvenile Spring-run entering the Delta from the Sacramento River and passing through the DCC or Georgiana Slough and continuing to migrate westward in the mainstem San Joaquin River would be expected to experience no velocity changes likely to influence their survival or behavior. Fish that move southward enough in the corridors of the Old and Middle rivers to reach areas of altered velocities may be more likely to continue moving toward the export facilities and become vulnerable to entrainment. Though the geographic footprint of velocity changes is relatively small, greater exports under the Proposed Project during April and May could affect a greater number of Spring-run Chinook Salmon juveniles than under the Existing Conditions scenario, with this season generally coinciding with the peak of juvenile Spring-run Chinook Salmon migration.

For Spring-run Chinook Salmon from the San Joaquin River basin, the absence of the HORB under the Proposed Project causes relatively large differences to velocities in the mainstem San Joaquin River between approximately Mossdale and Stockton. Velocities upstream of the HOR are higher under the Proposed Project (without HORB) and have the potential to be beneficial to juvenile Chinook Salmon and steelhead by increasing their migration rate. This increase in velocity occurs when HORB is not installed because the presence of the HORB creates hydraulic head that slows upstream velocities and the impact is stronger with higher San Joaquin River flows. However, velocities downstream of the HOR under the Proposed Project are reduced and may offset the potential benefit of increased velocities upstream of HOR. The absence of HORB under the Proposed Project will allow more San Joaquin River origin juvenile salmonids to pass through Old River and the Grant Line Canal and approach the export facilities. While this routing increases entrainment risk for these fish, available coded-wire-tagging and acoustic-tagging studies indicate survival in this region is very poor generally and not adversely influenced by export rates (SST 2017). Entrainment at the CVP has been observed to yield higher through-Delta survival (via trucking) than volitional migration through the Delta by other routes, even with positive OMR conditions (Buchanan et al. 2018; SJRGA 2011, 2013). Though entrainment has the potential to increase during April and May due to increased exports under the Proposed Project in these months, through-Delta survival of juvenile Spring-run Chinook Salmon originating from the San Joaquin River basin may not be impaired by these operations, relative to the Existing Conditions scenario (see also the analysis below based on the San Joaquin River-Origin Spring-run Chinook Salmon Structured Decision Model).

The junction routing analysis for the HOR junction (see the method description provided in Appendix E) indicates the proportion of flow moving into the Old River route and toward the CVP and SWP export facilities and is relevant for juvenile Spring-run Chinook Salmon emigrating from the San Joaquin River basin. Thus, lower flow proportion values indicate decreased flow toward the export facilities. Flow proportion into the Old River varied by month and water year type. Differences between the Proposed Project and Existing Conditions scenarios were apparent in November, April, and May (Figure 4.4-~~72~~73). For these months, flow proportion into the Old River route is higher under the Proposed Project scenario in all water year types, but the differences were clearest and most substantial in below-normal and drier years. In dry years, flow proportion into the Old River route was 40% greater under the Proposed Project than under the Existing Conditions scenario. Results for April and May in wet, above-normal, and below-normal water years were highly variable for the Existing Conditions scenario because placement of the HORB was variable under wetter conditions (the barrier was assumed not to be installed at Vernalis flow >5,000 cfs). This change in flow proportion indicates juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are much more likely to enter the Old River route under the Proposed Project than under the Existing Conditions scenario.

Juvenile Spring-run Chinook Salmon originating from the Sacramento River basin would not encounter the HOR junction and would therefore not be affected by these differences. No juvenile Spring-run Chinook Salmon are expected to be emigrating from the San Joaquin River basin in November, so differences in this month do not have biological significance. All juvenile salmon emigrating from the San Joaquin River basin must pass through the HOR junction. Thus, the Proposed Project is expected to result in an increased proportion of juvenile salmon passing through the Old River route. However, recent acoustic tagging studies indicate no difference in survival for fish migrating through the Old River route relative to fish continuing through the San Joaquin River route (Buchanan et al. 2018). It is

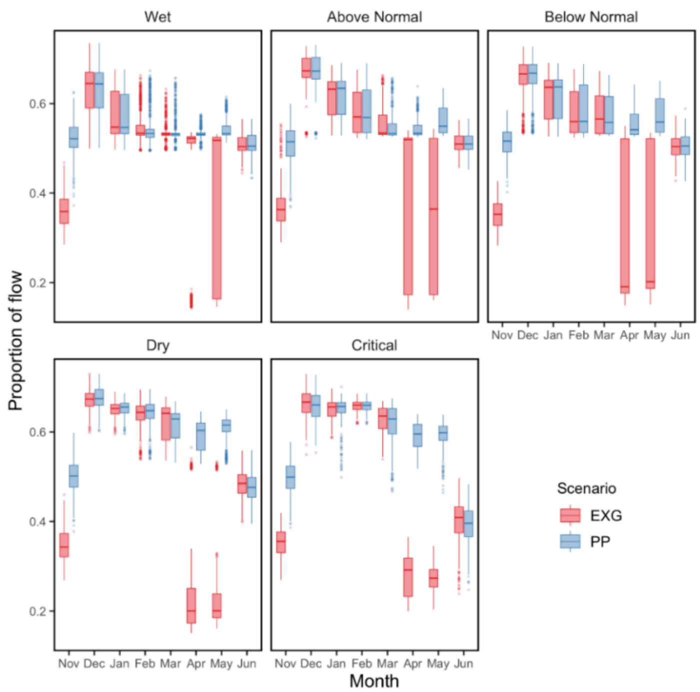


Figure 4.4-~~72~~73. Boxplots of Proportion of Flow Entering the Head of Old River by Month and Water Year Type

also important to note that although the Proposed Project does not include installation of the HORB, Spring-run Chinook Salmon juveniles may receive some ancillary protection during April and May from the risk assessment-based approach for OMR flow management included in the Proposed Project that would be undertaken for other species. Specifically, single year and cumulative loss thresholds for steelhead and Winter-run Chinook Salmon could provide additional protection for Spring-run Chinook Salmon.

Delta hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the November through June period evaluated above is approximately 30% to 60%, depending on the month and water year type (see Appendix H).

__Entrainment__

Entrainment Loss Density

To provide perspective on potential differences in entrainment loss of Spring-run Chinook Salmon juveniles between Existing Conditions and Proposed Project scenarios, the salvage-density method was used, as described for Winter-run Chinook Salmon (see Appendix E). The same caveats including those regarding length-at-date classification and the appropriate use of these results that are described for Winter-run Chinook Salmon also apply to Spring-run Chinook Salmon. In addition, as described for Winter-run Chinook Salmon, all months are evaluated in this analysis but only those Chinook Salmon that were reported as Spring-run Chinook Salmon based on their length at the time of salvage were included in the weighting and subsequent reporting of Spring-run Chinook Salmon loss density.

The salvage-density method suggested that entrainment loss of juvenile Spring-run Chinook Salmon at the SWP South Delta export facility could be appreciably greater under the Proposed Project scenario compared to the Existing Conditions scenario (Table 4.4-17). This is because most juvenile Spring-run Chinook Salmon entrainment occurs during the April–May period when the largest difference in South Delta exports is projected to occur between Proposed Project and Existing Conditions scenarios.[9] As described for Winter-run Chinook Salmon, it should be noted that this analysis is based on size-at-date criteria and does not reflect potential errors in Chinook Salmon race identification based on these criteria. Classification errors resulting from the use of size-at-date criteria are particularly pronounced for Spring-run Chinook Salmon, for which genetic studies have shown that the great majority of spring-run-sized fish may actually be Fall-run Chinook Salmon (Harvey et al. 2014). It is expected that the latest information (e.g., genetic assignment) would be used as it becomes available to assess and limit potential entrainment loss of Spring-run Chinook Salmon. In addition, a very small proportion (<1%) of Spring-run Chinook Salmon are likely to approach the South Delta (Zeug and Cavallo 2014).

During April-May, Spring-run Chinook Salmon juveniles may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in the Proposed Project that would be undertaken for other species. Specifically, single year and cumulative loss thresholds for steelhead and Winter-run Chinook Salmon could provide additional protection for Spring-run Chinook Salmon.

Outmigrant Survival

Delta Passage Model

The DPM integrates operational impacts of the Existing Conditions and Proposed Project scenarios that could influence through-Delta survival of migrating juvenile Chinook Salmon smolts, including Central Valley Spring-run Chinook Salmon. Functions included in the DPM include reach-specific flow-survival and flow travel-time relationships, flow-routing relationships and export-survival relationship. Uncertainty in the quantitative relationships included in the DPM were integrated into the analysis using Monte Carlo techniques. One hundred iterations of the model were run for each scenario where distributions for each parameter were resampled for each iteration. Model output reported here is annual through-Delta survival in the 82-year CalSim period and through-Delta survival aggregated by water year-type. Additional details of the method are provided in Appendix E.

Across the 82-year simulation period, mean through-Delta survival was 0.6% greater under the Existing Conditions scenario (26.4%, 95% CI 24.7-28.1) relative to the Proposed Project scenario (25.8%, 95% CI 24.2-27.5). Survival was greater under the Existing Conditions scenario for 64 of the 82 years, and was greater under the Proposed Project scenario in 18 years (Figure 4.4-~~73~~74). Differences in individual years were generally small (< 1.5%) with the largest difference occurring in the 1995 model year when survival under the Existing Conditions scenario was 1.6 % higher than under the Proposed Project scenario. Confidence intervals for through-Delta survival overlapped between scenarios in all years.

[9] Fish entrained during April-May would be expected to primarily be young-of-the-year; yearlings would tend to occur somewhat earlier in the winter, during a period when Existing Conditions and Proposed Project scenarios would not be expected to differ greatly in exports based on CalSim modeling.

Table 4.4-17. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-17 a – Table 4.4-17 f

Table 4.4-17 a. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	55	2,911	12,166	9,447	2,214	0	0	0	3	0	0
Proposed Project	2	56	2,514	31,196	25,239	2,187	0	0	0	3	0	0

Table 4.4-17 b. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	8	50	4,114	12,066	2,838	136	0	0	10	0	0	0
Proposed Project	8	48	3,216	45,615	11,693	135	0	0	9	0	0	0

Table 4.4-17 c. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	6	1,178	1,598	879	16	0	0	0	0	0	0
Proposed Project	2	6	974	5,987	3,090	16	0	0	0	0	0	0

Table 4.4-17 d. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	789	4,007	1,654	0	0	0	0	0	0	0
Proposed Project	0	0	638	9,429	3,511	0	0	0	0	0	0	0

Table 4.4-17 e. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	2	69	1,495	942	14	0	0	0	0	0	0
Proposed Project	0	2	74	2,155	1,160	14	0	0	0	0	0	0

Table 4.4-17 f. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	26,798	19,221	3,679	6,449	2,521
Proposed Project	61,197	60,724	10,076	13,579	3,405
Proposed Project vs. Existing	34,399 (128%)	41,503 (216%)	6,397 (174%)	7,130 (111%)	884 (35%)

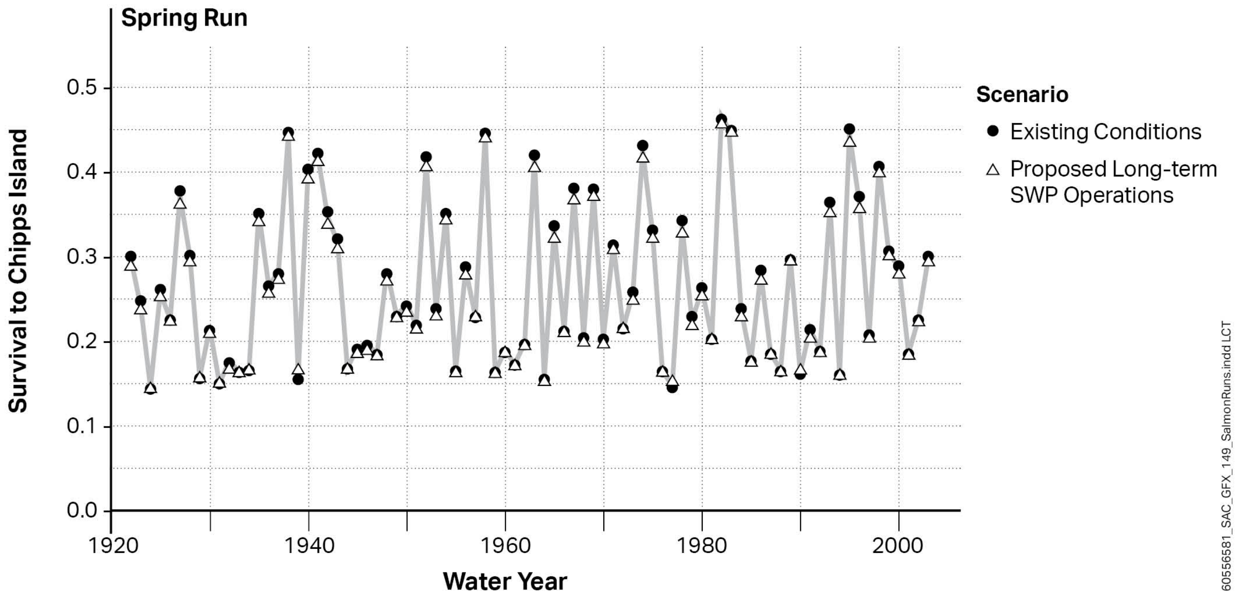


Figure 4.4-~~73~~74. Mean Estimates of Spring-run Chinook Salmon Through-Delta Survival with 95% Confidence Intervals for the Proposed Project and the Existing Conditions in Each Simulation Year

For both scenarios, mean survival rates tracked water year type with the highest value in wet years and the lowest value in critical years (Figure 4.4-~~74~~75). Mean through-Delta survival was greater for the Existing Conditions scenario relative to the Proposed Project scenario in all but critical water year types (Figure 4.4-~~74~~75). Although 95% confidence intervals for survival estimates overlapped between scenarios in each water year type, the largest difference occurred in wet years when mean survival for the Existing Conditions scenario was 0.9% higher than the Proposed Project scenario. The smallest difference occurred in dry years (0.06% higher for the Existing Conditions scenario) and in critical years, survival was 0.07% higher under the Proposed Project scenario (Figure 4.4-~~74~~75).

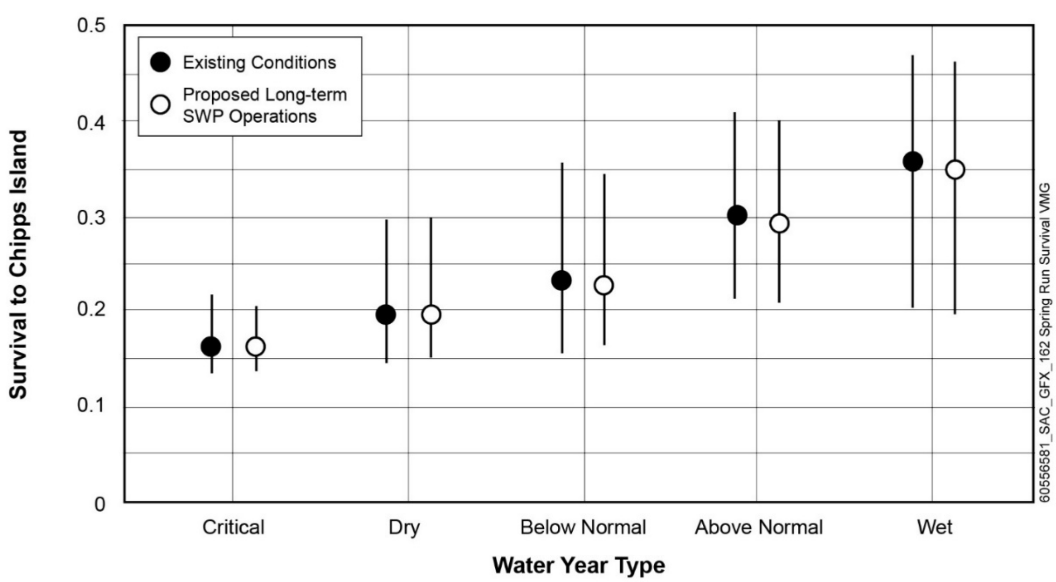


Figure 4.4-~~74~~75. Mean Through-Delta Survival with 95% Confidence Intervals for Juvenile Spring-run Chinook Salmon under the Proposed Project and the Existing Conditions. Values were summarized by water year-type over the 82-year CalSim period

Through-Delta survival impacts as represented by the DPM include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40% to 60% (see Appendix H).

San Joaquin River-origin Spring-run Chinook Salmon Structured Decision Model

The Delta Structured Decision Model was developed by the Central Valley Project Improvement Act Science Integration Team to evaluate the impact of different management decisions on the survival and routing of juvenile Fall-run Chinook Salmon. The model relies on survival-environment relationships and routing-environment relationships from acoustic studies conducted in the Sacramento and San Joaquin rivers and at the State and Federal export facilities. Only results from the San Joaquin River submodel are reported. The model and documentation has not been finalized and the code for the most recent version of the model that was used was accessed at https://github.com/FlowWest/chinookRoutingApp. Additional details of the model are provided in Appendix E.

Survival results from the SDM model were estimated for San Joaquin-origin Spring-run Chinook Salmon by weighting the daily proportion of Spring-run Chinook Salmon captured in the Sacramento trawl and reported as annual estimates and as aggregations by water year type. Sacramento River Spring-run Chinook Salmon timing was used because the reintroduced Spring-run Chinook Salmon population in the San Joaquin River has not existed long enough to generate a San Joaquin River-specific entry distribution.

Across the 82-year CalSim period, through-Delta survival was low (< 4%) for both the Proposed Project and Existing Conditions modeling scenarios (Figure 4.4-~~75~~76). Survival was higher under the Proposed Project scenario for all years, although the magnitude of the difference between scenarios was variable.

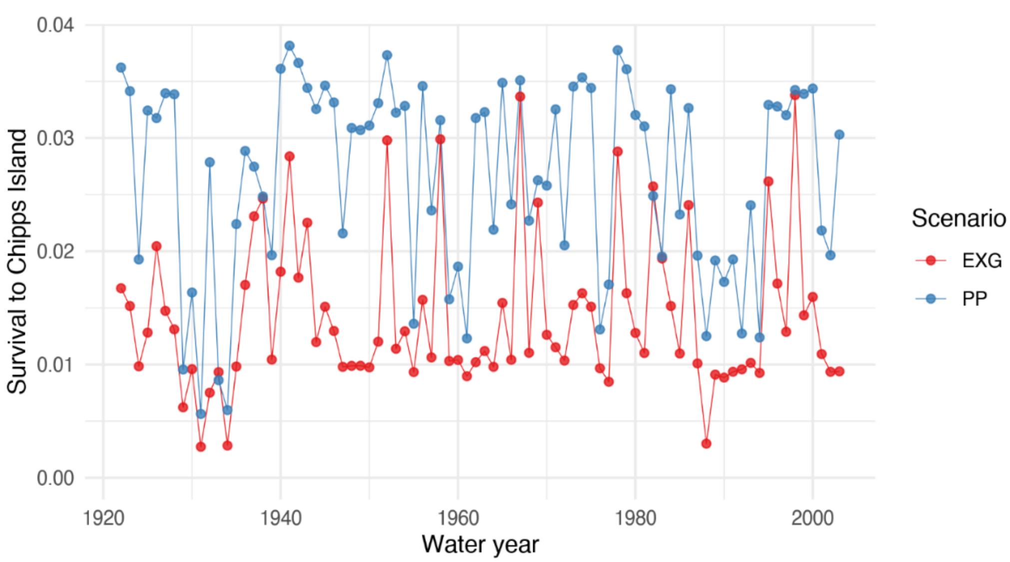


Figure 4.4-~~75~~76. Mean Estimates of San Joaquin River Spring-run Chinook Salmon Through-Delta Survival for the Proposed Project (PP) and the Existing Conditions (EXG) in Each Simulation Year

Through Delta survival of Spring-run Chinook Salmon under the Proposed Project scenario tracked water year-type with the highest values in wet and above-normal years and the lowest values in dry and critical years (Figure 4.4-~~76~~77). Interquartile ranges of survival under the Existing Conditions and Proposed Project scenarios overlapped only in critical years. However, in all water year types, interquartile ranges of survival were greater under the Proposed Project scenario.

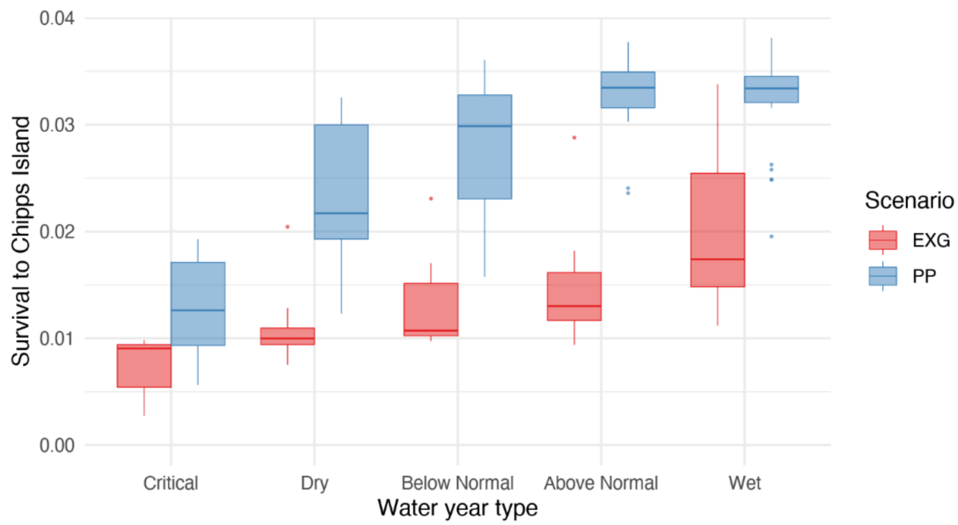


Figure 4.4-~~76~~77. Median Through-Delta Survival (Horizontal Line) with Interquartile Ranges (Boxes), Minimum and Maximum Values (Vertical Lines) for Juvenile San Joaquin River-origin Spring-run Chinook Salmon under the Proposed Project (PP) and the Existing Conditions (EXG). Values were summarized by water year-type over the 82-year CalSim period

Through-Delta survival impacts as represented by the San Joaquin River Structured Decision Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40% to 60% (see Appendix H).

STARS

The STARS model provides an assessment of potential differences between the Proposed Project and Existing Conditions scenarios in travel time, migration routing, and survival of juvenile Chinook Salmon emigrating from the Sacramento River through the Delta. The STARS model provides causal inference (flow affects routing and travel time which ultimately affects survival) based on studies conducted on Late Fall-run Chinook Salmon and the results contain some degree of uncertainty that comes with making predictions on out-of-sample conditions (i.e., predictions for Spring-run Chinook Salmon entering the Delta at different sizes and during different time periods). A complete description of the STARS model, limitations and assumptions, and the results of this analysis are provided in Appendix E (see Attachment 1, "Using the STARS Model to Evaluate the Effects of the Proposed Project on Juvenile Salmon Survival, Travel Time, and Migration Routing for the Long-Term Operation of the State Water Project Incidental Take Permit Application and CEQA Compliance").

Peak movement of juvenile Spring-run Chinook Salmon in the Sacramento River at Knights Landing generally occurs in December and again in March. However, juveniles also have been observed migrating between November and the end of May (Snider and Titus 1998, 2000a, 2000b, 2000c; Vincik et al. 2006; Roberts 2007). YOY Spring-run Chinook Salmon presence in the Delta peaks during April and May, as suggested by the recoveries of Chinook Salmon in the CVP and SWP salvage operations and the Chipps Island trawls of a size consistent with the predicted size of Spring-run fish at that time of year.

Run-specific analyses are not conducted using the STARS model. Rather, a daily analysis of juvenile Chinook Salmon entry into the Delta was conducted from October through June, which encompasses the Spring-run Chinook Salmon migration period. However, the discussion of the STARS model results for Spring-run Chinook Salmon considered the months of November through May based on the time period when they could potentially rear and emigrate from Delta.

The analysis revealed that overall, there generally was little difference in predicted survival between the Proposed Project and Existing Conditions scenarios (Figure 4.4-71). Specifically, the STARS model results suggest little difference in predicted through-Delta survival of Spring-run Chinook Salmon between the Proposed Project and Existing Conditions scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December. Although the STARS analysis showed decreases in Chinook Salmon survival under the Proposed Project scenario associated with entrainment into the Delta during November in all water year types (Figure 4.4-71), the difference was attributed mainly to DCC operations. Further, these differences in survival during November may not necessarily be applicable to emigrating Spring-run Chinook Salmon because it is likely that Spring-run Chinook Salmon emigrating out of the Sacramento River during November are yearling fish that may exhibit differences in susceptibility to routing into the Delta from the Late Fall-run Chinook Salmon used to develop the model. Therefore, the differences between the Proposed Project and Existing Conditions scenarios in outmigrant survival, as influenced by routing (entrainment into the interior Delta) and travel time, are not considered a substantial impact on the outmigrating Spring-run Chinook Salmon population.

Through-Delta survival impacts as represented by the STARS Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40% to 60%, depending on the month and water year type (see Appendix H).

Rearing Effects

The analysis of potential rearing effects provided for Winter-run Chinook Salmon is also applicable to Spring-run Chinook Salmon and indicates little potential for negative effects of the Proposed Project relative to Existing.

Water Transfers

Expansion of the water transfer window to include July to November would be expected to have limited overlap with Spring-run Chinook Salmon occurrence in the Delta. Yearlings generally may migrate in winter (as indicated by monitoring of Late Fall-run surrogate fish for entrainment management) and young-of-the-year Spring-run Chinook Salmon migrate through the Delta in spring, so potential for take would be limited.

Annual O&M Activities-related Impacts

Annual O&M activities that could potentially affect Spring-run Chinook Salmon include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities, including:
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance, including:
  - Aquatic Weed Control Program

The annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. These activities likely would have limited impacts on Spring-run Chinook Salmon when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.

Project Environmental Protective Measure-related Impacts

Environmental Protective Measures that could potentially affect Spring-run Chinook Salmon include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are expected to minimize operations-related impacts on Spring-run Chinook Salmon, improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Spring-run Chinook Salmon

Spring-run Chinook Salmon inhabit areas of the Delta that could be affected by the Proposed Project during the adult migration and juvenile rearing to outmigrating portions of their life cycle. Potential operations-related changes to migration and rearing habitat attributes, outmigrant survival, entrainment into the Delta from the Sacramento River, and entrainment at SWP facilities were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures.

The analyses conducted for each life stage of Spring-run Chinook Salmon, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of Spring-run Chinook Salmon are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on Spring-run Chinook Salmon, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

Fall-run and Late Fall-run Chinook Salmon

Conceptual Model

The SAIL conceptual model was prepared especially for Sacramento River Winter-run Chinook Salmon, but the cause and effects relationships it diagrams generally apply to the Fall-run and Late Fall-run Chinook Salmon populations in Sacramento River. Therefore, the analysis of changes in flows in the reach of the Sacramento River from the Feather River Confluence to the Delta and the potential impacts on adult Fall-run and Late Fall-run Chinook Salmon will be discussed in a similar manner as described for Winter-run Chinook Salmon. In addition, evaluation of juvenile habitat attributes potentially affected by the Proposed Project are evaluated in a similar manner to those described for Winter-run Chinook Salmon. The differences in the analyses between Winter-run Chinook Salmon and Spring-run Chinook Salmon are primarily associated with the differences in life stage timing.

Adult Fall-run Chinook Salmon immigrate into the Sacramento River generally from July through December and adult Late Fall-run Chinook Salmon immigrate generally from October through April.

Juvenile Fall-run Chinook Salmon emigrate to the Delta and ocean from December through June and Late Fall-run Chinook Salmon juveniles rear and emigrate year-round.

Operations-related Impacts

<u>**Immigrating Adults**</u>

Adult Fall-run Chinook Salmon of Sacramento River basin origin use the lower Sacramento River between the Delta and the confluence with the Feather River as a migration corridor. These immigrating adults can be present from July through December. Late Fall-run Chinook Salmon adults immigrate from October through April. During all months of the immigration period, average monthly simulated flows under the Proposed Project are slightly higher than under the Existing Conditions scenario except during November. During these periods, changes in simulated average monthly flows at Freeport under the Proposed Project, relative to the Existing Conditions scenario are generally relatively small (see Figure 4.4-58, Figures 4.4-59 through 4.4-63, and Table 4.4-15) and flows at Freeport are considered similar under the Proposed Project and Existing Conditions scenarios during most months of the year.

Because flows are generally similar under the Proposed Project and Existing Conditions scenarios, it is expected that habitat attributes such as water temperature, dissolved oxygen concentrations, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.3 feet (Appendix C, Table 1-2-1,), which would not likely reduce migration opportunities. In addition, little potential for differences in rates of straying exist for adult Fall-run Chinook Salmon between the Proposed Project and Existing Conditions scenarios. Specifically, other salmonids in the same genus (i.e., closely related to Chinook Salmon) such as adult Sockeye Salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989). Under the assumption that Sockeye Salmon responses to changes in olfactory cues are similar to those of Winter-Run Chinook Salmon, potential impacts of the Proposed Project on immigrating adult Spring-run Chinook Salmon in the Sacramento River are expected to be similar to those under the Existing Conditions scenario. Evidence from the Bay-Delta suggests that straying rates of Sacramento River basin hatchery-origin Chinook Salmon were very low (<1%) during the period from 1979 through 2007 (Marston et al. 2012), indicating that even across a wide range of differences in flow, straying is very low.

In the North Delta, migrating fish have multiple potential pathways as they move upstream into the Sacramento or Mokelumne river systems. Marston et al. (2012) studied stray rates for immigrating San Joaquin River basin adult salmon that stray into the Sacramento River basin. Results indicated that it was unclear whether reduced San Joaquin River pulse flows or elevated exports caused increased stray rates. The DCC, when open, can divert fish as they outmigrate along this route. The opening of the DCC when Salmon are returning to spawn to the Mokelumne and Cosumnes rivers is believed to lead to increased straying of these fish into the American and Sacramento rivers because of confusion over olfactory cues. Experimental DCC closures have been scheduled during the Fall-run Chinook Salmon migration season for selected days, coupled with pulsed flow releases from reservoirs on the Mokelumne River, in an attempt to reduce straying rates of returning adults. These closures have corresponded with reduced recoveries of Mokelumne River hatchery fish in the American River system and increased returns to the Mokelumne River hatchery (EBMUD 2012). However, the DCC is not an SWP facility and SWP facilities would not alter DCC operations. Therefore, the Proposed Project would not be expected to alter straying rates of Mokelumne River Fall-run Chinook Salmon.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on immigrating adult Fall-run and Late Fall-run Chinook Salmon the simulated Freeport flows include the combined impacts of the SWP and CVP. The

SWP is responsible for between approximately 20% to 60% of Delta water operations during the July through December Fall-run Chinook Salmon immigration period and between approximately 40% to 60% of Delta water operations during the October through April Late Fall-run Chinook Salmon immigration period, depending on month and water year type (see Appendix H).

Delta Hydrodynamic Assessment and Salmonid Junction Entry

In considering changes in flow proportion impacts, it is important to consider when juvenile salmon of various races may be present in the Delta. Juvenile Fall-run Chinook Salmon abundance in the Delta is greatest between February and May, whereas Late Fall-run Chinook Salmon are present in the Delta between November and July, with peaks in the January-February and April-May periods. Coded-wire-tagging and acoustic-tagging studies suggest few juvenile Chinook Salmon entering the Delta from the Sacramento River would be exposed to velocity changes observed in the South Delta under the Proposed Project scenario (e.g., Zeug and Cavallo 2014). Specifically, less than 1% of Fall-run Chinook Salmon and less than 2% of Late Fall-run Chinook Salmon are likely to approach the South Delta (Zeug and Cavallo 2014). Fish passing through the DCC or Georgiana Slough and continuing to migrate westward in the mainstem San Joaquin River would be expected to experience no velocity changes likely to influence their survival or behavior. Fish that move southward enough in the corridors of the Old and Middle rivers to reach areas of altered velocities may be more likely to continue moving toward the export facilities and become vulnerable to entrainment. Though the geographic footprint of velocity changes is relatively small, greater exports under the Proposed Project during April and May could affect a greater number of Fall-run and Late Fall-run Chinook Salmon juveniles than under the Existing Conditions scenario.

For Fall-run Chinook Salmon from the San Joaquin River basin, the absence of the HORB under the Proposed Project causes relatively large differences to velocities in the mainstem San Joaquin River between approximately Mossdale and Stockton. Velocities upstream of the HOR are higher under the Proposed Project (without HORB) and have the potential to be beneficial to juvenile Chinook Salmon and steelhead by increasing their migration rate. This increase in velocity occurs when HORB is not installed because the presence of the HORB creates hydraulic head that slows upstream velocities and the impact is stronger with higher San Joaquin River flows. However, velocities downstream of the HOR under the Proposed Project are reduced and may offset the potential benefit of increased velocities upstream of HOR. The absence of HORB under the Proposed Project will allow more San Joaquin River origin juvenile salmonids to pass through Old River and the Grant Line Canal and approach the export facilities. While this routing increases entrainment risk for these fish, available coded-wire-tagging and acoustic-tagging studies indicate survival in this region is very poor generally and not adversely influenced by export rates (SST 2017). Entrainment at the CVP has been observed to yield higher through-Delta survival (via trucking) than volitional migration through the Delta by other routes, even with positive OMR conditions (Buchanan et al. 2018; SJRGA 2011, 2013). Though entrainment has the potential to increase during April and May due to increased exports under the Proposed Project scenario in these months, through-Delta survival of juvenile Fall-run Chinook Salmon originating from the San Joaquin River basin may not be impaired by these operations, relative to the Existing Conditions scenario.

The junction routing analysis for the HOR junction, the flow proportion indicates the proportion of flow moving into the Old River route and toward the CVP and SWP export facilities and is relevant for juvenile Fall-run Chinook Salmon emigrating from the San Joaquin River basin. Thus, lower flow proportion values indicate decreased flow toward the export facilities. Flow proportion into the Old River varied by month and water year type. Differences between the Proposed Project and Existing Conditions scenarios were apparent in November, April, and May (Figure 4-~~72~~73). For these months, flow proportion into the Old River route is higher under the Proposed Project scenario in all water year types, but the differences were clearest and most substantial in below-normal and drier years. In dry years, flow proportion into the Old River route was 40% greater under the Proposed Project than under the Existing Conditions scenario. Results for April and May in wet, above-normal, and below-normal water years were highly variable for the Existing Conditions scenario because placement of the HORB was variable under wetter conditions (the barrier was assumed not to be installed at Vernalis flow >5,000 cfs). This change in flow proportion indicates juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are much more likely to enter the Old River route under the Proposed Project than under the Existing Conditions scenario. Juvenile Fall-run Chinook Salmon originating from the Sacramento River basin would not encounter the HOR junction and would therefore not be affected by these differences. No juvenile salmon are expected to be emigrating from the San Joaquin River basin in November, so differences in this month do not have biological significance. All juvenile salmon emigrating from the San Joaquin River basin must pass through the HOR junction. Thus, the Proposed Project is expected to result in an increased proportion of juvenile salmon passing through the Old River route. However, recent acoustic tagging studies indicate no difference in survival for fish migrating through the Old River route relative to fish continuing through the San Joaquin River route (Buchanan et al. 2018). It is also important to note that although the Proposed Project does not include installation of the HORB, Fall-run Chinook Salmon juveniles may receive some ancillary protection during April and May from the risk assessment-based approach for OMR flow management included in the Proposed Project that would be undertaken for other species.

These hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the period evaluated for San Joaquin River basin Fall-run Chinook Salmon (November–April) is approximately 40% to 60%, depending on the month and water year type (see Appendix H).

Mokelumne River Fall-run Chinook Salmon Junction Analysis

Juvenile Fall Run Chinook Salmon originating from the Mokelumne River must migrate through the mainstem San Joaquin River on their way to Chipps Island. Once these fish enter the San Joaquin River, they can potentially enter channels leading to the export facilities (corridors of the Old and Middle rivers) where hydrodynamic impacts of pumping are more likely to occur, and potentially cause entrainment at higher rates than Sacramento River Fall-run Chinook Salmon. The primary junctions where fish would be routed south are the junction of Old River and the San Joaquin River (hereafter the ORV) and the junction of Middle River and the San Joaquin River (hereafter the MRV). To estimate changes in the potential for Mokelumne River-origin Fall-run Chinook Salmon to be routed into the South Delta as a result of the Proposed Project, the proportion of water entering the ORV and the MRV under the Proposed Project and Existing Conditions modeling scenarios was compared (see the method description provided in Appendix E). Results were summarized from November through June for each water year type.

Middle River Junction

The MRV is located on the San Joaquin River mainstem upstream of the junction of the Mokelumne River and the San Joaquin River. Fall-run Chinook Salmon originating from the Mokelumne River could encounter this junction if they use distributary routes on the South Fork of the Mokelumne or if they migrate east at the junction of the Mokelumne River and the San Joaquin River. For the MRV, flow proportion indicates the proportion of flow away from the San Joaquin River. Thus, higher flow proportion values indicate increased flow south toward the export facilities. Differences between the Proposed Project and Existing Conditions scenarios were minimal in all months of each water year type (<1%; Figure 4.4-~~77~~78). The largest differences were observed in April and May of wet and above-normal year types. However, mean differences in April and May were always less than 1%. This small change in flow proportion indicates juvenile salmon reaching the MRV are likely to continue moving southward under the Proposed Project at a rate similar to the rate under the Existing Conditions scenario. Little information is currently available regarding the fraction of Mokelumne River-origin juvenile Chinook Salmon passing through the Delta that are likely to arrive at Middle River.

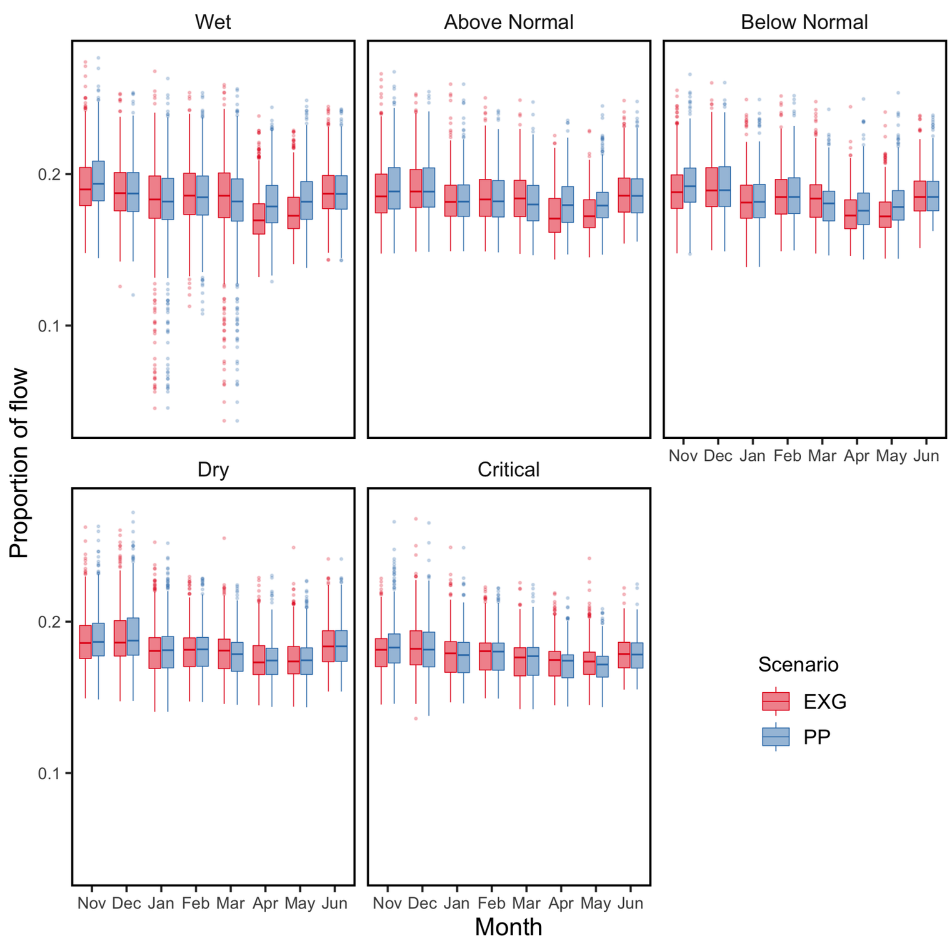


Figure 4.4-~~77~~78. Box and Whisker Plots of the Proportion of Flow Entering the Middle River Junction with the San Joaquin River. Proportions were summarized for the Proposed Project and Existing Conditions scenarios between November and June for each water year-type

Old River Junction

The ORV is located on the San Joaquin River mainstem just upstream of the junction of the Mokelumne River and the San Joaquin River and downstream of the junction with Middle River. Fall-run Chinook Salmon originating from the Mokelumne River could encounter this junction if they use distributary routes on the South Fork of the Mokelumne and then move west on the San Joaquin River or if they migrate east at the junction of the Mokelumne and San Joaquin rivers. For the ORV, flow proportion indicates the proportion of flow away from the San Joaquin River. Thus, higher flow proportion values indicate increased flow south toward the export facilities. Differences between the Proposed Project and Existing Conditions modeling scenarios were minimal in all months of each water year type (<1%; Figure 4.4-~~78~~79). The largest differences were observed in April and May of wet and above-normal year types. However, mean differences in April and May were always less than 0.7%. This small change in flow proportion indicates juvenile salmon reaching the ORV are likely to continue moving southward at a similar rate under the Proposed Project as they do under the Existing Conditions scenario. Little information is currently available about the fraction of Mokelumne River-origin juvenile Chinook Salmon passing through the Delta that are likely to arrive at Old River.

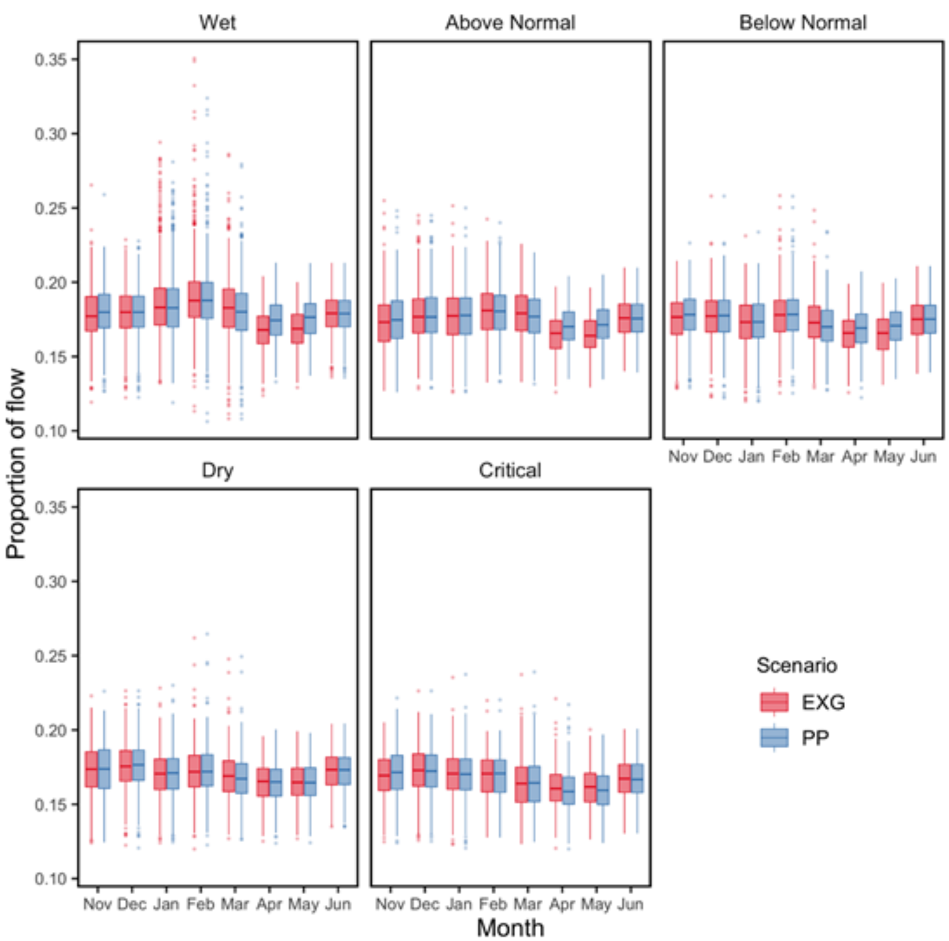


Figure 4.4-~~78~~79. Box and Whisker Plots of the Proportion of Flow Entering the Old River Junction with the San Joaquin River. Proportions were summarized for the Proposed Project and Existing Conditions scenarios between November and June for each water year-type

These hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the period evaluated for Mokelumne River Fall-run Chinook Salmon (November through April) is approximately 40% to 60%, depending on the month and water year type (see Appendix H).

Mokelumne River Fall-run Chinook Salmon Qualitative Discussion

Greater April-May South Delta export pumping under the Proposed Project would have the potential to result in greater entrainment loss of juvenile Mokelumne River Fall-run Chinook Salmon emigrating from the Mokelumne River than under the Existing Conditions scenario. However, available data on coded-wire tag releases suggests that historical entrainment losses have represented a small percentage of the population. During the 1992-2006 period, the total number of fish released in the Mokelumne River was around 25-26 million[10]; of these, an average of 9% were coded-wire-tagged (Workman 2018a, p.181), suggesting that around 2.25 million coded-wire-tagged juvenile Fall-run Chinook Salmon were released. The number of coded-wire-tagged fish released in the Mokelumne River that were recovered at the South Delta export salvage facilities during the 1992-2006 period was 292 (Workman 2018b, Figure 3). The loss represented by the number of fish counted in salvage requires expansion to account for the fraction of time that salvage was being sampled and for losses due to factors such as predation. The fraction of time that salvage was sampled during these years was around 11% to 19%[11], so a conservative multiplier of 10 is used for illustrative purposes. A multiplier of 4.33 was used to account for losses such as predation, which represents the SWP multiplier typically used (Workman [2018b] does not identify the facility where the fish recovered, but the SWP multiplier is conservatively used as it is higher than the CVP multiplier). Thus, with these assumptions, the estimated entrainment loss of Mokelumne River Fall-run Chinook Salmon would have been around 292 * (100/10) * 4.33 = around 12,600 fish. This loss would have represented around 0.6% of the total release.

For the 2007-2014 period, Workman (2018b, Figure 3) stated that 194 coded-wire-tagged fish were recovered at the salvage facilities. In more recent years, the fraction of time that salvage was sampled increased, ranging from around 18% to near 30%. Assuming the lower end of this range and applying the 4.33 multiplier to account for predation and other factors, the estimated entrainment loss of coded-wire-tagged fish during the 2007-2014 period could have been on the order of 194 * (100/18) * 4.33 = 4,700 fish. Considerably fewer coded-wire-tagged fish were released in the Mokelumne River during the 2007-2014 period; most releases occurred in the west Delta (Workman 2018b, Figure 3). It is unclear how many of these fish specifically were released in the river based on Workman (2018a, p.181), but the data compilation by Sturrock et al. (2019) suggests that around 4.2 million were

[10] Workman (2018a, p.181) in response to cross-examination regarding the number of coded-wire-tagged fish released in river during 1992-2006 stated that “an average of 9% of the Mokelumne River production was tagged in those years, and that is approximately 26 million fish”; this appears in rough agreement with the data collated by Sturrock et al. (2019) if limiting the data to Mokelumne River releases in April and May (for all months together, the total increases to just over 38 million fish).

[11] Salvage data are available at ftp://ftp.wildlife.ca.gov/salvage/.

released[12]. Given a coded-wire-tag fraction of 31% (Workman 2018a, p.181), this would suggest that around 1.3 million coded-wire-tagged fish were released in the Mokelumne River during the 2007-2014 period. Thus, the loss estimate of around 4,700 juvenile Fall-run Chinook Salmon in the 2007-2014 period could have represented around 0.4% of the total number released. As illustrated in the DSM2-HYDRO velocity analysis, little difference would be expected between the Proposed Project and Existing Conditions operational scenarios in the hydrodynamics of the lower San Joaquin River, where Mokelumne River Fall-run Chinook Salmon would enter the Delta (larger differences between scenarios are limited to the southern half of the South Delta, as illustrated in Figure 4.4-66).

Based on observed historical coded-wire tagging studies showing small proportions of Mokelumne River Fall-run Chinook Salmon entrained and based on the high pumping rates that occurred during the 1992-2006 period when those studies were conducted, greater April-May South Delta export pumping under the Proposed Project would not be expected to substantially impact Mokelumne River Fall-run Chinook Salmon. The Mokelumne River Chinook Salmon junction analysis described above shows similar conclusions.

These hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the period evaluated for ~~San Joaquin~~Mokelumne River basin Fall-run Chinook Salmon (November–April) is approximately 40% to 60%, depending on the month and water year type (see Appendix H).

Entrainment

Entrainment Loss Density

Analysis of potential differences in entrainment loss of Fall-run and Late Fall-run Chinook Salmon juveniles between the Proposed Project and Existing Conditions scenarios was undertaken with the salvage-density method, as described for the other races of Chinook Salmon. The same caveats including those regarding length-at-date classification and the appropriate use of these results that are described for the other races also apply to Fall-run and Late Fall-run Chinook Salmon. In addition, as described for Winter-run Chinook Salmon, all months are evaluated in this analysis but only those Chinook Salmon that were reported as Fall-run and Late Fall-run Chinook Salmon based on their length at the time of salvage were included in the weighting and subsequent reporting of loss density.

The salvage-density method suggested that entrainment loss of juvenile Fall-run Chinook Salmon at the SWP South Delta export facility could be appreciably greater under the Proposed Project scenario compared to the Existing Conditions scenario (Table 4.4-18). This is because considerable juvenile Fall-run Chinook Salmon entrainment occurs during the April–May period when the largest difference in South Delta exports is projected to occur between Existing Conditions and Proposed Project scenarios. As described for the other races of Chinook Salmon, it should be noted that the analysis herein is based on size-at-date criteria, and does not reflect potential errors in Chinook Salmon race identification

[12] As in the calculation for the 1992-2006 period, Sturrock et al.'s (2019) data were limited to releases in the Mokelumne River in the months of April and May. For all months of the year, the total released was around 4.7 million; had this number been used in the calculation, the percentage entrainment loss would have been lower.

Table 4.4-18. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-18 a – Table 4.4-18 f

Table 4.4-18 a. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,313	3,603	1,866	2,398	12,381	13,764	401	29	34	4	72	88
Proposed Project	1,251	3,691	1,611	6,148	33,076	13,593	396	29	33	4	94	88

Table 4.4-18 b. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	31	4,455	1,635	3,124	7,775	4,217	76	24	796	0	6	7
Proposed Project	31	4,248	1,278	11,810	32,033	4,208	77	24	781	0	8	8

Table 4.4-18 c. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	18	1,074	856	1,877	302	4	0	0	0	0	6
Proposed Project	0	19	888	3,208	6,599	299	3	0	0	0	0	6

Table 4.4-18 d. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	5	17	554	5,830	7,034	119	0	2	0	89	8	266
Proposed Project	6	18	448	13,720	14,936	117	0	2	0	100	10	285

Table 4.4-18 e. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	10	9	213	1,483	220	0	0	0	8	13	0
Proposed Project	1	10	10	308	1,826	225	0	0	0	8	19	90

Table 4.4-18 f. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	35,953	22,147	4,138	13,925	2,059
Proposed Project	60,015	54,507	11,023	29,642	2,497
Proposed Project vs. Existing	24,062 (67%)	32,360 (146%)	6,885 (166%)	15,717 (113%)	437 (21%)

based on these criteria (Harvey et al. 2014). Fall-run Chinook Salmon juveniles may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in the Proposed Project, which would be implemented in real time to protect CESA- or ESA-listed salmonids and smelts. Available data from studies of marked juvenile Fall-run Chinook Salmon suggest that losses at the salvage facilities comprise a small percentage of Delta migration mortality (e.g., ~0.1% of fish from the Sacramento River and ~2% of fish from the San Joaquin River) (Zeug and Cavallo 2014). In addition, less than 1% of Sacramento River Fall-run Chinook Salmon enter the Delta as indicated by coded-wire-tag studies (Zeug and Cavallo 2014); this suggests that increases in salvage would result in impacts on a very small proportion of the Fall-run Chinook Salmon population. Therefore, potential increases under the Proposed Project would also be expected to be a small percentage of overall Delta mortality.

The salvage-density method suggested that there would be little difference in potential entrainment loss of Late Fall-run Chinook Salmon between Existing Conditions and Proposed Project scenarios (Table 4.4-19), reflecting relatively little difference in potential South Delta exports during the main salvage period for Late Fall-run Chinook Salmon.

Outmigrant Survival

Delta Passage Model

Central Valley Fall-run Chinook Salmon

The DPM integrates operational impacts of the Existing Conditions and Proposed Project scenarios that could influence through-Delta survival of migrating juvenile Chinook Salmon smolts, including Central Valley Fall-run Chinook Salmon. Functions included in the DPM include reach-specific flow-survival and flow travel-time relationships, flow-routing relationships and export-survival relationship. Uncertainty in the quantitative relationships included in the DPM were integrated into the analysis using Monte Carlo techniques. One hundred iterations of the model were run for each scenario where distributions for each parameter were resampled for each iteration. Model output reported here is annual through-Delta survival in the 82-year CalSim period and through-Delta survival aggregated by water year-type. Additional details of the method are provided in Appendix E.

Across the 82-year simulation period, mean through-Delta survival was not greatly different between Proposed Project and Existing Conditions scenarios (0.5% greater for the Existing Conditions scenario (22.8%, 95% CI 21.1-24.5), relative to the Proposed Project scenario (22.3%, 95% CI 22.3-24.0)). Survival was greater under the Existing Conditions scenario for 58 of the 82 years, and was greater under the Proposed Project in 24 years (Figure 4.4-~~79~~80). Differences in individual years were generally small (< 1.5%), with the largest difference occurring in the 1941 model year when survival under the Existing Conditions scenario was 2.0 % higher than under the Proposed Project scenario. Confidence intervals for mean through-Delta survival overlapped between scenarios in all years.

For both scenarios, mean survival rates tracked water year type, with the highest values in wet years and the lowest values in critical years (Figure 4.4-~~80~~81). Mean through-Delta survival was greater for the Existing Conditions scenario relative to the Proposed Project scenario in wet, above-normal, and below-normal years, and was higher under the Proposed Project in dry and critical water year types

Table 4.4-19. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-19 a – Table 4.4-19 f

Table 4.4-19 a. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	765	5	0	0	0	0	0	4	1	8	8	680
Proposed Project	729	5	0	0	0	0	0	4	1	9	10	683

Table 4.4-19 b. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	534	44	0	0	0	0	0	0	8	5	33	330
Proposed Project	539	42	0	0	0	0	0	0	8	6	44	336

Table 4.4-19 c. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	234	113	21	0	0	0	0	0	0	0	0	120
Proposed Project	249	117	17	1	0	0	0	0	0	0	0	123

Table 4.4-19 d. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	39	0	3	2	0	0	0	0	0	2	19	670
Proposed Project	42	0	2	4	0	0	0	0	0	2	22	719

Table 4.4-19 e. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	94	6	0	0	0	0	0	0	0	3	0	355
Proposed Project	105	6	0	0	0	0	0	0	0	3	0	317

Table 4.4-19 f. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	1,471	954	488	734	458
Proposed Project	1,441	976	508	790	430
Proposed Project vs. Existing	-30 (-2%)	21 (2%)	20 (4%)	56 (8%)	-28 (-6%)

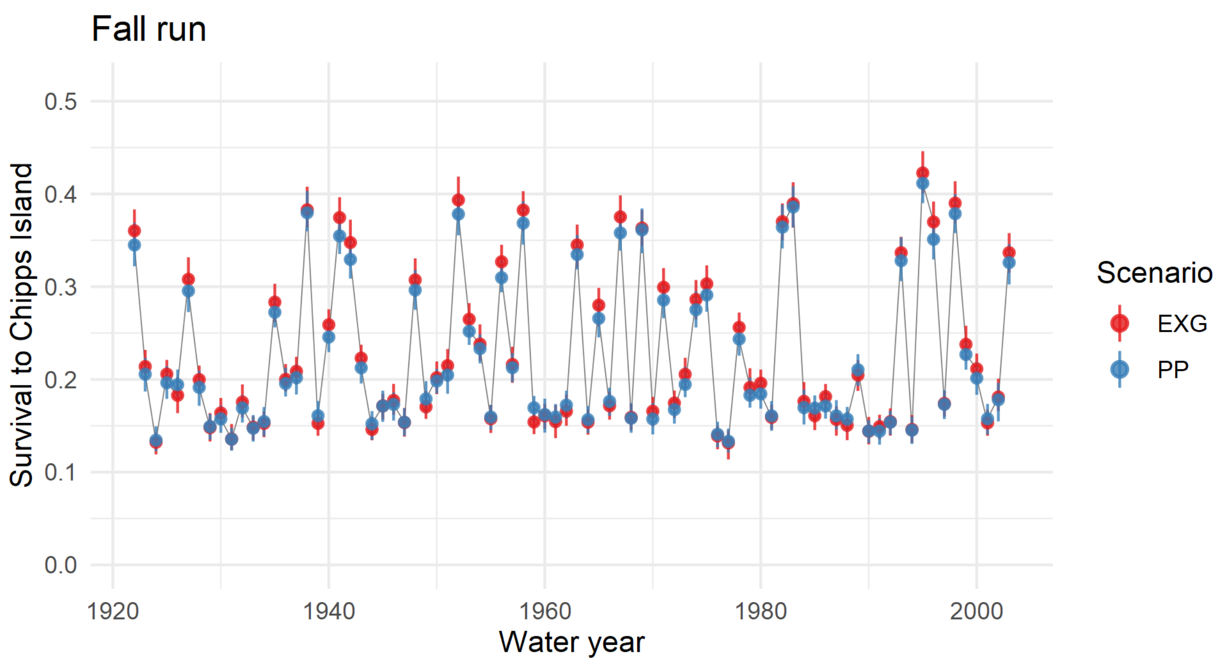


Figure 4.4-~~79~~80. Mean Estimates of Fall-run Chinook Salmon Through-Delta Survival with 95% Confidence Intervals for the Proposed Project and the Existing Conditions in Each Simulation Year

(Figure 4.4-~~80~~81). Although 95% confidence intervals for survival estimates overlapped between scenarios in each water year type, the largest difference occurred in wet years when mean survival for the Existing Conditions scenario was 1.1% higher than the Proposed Project. The smallest difference occurred in critical years when survival was 0.07% higher under the Proposed Project (Figure 4.4-~~80~~81).

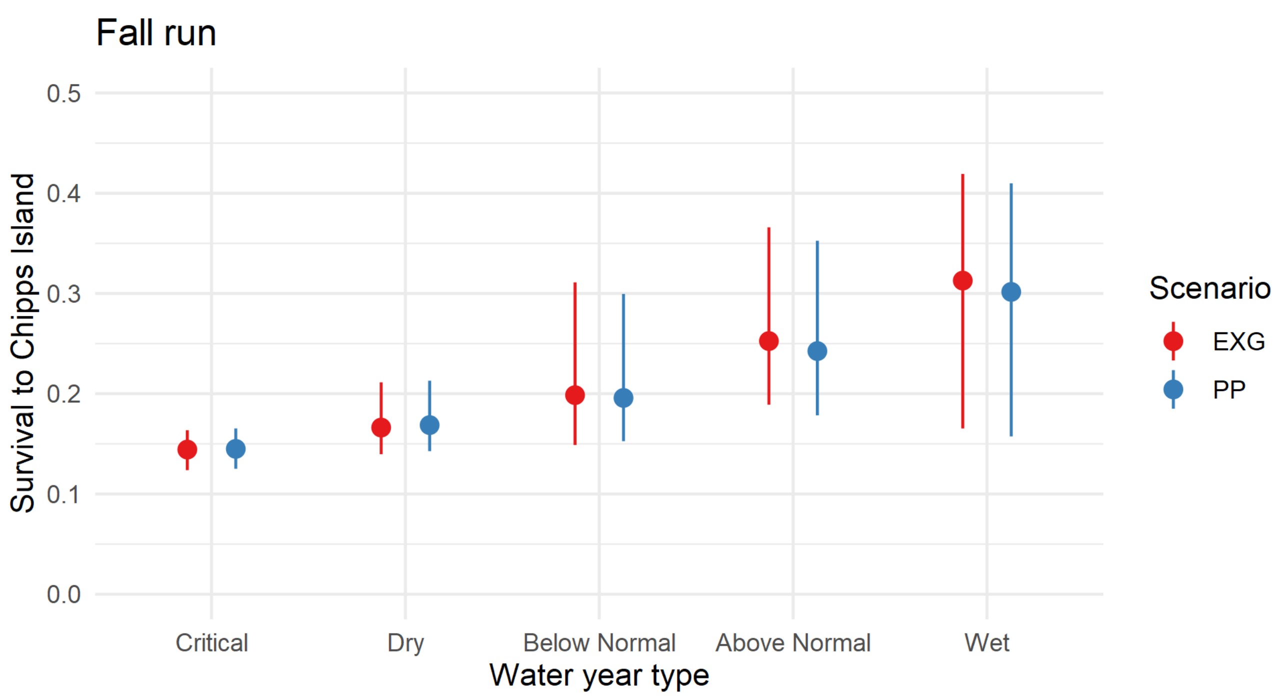


Figure 4.4-~~80~~81. Mean Through-Delta Survival with 95% Confidence Intervals for Juvenile Fall-run Chinook Salmon under the Proposed Project and the Existing Conditions. Values were summarized by water year-type over the 82-year CalSim period

Late Fall-run Chinook Salmon

Across the 82-year simulation period, mean through-Delta survival was 0.3% greater under the Existing Conditions scenario (22.0%, 95% CI 20.8-23.2), relative to the Proposed Project scenario (21.7%, 95% CI 20.4-22.9). Survival was greater under the Existing Conditions scenario for 57 of the 82 years and greater under the Proposed Project in 25 years (Figure 4.4-~~80~~81). Differences in individual years were generally small (< 1.0%), with the largest difference occurring in the 1975 model year when survival under the Existing Conditions scenario was 1.9 % higher than under the Proposed Project scenario. Confidence intervals for mean through-Delta survival overlapped between scenarios in all years.

For both scenarios, mean survival rates tracked water year type with the highest values in wet years and the lowest values in critical years (Figure 4.4-~~82~~83). Mean through-Delta survival was greater under the Existing Conditions scenario relative to the Proposed Project scenario in all water year types. However, differences were < 0.6% across all year types (Figure 4.4-~~82~~83). Although 95% confidence intervals for survival estimates overlapped between scenarios in each water year type, the largest difference occurred in wet years when mean survival for the Existing Conditions scenario was 0.56% higher than for the Proposed Project scenario. The smallest difference occurred in below-normal years when survival was 0.15% higher under the Existing Conditions scenario (Figure 4.4-~~82~~83).

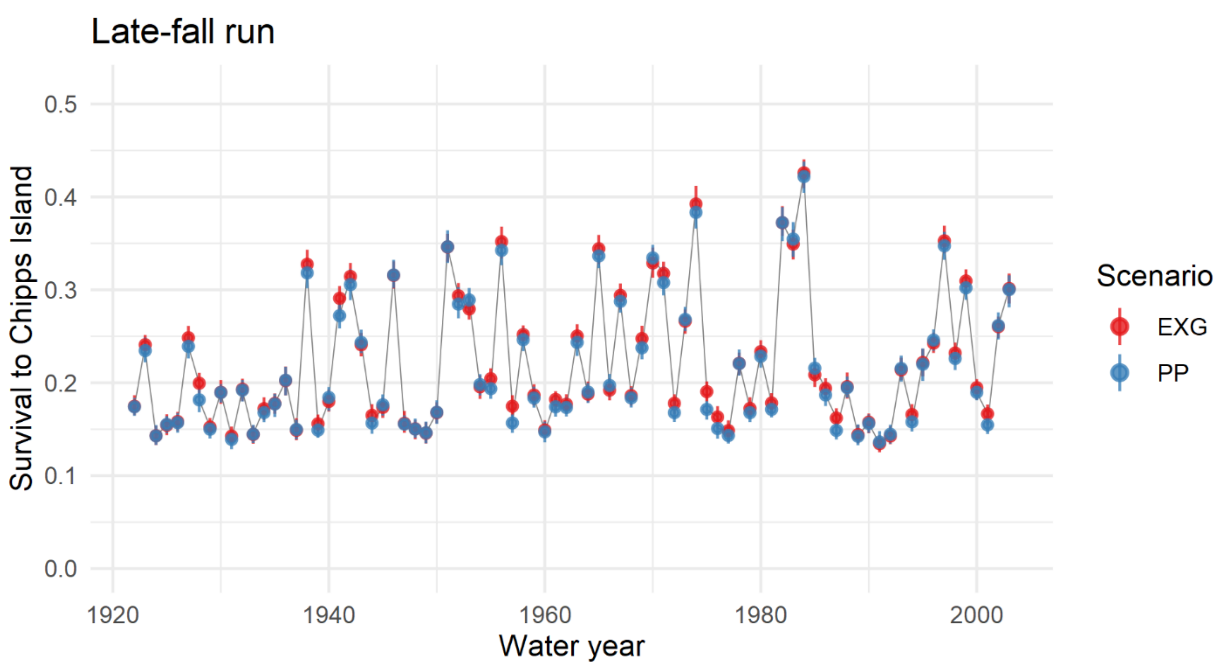


Figure 4.4-~~81~~82. Mean Estimates of Juvenile Late Fall-run Chinook Salmon Through-Delta survival with 95% Confidence Intervals for the Proposed Project and Existing Conditions in Each Simulation Year

Through-Delta survival impacts as represented by the DPM include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 20% to 60%, depending on the month and water year type (see Appendix H).

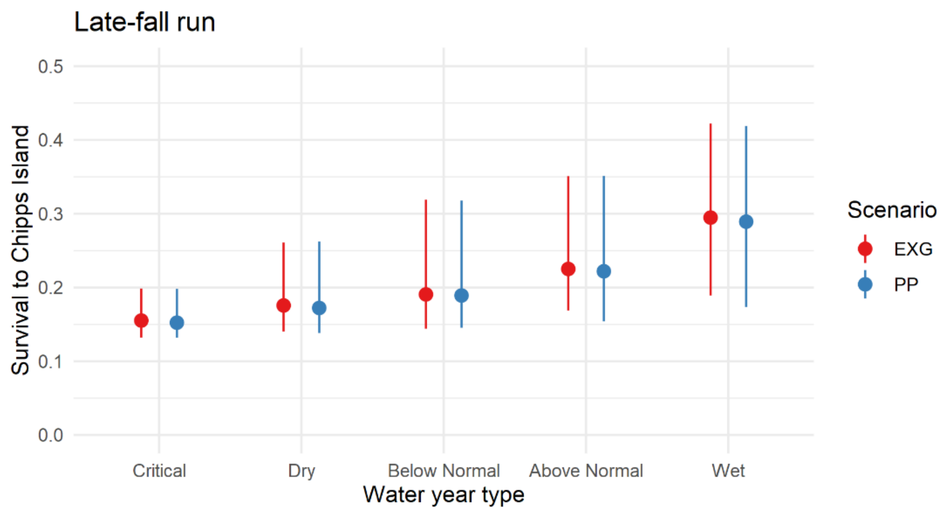


Figure 4.4-~~82~~83. Mean Through-Delta Survival with 95% Confidence Intervals for Juvenile Late Fall-run Chinook Salmon under the Proposed Project and the Existing Conditions. Values were summarized by water year-type over the 82-year CalSim period

San Joaquin River-Origin Fall-run Chinook Salmon Structured Decision Model

The Delta Structured Decision Model was developed by the Central Valley Project Improvement Act Science Integration Team to evaluate the impact of different management decisions on the survival and routing of juvenile Fall-run Chinook Salmon. The model relies on survival-environment relationships and routing-environment relationships from acoustic studies conducted in the Sacramento and San Joaquin rivers and at the State and Federal export facilities. Only results from the San Joaquin River submodel are reported. The model and documentation have not been finalized, and the code for the most recent version of the model that was used was accessed at https://github.com/FlowWest/chinookRoutingApp.

Survival results from the SDM model were estimated specifically for San Joaquin River-origin Fall-run Chinook Salmon by weighting daily survival values by the daily proportion of Fall-run Chinook Salmon captured in the Mossdale Kodiak trawl and reported as annual estimates and as aggregations by water year type.

Across the 82-year CalSim period through-Delta survival was low (< 4%) for both the Existing Conditions and Proposed Project scenarios (Figure 4.4-~~83~~84). Survival was higher under the Proposed Project scenario for all years, although the magnitude of the difference between scenarios was variable.

Through Delta survival under the both scenarios tracked water year-type with the highest values in wet years and the lowest values in critical years. However, the differences in survival between these water years is very small (Figure 4.4-~~84~~85). Interquartile ranges of survival were greater under the Proposed Project in all water year types although the range of survival values was small for both scenarios (Figure 4.4-~~84~~85).

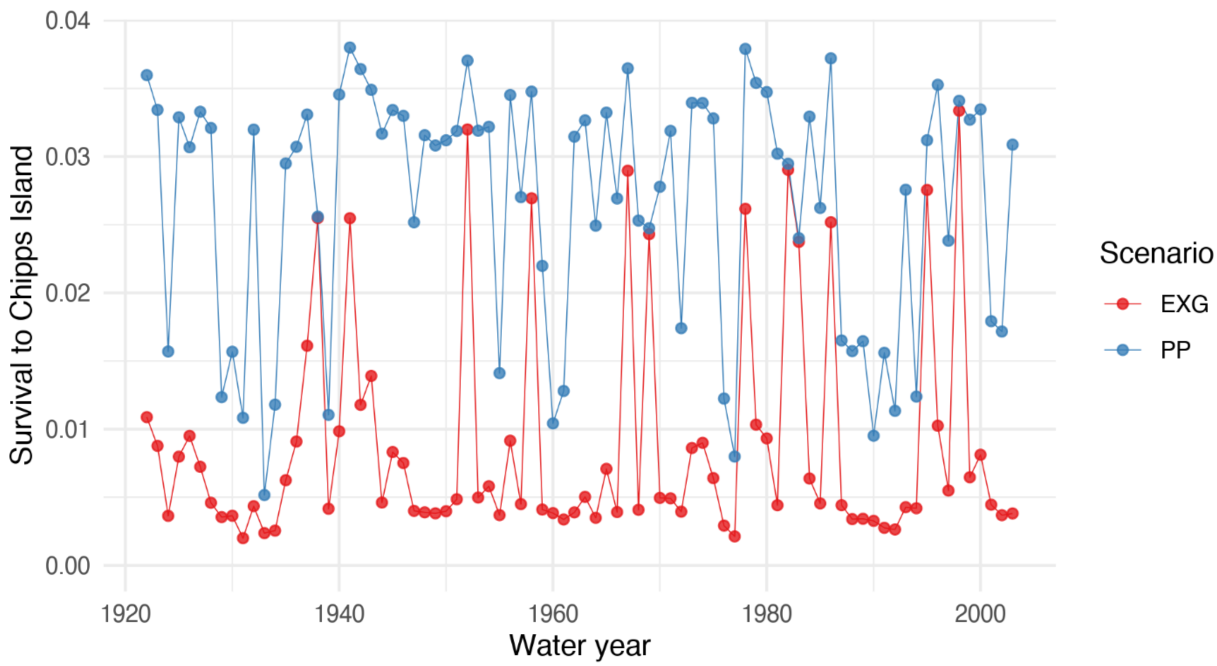


Figure 4.4-~~83~~84. Mean Estimates of San Joaquin River Fall-run Chinook Salmon Through-Delta Survival from for the Proposed Project (PP) and the Existing Conditions (EXG) in Each Simulation Year

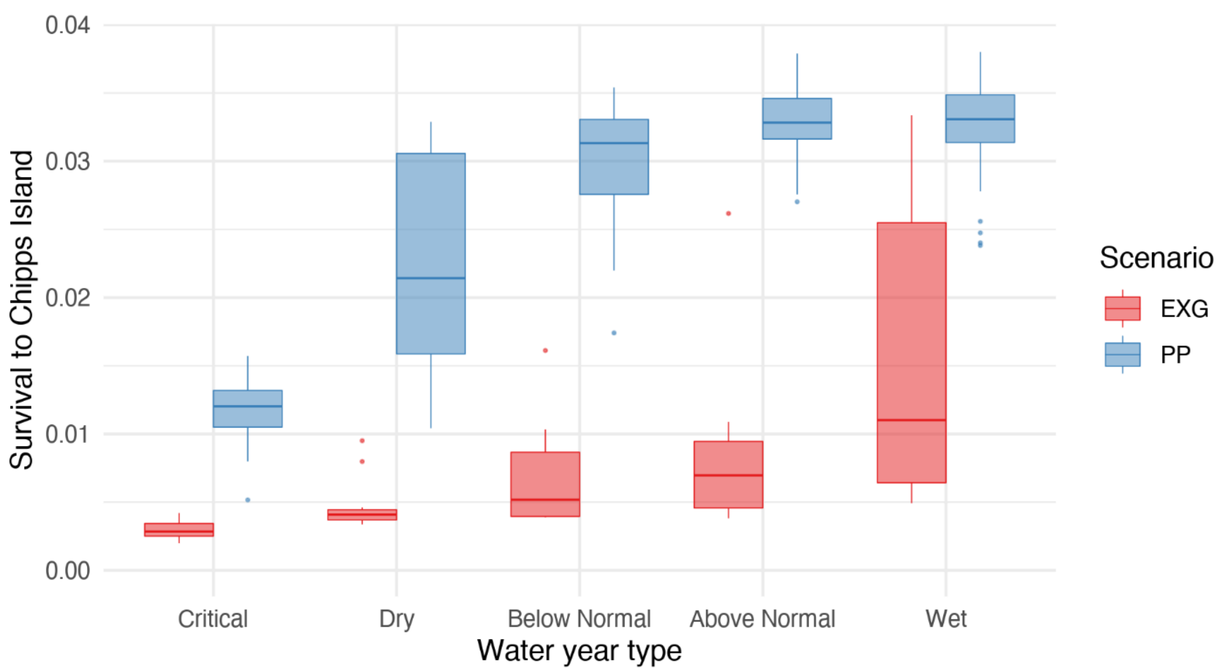


Figure 4.4-~~84~~85. Median Through-Delta Survival (horizontal line) with Interquartile Ranges (Boxes), Minimum and Maximum Values (Vertical Lines) for Juvenile San Joaquin River-origin Fall-run Chinook Salmon under the Proposed Project (PP) and the Existing Conditions (EXG). Values were summarized by water year-type over the 82-year CalSim period

Through-Delta survival impacts as represented by the Structured Decision Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 40% to 60%, depending on the month and water year type (see Appendix H).

STARS

The STARS model provides an assessment of potential differences between the Proposed Project and Existing Conditions scenarios in travel time, migration routing, and survival of juvenile Chinook Salmon emigrating from the Sacramento River through the Delta. The STARS model results suggest little difference in predicted through-Delta survival of Fall-run and Late Fall-run Chinook Salmon between scenarios, except for juveniles migrating before December. Fall-run Chinook Salmon outmigration occurs primarily from January through June and would not be affected by differences in routing that were modeled to occur during November. Late Fall-run Chinook Salmon fry rear in freshwater from April through the following April and outmigrate as smolts from October through February (Snider and Titus 2000a). Therefore, the differences between the Proposed Project and Existing Conditions scenarios in outmigrant survival, as influenced by routing (entrainment into the interior Delta) and travel time, are not considered a substantial impact on the outmigrating Fall-run and Late Fall-run Chinook Salmon population.

Through-Delta survival impacts as represented by the STARS Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 40% to 60%, depending on the month and water year type (see Appendix H).

Rearing Effects

The analysis of potential rearing effects provided for Winter-run Chinook Salmon is also applicable to Fall- and Late fall-run Chinook Salmon and indicates little potential for negative effects of the Proposed Project relative to Existing.

Water Transfers

Expansion of the water transfer window to include July to November would be expected to have limited overlap with Fall-run and Late Fall-run Chinook Salmon in the Delta, which occur primarily in the Delta primarily in winter and spring.

Annual O&M Activities-Related Impacts

Annual O&M activities that could potentially affect Fall- and Late Fall-run Chinook Salmon include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities, including:
    - Sediment Removal
    - Aquatic Weed Removal
- Clifton Court Forebay maintenance, including:
    - Aquatic Weed Control Program

The annual O&M activities listed above are ongoing activities that will continue under the Proposed Project scenario. These activities likely would have limited impacts on Chinook Salmon when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project scenario.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project scenario.

Project Environmental Protective Measure-Related Impacts

Environmental Protective Measures that could potentially affect Fall-run and Late Fall-run Chinook Salmon include:

- Clifton Court Forebay actions to reduce predation, including:
    - Continued evaluation of predator relocation studies
    - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements, including:
    - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
    - Continued refinement and improvement of the fish sampling and hauling procedures
    - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impact of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are expected to minimize operations-related impacts on Fall-run and Late Fall-run Chinook Salmon, improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Fall-run and Late Fall-run Chinook Salmon

Fall-run and Late Fall-run Chinook Salmon inhabit areas of the Delta that could be affected by the Proposed Project during the adult migration and juvenile rearing to outmigrating portions of their life cycle. Potential operations-related changes to migration and rearing habitat attributes, outmigrant survival, entrainment into the Delta from the Sacramento River, and entrainment at SWP facilities were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures.

The analyses conducted for each life stage of Fall-run and Late Fall-run Chinook Salmon, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of Fall-run and Late Fall-run Chinook Salmon are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on Fall-run and Late Fall-run Chinook Salmon, relative to the Existing Conditions scenario, and are considered **Less than Significant.**

Central Valley Steelhead

Conceptual Model

Central Valley Steelhead are present in the Sacramento River and Delta throughout the year. The SAIL conceptual model was prepared especially for life stage transitions of Sacramento River Winter-run Chinook Salmon, but the cause and impacts relationships it diagrams also apply to the Central Valley Steelhead population in Sacramento River. SAIL life stage transitions are the series of changes that these anadromous fish undergo throughout the life cycle. SAIL life stage transitions potentially affected by the Proposed Project in the Sacramento River from the confluence with the Feather River to the Delta include juvenile to subadult/adult and adult to spawning. Therefore, the analysis of changes in flows in the reach of the Sacramento River from the Feather River Confluence to the Delta and the potential impacts on adult Central Valley Steelhead will be discussed in a manner similar to that used to describe the impacts on Chinook Salmon. In addition, juvenile habitat attributes potentially affected by the Proposed Project are evaluated in a manner similar to that used for Chinook Salmon. The differences in the analyses between Winter-run Chinook Salmon and Spring-run Chinook Salmon are primarily associated with the differences in life stage timing.

Adult Central Valley Steelhead are present from July through March, and rearing and emigrating juveniles could be present year-round.

Operations-Related Impacts

Immigrating Adults

Adult Central Valley Steelhead use the lower Sacramento River between the Delta and the confluence with the Feather River from July through March for the purposes of immigration. During this period, changes in simulated average monthly flows at Freeport under the Proposed Project relative to the Existing Conditions scenario are generally relatively small (see Figure 4.4-58, Figures 4.4-59 through 4.4-63, and Table 4.4-15), and flows at Freeport are considered similar under the Proposed Project and Existing Conditions scenarios during most months of the year. In addition, the SWP is responsible for approximately 20% to 60% of Delta water operations, depending on the month and water year type.

Because flows are generally similar under the Proposed Project and Existing Conditions scenarios, it is expected that habitat attributes such as water temperature, dissolved oxygen concentrations, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach, depth and velocity is also anticipated to be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.3 feet (Table 1-2-1, Appendix C), which would not likely reduce migration opportunities. In addition, for adult steelhead, there is little potential for differences in rates of straying between the Proposed Project and Existing Conditions scenarios because other salmonids in the same genus (i.e., salmonids closely related to steelhead), such as adult Sockeye Salmon, detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989). Therefore, the potential impacts of the Proposed Project on immigrating adult steelhead in the Sacramento River are expected to be similar to those under the Existing Conditions scenario.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on immigrating adult Central Valley Steelhead. The simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for approximately 20% to 60% of Delta water operations during the July through March Central Valley Steelhead immigration period, depending on month and water year type (see Appendix H).

Delta Hydrodynamic Analysis

Based on the results of the Delta Hydrodynamic Analysis presented in the discussion of Winter-run Chinook Salmon above, changes in South Delta hydrodynamics could occur in the spring and fall under the Proposed Project scenario relative to the Existing Conditions scenario. Fish passing through the DCC or Georgiana Slough and continuing to migrate westward in the mainstem San Joaquin River will experience no velocity changes likely to influence their survival or behavior. Fish that move southward enough in the corridors of the Old and Middle rivers to reach areas of altered velocities may be more likely to continue moving toward the export facilities and become vulnerable to entrainment. However, velocity changes that could occur in the spring and fall are not likely to affect Central Valley Steelhead because most Central Valley Steelhead are expected to have exited the Delta by April and May and generally occur in low numbers in the region between September and November. In addition, implementing OMR management, including single-year and cumulative loss thresholds for steelhead, would limit entrainment.

Delta hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the April and May period, when changes to Delta hydrodynamics are greatest under the Proposed Project, is approximately 40% to 60%, depending on the month and water year type (see Appendix H).

Entrainment

Entrainment Loss Density

The entrainment loss-density method was used to assess potential differences in entrainment loss of steelhead juveniles between the Proposed Project and Existing Conditions scenarios. The same caveats described for other species apply to steelhead. Specifically, the estimates of entrainment loss obtained from the entrainment loss density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim-modeled differences in South Delta exports between the evaluated scenarios. Therefore, the results are basically a description of differences in export flows weighted by monthly loss density. Historical loss density numbers provide some perspective on the absolute numbers of fish being entrained, but are a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected. Although the emphasis is consideration of the relative difference between scenarios, it is important to appreciate that the modeling is limited in its representation of real-time adjustments to operations in order to minimize impacts on listed fishes, so that differences between scenarios are likely to be less than suggested by the method.

The salvage-density method suggested that entrainment loss of juvenile steelhead at the SWP South Delta export facility could be modestly greater under the Proposed Project scenario, relative to the Existing Conditions scenario ranging from 5% in above-normal years to 16% in wet years (Table 4.4-20), primarily because of increased exports during April and May. However, because the loss density method relies on CalSim results, this analysis does not account for real-time operational adjustments that would be undertaken to limit entrainment loss, including risk assessment for OMR management that includes consideration of factors such as salvage thresholds. Real-time OMR management, combined with the need to keep entrainment below the authorized take limit from the NMFS ROC on LTO Biological Opinion, would be expected to limit entrainment and salvage loss of steelhead juveniles.

Water Transfers

Expansion of the water transfer window to include July to November would be expected to have limited overlap with Steelhead in the Delta, which occur primarily in the Delta primarily in winter and spring.

Annual O&M Activities-related Impacts

Annual O&M activities that could potentially affect Central Valley Steelhead include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Table 4.4-20. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-20 a – Table 4.4-20 f

Table 4.4-20 a. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,277	1,362	2,010	443	318	347	20	2	3	8	10	28
Proposed Project	1,216	1,395	1,736	1,135	850	343	20	2	3	10	13	29

Table 4.4-20 b. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	3,720	5,436	2,058	248	197	82	12	0	0	0	30	325
Proposed Project	3,759	5,184	1,608	936	810	82	12	0	0	0	40	331

Table 4.4-20 c. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	309	2,756	2,184	254	106	48	5	0	0	0	0	14
Proposed Project	329	2,844	1,807	951	373	48	5	0	0	0	0	14

Table 4.4-20 d. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	476	2,056	2,995	471	151	42	18	0	0	1	33	82
Proposed Project	518	2,146	2,424	1,109	321	42	16	0	0	1	37	88

Table 4.4-20 e. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	84	1,481	540	155	77	27	5	0	0	0	4	0
Proposed Project	94	1,494	579	223	27	6	0	0	0	0	6	0

Table 4.4-20 f. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	5,829	12,107	5,677	6,326	2,373
Proposed Project	6,751	12,762	6,371	6,704	2,524
Proposed Project vs. Existing	923 (16%)	655 (5%)	694 (12%)	378 (6%)	151 (6%)

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. These activities likely would have limited impacts on steelhead when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.

Project Environmental Protective Measure-related Impacts

Environmental Protective Measures that could potentially affect Central Valley Steelhead include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are expected to minimize operations-related impacts on Central Valley Steelhead, improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Central Valley Steelhead

Central Valley Steelhead inhabit areas of the Delta that could be affected by the Proposed Project during the adult migration and juvenile rearing to outmigrating portions of their life cycle. Potential operations-related changes to migration and rearing habitat attributes, outmigrant survival, entrainment into the Delta from the Sacramento River, and entrainment at SWP facilities were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures.

The analyses conducted for each life stage of Central Valley Steelhead, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of steelhead are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on Central Valley Steelhead, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

Central California Coast Steelhead

The Central California Coast Steelhead DPS includes all naturally spawned populations of steelhead in streams from the Russian River to Aptos Creek, in Santa Cruz County (inclusive). It also includes the drainages of San Francisco and San Pablo bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin rivers. Critical habitat for CCC Steelhead includes stream reaches in the Russian River, Bodega, Marin Coastal, San Mateo, Bay Bridge, Santa Clara, San Pablo, and Big Basin Hydrologic Units. Because CCC Steelhead do not occur in the Delta, changes in Delta outflow are the only mechanism by which SWP operations could affect CCC Steelhead or their Designated Critical Habitat. Operation of the SWP would not substantially alter Delta outflow on an annual basis (Figure 4.4-~~85~~86), or on a monthly basis (Figure 4.4-~~86~~87). Because no spawning occurs in San Pablo or San Francisco bays, these areas are potentially used for rearing and migration. Slightly reduced outflows are not expected to substantially alter CCC steelhead rearing and migration habitat attributes in the San Francisco or San Pablo bays, including salinity distribution, food availability, migration cues, dilution of toxins, or other habitat attributes. Therefore, slightly reduced outflow would not substantially affect CCC Steelhead in San Francisco or San Pablo bays. In addition, these minor reductions in Delta Outflow would not substantially affect designated critical habitat for this DPS. Therefore, impacts of the Proposed Project on CCC Steelhead are considered **Less Than Significant**.

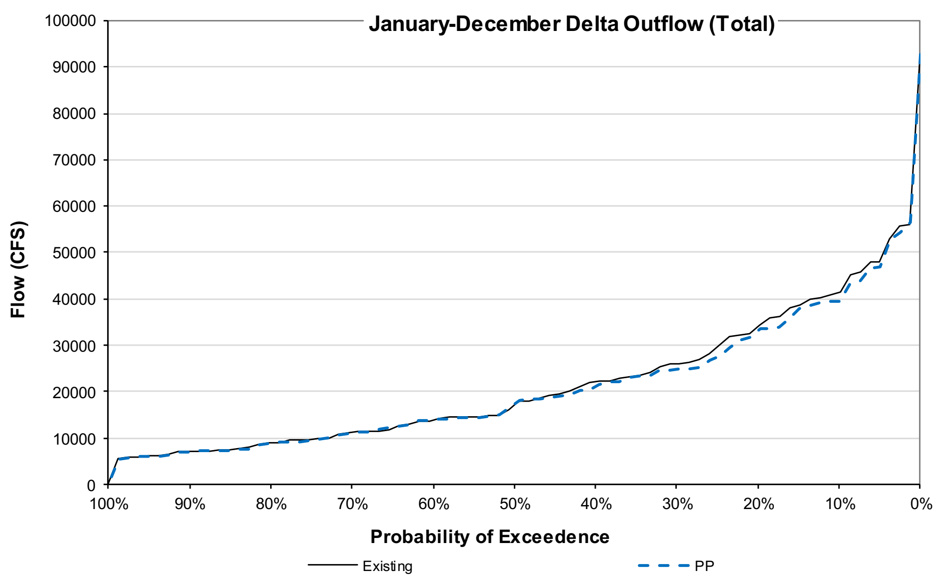


Figure 4.4-~~85~~86. Cumulative Probability Distribution of Simulated Annual Total Delta Outflow under the Proposed Project and Existing Conditions CalSim II Modeling Scenarios

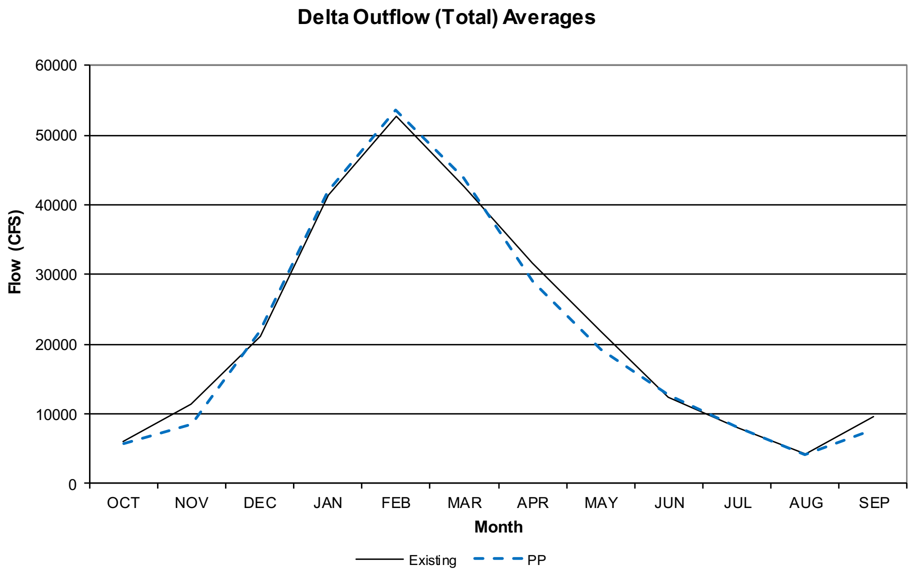


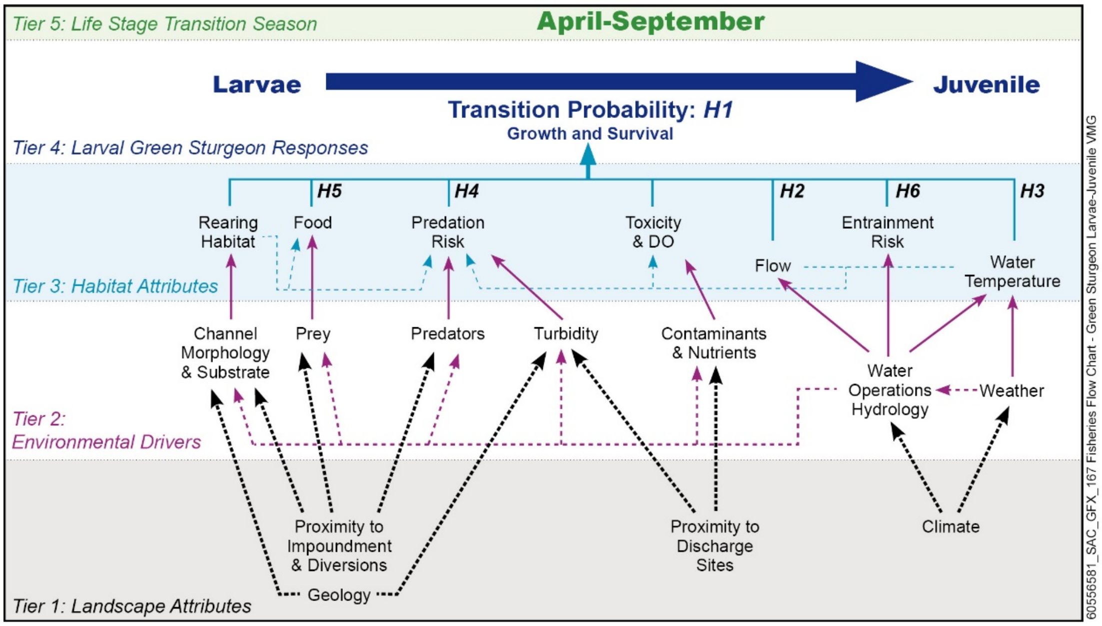
Figure 4.4-~~86~~87. Monthly Average Simulated Total Delta Outflow under the Proposed Project and Existing Conditions CalSim II Modeling Scenarios

North American Green Sturgeon

Conceptual Model

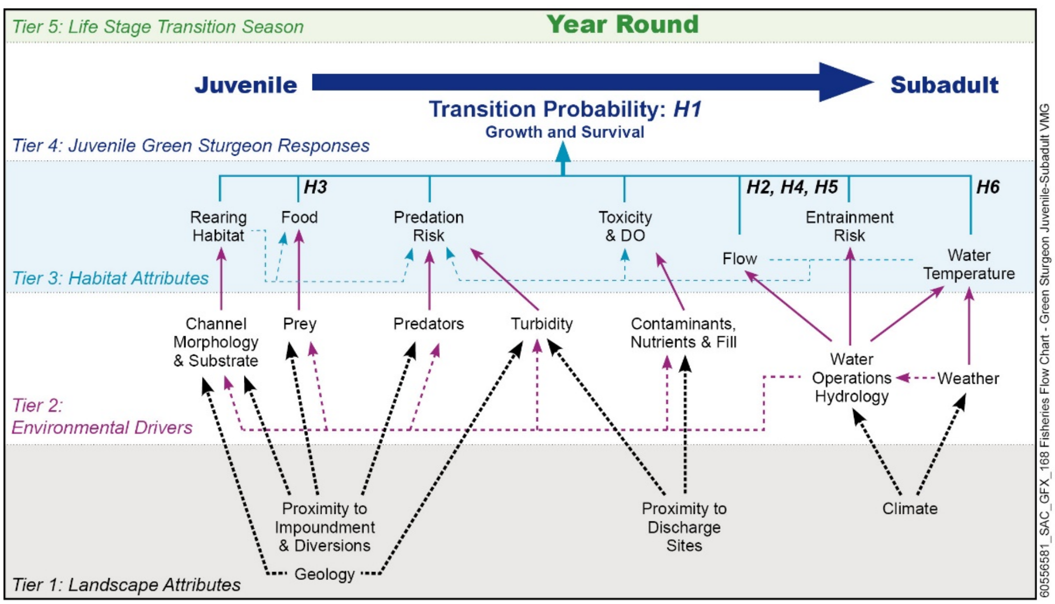
The Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) conceptual models describe life stage transitions of Green Sturgeon. SAIL life stage transitions that could be affected by the Proposed Project in the Sacramento River from the Feather River confluence to the Delta include larvae to juvenile, juvenile to subadult/adult, adult to spawning transitions.

Green Sturgeon adults enter the Sacramento River from the Delta as early as February and ultimately make their way upstream to spawn in deep pools from the GCID oxbow (near Hamilton City) to the Cow Creek confluence (Heublein et al. 2017b). Elevated flows during the late winter and early spring months may provide an important cue for spawning Green Sturgeon adults to initiate their upstream migrations (Heublein et al. 2009; NMFS 2018). Green Sturgeon spawn in most years from April through July, but spawn in occasional years as late as October. After spawning, the adults hold in the river for varying amounts of time, but typically emigrate back to the San Francisco Estuary and the ocean from about October through December (Heublein et al. 2017b). Green Sturgeon larvae complete metamorphosis and become juveniles during April through September, as described by the SAIL conceptual model (Heublein et al. 2017b), for the geographic area from Bend Bridge on the Sacramento River to the Golden Gate Bridge. The period for juveniles less than or equal to 5 months old, considered to be the ages of most juveniles rearing in or migrating through the Sacramento River upstream of the Delta, is May through December. During most of the juvenile Green Sturgeon rearing period, the juveniles are likely to be found anywhere from the upstream spawning habitat near the Cow Creek confluence to the Delta. The SAIL conceptual models for the life stage transitions, and habitat attributes, environmental drivers, and landscape attributes potentially affected by the Proposed Project are shown in Figures 4.4-~~85~~86, 4.4-~~86~~87, and 4.4-~~87~~88.



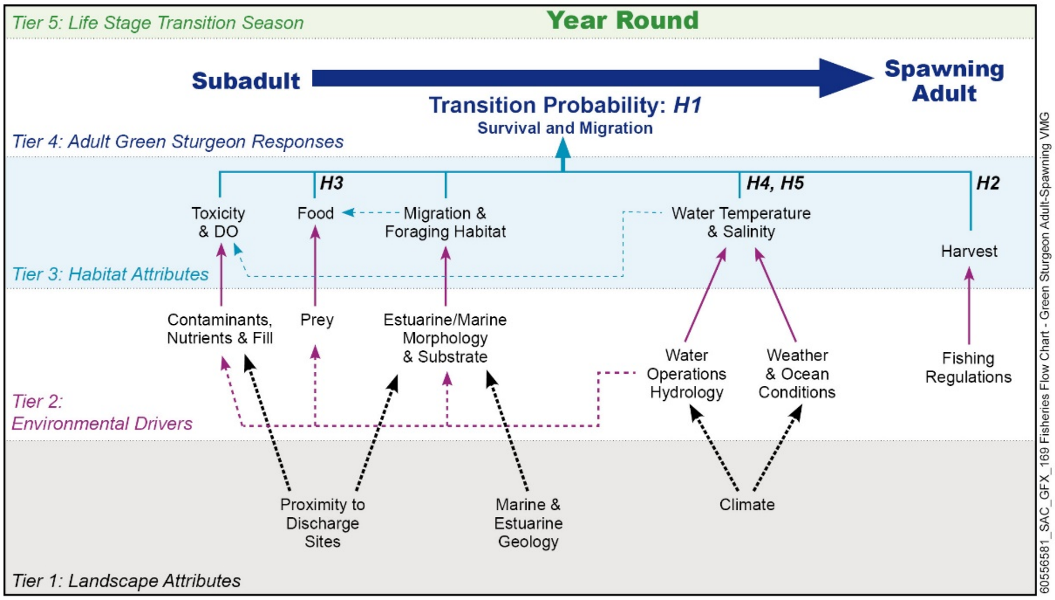
Source: Adapted from Heublein et al. 2017b

Figure 4.4-~~85~~86. SAIL Conceptual Model for the Larvae to Juvenile Life Stage Transition of Green Sturgeon



Source: Adapted from Heublein et al. 2017b

Figure 4.4-~~86~~87. SAIL Conceptual Model for the Juvenile to Subadult Life Stage Transition of Green Sturgeon



Source: Adapted from Heublein et al. 2017b

Figure 4.4-~~87~~88. SAIL Conceptual Model for the Adult to Spawning Adult Life Stage Transition of Green Sturgeon

Operations-related Impacts

Immigrating Adults and Emigrating Juveniles

Green Sturgeon use the lower Sacramento River, between the Delta and the confluence with the Feather River, at different times of the year based on the timing of individual life stage activities. Adult Green Sturgeon could occupy the river throughout the entire year for the purposes of immigration and holding (pre- and post-spawn). During the year, changes in simulated average monthly flows at Freeport under the Proposed Project, relative to the Existing Conditions scenario are generally relatively small (see Figure 4.4-58, Figures 4.4-59 through 4.4-63, and Table 4.4-15).

Because reach-specific relationships between Green Sturgeon habitat attributes and flow are not readily available, a detailed discussion of flow-related impacts on habitat is inappropriate. Nonetheless, because flows are generally similar under the Proposed Project and Existing Conditions scenarios, it is expected that habitat attributes such as food availability, water temperature, migration and foraging habitat, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.3 feet (Appendix C, Table 1-2-1,), which would not likely reduce migration opportunities. In addition, larger differences in flow between the Proposed Project and Existing Conditions scenarios that occur during September and November would not occur with sufficient duration or frequency to result in long-term changes in habitat attributes for Green Sturgeon. Specifically, these reductions occur in 2 non-consecutive months of the year-round period of potential presence. In addition, reductions during September occur primarily during wet years. During November reductions occur with varying magnitude depending on the water year type (ranging from about 6% to 13% reduction). Therefore, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of the Proposed Project associated with flow on immigrating adult Green Sturgeon in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Spawning and egg incubation occur in the Sacramento River upstream of the confluence of the Feather River and in the Feather River, and are not evaluated further. Green Sturgeon juveniles emigrate and rear in Sacramento River from the confluence with the Feather River through the Delta year-round. Similar to the adult habitat attributes, because flows are similar under both scenarios during most months, habitat attributes including food availability, rearing habitat, water temperature, predation risk, and other habitat attributes are anticipated to be similar.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on Green Sturgeon in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 60% of Delta water operations during the year, depending on the month and water year type (see Appendix H).

Entrainment

Salvage Density

The salvage-density method was used to assess potential differences in salvage of juvenile Green Sturgeon between the Proposed Project and Existing Conditions scenarios. The same caveats described for other species apply to Green Sturgeon. Specifically, the estimates of entrainment loss obtained from the salvage-density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim-modeled differences in South Delta exports between the evaluated scenarios. Therefore, the results are basically a description of differences in export flows weighted by monthly ~~loss~~ salvage density. Historical loss density numbers provide some perspective on the absolute numbers of fish being entrained, but are a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected. Although the emphasis is consideration of the relative difference between scenarios, it is important to appreciate that the modeling is limited in its representation of real-time adjustments to operations in order to minimize impacts on listed fishes, so that differences between scenarios are likely to be less than suggested by the method. In addition, in contrast to the salmonid loss density analyses, this analysis is based on salvage rather than fish loss (which is a calculation of loss associated with Clifton Court Forebay and regional mortality that is expanded from salvage).

Historically, Green Sturgeon salvage has been relatively low, but has been greatest in wet years (see https://apps.wildlife.ca.gov/Salvage). In recent years the low numbers of Green Sturgeon salvaged has been reported to be a very small percentage of the most recently available population estimate (i.e., ~4,400 juveniles; Mora et al. 2018).

Under the Proposed Project, the salvage-density method suggested that salvage of Green Sturgeon would remain low and be similar to the Existing Conditions scenario, particularly in wet years when most salvage occurred historically (Table 4.4-21). Green Sturgeon salvage under the Proposed Project also would continue to be limited and real-time operations would be adjusted to remain below the protective level required by the NMFS ROC on LTO Biological Opinion.

Water Transfers

Expansion of the water transfer window to include July to November would overlap Green Sturgeon occurrence in the Delta and potential for salvage could increase based on historical patterns in salvage density (Table 4.4-22). However, relatively few Green Sturgeon are entrained and salvage would be required to remain below the protective level required by the NMFS ROC on LTO Biological Opinion.

Annual O&M Activities-related Impacts

Annual O&M activities that could potentially affect Green Sturgeon include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
    - Sediment Removal
    - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
    - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. Although Green Sturgeon could potentially be present at the locations where O&M activities would occur year-round, it is not likely that large numbers of individuals would be present during O&M activities. These activities likely would have limited impacts on Green Sturgeon when they are implemented because existing permit conditions, including BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project. Therefore, annual O&M activities likely would have limited impacts on Green Sturgeon.

Table 4.4-21. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-21 a – Table 4.4-21 f

Table 4.4-21 a. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	5	3	0	0	2	7	32	10	2	1	0
Proposed Project	2	6	2	0	0	2	7	32	9	3	1	0

Table 4.4-21 b. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	5	0	0	0	0	4	0	0	0	0	0
Proposed Project	2	4	0	0	0	0	4	0	0	0	0	0

Table 4.4-21 c. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	1	0	0	0	0	0	0	0	0	0	0	0

Table 4.4-21 d. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	2	0	0	0	0	0	0	0	0	13
Proposed Project	0	0	2	0	0	0	0	0	0	0	1	14

Table 4.4-21 e. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	1	0	0	0	0	0	0	0	4	0
Proposed Project	0	0	1	0	0	0	0	0	0	0	6	0

Table 4.4-21 f. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	63	11	1	15	5
Proposed Project	63	11	1	16	7
Proposed Project vs. Existing	0 (0%)	0 (-1%)	0 (6%)	1 (3%)	2 (36%)

Project Environmental Protective Measure-related Impacts

Environmental Protective Measures that could potentially affect Green Sturgeon include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures would not substantially affect Green Sturgeon, but could minimize operations-related impacts on Green Sturgeon or indirectly benefit the species by reducing pre-screen mortality and increasing survival or salvaged fish.

Significance of Impacts on Green Sturgeon

Green Sturgeon inhabit areas of the Delta that could be affected by the Proposed Project throughout year as adults and juveniles.

The analyses conducted for each life stage of Green Sturgeon, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of Green Sturgeon are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on Green Sturgeon, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

White Sturgeon

Conceptual Model

Similar to the SAIL conceptual model developed for Green Sturgeon, a SAIL conceptual model describes life stage transitions of White Sturgeon. SAIL life stage transitions that could be affected by the Proposed Project in the Sacramento River from the Feather River confluence to the Delta include larvae to juvenile, juvenile to subadult/adult, adult to spawning transitions. The SAIL conceptual models for the life stage transitions, and habitat attributes, environmental drivers, and landscape attributes potentially affected by the Proposed Project are shown in Figures 4.4-~~88~~89, 4.4-~~89~~90, and 4.4-~~90~~91.

Source: Adapted from Heublein et al. 2017

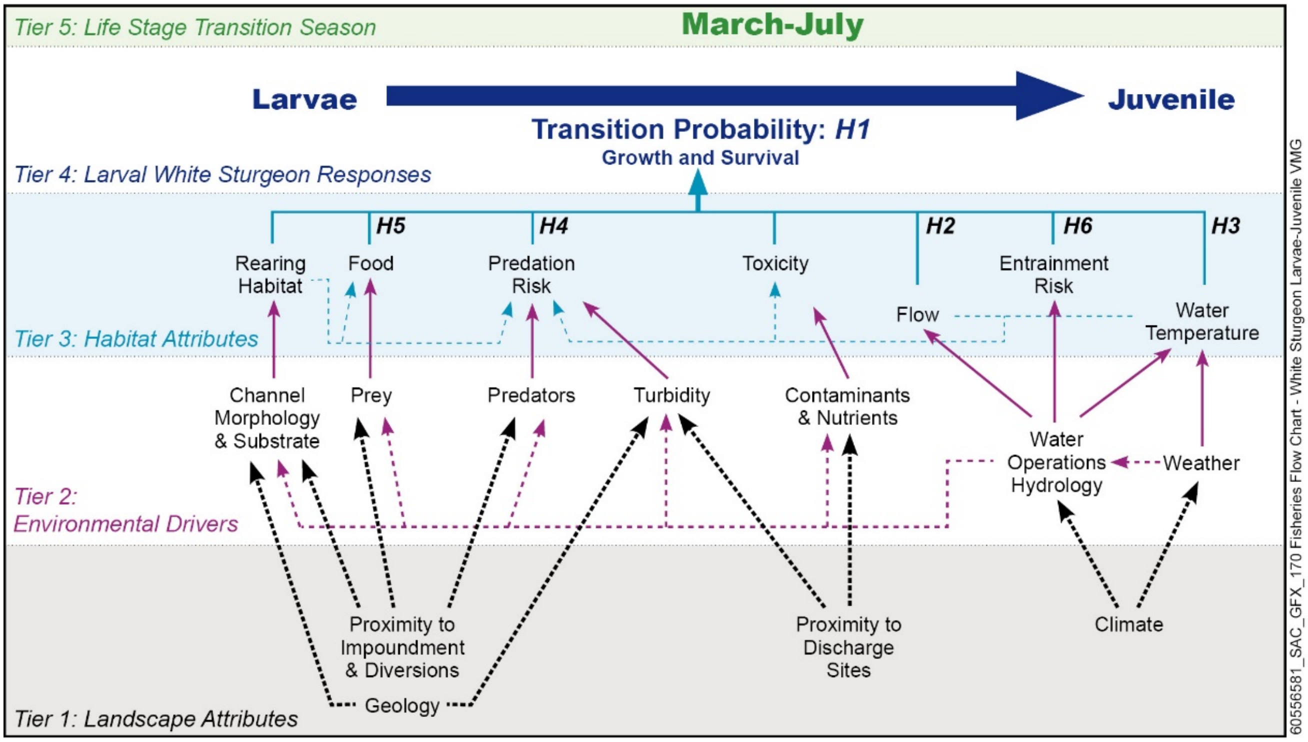
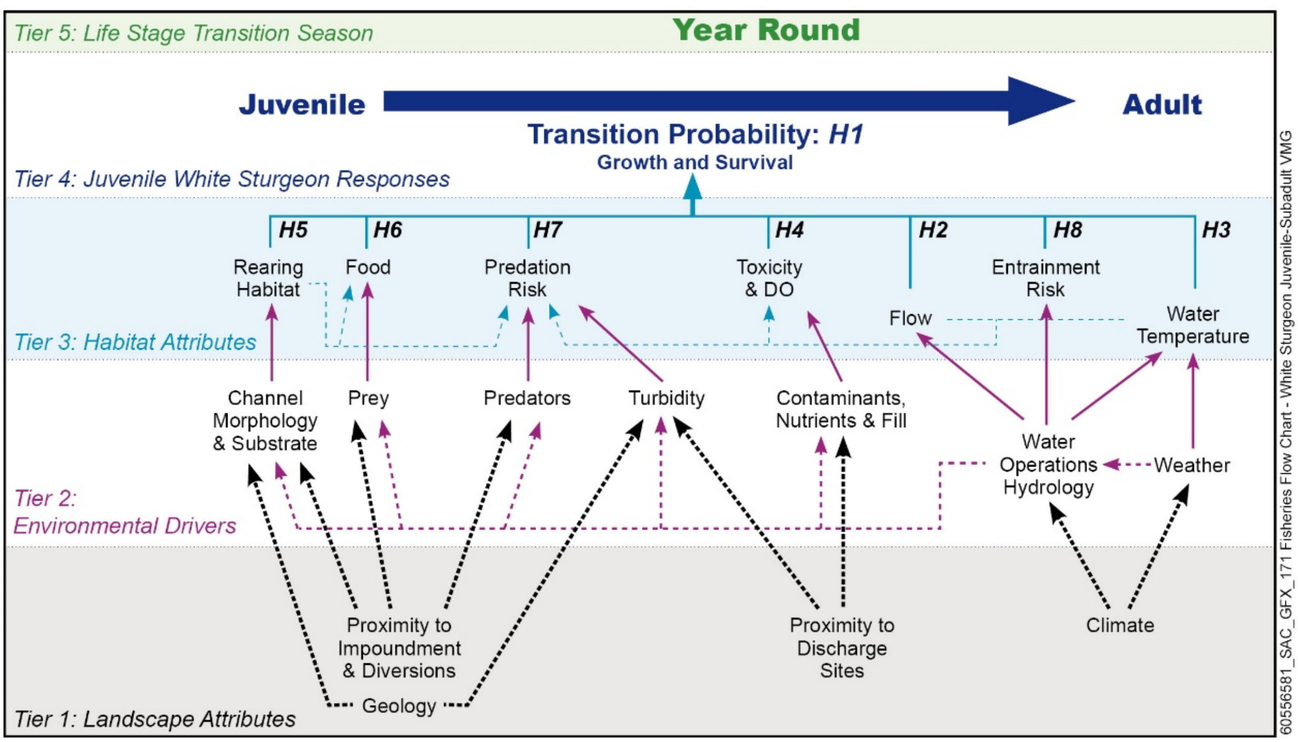
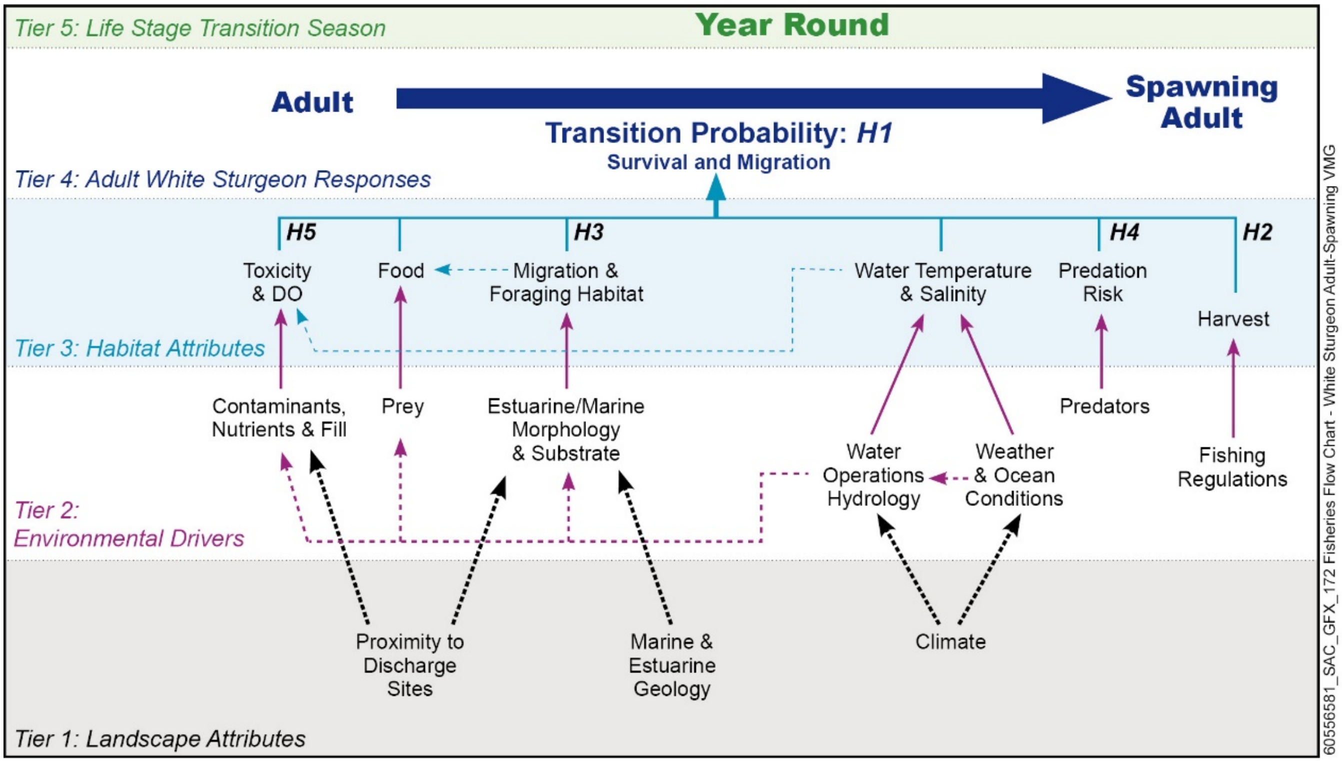


Figure 4.4-~~88~~89. SAIL Conceptual Model for the Larvae to Juvenile Life Stage Transition



Source: Adapted from Heublein et al. 2017

Figure 4.4-~~89~~90. SAIL Conceptual Model for the Juvenile to Subadult Life Stage Transition



Source: Adapted from Heublein et al. 2017

Figure 4.4-~~90~~91. SAIL Conceptual Model for the Adult to Spawning Adult Life Stage Transition

Adult white sturgeon spend most of their lives in brackish and seawater estuary habitats (Moyle 2002; Gleason et al. 2008). Tagging studies suggest that most white sturgeon remain year-round in the estuary and lower Sacramento and San Joaquin rivers (Kohlhorst et al. 1991). Elevated flows during late winter and early spring may provide an important cue for spawning White Sturgeon adults to initiate their upstream spawning migrations (Heublein et al. 2017). Spawning occurs in deep water in the middle and lower Sacramento River from Verona (RM 80) to just upstream of Colusa (~RM 156) (Heublein et al. 2017) and, therefore, is not evaluated further. Adults typically return promptly to the Delta/Estuary after spawning. Larval White Sturgeon distribution ranges from downriver of spawning habitats in the Sacramento and San Joaquin rivers to the approximate downstream extent of the Delta at Chipps Island. Based on the SAIL conceptual model for the larvae to juvenile life stage transition, the time period when larval White Sturgeon may be present in the Delta and Sacramento River from the confluence of the Feather River to the Delta is March through July. Radtke (1966) indicates that the Sacramento River and Delta are used by juvenile White Sturgeon, with the majority of juveniles captured in the Sacramento River. Larger juvenile white sturgeon are more common in estuarine areas. Based on the SAIL conceptual model for the juvenile to subadult/adult life stage transition, juvenile White Sturgeon may be present in the Delta and Sacramento River from the confluence of the Feather River year-round.

Operations-related Impacts

Immigrating Adults and Emigrating Juveniles

White Sturgeon adults and juveniles use the reach of the Sacramento River from the confluence with the Feather River through the Delta year-round. Changes in flows during the year are described above for Green Sturgeon. Similarly, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of the Proposed Project associated with flow on immigrating adult and emigrating juvenile White Sturgeon habitat attributes described in the SAIL conceptual models in the Sacramento River generally are expected to be similar to those under the Existing Conditions scenario, and differences are not expected to be substantial. Statistically significant positive correlations between White Sturgeon year-class strength and Delta outflow have been found for November–February and March–July outflow averaging periods (Fish 2010). Other similar analyses were found that also examined the April-May outflow (ICF International 2016a, p.5-197 to p.5-205). The mechanisms for these correlations are uncertain and could reflect upstream or in-Delta impacts. Appreciable amounts of variation are left unexplained by the relationships (i.e., r^2 of ~70%), with differences possibly reflecting hydrological conditions as opposed to operational differences in outflow, and which would be expected to give limited differences in year-class strength between the Existing Conditions and Proposed Project scenarios.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on White Sturgeon in the Sacramento River. The simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 60% of Delta water operations during the year, depending on the month and water year type, and specifically about 40% to 50% of Delta water operations during April and May (see Appendix H).

Entrainment

Salvage Loss Density

The salvage-density method was used to assess potential differences in salvage of juvenile White Sturgeon between the Proposed Project and Existing Conditions scenarios. The same caveats described for other species apply to White Sturgeon. In addition, in contrast to the salmonid loss density analyses, this analysis is based on salvage rather than fish loss (which is a calculation of loss associated with Clifton Court Forebay and regional mortality that is expanded from salvage).

Under the Proposed Project, the salvage-density method suggested that salvage of White Sturgeon would remain low and be similar to the Existing Conditions scenario (Table 4.4-22). During dry and critical years, the percentage increase in White Sturgeon salvage is relatively high because so few White Sturgeon are salvaged and increases in salvage of three fish translate to relatively large percentages. Nonetheless, salvage during dry and critically dry years is expected to be a very small proportion of the White Sturgeon population. White Sturgeon salvage under the Proposed Project also could be limited incidentally by real-time OMR management actions that would be implemented for listed species.

Table 4.4-22. Estimates of White Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-22 a – Table 4.4-22 f

Table 4.4-22 a. Estimates of White Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	22	10	7	2	0	4	24	30	14	10	28	14
Proposed Project	21	10	6	5	1	0	0	30	14	12	0	14

Table 4.4-22 b. Estimates of White Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	1	4	0	0	0	0	0	0	1	0	6
Proposed Project	0	1	0	0	0	0	0	0	0	2	0	6

Table 4.4-22 c. Estimates of White Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	1	0	0	4	0	0	0	0	2	3
Proposed Project	0	0	1	0	0	4	0	0	0	0	2	3

Table 4.4-22 d. Estimates of White Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	1	0	0	2	0	0	1	0	1	1	4
Proposed Project	1	1	0	0	0	0	0	1	0	1	1	4

Table 4.4-22 e. Estimates of White Sturgeon Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	2	0	1	0	0	0	0	2	2	5	1
Proposed Project	1	2	0	1	0	0	0	0	2	2	7	1

Table 4.4-22 f. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	165	12	9	11	14
Proposed Project	176	12	10	15	17
Proposed Project vs. Existing	11 (6%)	-1 (-5%)	1 (6%)	3 (28%)	3 (20%)

Water Transfers

Expansion of the water transfer window to include July to November would overlap White Sturgeon occurrence in the Delta and potential for salvage could increase based on historical patterns in salvage density (Table 4.4-23). However, relatively few White Sturgeon are entrained and so any effects of water transfers would be expected to be limited.

Annual O&M Activities-Related Impacts

Annual O&M activities that could potentially affect White Sturgeon include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. Although White Sturgeon could potentially be present at the locations where O&M activities would occur year-round, it is not likely that large numbers of individuals would be present during O&M activities. Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. These activities likely would have limited impacts on White Sturgeon when they are implemented because existing permit conditions including BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project. Therefore, annual O&M activities likely would have limited impacts on White Sturgeon.

Project Environmental Protective Measure-Related Impacts

Environmental Protective Measures that could potentially affect White Sturgeon include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures

- Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures would not substantially affect White Sturgeon, but could minimize operations-related impacts on White Sturgeon or indirectly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on White Sturgeon

White Sturgeon inhabit areas of the Delta that could be affected by the Proposed Project throughout year as adults and juveniles.

The analyses conducted for each life stage of White Sturgeon, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of White Sturgeon are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on White Sturgeon, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

Pacific Lamprey and River Lamprey

Sacramento River Pacific Lamprey adults enter the Sacramento River from the Delta primarily during about March through June and hold in the river for about a year prior to spawning (Moyle et al. 2015). Eggs and pro-larvae incubate for about 1 to 1.5 months. After larvae (ammocoetes) emerge, they drift downstream and burrow into fine sediments primarily in off-channel habitats, where they rear (Schultz et al. 2014; Moyle et al. 2015). After 5 or more years, ammocoetes metamorphose to the macrophthalmia (juvenile) stage and migrate downstream to the Delta and ocean, typically migrating during winter and spring pulse flow events (Goodman et al. 2015).

River Lamprey life history is poorly known, especially in California (Moyle et al. 2015). Adults migrate from the ocean to spawning areas during the fall and late winter (Beamish 1980). Spawning is believed to occur from February through May in riffle habitats in small tributary streams (Moyle 2002), and therefore are not evaluated further. After the larvae (ammocoetes) emerge, they drift downstream and burrow into sediments in pools or side channels where they rear. After several years, the larvae metamorphose in late July and the juvenile (macrophthalmia) migrate downstream in the following year from May to July (Moyle 2002).

Operations-related Impacts

Immigrating Adults, Ammocoetes, and Migrating Juveniles

Adult Pacific Lamprey use the river from March through June for the purposes of immigration. Larval lampreys (ammocoetes) could potentially occur in the evaluated reach of the Sacramento River year-round, while juveniles typically emigrate during winter and spring. During all months, changes in simulated average monthly flows at Freeport under the Proposed Project, relative to the Existing Conditions scenario are generally relatively small (see Figure 4.4-58, Figures 4.4-59 through 4.4-63, and Table 4.4-15). Because reach-specific relationships between lamprey habitat attributes and flow are not readily available, a detailed discussion of flow-related impacts on habitat is inappropriate. Nonetheless, because flows are generally similar under the Proposed Project and Existing Conditions scenarios, it is expected that habitat attributes such as food availability, water temperature, migration habitat, depth, burrowing substrate for ammocoetes, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is less than one foot (Appendix C, Table 1-2-1), which would not likely reduce migration opportunities. In addition, larger differences in flow between the Proposed Project and Existing Conditions scenarios that occur during September and November would not occur with sufficient duration or frequency to result in long-term changes in habitat attributes for juvenile Pacific Lamprey. Specifically, these reductions occur in 2 non-consecutive months and reductions in September occur mostly during wet years (see Appendix C). Therefore, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, the potential impacts of the Proposed Project associated with flow on immigrating adult Pacific Lamprey and on emigrating and rearing juveniles in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on lampreys in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 60% of Delta water operations during the year, depending on the month and water year type (see Appendix H).

Like Pacific Lamprey, River Lamprey use the lower Sacramento River, between the Delta and the confluence with the Feather River as rearing and migratory habitat. Adult River Lamprey likely use the river from September through May for the purposes of immigration. Larval lamprey could use the reach year-round and juveniles migrate from May through July. As described for Pacific Lamprey, changes in flows that occur would not be anticipated to be of sufficient frequency or duration to substantially alter habitat attributes for these life stages. Therefore, these flow reductions are not expected to result in substantial impacts on River Lamprey.

Entrainment

Daily Salvage Loss Density

The salvage-density method was used to assess potential differences in salvage of lampreys between the Proposed Project and Existing Conditions scenarios. The same caveats described for other species apply to lampreys. In addition, because the species identity of most salvaged lampreys is unknown, the analysis was based on the salvage density of combined Pacific Lamprey and River Lamprey[13].

The salvage-density method suggested that salvage of lampreys could be similar between Proposed Project and Existing Conditions scenarios in wetter years, with modestly greater salvage under the Proposed Project in drier years (Table 4.4-23). It is important to note that salvage of lampreys at the South Delta export facilities is inefficient relative to species such as Chinook Salmon and Striped Bass (Goodman et al. 2017). Therefore, entrainment loss of lampreys is likely to be greater per fish observed in salvage than loss for these other species. Information on the population-level importance of South Delta entrainment loss to lampreys is lacking, although Goodman et al. (2017) suggested that there is the potential for metapopulation-level impacts depending on how much of the total river flow is exported. Given the seasonality of lamprey occurrence in salvage—the greatest numbers occur in winter and spring (Table 4.4-23)—it would be expected that lampreys could receive some ancillary protection from real-time OMR management that would occur under the Proposed Project for listed fishes. In particular, the first flush action to protect adult Delta Smelt may coincide with considerable movement of lamprey into the Delta. Sacramento River lamprey have been observed to move within two days of peak streamflow or rain events (Goodman et al. 2015), leading Goodman et al. (2017) to predict that curtailment of exports during these periods would substantially reduce entrainment. As described in the project description and summarized above for Delta Smelt in the discussion *Consideration of OMR*, the first flush action would be expected to be triggered more often under the Proposed Project than under the Existing Conditions scenario (Figure 4.4-50), which could limit impacts on lamprey from entrainment under the Proposed Project, relative to the Existing Conditions scenario. Goodman et al. (2017) suggested that predator removal in the vicinity of diversion facilities also would be likely to improve lamprey survival. This potential positive impact of the Proposed Project would have the potential to limit entrainment differences between the Proposed Project and Existing Conditions scenarios.

Water Transfers

Expansion of the water transfer window to include July to November would have limited potential to increase lamprey salvage based on historical patterns in salvage density (Table 4.4-24).

[13] The salvage database at https://apps.wildlife.ca.gov/Salvage does not include any recorded species-specific data for Pacific Lamprey or River Lamprey at the SWP facility, so the analysis in this DEIR was based solely on the “Lamprey Unknown” category in the database.

Table 4.4-23. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-23 a – Table 4.4-23 f

Table 4.4-23 a. Estimates of Lamprey Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	775	100	14	21	18	34	29	6	0	0	0	93
Proposed Project	738	103	12	54	48	34	29	6	0	0	0	93

Table 4.4-23 b. Estimates of Lamprey Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	93	178	80	2	2	7	2	0	0	0	4	28
Proposed Project	94	170	63	9	10	7	2	0	0	0	0	28

Table 4.4-23 c. Estimates of Lamprey Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	42	14	61	5	11	43	14	0	0	0	0	0
Proposed Project	45	14	51	17	39	43	13	0	0	0	0	0

Table 4.4-23 d. Estimates of Lamprey Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	188	34	58	18	26	6	16	0	0	3	1	17
Proposed Project	204	36	47	43	54	6	14	0	0	3	1	18

Table 4.4-23 e. Estimates of Lamprey Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	36	17	22	8	20	5	3	0	0	0	0	4
Proposed Project	40	17	23	11	25	5	3	0	0	0	0	3

Table 4.4-23 f. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	1,091	398	190	366	114
Proposed Project	1,118	389	222	427	128
Proposed Project vs. Existing	26 (2%)	-9 (-2%)	31 (17%)	61 (17%)	14 (12%)

Annual O&M Activities-related Impacts

Annual O&M activities that could potentially affect Pacific Lamprey and River Lamprey are the following:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities, including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance, including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. Although lampreys could potentially be present at the locations where O&M activities would occur, it is not likely that large numbers of individuals would be present during O&M activities. These activities likely would have limited impacts on lampreys when they are implemented because existing permit conditions, including BMPs, would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project. Therefore, annual O&M activities likely would have limited impacts on Pacific Lamprey and River Lamprey.

Project Environmental Protective Measure-Related Impacts

Environmental Protective Measures that could potentially affect Pacific Lamprey and River Lamprey include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and

various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures would not substantially affect Pacific Lamprey and River Lamprey, but could minimize operations-related impacts or indirectly benefit these species by potentially reducing pre-screen mortality and potentially increasing survival of salvaged fish.

Significance of Impacts on River Lamprey and Pacific Lamprey

Pacific Lamprey inhabit areas of the Delta that could be affected by the Proposed Project from March through June for migration, and throughout year as larvae. River Lamprey inhabit areas of the Delta that could be affected by the Proposed Project from September through May for adult migration, May through July for juvenile migration, and throughout year as larvae.

The analyses conducted for each life stage of Pacific Lamprey and River Lamprey, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of Pacific Lamprey and River Lamprey are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on lampreys, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

Native Minnows

Operations-related Impacts

<u>**Spawning and Resident Adults and Juveniles**</u>

Native Minnow Residence

Native adult and juvenile minnows reside in the Sacramento River from the confluence with the Feather River through the Delta throughout the entire year. As described above for Green Sturgeon, reach-specific habitat attribute-flow relationships are not readily available for native minnows. Further, because flows are generally similar under the Proposed Project and Existing Conditions scenarios (Figure 4.4-58 through Figure 4.4-63), it is expected that habitat attributes such as food availability, water temperature, depth, and other attributes would also be similar. In addition, larger differences in flow between the Proposed Project and Existing Conditions scenarios that occur during September and November would not occur with sufficient duration or frequency to result in long-term changes in habitat attributes for resident native minnows. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.3 feet (Appendix C, Table 1-2-1), which would not likely alter foraging opportunities. Specifically, these reductions occur in 2 non-consecutive months of the year-round period of potential presence. In addition, reductions during September occur primarily during wet years. Therefore, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of the Proposed Project associated with flow on resident native minnows in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Although flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on native minnows residing in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 60% of Delta water operations during the year, depending on the month and water year type (see Appendix H).

Sacramento Splittail Spawning

Sacramento Splittail use the lower Sacramento River, between the Delta and the confluence with the Feather River, solely for spawning purposes from February through May. During all of these months, simulated average monthly flows at Freeport under the Proposed Project, relative to the Existing Conditions scenario are similar (see Figure 4.4-58, Figures 4.4-59 through 4.4-63, and Table 4.4-15). Likewise, flow into the Yolo Bypass—which as previously discussed in the "Environmental Setting" section is one of the most important habitats for Sacramento Splittail—generally would be similar between the Proposed Project and Existing Conditions scenarios during the Sacramento Splittail spawning period (Figures 4.4-18 through 4.4-21). Therefore, potential flow-related impacts of the Proposed Project on Sacramento Splittail spawning in the Sacramento River and Yolo Bypass are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on Sacramento Splittail spawning in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 40% to 60% of Delta water operations during the February through May spawning period, depending on month and water year type (see Appendix H).

Hardhead Spawning

Hardhead use the lower Sacramento River, between the Delta and the confluence with the Feather River, at different times of the year based on the timing of individual life stage activities. Spawning Hardhead use the river in the months of April, May, and June when flows under the Proposed Project are similar to flows under the Existing Conditions scenario. Therefore, potential flow-related impacts of the Proposed Project on Hardhead spawning in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on Hardhead spawning in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 30% to 50% of Delta water operations during the April through June spawning period, depending on month and water year type (see Appendix H).

Central California Roach Spawning

Central California Roach use the lower Sacramento River between the Delta and the confluence with the Feather River for spawning during the months of March through June when flows under the Proposed Project are similar to flows under the Existing Conditions scenario. Therefore, potential flow-related impacts of the Proposed Project on Central California Roach spawning in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on Central California Roach spawning in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 30% to 60% of Delta water operations during the March through June spawning period, depending on month and water year type (see Appendix H).

Entrainment

Daily Salvage Loss Density

The salvage-density method was used to assess potential differences in salvage of native minnows between Existing Conditions and Proposed Project scenarios and the same caveats described for other species apply to native minnows regarding the method. The analysis focused on Sacramento Splittail and Hardhead.

The salvage-density method suggested the potential for appreciable increases in entrainment of Sacramento Splittail (Table 4.4-24), reflecting the species' considerable occurrence during the April-May period, during which exports under the Proposed Project would be greater than the Existing Conditions scenario. Sacramento Splittail may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in the Proposed Project that would be implemented to protect listed salmonids and smelts. Although there is the potential for increased entrainment, analyses of historical data do not suggest entrainment has negative population-level effects (Sommer et al. 1997). In addition, the main driver of Sacramento Splittail population dynamics appears to be inundation of floodplain habitat such as the Yolo Bypass, which as described above would not change under the Proposed Project (Sommer et al. 1997).

Hardhead are salvaged in very small numbers at the SWP South Delta export facility, a situation which would not be expected to change under the Proposed Project (Table 4.4-25).

Water Transfers

Expansion of the water transfer window to include July to November could somewhat increase Sacramento Splittail salvage based on historical patterns in salvage density (Table 4.4-25), but for the reasons discussed in the Daily Salvage Loss Density section, would be expected to have limited effects. Expansion of the water transfer window would not be expected to increase salvage of Hardhead based on historical patterns in salvage density (Table 4.4-26).

Table 4.4-24. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-24 a – Table 4.4-24 f

Table 4.4-24 a. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	510	288	845	762	83,826	371,239	185,923	6,669	442	96	44	131
Proposed Project	486	295	730	1,955	223,941	366,627	183,875	6,611	423	112	57	132

Table 4.4-24 b. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	361	725	1,629	144	7,404	13,762	3,976	207	63	15	34	77
Proposed Project	365	692	1,273	546	30,504	13,733	4,036	203	62	18	44	78

Table 4.4-24 c. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	63	277	306	47	304	3,080	829	106	18	119	534	86
Proposed Project	67	286	253	176	1,068	3,041	782	102	17	133	665	89

Table 4.4-24 d. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	197	278	514	301	70	106	161	7	17	49	24	93
Proposed Project	214	290	416	708	149	104	146	8	17	55	28	100

Table 4.4-24 e. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	47	475	257	111	82	68	21	0	1	17	36	99
Proposed Project	52	479	275	161	101	69	24	1	1	17	52	88

Table 4.4-24 f. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	650,775	28,396	5,768	1,817	1,214
Proposed Project	785,243	51,553	6,679	2,235	1,320
Proposed Project vs. Existing	134,468 (21%)	23,157 (82%)	910 (16%)	418 (23%)	106 (9%)

Table 4.4-25. Estimates of Hardhead Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-25 a – Table 4.4-25 f

Table 4.4-25 a. Estimates of Hardhead Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	1	0	0	0	0	0	0	0	0	0	0
Proposed Project	1	1	0	1	0	0	0	0	0	0	0	0

Table 4.4-25 b. Estimates of Hardhead Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	0	1	0	0	0	0	0	0	0	0

Table 4.4-25 c. Estimates of Hardhead Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	0	0

Table 4.4-25 d. Estimates of Hardhead Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	1	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	1	0	0	0	0	0	0	0	0	0	0

Table 4.4-25 e. Estimates of Hardhead Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	1
Proposed Project	0	0	0	0	0	0	0	0	0	0	0	1

Table 4.4-25 f. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	2	1	0	1	1
Proposed Project	3	1	0	1	1
Proposed Project vs. Existing	1 (29%)	1 (96%)	0 (0%)	0 (4%)	0 (-6%)

Annual O&M Activities-related Impacts

Annual O&M activities that could potentially affect native minnows include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program.

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. Native minnows could potentially be present at the locations where O&M activities would occur. These activities likely would have limited impacts on native minnows when they are implemented because existing permit conditions, including BMPs, would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project. Therefore, annual O&M activities likely would have similar impacts on native minnows under the Proposed Project scenario as currently occur under the Existing Conditions scenario

Project Environmental Protective Measure-related Impacts

Environmental Protective Measures that could potentially affect native minnows include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures would not substantially affect native minnows, but could minimize operations-related impacts or indirectly benefit these species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Native Minnows

Native minnows inhabit areas of the Delta that could be affected by the Proposed Project throughout the year. In addition, impacts could occur to Sacramento Splittail spawning from February through May, Hardhead spawning from April through June, and Central California Roach spawning from March through June.

The analyses conducted for native minnows presented in the sections above and summarized in Table 4.4-6 show that impacts on all life stages of these species are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on native minnows, relative to the Existing Conditions scenario, and are considered **Less than Significant.**

Striped Bass

Operations-related Impacts

Immigrating and Spawning Adults and Rearing and Emigrating Juveniles

Striped Bass use the lower Sacramento River, between the Delta and the confluence with the Feather River for immigration and spawning from April through June. Striped Bass larvae and fry, as well as juvenile rearing and emigration use the river throughout the year. During the year, changes in simulated average monthly flows at Freeport under the Proposed Project, relative to the Existing Conditions scenario are generally relatively small (see Figure 4.4-58, Figures 4.4-59 through 4.4-63, and Table 4.4-15). Because reach-specific relationships between Striped Bass habitat attributes and flow are not readily available, a detailed discussion of flow-related impacts on habitat is inappropriate. Nonetheless, because flows are generally similar under the Proposed Project and Existing Conditions scenarios, it is expected that habitat attributes such as migration and foraging habitat, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is less than one foot (Appendix C, Table 1-2-1), which would not likely reduce migration opportunities. In addition, larger differences in flow between the Proposed Project and Existing Conditions scenarios that occur during the spawning and larval migration period, which would not affect Striped Bass migration to spawning areas or larval dispersal. Therefore, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of the Proposed Project associated with flow on Striped Bass in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

There is a negative correlation between the fall X2 and Striped Bass fall midwater trawl index (Mac Nally et al. 2010), which suggests that relative to the Existing Conditions scenario, there could be a potential negative impact of the Proposed Project as a result of greater X2 in fall following wet years and a potential positive impact of the Proposed Project as a result of smaller X2 in fall following above-normal years. However, any such differences generally would be expected to have limited impacts on the Striped Bass population because, as described by Grimaldo et al. (2009), population dynamics in the San Francisco estuary exhibit density dependence between age-1 and age-2 year classes, a bottleneck that dampens variation from impacts early in life (Kimmerer et al. 2000).

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on Striped Bass immigration and spawning, or rearing and emigration in the Sacramento River. These results represent combined impacts of the SWP and CVP. The SWP is responsible for between approximately 30% to 60% of Delta water operations during the April through June spawning period, approximately 20% to 60% during the year-round rearing and emigration period, depending on month and water year type, and also approximately 20% to 60% during the fall X2 period (September through December; Mac Nally et al. 2010) (see Appendix H).

Entrainment

Entrainment Loss Density

The salvage-density method was used to assess potential differences in salvage of Striped Bass between the Proposed Project and Existing Conditions scenarios and the same caveats described for other species apply to Striped Bass. In addition, salvage of juvenile Striped Bass occurs following a period wherein early life stages, particularly larvae, could be vulnerable to entrainment, so a qualitative discussion of entrainment risk for larvae is also provided.

The salvage-density method suggested similar entrainment of juvenile Striped Bass under the Proposed Project and Existing Conditions scenarios because most salvage occurs following the April-May period when export differences between scenarios are greatest (Table 4.4-26). Most Striped Bass spawning occurs between May 10 and June 12 (Turner 1976), which suggests that larvae occurring in May could be subject to greater entrainment risk under the Proposed Project. However, entrainment during May could be limited even with increased exports (as indicated by CalSim modeling) because real-time decision-making and OMR management actions that would be implemented to protect listed salmonids and smelts could incidentally protect Striped Bass larvae. Also, as previously noted, density-dependence during the juvenile stage of the Striped Bass life cycle means that losses of early life stages do not necessarily translate into proportional reductions in abundance of older individuals (Kimmerer et al. 2001), and entrainment has not recently been identified as a significant driver of juvenile abundance (Mac Nally et al. 2010; Thomson et al. 2010).

Water Transfers

Expansion of the water transfer window to include July to November could increase Striped Bass salvage based on historical patterns in salvage density (Table 4.4-27), but for the reasons discussed in the Entrainment Loss Density section, would be expected to have limited effects.

Table 4.4-26. Estimates of Striped Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-26 a – Table 4.4-26 f

Table 4.4-26 a. Estimates of Striped Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	16,365	14,097	6,417	370	1,384	189,529	420,659	139,742	13,721	13,838	40,699	26,922
Proposed Project	15,592	14,440	5,542	948	3,698	187,174	416,026	138,524	13,140	16,054	52,695	27,019

Table 4.4-26 b. Estimates of Striped Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	6,937	8,239	3,670	185	13,618	445,984	439,538	61,723	7,125	2,429	82,767	50,490
Proposed Project	7,010	7,857	2,868	700	56,111	445,029	446,172	60,520	6,992	2,954	109,875	51,396

Table 4.4-26 c. Estimates of Striped Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	3,051	6,376	6,747	247	11,436	108,672	112,219	17,203	2,476	13,631	41,439	14,972
Proposed Project	3,248	6,579	5,582	927	40,206	107,325	105,849	16,539	2,345	15,280	51,603	15,454

Table 4.4-26 d. Estimates of Striped Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	9,108	4,796	2,378	610	6,695	147,298	189,305	3,963	2,809	37,008	61,346	45,471
Proposed Project	9,917	5,008	1,925	1,436	14,215	144,850	171,346	4,460	2,770	41,564	69,874	48,768

Table 4.4-26 e. Estimates of Striped Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	12,671	5,392	931	70	11,433	164,461	35,176	842	1,349	6,590	17,031	5,671
Proposed Project	14,068	5,441	998	101	14,077	167,699	39,757	1,250	1,458	6,820	24,398	5,059

Table 4.4-26 f. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	883,742	1,122,706	338,470	510,788	261,617
Proposed Project	890,853	1,197,484	370,936	516,133	281,126
Proposed Project vs. Existing	7,110 (1%)	74,778 (7%)	32,466 (10%)	5,345 (1%)	19,509 (7%)

Annual O&M Activities-related Impacts

Annual O&M activities that could potentially affect Striped Bass include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. Although Striped Bass could be present at the locations where O&M activities would occur year-round, conducting these activities likely would have limited impacts on Striped Bass when they are implemented because existing permit conditions, including BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project. However, vegetation maintenance is intended to reduce predator populations locally and could result in reduced Striped Bass abundance in the CCF and near the BSPP. However, because these activities are ongoing under the Proposed Project, annual O&M activities likely would have similar impacts on Striped Bass under the Proposed Project scenario as currently occur under the Existing Conditions scenario.

Project Environmental Protective Measure-related Impacts

Environmental Protective Measures that could potentially affect Striped Bass include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation and could potentially reduce freshwater bass abundance in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are not expected to substantially affect Striped Bass.

Significance of Impacts on Striped Bass

Striped Bass inhabit areas of the Delta that could be affected by the Proposed Project throughout year as adults and juveniles. In addition, spawning occurs from April through June.

The analyses conducted for Striped Bass, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of the species are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on Striped Bass, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

American Shad

Operations-related Impacts

Immigrating and Spawning Adults and Rearing and Emigrating Juveniles

American Shad use the lower Sacramento River, between the Delta and the confluence with the Feather River, in a similar manner during the same time periods as Striped Bass. As described for Striped Bass, the changes in flow that could occur as a result of implementing the Proposed Project would not likely substantially affect American Shad immigration and spawning, or rearing and emigration.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on American Shad immigration and spawning, or rearing and emigration in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 30% to 60% of Delta water operations during the April through June spawning period, and approximately 20% to 60% during the year-round rearing and emigration period, depending on month and water year type (see Appendix H).

Entrainment

Entrainment Loss Density

The salvage-density method was used to assess potential differences in salvage of American Shad between the Proposed Project and Existing Conditions scenarios and the same caveats described for other species apply to American Shad. As discussed for Striped Bass, salvage of juvenile American Shad occurs following a period wherein early life stages, particularly larvae, could be vulnerable to entrainment, so a qualitative discussion of entrainment risk for larvae is also provided.

Juvenile American Shad occur in the Delta mostly in the summer, a period during which relatively little difference in simulated South Delta exports occurs between the Proposed Project and Existing Conditions scenarios. Therefore, salvage is similar under the Proposed Project and Existing Conditions scenarios (Table 4.4-27).

Larval American Shad could be susceptible to entrainment following spawning and movement to the Delta during spring. However, in contrast to Striped Bass, a greater portion of the American Shad population rears in the Sacramento River and its tributaries upstream of the Delta (Stevens et al. 1987). Thus, most American Shad entering the Delta after spring would be expected to be of sufficiently large size to be salvaged. American Shad occurring near the South Delta may also receive some ancillary protection from the risk assessment-based approach for OMR flow management described in the project description that would be undertaken for listed salmonids and smelts.

Water Transfers

Expansion of the water transfer window to include July to November could increase American Shad salvage based on historical patterns in salvage density (Table 4.4-28). However, as noted by Stevens et al. (1977), the main summer nursery of American Shad appears to be lower Feather and to extend from Colusa on the Sacramento River to the north Delta, with only modest numbers of fish using the south Delta; this greater use of the northern Delta is also apparent during fall (Stevens 1966). This would tend to limit the potential for impact from the expansion of the water transfer window by limiting the spatial overlap of the species with the hydrodynamic influence of the south Delta export facilities (see Delta Hydrodynamic Analysis for Winter-run Chinook Salmon).

Annual O&M Activities-related Impacts

Annual O&M activities that could potentially affect American Shad include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
    - Sediment Removal
    - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
    - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. Although American Shad could potentially be present at the locations where O&M activities would occur year-round, it is not likely that large numbers of individuals would be present during O&M activities. These activities likely would have limited impacts on American Shad when they are implemented because existing permit conditions, including BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Table 4.4-27. Estimates of American Shad Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-27 a – Table 4.4-27 f

Table 4.4-27 a. Estimates of American Shad Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	27,099	2,932	710	135	504	17,477	304,848	238,808	51,953	26,181	67,845	37,299
Proposed Project	25,819	3,003	613	347	1,346	17,260	301,490	236,725	49,754	30,374	87,843	37,433

Table 4.4-27 b. Estimates of American Shad Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	14,784	4,619	722	61	301	57,079	739,128	316,898	88,076	5,282	54,065	73,059
Proposed Project	14,939	4,405	564	229	1,240	56,957	750,284	310,721	86,430	6,424	71,772	74,370

Table 4.4-27 c. Estimates of American Shad Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	9,796	4,334	1,272	50	1,103	4,323	83,949	59,788	10,313	25,516	39,988	36,789
Proposed Project	10,427	4,471	1,053	186	3,877	4,269	79,184	57,480	9,769	28,602	49,795	37,975

Table 4.4-27 d. Estimates of American Shad Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	10,806	1,839	426	208	78	3,672	157,662	17,665	15,815	29,512	61,095	56,298
Proposed Project	11,765	1,921	345	491	166	3,611	142,705	19,883	15,596	33,145	69,588	60,380

Table 4.4-27 e. Estimates of American Shad Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	7,617	2,319	114	25	200	22	2,243	1,830	9,801	7,782	14,112	11,577
Proposed Project	8,457	2,341	122	36	246	23	2,536	2,715	10,596	8,053	20,216	10,329

Table 4.4-27 f. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	775,791	1,354,073	277,220	355,078	57,643
Proposed Project	792,009	1,378,334	287,088	359,596	65,670
Proposed Project vs. Existing	16,218 (2%)	24,261 (2%)	9,868 (4%)	4,517 (1%)	8,027 (14%)

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project. Therefore, annual O&M activities likely would have limited impacts on American Shad.

Project Environmental Protective Measure-related Impacts

Environmental Protective Measures that could potentially affect ~~Pacific Lamprey and River Lamprey~~American Shad include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures would not substantially affect American Shad, but could minimize operations-related impacts or indirectly benefit these species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on American Shad

American Shad inhabit areas of the Delta that could be affected by the Proposed Project throughout year as adults and juveniles. In addition, spawning occurs from April through June.

The analyses conducted for American Shad, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of the species are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on American Shad, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

Non-native Freshwater Bass

Operations-related Impacts

Resident Adults and Juveniles

Non-native freshwater bass use the lower Sacramento River between the Delta and the confluence with the Feather River year-round. Spawning generally occurs during the spring months based on water temperature. During the year, changes in simulated average monthly flows at Freeport under the Proposed Project, relative to the Existing Conditions scenario are generally relatively small (see Figure 4.4-58, Figures 4.4-59 through 4.4-63, and Table 4.4-15).

Because reach-specific relationships between non-native freshwater bass habitat attributes and flow are not readily available, a detailed discussion of flow-related impacts on habitat is inappropriate. Nonetheless, because flows are generally similar under the Proposed Project and Existing Conditions scenarios, it is expected that habitat attributes such as food availability, water temperature, and foraging habitat, and other attributes would also be similar. In addition, larger differences in flow between the Proposed Project and Existing Conditions scenarios that occur during September and November would not occur with sufficient duration or frequency to result in long-term changes in habitat attributes for these species, and do not occur during the spawning periods. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.3 feet (Appendix C, Table 1-2-1), which would not likely alter foraging opportunities. Specifically, these reductions occur in 2 non-consecutive months of the year-round period of potential presence. Therefore, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of the Proposed Project associated with flow on resident non-native freshwater bass in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Flows are similar most of the time under the Proposed Project and Existing Conditions scenarios and are not anticipated to result in substantial impacts on non-native bass in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 60% during the year, depending on month and water year type (see Appendix H).

Entrainment

Entrainment Loss Density

The salvage-density method was used to assess potential differences in salvage of non-native freshwater bass between the Proposed Project and Existing Conditions scenarios, and the same caveats described for other species apply to the method.

The salvage-density method suggested the potential for entrainment of Largemouth Bass to moderately increase under the Proposed Project relative to the Existing Conditions scenario, particularly in intermediate water years (above normal, below normal, and dry; Table 4.4-28). This

Table 4.4-28. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-28 a – Table 4.4-28 f

Table 4.4-28 a. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	57	20	18	3	1,546	8,764	21,393	1,583	333	220	142	59
Proposed Project	55	20	16	9	4,130	8,655	21,158	1,569	319	255	184	60

Table 4.4-28 b. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	15	23	21	1	1,352	5,892	3,685	1,209	146	142	121	132
Proposed Project	15	22	17	5	5,572	5,880	3,741	1,186	144	173	161	134

Table 4.4-28 c. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	33	20	26	25	2,023	3,061	7,707	888	230	309	126	81
Proposed Project	35	21	22	94	7,112	3,023	7,269	854	218	346	157	84

Table 4.4-28 d. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	33	5	9	9	2,860	7,271	4,764	85	199	401	137	60
Proposed Project	36	6	8	21	6,072	7,150	4,312	95	196	450	156	65

Table 4.4-28 e. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	84	74	10	14	925	7,579	3,192	85	238	278	190	77
Proposed Project	94	74	11	21	1,138	7,728	3,607	127	257	288	273	69

Table 4.4-28 f. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	34,140	12,741	14,528	15,833	12,747
Proposed Project	36,430	17,048	19,234	18,567	13,687
Proposed Project vs. Existing	2,290 (7%)	4,308 (34%)	4,706 (32%)	2,733 (17%)	940 (7%)

reflects the overlap in historical patterns of entrainment with the spring (April/May) period during which simulated South Delta exports were appreciably different under the Proposed Project and Existing Conditions scenarios. Largemouth Bass occurring near the South Delta may also receive some ancillary protection from the risk assessment-based approach for OMR flow management included in the Proposed Project that would be implemented to protect listed salmonids and smelts. It should be noted, however, that analyses by Grimaldo et al. (2009) did not find a significant relationship between Largemouth Bass salvage and OMR flows. Grimaldo et al. (2009) suggested that the littoral (nearshore)habitat occupied by the species probably provides a buffer from entrainment, which is in contrast to pelagic species such as Delta Smelt. Overall, differences in South Delta exports would be expected to have limited impact on changes in Largemouth Bass entrainment under the Proposed Project.

Smallmouth Bass and Spotted Bass are salvaged in very small numbers at the SWP South Delta export facility, a situation which would not be expected to change under the Proposed Project (Table 4.4-29 and Table 4.4-30).

Water Transfers

Expansion of the water transfer window to include July to November could increase non-native bass salvage based on historical patterns in salvage density (primarily for Largemouth Bass; see Table 4.4-29), but given that the main salvage period is in summer, such effects would be limited.

Annual O&M Activities-related Impacts

Annual O&M activities that could potentially affect non-native freshwater bass include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under the Proposed Project. Although non-native freshwater bass could potentially be present at the locations where O&M activities would occur year-round. These activities likely would have limited impacts on non-native freshwater bass when they are implemented because existing permit conditions, including BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under the Proposed Project.

Table 4.4-29. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-29 a – Table 4.4-29 f

Table 4.4-29 a. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	1	0	0	0	0	0	1	11	5	0	0
Proposed Project	2	1	0	0	0	0	0	1	11	6	0	0

Table 4.4-29 b. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	0	2	0	0	2	5	0	0	0	0	0
Proposed Project	1	0	1	0	0	2	6	0	0	0	0	0

Table 4.4-29 c. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	6	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	6	0	0

Table 4.4-29 d. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	1	0	1	0	78	1	2	6	1	0
Proposed Project	0	0	1	0	2	0	70	1	2	7	1	0

Table 4.4-29 e. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	1	0	0	0	0	1	0	0
Proposed Project	0	0	0	0	1	0	0	0	0	1	0	0

Table 4.4-29 f. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	20	10	6	89	2
Proposed Project	21	10	7	84	2
Proposed Project vs. Existing	0 (1%)	0 (-2%)	1 (10%)	-5 (-6%)	0 (14%)

Table 4.4-30. Estimates of Spotted Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 4.4-30 a – Table 4.4-30 f

Table 4.4-30 a. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	1	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	1	0	0

Table 4.4-30 b. Estimates of Spotted Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	0	0

Table 4.4-30 c. Estimates of Spotted Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	2	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	1	0	0	0	0	0	0	0	0	0

Table 4.4-30 d. Estimates of Spotted Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Proposed Project	0	0	0	0	0	0	0	0	0	0	0	0

Table 4.4-30 e. Estimates of Spotted Bass Salvage (Numbers of Fish Per Month) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	3	0	0	0
Proposed Project	0	0	0	0	0	0	0	0	3	0	0	0

Table 4.4-30 f. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Proposed Project Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Scenario	Wet	Above Normal	Below Normal	Dry	Critical
Existing	1	0	2	0	3
Proposed Project	1	0	1	0	4
Proposed Project vs. Existing	0 (16%)	0 (0%)	0 (-16%)	0 (0%)	0 (14%)

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project. However, vegetation maintenance is intended to reduce predator populations locally and could result in reduced non-native freshwater bass abundance in the CCF and near the BSPP. However, because these activities are ongoing under the Proposed Project, annual O&M activities likely would have similar impacts on non-native freshwater bass under the Proposed Project scenario as currently occur under the Existing Conditions scenario.

Project Environmental Protective Measure-Related Impacts

Environmental Protective Measures that could potentially affect Striped Bass include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation and could potentially reduce freshwater bass abundance in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are not expected to substantially affect non-native freshwater bass species.

Significance of Impacts on Non-native Freshwater Bass

Non-native freshwater bass inhabit areas of the Delta that could be affected by the Proposed Project throughout year as adults and juveniles. In addition, spawning generally occurs during Spring.

The analyses conducted for non-native freshwater bass, which are presented in the sections above and summarized in Table 4.4-6, show that impacts on all life stages of these species are less than significant. Therefore, impacts associated with implementing the Proposed Project in its entirety would not cause a substantial adverse impact on non-native freshwater bass, relative to the Existing Conditions scenario, and is considered **Less than Significant**.

Killer Whale

Potential impacts of the Proposed Project on Southern Resident Killer Whale could occur as an indirect impact of SWP operations as a result of impacts on Chinook Salmon because they are a medium-priority prey species for this Killer Whale DPS (i.e., comprise 18% to 41% of the killer whale diet when the DPS is off the coast of California and Oregon).

Reductions in Sacramento River flow during the spring juvenile Chinook Salmon outmigration period could increase the duration of juvenile travel time and decrease survival, along with potential increases in entrainment that could occur during the spring could potentially result in reduced ocean abundance of Chinook Salmon, although results of analyses presented above for Chinook Salmon indicate that impacts would generally be similar under the Proposed Project and Existing Conditions scenarios.

Studies have suggested that most Chinook Salmon in the coastal ocean off California appear to be of hatchery origin (Barnett-Johnson et al. 2007; Johnson et al. 2016). Impacts of the Proposed Project on Central Valley Chinook Salmon stocks would not be expected to occur to hatchery-origin juvenile Chinook Salmon released downstream of the Delta. The percentage of hatchery-origin fish released downstream of the Delta has been variable over time. For example, from the mid-1980s to 2012, the proportion of hatchery-origin Fall-run Chinook Salmon juveniles released downstream of the Delta by state and federal hatcheries varied from around 20% to 60% (Huber and Carlson 2015). Similarly, from 2013 to 2017, the percentage of juvenile Fall-run and Spring-run Chinook Salmon released by state Central Valley hatcheries downstream of the Delta varied between 24% (2016) and 60% (2013) (California Department of Fish and Wildlife 2018).

The Proposed Project is not likely to negatively impact individual Central Valley Chinook Salmon from operation of the export facilities and is not expected to result in decreased overall ocean abundance or availability of prey for killer whale, when considered with hatchery production.

Central Valley Chinook Salmon stocks generally are a medium priority prey species that comprise 18-41% of the killer whale diet (only when off the coast of California and Oregon). In addition, hatchery-origin Chinook Salmon released downstream of the Delta also are not affected by SWP facilities and operations, but likely contribute to the killer whale prey base. Therefore, reductions in Chinook Salmon ocean abundance as a result of the Proposed Project likely would not result in population-level impacts on killer whale.

Significance of Effects on Killer Whale

Overall, because reductions in Chinook Salmon abundance in the ocean likely would not result in population-level impacts on killer whale, the impacts of the Proposed Project on Southern Resident Killer Whale are considered **Less than Significant**.

4.4.8 Mitigation Measures

No potentially significant impacts were identified in the analysis of impacts of the Proposed Project on special-status, or recreationally and commercially important fish and aquatic resources. Therefore, no mitigation is required.

4.5 TRIBAL CULTURAL RESOURCES

This section analyzes and evaluates the potential direct and indirect impacts of the project on known and unknown tribal cultural resources (TCRs) as defined by Assembly Bill 52 (AB 52), Statutes of 2014, in Public Resources Code (PRC) Section 21074).

TCRs were added as a distinct resource subject to review under CEQA, effective January 1, 2015, under AB 52. This is a new category of resources under CEQA and includes site features, places, cultural landscapes, and sacred places or objects, which are of cultural value to a tribe.

4.5.1 REGULATORY SETTING

4.5.1.1 CALIFORNIA ENVIRONMENTAL QUALITY ACT

CEQA requires public agencies to consider the impacts of their actions on TCRs. Under PRC Section 21084.2, a "project with an effect that may cause a substantial adverse change in the significance of a tribal cultural resource is a project that may have a significant effect on the environment."

CEQA also requires lead agencies to consider whether projects will affect TCRs. PRC Section 21074 states the following:

- (a) "Tribal cultural resources" are either of the following:
  - (1) Sites, features, places, cultural landscapes, sacred places, and objects with cultural value to a California Native American tribe that are either of the following:
    - (A) Included or determined to be eligible for inclusion in the California Register of Historical Resources.
    - (B) Included in a local register of historical resources as defined in subdivision (k) of Section 5020.1.
  - (2) A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Section 5024.1. In applying the criteria set forth in subdivision (c) of Section 5024.1 for the purposes of this paragraph, the lead agency shall consider the significance of the resource to a California Native American tribe.
- (b) A cultural landscape that meets the criteria of subdivision (a) is a tribal cultural resource to the extent that the landscape is geographically defined in terms of the size and scope of the landscape.
- (c) A historical resource described in Section 21084.1, a unique archaeological resource as defined in subdivision (g) of Section 21083.2, or a "nonunique archaeological resource" as defined in subdivision (h) of Section 21083.2 may also be a tribal cultural resource if it conforms with the criteria of subdivision (a).

Assembly Bill 52

AB 52, signed by Governor Edmund G. Brown Jr. in September 2014, establishes a new class of resources under CEQA: "tribal cultural resources" (or TCRs). AB 52 (PRC Sections 21080.3.4, 21080.3.2, and 21082.3) states that upon written request by a California Native American Tribe, a CEQA lead agency must begin consultation once it determines that the project application is complete, before the agency issues a NOP of an EIR or notice of intent to adopt a negative declaration or mitigated negative declaration. AB 52 also required a revision of State CEQA Guidelines Appendix G, the environmental checklist. This revision created a new category for TCRs.

As defined in PRC Section 21074, to be considered a TCR, a resource must be either:

1. listed or determined to be eligible for listing, on the national, state, or local register of historic resources; or
2. a resource that the lead agency determines, in its discretion and supported by substantial evidence, to treat as a tribal cultural resource pursuant to the criteria in PRC Section 50241(c). PRC Section 5024.1(c) provides that a resource meets criteria for listing as an historic resource in the California Register if any of the following apply:
   (1) It is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage.
   (2) It is associated with the lives of persons important in our past.
   (3) It embodies the distinctive characteristics of a type, period, region, or method of construction, or represents the work of an important creative individual, or possesses high artistic values.
   (4) It has yielded, or may be likely to yield, information important in prehistory or history.

4.5.2 Native American Consultation

DWR sent letters by certified mail, return receipt, on May 3, 2019, to 16 California Native American Tribes that had requested formal notification of Proposed Projects from DWR under AB 52: Barona Band of Mission Indians, Big Pine Paiute Tribe of the Owens Valley, Fernandeño Tataviam Band of Mission Indians, Ione band of Miwok Indians, Karuk Tribe, Mechoopda Indian Tribe of Chico Rancheria, Middletown Rancheria of Pomo Indians of California, Pit River Tribe, San Luis Rey Band of Mission Indians, San Manuel Band of Mission Indians, Shasta Indian Nation, Tongva Ancestral Territorial Tribal Nation, United Auburn Indian Community of the Auburn Rancheria, Wilton Rancheria, Wintu Tribe of Northern California & Toyon-Wintu Center and Yocha Dehe Wintun Nation.

Return receipts, evidencing delivery of the letters, were received from 15 of the Tribes. The letter to the Wintu Tribe of Northern California was sent twice and returned twice, even though a phone call following the initial return of the letter confirmed that the address was correct. Six Tribes responded to DWR's letter with a letter or email. Five of the Tribes (Fernandeño Tataviam Band of Mission Indians, Karuk Tribe, United Auburn Indian Community of the Auburn Rancheria, Wilton Rancheria, and Yocha Dehe Wintun Nation) requested consultation on the project while the sixth Tribe, San Manuel Band of

Mission Indians, indicated no concerns and that they did not require additional consultation pursuant to CEQA.

~~DWR met with Wilton Rancheria on June 17, 2019.~~ Letters acknowledging requests for consultation were sent on June 28, 2019, to Fernandeño Tataviam Band of Mission Indians, Karuk Tribe, United Auburn Indian Community of the Auburn Rancheria and Yocha Dehe Wintun Nation. ~~DWR met on September 6, 2019 with the Yocha Dehe Wintun Nation and subsequently provided them with GIS shape files of the project areas.~~ DWR has reached closure of AB 52 consultation with ~~Wilton Rancheria and the Yocha Dehe Wintun Nation. DWR is currently reaching out to Fernandeño Tataviam Band of Mission Indians, the Karuk Tribe, and the United Auburn Indian Community of the Auburn Rancheria~~each tribe, and concluded AB 52 consultation for the project on March 19, 2020.

4.5.3 Environmental Impacts and Mitigation Measures

4.5.3.1 Thresholds of Significance

Based on Appendix G of the State CEQA Guidelines, the project would result in a potentially significant impact on TCRs if it would:

- cause a substantial adverse change in the significance of a historical resource pursuant to Section 15064.5;
- cause a substantial adverse change in the significance of an archaeological resource pursuant to Section 15064.5;
- disturb any human remains, including those interred outside of dedicated cemeteries; or
- cause a substantial adverse change in the significance of a tribal cultural resource as defined in PRC Section 21074.

4.5.3.2 Impact Analysis

Impact 4.5-1: Impacts on tribal cultural resources.

Consultation with the Fernandeño Tataviam Band of Mission Indians, the Karuk Tribe, United Auburn Indian Community of the Auburn Rancheria, Wilton Rancheria, and the Yocha Dehe Wintun Nation has been performed and has not resulted in the identification of TCRs as described under AB 52 and PRC Section 21074.

As a result of this consultation process, it is concluded that the Proposed Project would have **no impact** on TCRs.

4.6 OTHER CEQA DISCUSSIONS

4.6.1 Cumulative Impacts

4.6.1.1 CEQA Requirements for Cumulative Assessment

As stated in CEQA Section 21083(b)(2), a project may have a significant impact on the environment if "its effects are individually limited but cumulatively considerable." In this context, "cumulatively considerable" means that the incremental impacts of an individual project are significant when viewed in connection with the impacts of past projects, the impacts of other current projects, and the impacts of probable future projects (State CEQA Guidelines Section 15065[a][3]). Section 15355 of the State CEQA Guidelines defines "cumulative impacts" as:

> …two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts.
>
> (e) The individual effects may be changes resulting from a single project or a number of separate projects.
>
> (f) The cumulative impact from several projects is the change in the environment, which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time.

Section 15064 of the State CEQA Guidelines explains that, "[t]he mere existence of significant cumulative impacts caused by other projects alone shall not constitute substantial evidence that the Proposed Project's incremental impacts are cumulatively considerable."

The analysis presented in this section is consistent with statutory and regulatory requirements to assess cumulative impacts and includes:

1. A determination of whether the impacts of related past, present, and future plans and projects would cause a cumulatively significant impact; and
2. A determination as to whether implementation of the Proposed Project would have a "cumulatively considerable" contribution to any significant cumulative impact. [See Sections 15130(a), (b), Section 15355(b), Section 15064(h), and Section 15065(a)(3), (c) of the State CEQA Guidelines.]

The discussion of cumulative impacts should reflect the severity of the impacts as well as the likelihood of their occurrence; however, the discussion does not need to be as detailed as the discussion of environmental impacts attributable to the Proposed Project alone. The analysis should be guided by the standards of practicality and reasonableness, and it should focus on the cumulative impact(s) to which the other identified projects contribute, rather than to the attributes of other projects which do not contribute to the cumulative impact (CEQA Guidelines 15130[b]).

4.6.1.2 Cumulative Context and Approach

Section 15130(b)(1) of the State CEQA Guidelines identifies two approaches to analyzing cumulative impacts. The first is a summary approach (also known as the "plan" approach), wherein the relevant projections, as contained in an adopted general plan or related planning document that evaluates regional or area-wide conditions, are summarized. The second is the "list" approach, by which a defined set of past, present, and reasonably anticipated future projects producing related or cumulative impacts is considered for analysis.

The cumulative analysis used for this DEIR uses the “list” approach. Table 4.6-1 shows known past, present, and reasonably foreseeable future projects, the impacts of which may combine with impacts from the Proposed Project to cause cumulative impacts. The projects listed in Table 4.6-1 serve as the foundational information for conducting the cumulative impact assessments for the resources addressed in the DEIR.

The table identifies projects that have occurred, are occurring, or are reasonably expected to occur in the future and that may affect similar environmental resources as the proposed long-term SWP operations. The table includes the name of the project, lead agency(ies), summary description of the scope of the project, and citations for the references in Chapter 6, listing project source documentation.

Table 4.6-1 does not include possible future projects that are considered to be speculative. For this analysis, if a project is only in preliminary planning stage, does not have a defined physical footprint and operational criteria, has not completed applicable environmental review, or has not been authorized or budgeted by sponsoring authorities, it is considered to be speculative. Accordingly, insufficient information exists to include and evaluate such projects at this time, and they are not considered a reasonably foreseeable future projects.

Not all of the projects included in this table are considered for the cumulative assessment of each resource topic analyzed in the DEIR. For each resource topic, the geographic and temporal context for cumulative analysis was considered, and the list of projects in Table 4.6-1 were screened against these contexts to identify those projects that have the potential to combine with impacts from the Proposed Project to cause a cumulative impact.

As discussed in the Initial Study (provided in Appendix A), the Proposed Project would have no impacts on aesthetics, agricultural resources, air quality, terrestrial biological resources, cultural resources, energy, geology and soils, greenhouse gas emissions, hazards and hazardous materials, land use and planning, mineral resources, noise, population and housing, public services, recreation, transportation, tribal cultural resources, utilities and service systems, and wildfire; and therefore, it would not contribute to potential cumulative impacts on these resource topics.

Thus, the cumulative impacts analysis in this DEIR is limited to the potential of the project to contribute to potentially significant cumulative impacts related to the topics of hydrology, surface water quality, aquatic resources and tribal cultural resources.

4.6.1.3 Hydrology

The cumulative baseline for hydrology is the same environmental setting as that described for the Proposed Project in Section 4.2.

The geographic context for cumulative impact analysis of hydrology is limited to those projects shown in Table 4.6-1 with potential to also cause changes to surface water hydrology within the same water bodies (i.e., the Sacramento River downstream from the Feather River confluence, the Delta, and the San Luis Reservoir). Because the Proposed Project would not change surface water hydrology outside these three water bodies, it could not contribute to a potential cumulative impact on other water bodies.

The changes to hydrology from the Proposed Project could occur until conditions change that would warrant further modification of future SWP operations; therefore, the temporal context for cumulative impact analysis also would coincide with this period.

Discussion of Cumulative Impact to Hydrology

Changes in hydrology resulting from the Proposed Project and other past, present and reasonably foreseeable future projects, by themselves, are not considered significant environmental impacts. Like the analysis for the Proposed Project, however, such changes could have secondary impacts on surface water quality and aquatic resources. Therefore, cumulative impacts relating to hydrology are addressed in conjunction with these topics, in the following discussion.

4.6.1.4 Surface Water Quality

The baseline for evaluating cumulative impacts on water quality is the same environmental setting as that described for the Proposed Project in Section 4.3.

As discussed in Section 4.3, the evaluation criteria used for analysis of impacts on surface water quality represent a combination of the applicable State CEQA Guidelines Appendix G criteria and professional judgment that consider scientific and factual data as well as current regulation standards, and consultation with agencies or knowledge of the area, or both, as required pursuant to CEQA.

As discussed in Section 4.3, the majority of surface water quality indicators under the Proposed Project scenario would be similar to the Existing Conditions scenario. However, the Proposed Project would result in less-than-significant increases in salinity in the Delta, particularly in the late fall and winter months because of the Delta Smelt Summer-Fall Habitat Action.

Direct and indirect impacts on surface water quality from the Proposed Project would be limited to the Delta; therefore, the geographic context for cumulative analysis of surface water quality impacts is limited to those projects shown in Table 4.6-1 with the potential to affect surface water quality in the Delta.

Impacts on surface water quality would occur over the lifetime of the proposed long-term SWP operations until such time as conditions change that would warrant further modification of future SWP operations. Therefore, the temporal context for cumulative analysis of impacts on surface water quality would extend to any past, present, or future options that would affect Delta surface water quality during the lifetime of SWP operations.

The majority of past, present, and reasonably foreseeable projects that are shown in Table 4.6-1 could potentially have impacts on surface water quality. Specific quantifiable details regarding the surface water quality impacts of every project were not available, and therefore the analysis below was conducted qualitatively and in the context that the cumulative projects would be subject to a variety of laws and regulatory processes that would require avoidance or mitigation of impacts on surface water quality.

Table 4.6-1. List of Cumulative Projects– Table 4.6-1 a – Table 4.6-1 f

Table 4.6-1 a. List of Cumulative Projects – Water Supply, Water Management, and Water Quality Projects and Actions

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Central Valley Project Long-term Operation	No	No	**Yes**	U.S. Bureau of Reclamation (Reclamation), California Department of Water Resources (DWR), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS)	Reclamation and DWR reinitiated consultation on the Coordinated Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP). Reclamation completed a biological assessment to support consultation under Section 7 of the Endangered Species Act (ESA) of 1973, as amended, that documents the potential effects of the proposed action on federally listed endangered and threatened species that have the potential to occur in the project area and critical habitat for these species. The USFWS and NMFS will be issuing biological opinions that may contain Reasonable and Prudent Actions that limit the operations of the CVP and SWP for protecting federally listed endangered and threatened species.
Central Valley Project and State Water Project Coordinated Operation Agreement (COA) 2018 Addendum[14]	No	**Yes**	No	Reclamation and DWR	Reclamation and DWR operate their respective facilities in accordance with the COA. The COA defines the project facilities and their water supplies, sets forth procedures for coordinating operations, and identifies formulas for sharing joint responsibilities for meeting Delta standards and other legal uses of water. The COA further identifies how unstored flow is shared, sets up a framework for exchange of water and services between the projects, and provides for periodic review of the agreement. In 2018, Reclamation and DWR amended four key elements of the COA to address changes since the COA originally was signed: (1) in-basin uses; (2) export restrictions; (3) CVP use of Banks Pumping Plant up to 195,000 acre-feet per year (AFY); and (4) periodic review. The COA sharing percentages for meeting Sacramento Valley in-basin uses now vary from 80% responsibility of the CVP and 20% responsibility of the SWP in wet year types to 60% responsibility of the CVP and 40% responsibility of the SWP in critical year types.
Central Valley Regional Water Quality Control Board (RWQCB) Irrigated Lands Regulatory Program	No	**Yes**	No	Central Valley RWQCB	The Irrigated Lands Regulatory Program regulates discharges from irrigated agricultural lands. Its purpose is to prevent agricultural discharges from impairing the waters that receive the discharges. The California Water Code authorizes the State Water Resources Control Board (SWRCB) and RWQCBs to conditionally waive waste discharge requirements if this is in the public interest. On this basis, the Los Angeles, Central Coast, Central Valley, and San Diego Regional Water Quality Control Boards have issued conditional waivers of waste discharge requirements to growers that contain conditions requiring water quality monitoring of receiving waters. In 2010, the Central Valley RWQCB proposed to expand the requirements to groundwater especially for regulation of discharges with higher concentrations of nutrients (Central Valley RWQCB 2011). Participation in the waiver program is voluntary; however, non-participant dischargers must file a permit application as an individual discharger, stop discharging, or apply for coverage by joining an established coalition group. The waivers must include corrective actions when impairments are found.
Delta-Mendota Canal/California Aqueduct Intertie	No	**Yes**	No	Reclamation	The Delta-Mendota Canal (DMC)/California Aqueduct Intertie consists of constructing and operating a pumping plant and pipeline connection between the DMC and the California Aqueduct. The Intertie, which is now operational, is used to achieve multiple benefits, including meeting current water supply demands, allowing the maintenance and repair of the CVP Delta export and conveyance facilities, and providing operational flexibility to respond to emergencies related to both the CVP and the SWP. The Intertie includes a 450-cubic feet per second (cfs) pumping plant at the DMC that allows up to 400 cfs to be pumped from the DMC to the California Aqueduct via an underground pipeline. The additional 400 cfs allows the Jones Pumping Plant to pump to its authorized amount of 4,600 cfs. Because the California Aqueduct is approximately 50 feet higher in elevation than the DMC, up to 900 cfs flow can be conveyed from the California Aqueduct to the DMC using gravity flow. The Intertie is owned by the federal government and operated by the San Luis and Delta–Mendota Water Authority (SLDMWA). An agreement among Reclamation, DWR, and SLDMWA identifies the responsibilities and procedures for operating the Intertie. (Reclamation and SLDMWA 2015)
Eastern San Joaquin Integrated Conjunctive Use Program	No	**Yes**	No	Northeastern San Joaquin County Groundwater Banking Authority (NSJCGBA)	The Integrated Conjunctive Use Program is to develop approximately 140,000 to 160,000 AF per year of new surface water supply for the basin that will be used to directly and indirectly to support conjunctive use by the Northeastern San Joaquin County Groundwater Banking Authority (NSJCGBA) member agencies. This amount of water would support groundwater recharge at a level consistent with the NSJCGBA's objectives for conjunctive use and the underlying groundwater basin. Within this framework, the program would implement the following categories of conjunctive use projects and actions: water conservation measures; water recycling; groundwater banking; water transfers; development of surface storage facilities; groundwater recharge; river withdrawals; and construction of pipelines and other facilities. To enable and facilitate sustainable and reliable management of San Joaquin County's water resources, NSJCGBA developed a series of Basin Management Objectives to support conjunctive use and address a variety of water resources issues, including groundwater overdraft, saline groundwater intrusion, degradation of groundwater quality, environmental quality, land subsidence, supply reliability, water demand, urban growth, recreation, agriculture, flood protection, and other issues. The purpose of the Basin Management Objectives is to ensure the long-term sustainability of water resources in the San Joaquin Region. A Final Environmental Impact Report (EIR) for the program was released in February 2011. (NSJCGBA 2011)
Long-term and short-term water transfers	No	**Yes**	No	Reclamation, San Luis and Delta–Mendota Water Authority (SLDMWA), Biggs–West Gridley Water District	These projects provide water to municipal, agricultural, and ecosystem water users, including wildlife refuges with programs that transfer water from Northern California to the San Joaquin Valley and Southern California across the Delta. (Reclamation and SLDMWA 2015; Biggs–West Gridley Water District 2015)

[14] 2018 COA Addendum is included in the proposed SWP Long Term Operations evaluated in this Draft EIR.

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Los Vaqueros Reservoir Expansion Phase 2	**Yes**	No	No	Reclamation, Contra Costa Water District (CCWD), DWR	Los Vaqueros Reservoir is an off-stream reservoir in the Kellogg Creek watershed west of the Delta. The Los Vaqueros Reservoir initial construction was completed in 1997 as a 100,000 acre feet (AF) off-stream storage reservoir, owned and operated by CCWD to improve delivered water quality and emergency storage reliability to its customers. In 2012, the Los Vaqueros Reservoir was expanded to a total storage capacity of 160,000 AF (Phase 1), to provide additional water quality and supply reliability benefits, and to adjust the timing of its Delta water diversions to accommodate the life cycles of Delta aquatic species, thus reducing species' impacts and providing a net benefit to the Delta environment. As part of the Storage Investigation Program described in the CALFED Bay Delta Program Record of Decision (ROD), additional expansion up to 275,000 AF (Phase 2) is being evaluated by CCWD, DWR, and Reclamation. The alternatives considered in the evaluation also consider methods to convey water from Los Vaqueros Reservoir to the South Bay Aqueduct, to provide water to the Zone 7 Water Agency, Alameda County Water District, and Santa Clara Valley Water District. The Final EIS/EIR was released by Reclamation and CCWD on March 15, 2010. Construction is planned to begin as early as 2021, with a 6-year construction period. (Reclamation 2018b)
Merced Irrigation District's Merced River Hydroelectric Project	No	**Yes**	No	Federal Energy Regulatory Commission (FERC), Merced Irrigation District (ID)	The Merced River Hydroelectric Project is on the Merced River in Mariposa County and includes both Lake McClure and McSwain Reservoir, two powerhouses (New Exchequer and McSwain), and recreation facilities. The project does not include any transmission lines, canals, or open conduits. The installed capacity of the Merced River Hydroelectric Project is 103.5 megawatts (Merced ID n.d.).The initial FERC license expired on February 28, 2014. The objective of the relicensing process is to continue operation and maintenance of the Merced River Hydroelectric Project facilities for electric power generation, along with implementation of any terms and conditions to be considered for inclusion in a new FERC hydroelectric license. (Merced ID 2015)
Sacramento Regional Wastewater Treatment Plant Facility Upgrade Project (EchoWater)	No	No	**Yes**	Sacramento County Regional Sanitation District (Sacramento County RSD)	Sacramento County RSD is upgrading its existing facilities at the Sacramento Regional Wastewater Plant to meet new National Pollutant Discharge Elimination System (NPDES) permit requirements. Project implementation would not result in an increase in permitted wastewater treatment capacity; however, it would result in improved treated effluent water quality. The project will upgrade existing secondary treatment facilities to advanced unit processes, including improved nitrification/denitrification and filtration. The upgrade involves 20 separate construction projects, with construction currently underway through 2023. (Sacramento County RSD n.d.)
Sacramento Stormwater Quality Partnership	No	**Yes**	No	Sacramento County, Cities of Sacramento, Citrus Heights, Elk Grove, Folsom, Galt, and Rancho Cordova	The Sacramento Stormwater Quality Partnership (SSQP) is a collaboration of public agencies that protects and improves water quality in local waterways for the benefit of the community and the environment. The partnership's main charge is to oversee compliance with the Sacramento area-wide Municipal Stormwater Permit, which is designed to comply with State and federal clean water regulations (NPDES Stormwater Permit No. CAS082597). The goals of the partnership are to: educate and inform the public about urban runoff pollution; encourage public participation in community and clean-up events; work with industries and businesses to encourage pollution prevention; require construction activities to reduce erosion and pollution; and require developing projects to include pollution controls that will continue to operate after construction is completed. Program elements include monitoring, target pollutant reduction, special studies (such as evaluating the effectiveness of BMPs), and public outreach. (Sacramento Stormwater Quality Partnership 2016)
Shasta Lake Water Resources Investigation	No	No	**Yes**	Reclamation	Reclamation undertook the Shasta Lake Water Resources Investigation to determine the type and extent of federal interest in a multiple purpose plan to modify Shasta Dam and Reservoir, to: increase survival of anadromous fish populations in the upper Sacramento River; increase water supplies and water supply reliability to agricultural, municipal and industrial users, and environmental purposes; and, to the extent possible through meeting these objectives, include features to benefit other identified ecosystem, flood damage reduction, and related water resources needs, consistent with the objectives of the CALFED Bay-Delta Program. The alternatives for expansion of Shasta Lake include, among other features, raising the dam from 6.5 to 18.5 feet above current elevation, which would result in additional storage capacity of 256,000 to 634,000 AF, respectively (Reclamation 2015). The increased capacity is expected to improve water supply reliability and increase the cold-water pool, which would provide improved water temperature conditions for anadromous fish in the Sacramento River downstream from the dam. The final Environmental Impact Statement (EIS)was released in 2014, and the final feasibility study was released in 2015. No Record of Decision (ROD) has been issued. However, in March 2018, Congress appropriated $20 million for Shasta preconstruction activities. The Shasta Dam Raise Project is expected to be complete by February 2024. (Reclamation 2018a)
Sites Reservoir Project	No	No	**Yes**	Reclamation, Sites Project Authority	The Sites Reservoir Project involves construction of offstream surface storage north of the Delta for enhanced water management flexibility in the Sacramento Valley, increased California water supply reliability, and storage and operational benefits for programs to enhance water supply reliability, both locally and statewide, benefit Delta water quality, and improve ecosystems. Secondary objectives for the project are to: (1) allow flexible hydropower generation to support integration of renewable energy sources, (2) develop additional recreation opportunities, (3) provide potential public benefits to sensitive fishes throughout the Delta watershed, and (4) provide incremental flood damage reduction opportunities (Sites Project Authority and Reclamation 2017). The Draft Environmental Impact Report (DEIR)/EIS /EIS was released for public review on August 14, 2017.
State Water Project (SWP) Oroville Project	No	**Yes**	No	FERC, DWR	The Oroville Facilities, as part of the SWP, also are operated for flood management, power generation, water quality improvement in the Delta, recreation, and fish and wildlife enhancement. The objective of the relicensing process is to continue operation and maintenance of the Oroville facilities for electric power generation, along with implementation of any terms and conditions to be considered for inclusion in a new FERC hydroelectric license. The initial FERC license for the Oroville Facilities, issued on February 11, 1957, expired on January 31, 2007. DWR published the Final EIR in June 2008 and the Notice of Determination (NOD) in July 2008 (DWR 2008). DWR is awaiting the FERC license renewal.

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Stockton Deep Water Ship Channel Demonstration Dissolved Oxygen Project	**Yes**	No	No	DWR	The Stockton Deep Water Ship Channel Demonstration Dissolved Oxygen Project is a multiple-year study of the effectiveness of elevating dissolved oxygen (DO) concentrations in the channel. DO concentrations drop as low as 2 to 3 milligrams per liter (mg/L) during warmer and lower water flow periods in the San Joaquin River. The low DO levels can adversely affect aquatic life, including the health and migration behavior of anadromous fish (e.g., salmon). The objective of the study is to maintain DO levels above the minimum recommended levels specified in the State's Water Quality Control Plan (WQCP) for the Sacramento and San Joaquin river basins. The Basin Plan water quality objectives for DO are 6.0 mg/l in the San Joaquin River (between Turner Cut and Stockton, September 1 through November 30) and 5.0 mg/l the remainder of the year. The project's full-scale aeration system includes two 200-foot-deep u-tube aeration tubes; two vertical turbine pumps capable of pumping more than 11,000 gallons of water each; a liquid-to-gas oxygen supply system; and numerous pieces of ancillary equipment and control systems. The system has been sized to deliver approximately 10,000 pounds of oxygen per day into the Deep Water Ship Channel. The aeration system is anticipated to be operated only when channel DO levels are below the Basin Plan DO water quality objectives (approximately 100 days per year). The project study includes an ongoing assessment of DO levels in the channel and vicinity and a study of potential adverse effects of low DO on salmon. The final report was released in December 2010. (DWR 2010b).
Turlock Irrigation District and Modesto Irrigation District Don Pedro Project	No	**Yes**	No	FERC, Turlock Irrigation District (TID), Modesto Irrigation District (MID)	The Don Pedro Project is on the Tuolumne River in Tuolumne County. The initial license was issued for operations between 1971 and 1991, followed by requirements to evaluate fisheries water needs in the Tuolumne River. In 1987, after the Turlock Irrigation District and Modesto Irrigation District applied to amend their license to add a fourth generating unit, FERC approved an amended fish study plan with possible changes in 1998. In 1996, FERC amended the license to implement amended minimum flow criteria and require fish monitoring studies for completion in 2005. In 2002, NMFS requested that FERC initiate formal consultation on the effects of the Don Pedro Project on Central Valley Steelhead. FERC approved the Summary Report on fisheries in 2008. In 2009, NMFS, USFWS, the California Department of Fish and Wildlife (CDFW), and several environmental interest groups filed requests for rehearing on the license. FERC denied portions of the request but required instream flow studies to be conducted and required NMFS to be included for consultation on any authorized changes to minimum flow release schedules. FERC also directed appointment of an administrative law judge to assist in assessing the need for and feasibility for interim measures before relicensing. A final report was completed in 2010. Following completion of the report and a monitoring plan by the affected districts, FERC approved an order modifying and approving instream flow and monitoring study plans. A final license application, including an Environmental Report, was submitted to FERC in April 2014 (TID and MID 2014). An amendment to the final license application was submitted to FERC in October 2017 (TID and MID n.d). The license expired in 2016. The objective of the relicensing process is to continue operation and maintenance of the Don Pedro Project facilities for electric power generation, along with implementation of any terms and conditions to be considered for inclusion in a new FERC hydroelectric license.
Upper San Joaquin River Basin Storage Investigation	No	No	**Yes**	Reclamation, DWR	The Upper San Joaquin River Basin Storage Investigation is being conducted by Reclamation and DWR to evaluate alternative plans to increase Upper San Joaquin River Storage, to enhance the San Joaquin River restoration efforts and improve water supply reliability for agricultural, municipal and industrial, and environmental uses in the Friant Division, the San Joaquin Valley, and other regions of the state. The investigation is evaluating integration of conjunctive management and water transfer concepts into plan formulations. Additional storage also is expected to provide incidental flood damage reduction benefits. (Reclamation 2014) Reclamation is analyzing alternatives for a new dam and a 1,260,000 AF reservoir along the San Joaquin River, upstream from Millerton Lake in an area known as Temperance Flat. Primary planning objectives are to: (1) increase water supply reliability, and (2) enhance flow and temperature conditions to support the San Joaquin River Restoration Program. Operation variables include reservoir carryover, new or shifting water supply beneficiaries, and alternative conveyance routes. Reclamation released a Draft Feasibility Report in February 2014 and a Draft EIS in September 2014 (Reclamation 2017).
Voluntary Agreements	No	No	**Yes**	SWRCB, California Natural Resources Agency (CNRA), Water Rights Holders	The California Natural Resources Agency has been leading an effort to negotiate voluntary agreements with water users, to support environmental objectives through a broad set of tools while protecting water supply reliability. DWR and CDFW have submitted documents to the SWRCB that reflect progress to define a framework to improve conditions for fish through targeted river flows and a suite of habitat-enhancing projects, including floodplain inundation and physical improvement of spawning and rearing areas. Further work and analysis is needed to determine whether the agreements can meet environmental objectives required by law and identified in the SWRCB update to the Bay-Delta Water Quality Control Plan.
Yuba River Watershed Hydroelectric Projects	No	**Yes**	No	FERC, Nevada Irrigation District, Pacific Gas and Electric Company (PG&E)	The Nevada Irrigation District is applying for a new license for the Yuba-Bear Project (FERC Project No. 2266), and PG&E is applying for the Drum-Spaulding Project (FERC Project No. 2310). The Yuba-Bear Project is on the Middle and South Yuba rivers, Bear River, and Jackson and Canyon creeks (FERC 2014). Concurrently, PG&E is applying for a license renewal for the Drum-Spaulding Project on the Bear and Yuba rivers. Operations of the two projects are coordinated in many factors. The FERC relicensing processes for these two projects in underway. (Yuba River Watershed Information System n.d)
Yuba River Development Project Relicensing	No	**Yes**	No	FERC, Yuba County Water Agency	The Yuba County Water Agency is seeking to renew its 50-year FERC license for the Yuba River Development Project (FERC Project No. 2246). The Yuba River Development Project is on the Yuba River, the Middle Yuba River, and Oregon Creek in Yuba County, and consists of one reservoir (New Bullards Bar on the North Yuba River), two diversion dams (Our House Diversion Dam on the Middle Yuba River and Log Cabin Diversion Dam on Oregon Creek), three powerhouses (New Colgate, Fish Release, and Narrows No. 2), and various recreational facilities and appurtenant facilities (Yuba County Water Agency 2016). The new Bullards Bar Reservoir has a capacity of 969,600 AF. The initial FERC license expired April 30, 2016, and the Yuba County Water Agency engaged in FERC's integrated licensing process to prepare an application for a new license. The Yuba County Water Agency filed a Draft Application for a New License Major Project–Existing Dam, on December 3, 2013, and a Final Application for a New License Major Project–Existing Dam, on April 28, 2014. FERC issued the Final EIS in January 2019.

Table 4.6-1 b. List of Cumulative Projects – Habitat Improvement Projects and Actions

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Battle Creek Salmon and Steelhead Restoration Project	No	**Yes**	No	Reclamation and SWRCB	Construction of the Battle Creek Salmon and Steelhead Restoration Project was initiated in 2009 to reestablish approximately 42 miles of prime salmon and steelhead habitat on Battle Creek, plus an additional 6 miles on its tributaries. The species benefited by the project include Central Valley Spring-run Chinook Salmon (State and federally listed as threatened), Sacramento River Winter-run Chinook Salmon (State and federally listed as endangered), and Central Valley Steelhead (federally listed as threatened). Restoration of Battle Creek will be accomplished primarily through the modification of the Battle Creek Hydroelectric Project (FERC Project No. 1121) facilities and operations, including instream flow releases. Facility changes include removal of five diversion dams and construction of fish ladders and fish screens at three diversion dams. PG&E is the owner and licensee of the Hydroelectric Project. Any changes to the Hydroelectric Project trigger the need for PG&E to seek a license amendment from FERC. The Restoration Project has been developed in collaboration with various resource agencies, including USFWS, NMFS, CDFW, and the Bay-Delta Authority, and in conjunction with participation from the public, including the Greater Battle Creek Watershed Working Group and the Battle Creek Watershed Conservancy. The project currently is being implemented. (Reclamation 2018c)
Cache Slough Area Restoration	No	No	**Yes**	DWR and CDFW	The Cache Slough Complex is in the North Delta where Cache Slough and the southern Yolo Bypass meet. It currently includes Liberty Island, Little Holland Tract, Prospect Island, Little Egbert Tract, and the surrounding waterways. Levee height on these tracts is restricted and designed to allow overtopping in large flow events to convey water from the upper Yolo Bypass. Since 1983 and 1998 respectively, Little Holland Tract and Liberty Island have remained breached. Restoration is occurring naturally on the islands. Restoration in the Cache Slough Complex was identified as an Interim Delta Action by former Governor Schwarzenegger in July 2007. Other planning processes, such as Delta Vision and the Delta Risk Management Strategy, also have identified the Cache Slough Area as a potential priority restoration site. The Cache Slough Complex has the potential for restoration success because of its relatively high tidal range, historic dendritic channel network, minimal subsidence, and remnant riparian and vernal pool habitat. Restoration efforts would support native species, including Delta Smelt, Longfin Smelt, Sacramento Splittail, and Chinook Salmon, by creating or enhancing natural habitats and improving the food web fish require. Surrounding lands that are at elevations that would function as floodplain or marsh if not separated by levees also could be included in the Cache Slough Area. This broader area includes roughly 45,000 acres of existing and potential open water, marsh, floodplain, and riparian habitat. The goals of restoration in the Cache Slough Complex are to: (1) re-establish natural ecological processes and habitats to benefit native species, (2) contribute to scientific understanding of restoration ecology, and (3) maintain or improve flood safety. Three restoration actions currently are contemplated in the Cache Slough Complex, including restoration actions at Calhoun Cut, Little Holland Tract, and Prospect Island. These are briefly described in the following: • Calhoun Cut: Calhoun Cut is a human-made, excavated, east-west running channel that originally was created to improve navigation in the area. The channel begins at the confluence of Lindsey and Barker sloughs and runs west in a straight line until it intersects the terminal portion of Lindsey Slough. Calhoun Cut adversely influences tidal action in the historic arms of Lindsey Slough. Restoration of tidal action would entail removal of features that restrict flow through the slough, excavating starter channels to begin channel evolution and promote tidal flow, and potentially block Calhoun Cut to restore the tidal channel system in Lindsey Slough. • Little Holland Tract: Little Holland Tract encompasses about 1,640 acres within the Cache Slough Complex. Similar to Prospect Island, Little Holland Tract was acquired by the federal government (U.S. Army Corps of Engineers [USACE]) in anticipation of transferring ownership to USFWS as a component of a North Delta National Wildlife Refuge. The tract has been subject to tidal influence since 1983, when levees separating Little Holland Tract and the toe drain failed. Since that time, the site has naturally returned to a mixture of tidally influenced emergent wetlands, mudflats, and riparian habitat. Restoration actions would complement what has occurred naturally by increasing wetland values at the site.
California EcoRestore	No	No	**Yes**	CNRA	California EcoRestore is an initiative by CNRA to coordinate and advance habitat restoration of aquatic and upland habitat within the Delta (CNRA 2015a, 2015b). Some of these programs or projects would be funded by federal and State water agencies that are required to mitigate impacts of the CVP and SWP. Other programs would be sponsored by a combination of funds from State bonds (Proposition 1 and 1E), Assembly Bill 32's Greenhouse Gas Reduction Fund, federal agencies, local agencies, and private investments. The California Delta Conservancy is to lead implementation of identified restoration projects, in collaboration with local governments and with a priority on using public lands in the Delta.
Decker Island Habitat Development	**Yes**	No	No	DWR	The Decker Island Habitat Development/Levee Improvement Project provides 26 acres of fish and wildlife habitat at the northern tip of Decker Island and recreates historical river habitat. Although the project has been completed, long-term maintenance and monitoring continue. For more information see https://water.ca.gov/Programs/Integrated-Regional-Water-Management/Delta-Ecosystem-Enhancement-Program/Decker-Island-Habitat-Development.
Delta Islands and Levees Feasibility Study	**Yes**	No	No	USACE and DWR	The final feasibility study and EIS was released in September 2018. This report addressed flood risk management, ecosystem restoration, water quality, water supply, and several other issues. DWR's Delta Risk Management Strategy studies were used to define problems, opportunities, and specific planning objectives. The feasibility study provides the mechanism by which USACE can participate in a cost-shared solution to a variety of water resources needs under its authority. USACE and DWR share the cost of the feasibility study equally. (USACE 2018)

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Dutch Slough Tidal Marsh Restoration Project	**Yes**	No	No	DWR and California State Coastal Conservancy	The Dutch Slough Tidal Marsh Restoration Project, near Oakley in eastern Contra Costa County, would restore wetland and uplands, and provide public access to the 1,166-acre Dutch Slough property owned by DWR. The property is composed of three parcels, separated by narrow, human-made sloughs. The project would provide ecosystem benefits, including habitat for sensitive aquatic species. It also would be designed and implemented to maximize opportunities to assess development of those habitats and measure ecosystem responses so that future Delta restoration projects will be more successful. Construction on two of the parcels began in May 2018 and is expected to be completed in 2019, followed by revegetation planting. Restoration of the third parcel, Burroughs, is to begin in 2020. (DWR 2019b) Two neighboring projects proposed by other agencies that are related to the Dutch Slough Restoration Project collectively contribute to meeting project objectives. These include the City of Oakley's proposed Community Park and Public Access Conceptual Master Plan, for 55 acres adjacent to the wetland restoration project and 4 miles of levee trails on the perimeter of the DWR lands. The City Community Park will provide parking and trailheads for the public access components of the Dutch Slough Restoration Project. The Ironhouse Sanitary District is proposing the West Marsh Creek Delta Restoration Project, a restoration of a portion of the Marsh Creek delta on an adjacent 100-acre parcel it owns west of Marsh Creek. The Ironhouse Project could provide fill material for, and be linked to, the Dutch Slough Restoration lands.
Ecosystem Restoration Program Conservation Strategy	No	**Yes**	No	CDFW	The Ecosystem Restoration Program (ERP) is a multi-agency effort aimed at improving and increasing aquatic and terrestrial habitats and ecological function in the Delta and its tributaries. The ERP Focus Area includes the Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. Principal participants overseeing the ERP are CDFW, USFWS, and NMFS, collectively known as the ERP Implementing Agencies. The ERP implements restoration projects through grants administered by the ERP Grants Program. The vast majority of these projects focus on fish passage issues, species assessment, ecological processes, environmental water quality, or habitat restoration. The ERP is guided by the following six strategic goals: • recover endangered and other at-risk species and native biotic communities; • rehabilitate ecological processes; • maintain or enhance harvested species populations; • protect and restore habitats; and • prevent the establishment of and reduce impacts from non-native invasive species; and • improve or maintain water and sediment quality.
Folsom Lake Temperature Control Device	No	No	**Yes**	El Dorado Irrigation District (EID) and Reclamation	EID, in collaboration with Reclamation, constructed facilities on the bank of Folsom Lake to withdraw water from the warm upper reaches of the lake while preserving the cold water pool at the bottom of the lake, to protect downstream aquatic species. The facilities include a large-diameter, concrete-lined vertical shaft and five lined horizontal adits extending from the shaft. This structure, a temperature control device (TCD), replaced EID's five existing raw pump casings that extracted water from Folsom Lake at a rate of 19.5 million gallons per day (mgd). The new facility is sized to accommodate a maximum extraction rate of 74 mgd over an 18-hour period, which is equivalent to 52 mgd. The temperature control device began operation in spring 2003 (Reclamation, USFWS, and Water Forum 2007).
Fremont Landing Conservation Bank	**Yes**	No	No	CDFW	The project is the restoration, enhancement, and preservation of 100 acres of habitat for the federally and State-listed Chinook Salmon and Central Valley Steelhead at the Fremont Landing Conservation Bank site. Construction of the Fremont Landing Conservation Bank was completed and the Banks successfully met performance standards for the final year of monitoring in 2018 (Wildlands 2018). The project preserves and enhances 40 acres of existing riparian and wetland habitat and restores/creates 60 acres of riparian woodland and wetland sloughs within the floodplain of the Sacramento River. Three borrow pits are connected to the Sacramento River to reduce/eliminate fish stranding. The project also includes preservation and restoration of shaded riverine aquatic habitat and placement of large woody debris along the Sacramento River.
Goat Island at Rush Ranch Tidal Marsh Restoration	No	No	**Yes**	Solano Land Trust	This project would restore unrestricted tidal flows to Goat Island Marsh, currently a diked, muted marsh with broken tide gates. Proposed actions include excavating a breach in the levee and constructing a tidal channel, lowering the remainder of the perimeter levee, closing the levee portion of the Marsh Trail, expanding marsh ponds, and revegetating the levee excavation site and marsh-terrestrial ecotone. A boardwalk would be constructed concurrently with project implementation, to provide alternate public access (Solano County 2015). Eighty acres tidal marsh. Adjacent Suisun Hill Restoration and Lower Spring Branch Creek Restoration adds additional land and habitat values. This project has been identified as one of the projects that will be implemented under California EcoRestore. Construction is pending financing for construction.
Hill Slough Restoration Project	No	No	**Yes**	CDFW	The Hill Slough Tidal Marsh Restoration Project will restore tidal marsh and enhance upland managed wildlife habitat. The restoration design consists of (1) breaching eight perimeter and two internal levees, to open most of the site to tidal action from surrounding sloughs; (2) lowering some segments of existing levees to provide high marsh habitat and improving levees in other areas, to provide flood protection for the surrounding area; (3) improving some water control structures; (4) raising the elevation of Grizzly Island Road through the project site to reduce flood risks; (5) adding a loop trail and parking area for improved public access; and (6) upgrading three transmission towers and lines in areas subject to tidal inundation. The project will create approximately 750 acres of restored tidal marsh and upland fish and wildlife habitat, and 200 acres of enhanced wildlife habitat. This project has been identified as one of the projects that will be implemented under California EcoRestore. Construction currently is underway. (CNRA n.d.h)
Lower Mokelumne River Spawning Habitat Improvement Project	No	**Yes**	No	East Bay Municipal Utility District (EBMUD)	The Mokelumne River is tributary to the Delta and supports five species of anadromous fish. The Proposed Project would initially place 4,000 to 5,000 cubic yards of suitably sized salmonid spawning gravel annually for a 3-year period at two specific sites, and then provide annual supplementation of 600 to 1,000 cubic yards thereafter. Work will be conducted each year over 1 week in August and September. Fall-run Chinook Salmon and steelhead are the primary management focus in the river. Availability of spawning gravel in this section of the Mokelumne River has been determined to be deficient because historic gold and aggregate mining operations removed gravel annually, and upstream dams have reduced gravel transport to the area. This area was chosen because it is known to have supported Fall-run Chinook Salmon and Steelhead spawning in the past, and because the substrate is suitable for habitat improvement. A final Initial Study (IS)/Mitigated Negative Declaration (MND) was released in August 2014 (EBMUD 2014).

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Lower Sherman Island Wildlife Area (LSIWA) Land Management Plan (LMP)	**Yes**	No	No	CDFW	The Lower Sherman Island Wildlife Area (LSIWA) occupies roughly 3,100 acres, primarily marsh and open water, at the confluence of the Sacramento and San Joaquin rivers in the west Delta. This extensive tract of natural vegetation and Delta waters provides diverse and valuable wildlife habitats and related recreational opportunities and is integral to the functioning and human use of the Delta. The mission of CDFW is to manage California's diverse fish, wildlife, and plant resources, and the habitats on which they depend, for their ecological values and for their use and enjoyment by the public. The LMP is consistent with that mission. The purpose of the Land Management Plan (LMP)is to: (1) guide management of habitats, species, and programs described in the LMP to achieve CDFW's mission to protect and enhance wildlife values; (2) serve as a guide for appropriate public uses of the LSIWA; (3) serve as descriptive inventory of fish, wildlife, and native plant habitats that occur on or use the LSIWA; (4) provide an overview of the property's operation and maintenance and of the personnel requirements associated with implementing management goals (this LMP also serves as a budget planning aid for annual regional budget preparation); and (5) present the environmental documentation necessary for compliance with State and federal statutes and regulations, provide a description of potential and actual environmental impacts that may occur during plan management, and identify mitigation measures to avoid or lessen these impacts. The final Land Management Plan was released in April 2007. (CDFG 2007)
North Delta Flood Control and Ecosystem Restoration Project	**Yes**	No	No	DWR	The North Delta Flood Control and Ecosystem Restoration Project has been proposed by DWR at an area near the confluence of the Cosumnes and Mokelumne rivers, encompassing approximately 197 square miles. Consistent with objectives contained in the CALFED ROD, the project is intended to improve flood management and provide ecosystem benefits in the North Delta area through actions such as construction of setback levees and configuration of flood bypass areas to create quality habitat for species of concern. These actions are focused on the McCormack-Williamson Tract and Staten Island. The project would implement flood control improvements in a manner to benefit aquatic and terrestrial habitats, species, and ecological processes. Flood control improvements are needed to reduce damage to land uses, infrastructure, and the Bay-Delta ecosystem, resulting from overflows caused by insufficient channel capacities and catastrophic levee failures in the 197-square-mile project study area. The Proposed Project as described in the Final EIR (DWR 2010a) included: portions of the levee system degraded to allow controlled flow across McCormack-Williamson Tract; levee modification to mitigate hydraulic impacts; channel dredging to increase flood conveyance capacity; an off-channel detention basin on Staten Island; ecosystem restoration where floodplain forests and marshes would be developed at McCormack-Williamson Tract and the Grizzly Slough property; setback levee on Staten Island to expand the floodway conveyance; and opening up the southern portion of the McCormack-Williamson Tract to boating; improving Delta Meadows property; providing access and interpretive kiosks for wildlife viewing; and providing restroom, circulation, parking, and signage infrastructure to support such uses.
Prospect Island Tidal Habitat Restoration Project	No	**Yes**	No	DWR and CDFW	Prospect Island is in the Cache Slough Complex in the Delta immediately east of the southern end of the Yolo Bypass. The Project goal is to convert roughly 1,609 acres of flooded uncultivated land to fully tidal habitat. Restoration activities will restore tidal action with an estimated 1,360 habitat acreage credits. For a more detailed project description see https://water.ca.gov/Programs/Environmental-Services/Restoration-Mitigation-Compliance/Delta-Projects.
Riparian Habitat Joint Venture Project	**Yes**	No	No	California Partners in Flight	The Riparian Habitat Joint Venture (RHJV) project was initiated by California Partners in Flight in 1994. To date, 18 federal, state and private organizations have signed the Cooperative Agreement to protect and enhance habitats for native land birds throughout California. These organizations include CDFW, DWR, California State Lands Commission, Ducks Unlimited, National Audubon Society, National Fish and Wildlife Foundation, The Nature Conservancy, The Trust for Public Land, CNRA, Reclamation, USFWS, and Wildlife Conservation Board. The RHJV, modeled after the successful joint venture projects of the North American Waterfowl Management Plan, reinforces other collaborative efforts currently underway that protect biodiversity and enhance natural resources as well as the human element they support. The vision of the RHJV is to restore, enhance, and protect a network of functioning riparian habitat across California, to support the long-term viability of land birds and other species. A wide variety of other species of plants and wildlife will benefit through the protection of forests along rivers, streams and lakes. The RHJV mission is to provide leadership and guidance to promote the effective conservation and restoration of riparian habitats in California through the following goals: (1) identify and develop technical information based on sound science for a strategic approach to conserving and restoring riparian areas in California; (2) promote and support riparian conservation on the ground by providing guidance, technical assistance and a forum for collaboration; and (3) develop and influence riparian policies through outreach and education. In 2004, Partners in Flight prepared The Riparian Bird Conservation Plan, a guidance document that outline a strategy for conserving riparian birds, including birds using the Delta. In 2009, a California Riparian Habitat Restoration Handbook was released; it demonstrates how to approach riparian restoration design from an ecological perspective and describes the existing ecological conditions. (RHJV 2009)
Liberty Island Conservation Bank	**Yes**	No	No	Reclamation District 2093	This project received permits and approvals in 2009 to create a conservation bank on the northern tip of Liberty Island to preserve, create, restore, and enhance habitat for native Delta fish species, including Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Chinook Salmon, California Central Valley Steelhead, Delta Smelt, and Central Valley Fall-run and Late Fall-run Chinook Salmon. The project consists of creating tidal channels, perennial marsh, riparian habitat, and occasionally flooded uplands on the site. The project also includes the breaching of the northernmost east-west levee, and preservation and restoration of shaded riverine aquatic habitat along the levee shorelines of the tidal sloughs. The island's private levees failed in the 1997 flood and were not recovered, leaving all but the upper 1,000 acres and the adjacent levees permanently flooded. These upper acres encompass the proposed bank. The lower nearly 4,000 acres will remain, at least for the near future, predominantly open water and subtidal because tidal elevations are too great for marsh or riparian habitat.
Lookout Slough Tidal Habitat Restoration Project	No	**Yes**	No	DWR and Ecosystem Investment Partners	This multi-beneficial tidal restoration project is located in the Cache Slough area of the Delta northwest of Liberty Island. Project goals are to restore approximately 3,400-acre site to a tidal wetland, creating habitat and producing food for Delta Smelt and other listed fish species. In addition to the restoration of important tidal wetland habitat, the project will also provide flood protection by expanding flood conveyance and storage for the Yolo Bypass. Restoration activities will restore tidal action with an estimated 3,000 habitat acreage credits for Delta Smelt. For a more detailed project description see https://water.ca.gov/Programs/Environmental-Services/Restoration-Mitigation-Compliance/Delta-Projects.

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Lower Yolo Ranch Restoration Project	No	No	**Yes**	DWR and State and Federal Contractors Water Agency (SFCWA)	The Lower Yolo Ranch Restoration Project is located in near Liberty Island in the Delta. The project will restore about 1,670 acres on a site which has historically been used for pasture/cattle grazing. For a more detailed project description see http://resources.ca.gov/ecorestore/california-ecorestore-projects/.
Lower American River Flow Management Standard Implementation	No	**Yes**	No	Sacramento Water Forum and Reclamation	The Sacramento Water Forum developed a modified Flow Management Standard (FMS) for the Lower American River that was released in October 2015. The modified FMS will significantly lower water temperatures in the Lower American River during the crucial rearing season for juvenile steelhead; provide better overall habitat conditions; significantly improve water supply reliability in the American River basin by avoiding low reservoir levels; and avoid redirected impacts on Sacramento River fisheries.
Lower American River Temperature Reduction Modeling Project (formerly Lake Natomas Temperature Curtains Pilot Project)	No	No	**Yes**	USFWS, Anadromous Fish Restoration Program; Reclamation; Sacramento Water Forum	The objective of the Lower American River Temperature Reduction Modeling Project is to develop predictive tools that will: (1) reduce uncertainties in the performance of identified temperature control actions that could be implemented to improve the management of cold water resources in the Folsom/Natoma Reservoir system and the Lower American River, and (2) be available for daily operations, planning, and salmon and steelhead habitat studies by other project operators and other stakeholders. The project adapted, calibrated, and verified existing thermodynamic and hydrologic mathematical models for application at Folsom Reservoir, Lake Natoma, and the Lower American River. The models were used to assess the effectiveness of the identified actions individually and in combination to support a recommendation as to development and implementation of one or more actions for reducing temperatures in the Lower American River. The actions identified to improve transport of cold water through Lake Natoma and reduce the temperature of the Lower American River included: a Nimbus Dam curtain, a Lake Natoma plunge zone curtain, Nimbus powerplant debris wall removal, dredging Lake Natoma, and modifying Folsom Powerplant peak loading operation.
Restoration of Eastern Delta Floodplain Habitats on Grizzly Slough in the Cosumnes River Watershed	**Yes**	No	No	CNRA	The Grizzly Slough Floodplain Restoration Project is one of two main elements of the North Delta Flood Control and Ecosystem Restoration Project that consists of flood management and habitat improvements where the Mokelumne River, Cosumnes River, Dry Creek, and Morrison Creeks converge. Flood flows and high water conditions in this area threaten levees, bridges, and roadways. The North Delta project will reduce flooding and provide contiguous aquatic and floodplain habitat along the downstream portion of the Cosumnes Preserve, by modifying levees on Grizzly Slough. Benefits to ecosystem processes, fish, and wildlife will be achieved by recreating floodplain seasonal wetlands and riparian habitat on the Grizzly Slough property. Construction is targeted for 2019 or later (CNRA n.d.b).
San Francisco Bay Delta Action Plan	No	**Yes**	No	U.S. Environmental Protection Agency (EPA)	In 2012, EPA identified seven key activities to advance the protection and restoration of aquatic resources and ensure a reliable water supply in the San Francisco Bay-Delta Estuary watershed. EPA's Action Plan included the following actions: (1) strengthen estuarine habitat protection standards; (2) advance regional water quality monitoring and assessment; (3) accelerate water quality restoration through Total Maximum Daily Loads; (4) strengthen selenium water quality criteria; (5) prevent pesticide pollution; (6) restore aquatic habitats while managing methylmercury; and (7) support the Bay-Delta Conservation Plan.
Sustainable Groundwater Management Act	No	**Yes**	No	SWRCB, California Department of Toxic Substances Control, DWR	DWR has developed a strategic plan for its Sustainable Groundwater Management (SGM) Program. DWR's SGM Program will implement the new and expanded responsibilities identified in the 2014 Sustainable Groundwater Management Act (SGMA). Some of these expanded responsibilities include: (1) developing regulations to revise groundwater basin boundaries; (2) adopting regulations for evaluating and implementing Groundwater Sustainability Plans (GSPs) and coordination agreements; (3) identifying basins subject to critical conditions of overdraft; (4) identifying water available for groundwater replenishment; and (5) publishing best management practices for the sustainable management of groundwater. More than 99% of the state's high- and medium-priority basins are now covered by groundwater sustainability agencies that now are tasked with submitting groundwater sustainability plans, beginning in 2020. (CNRA 2019)
Tule Red Restoration Project	**Yes**	No	No	SFWCA; California Department of Fish and Wildlife	State and Federal Contractors Water Agency's (SFCWA) Tule Red tidal marsh restoration project was recently completed and became operational on October 15, 2019 (http://sfcwa.org/project/tule-red-restoration-project/). It is unclear how many acres are being restored, but it appears to be between 350-420 acres (https://www.swc.org/in-the-news/2739/state-water-contractors-provide-over-7-million-in-funding-for-the-tule-red-tidal-restoration-project).
Winter Island	No	**Yes**	No	DWR	DWR's Fish Restoration Program (FRP) acquired approximately 589 acres on Winter Island in 2016 for tidal wetland restoration. DWR is planning to implement the Winter Island Tidal Habitat Restoration Project, which will restore tidal connectivity to the interior of Winter Island to create aquatic habitat at intertidal and shallow sub-tidal elevations, associated high marsh, and riparian habitats on the site to benefit native fish species. The Project is intended to partially fulfill the 8,000-acre tidal habitat restoration obligations of DWR, contained within Reasonable and Prudent Alternative (RPA) 4 of the 2008 U.S. Fish and Wildlife Service (USFWS) Delta Smelt Biological Opinion and referenced in RPA I.6.1 of the 2009 National Marine Fisheries Service (NMFS) Salmonid Biological Opinion, for long-term coordinated operations of the State Water Project and the federal Central Valley Project. The goal of the project is to restore unrestricted tidal connectivity to the interior of Winter Island to create tidal wetland, associated high marsh, and riparian habitats on the site to benefit native fish species. Preliminary planning, conceptual design, and baseline data collection (e.g., topography and bathymetry) were conducted in 2016. DWR circulated an IS/MND for public review and comment in August 2018.

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project	No	No	**Yes**	Reclamation and DWR	Reclamation and DWR are partnering to reconnect floodplain habitat and improve fish passage for young salmon. The Yolo Bypass Salmonid Habitat Restoration Project (see https://www.usbr.gov/mp/bdo/yolo-bypass.html) works to reconnect the floodplain for fish during the winter season and improve connectivity within the bypass and to the Sacramento River. The project provides seasonal inundation that mimics the natural process of the Yolo Bypass floodplain and improves connectivity within the bypass and to the Sacramento River. The project primarily consists of a new Fremont Weir headworks structure, a new outlet channel, and downstream channel improvements. This enables juvenile salmon to feed in a food-rich area for a longer time, allowing them to grow rapidly in size and improving their chances of survival as they travel to the ocean. Improvements will also reduce stranding and migratory delays of adult salmon and sturgeon due to passage barriers. The project is in accordance with Reasonable and Prudent Alternative (RPA) actions I.7 and I.6.1, in the 2009 National Marine Fisheries Service Biological Opinion (2009 NMFS BiOp) on the Long-Term Operations (LTO) of the Central Valley Project and State Water Project (LTO) and part of the Reinitiation of Consultation (ROC) on LTO.
Yolo Bypass Wildlife Area Land Management Plan	No	**Yes**	No	CDFW	The Yolo Bypass Wildlife Area is made up of approximately 16,770 acres of managed wildlife habitat and agricultural land in the Yolo Bypass. The bypass conveys seasonal high flows from the Sacramento River to help control river stage and protect the cities of Sacramento, West Sacramento, and Davis, and other local communities, farms, and lands from flooding. Substantial environmental, social, and economic benefits are provided by the Yolo Bypass, benefiting Californians. The purposes of the Yolo Bypass Wildlife Area Land Management Plan are to: (1) guide the management of habitats, species, appropriate public use, and programs to achieve CDFW's mission; (2) direct an ecosystem approach to managing the Yolo Bypass Wildlife Area, in coordination with the objectives of the CALFED ERP; (3) identify and guide appropriate, compatible public-use opportunities in the Yolo Bypass Wildlife Area; (4) direct management of the Yolo Bypass Wildlife Area in a manner that promotes cooperative relationships with adjoining private-property owners; (5) establish a descriptive inventory of the sites and the wildlife and plant resources that occur in the Yolo Bypass Wildlife Area; (6) provide an overview of the Yolo Bypass Wildlife Area's operation, maintenance, and personnel requirements to implement management goals, and serve as a planning aid for preparation of the annual budget for the Bay-Delta Region (Region 3); and (7) present the environmental documentation necessary for compliance with State and federal statutes and regulations, provide a description of potential and actual environmental impacts that may occur during plan management, and identify mitigation measures to avoid or lessen these impact. The final Land Management Plan was released in June 2008 (CDFG 2008).
Yolo Flyway Farms Tidal Habitat Restoration Project	No	**Yes**	No	DWR and Reynier Fund, LLC	The Yolo Flyway Farms Tidal Habitat Restoration Project goals are to restore seasonal wetland and cattle grazing land to sub-tidal, intertidal, and seasonal wetlands to benefit native fish species. The 359-acre project involves restoring and enhancing approximately 300 acres of tidal freshwater wetlands, and an additional 30 acres of seasonal wetlands, at the southern end of the Yolo Bypass in the Cache Slough Complex area in the Sacramento–San Joaquin Delta (Delta). The proposed Project seeks to partially restore historical ecological functions in the current, highly altered regional landscape. DWR and Reynier Fund, LLC. are restoring this project to help meet the 2008 USFWS Delta Smelt Operations Criteria and Plan (OCAP) Biological Opinion's requirement to restore 8,000 acres of tidal wetlands in the Delta. The Project will also contribute to restoration requirements of the 2009 NMFS OCAP BiOp.

Table 4.6-1 c. List of Cumulative Projects – Fish Passage and Diversion Screening Projects and Actions

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Red Bluff Diversion Dam Fish Passage Improvement Project	No	**Yes**	No	Reclamation and Tehama Colusa Canal Authority (TCCA)	The project modified the Red Bluff Diversion Dam to reduce or minimize impacts on migration of anadromous fish and improve the reliability of agricultural water supply in the Tehama-Colusa and Corning Canal systems. The project included a new pumping plant and fish screen with a pumping capacity of 2,500 cfs. The initial installed pumping capacity is 2,000 cfs. No increase in water diversions occurs above 2,500 cfs. The original diversion dam currently is in the decommissioning process. Construction began in spring 2010, and the facility began full operation in summer 2012. (TCCA 2013)
Anadromous Fish Screen Program	No	**Yes**	No	Reclamation and USFWS	The primary objective of the Anadromous Fish Screen Program (AFSP) is to protect juvenile Chinook Salmon (all runs), Steelhead, Green and White Sturgeon, Striped Bass, and American Shad from entrainment at priority diversions throughout the Central Valley. Section 3406 (b)(21) of the Central Valley Project Improvement Act (CVPIA) requires the Secretary of the Interior to assist the State in developing and implementing measures to avoid losses of juvenile anadromous fish resulting from unscreened or inadequately screened diversions on the Sacramento and San Joaquin rivers, their tributaries, the Delta, and Suisun Marsh. In addition, all AFSP projects must meet Goal 3 of the CALFED ERP's Draft Stage 1 Implementation Plan. (USFWS 2015)
American Basin Fish Screen and Habitat Improvement Project	No	**Yes**	No	Reclamation, CDFW, and Natomas Central Mutual Water Company	Reclamation and CDFW authorized and provided funds to the Natomas Central Mutual Water Company (Natomas Mutual), to construct and operate the American Basin Fish Screen and Habitat Improvement Project. The purposes of the project are to: (1) avoid or minimize potentially adverse effects on fish, particularly anadromous juvenile fish, because of water diversions from the Sacramento River and Natomas Cross Canal by Natomas Mutual and other small pumps operated by individual landowners for diversion of water into the Natomas Basin; (2) ensure reliability of Natomas Mutual's water diversion and distribution facilities for beneficial uses of its water supply within its service area; and (3) maintain important habitat in the Natomas Basin, created by operation of the Natomas Mutual's water distribution facilities. The project would result in modifications of Natomas Mutual's water diversion and distribution system adjacent to the Sacramento River and Natomas Cross Canal in Sacramento and Sutter counties. The modifications include construction and operation of one or two positive-barrier fish screen diversion facilities; decommissioning and removing the Verona Diversion Dam and lift pumps; removing five pumping plants and one small private diversion; and modifying the distribution system. The project is anticipated to be implemented in three phases. A ROD was signed on April 20, 2009 (Reclamation 2009b).

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Yolo Bypass Fish Passage Projects	No	**Yes**	No	DWR and Reclamation	The Yolo Bypass Habitat Restoration Program is tasked with developing and implementing restoration actions in the Yolo Bypass that satisfy the 2009 National Marine Fisheries Service Biological Opinion (NMFS BiOp) for the long-term operation of the State Water Project as described in the 2012 Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan. Six separate projects have been identified and are being evaluated and implemented to carry out the RPA Actions specific to the Yolo Bypass. There are many project under the Yolo Bypass Habitat Restoration Projects for a complete listing and description of restoration projects under this program see https://water.ca.gov/Programs/Environmental-Services/Restoration-Mitigation-Compliance/Yolo-Bypass-Projects.

Table 4.6-1 d. List of Cumulative Projects – Invasive Species Control Programs and Actions

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Egeria Densa Control Program	No	**Yes**	No	California Department of Boating and Waterways (DBW)	The Egeria Densa Control Program (EDCP) is part of DBW's Aquatic Pest Control Program. Cal Boating has operated the EDCP in the Delta and its tributaries since program inception in 2001. The program was developed to respond to 1997 State legislation (Rainey, Assembly Bill 2193), authorizing the program. A Final EIR was published for the program in 2001. A second addendum to the 2001 EIR was published in January 2006, with a 5-year program review and future operations plan. In June 2007, NMFS analyzed the potential effects of continued implementation of the EDCP on listed salmonids and Green Sturgeon and issued a Biological Opinion continuation of the program for 5 years (2007 through 2011). DBW received the Section 7 Biological Opinion from USFWS along with a letter of concurrence from NMFS in May 2013. Both documents were valid until 2017 (CDPR 2014). The program includes treatment with herbicides, environmental monitoring, regulatory compliance, and surveillance.
Arundo Control and Restoration Program	No	**Yes**	No	DWR	The Arundo Control and Restoration Program is part of the larger Delta Ecosystem Enhancement Program, operated by DWR. *Arundo donax* is an invasive species that is devastating Delta riparian habitat. The Arundo Control and Restoration Program aims to develop expertise in Arundo control, effective restoration techniques in the controlled areas, resources requirements, and landowner contacts to solicit their cooperation (DWR 2019a). As of 2019, the project currently is active.
Water Hyacinth Control Program	No	**Yes**	No	DBW	The Water Hyacinth Control Program is part of DBW's Aquatic Pest Control Program. DBW has operated the Water Hyacinth Control Program in the Delta and its tributaries since program inception. In 1982, State legislation made DBW the lead agency for the control of water hyacinth in the Delta, its tributaries, and Suisun Marsh. The initial control plan used both short and long-term methods that involved chemical, mechanical, and biological control measures. The primary and most successful control measure is chemical spraying. Permits for the program were obtained in 2001. DWB published a Final Programmatic Environmental Impact Report in 2009. The selected alternative is a continuation of the program.
Invasive Species Program	No	**Yes**	No	CDFW	The Invasive Species Program participates on efforts to prevent introduction of non-native invasive species in California, detect and respond to introductions when they occur, and prevent the spread of non-native invasive species that have become established. Program activities include development of the California Aquatic Invasive Species Management Plan, the Marine Invasive Species Monitoring Program, and informational and education activities for Quagga/Zebra Mussels, New Zealand Mudsnails, Northern Pike (in Lake Davis), and dwarf eelgrass.
California Aquatic Invasive Species Management Plan	No	**Yes**	No	CDFW	The California Aquatic Invasive Species Management Plan (CAISMP) was released in January 2008. The plan's overall goal is to identify the steps that need to be taken to minimize the harmful ecological, economic, and human health impacts of aquatic invasive species in California. This plan provides the state's first comprehensive, coordinated effort to prevent new invasions, minimize impacts from established aquatic invasive species, and establish priorities for action statewide. In addition, it proposes a process for annual plan evaluation and improvement, so that aquatic invasive species can continue to be managed in the most efficient manner in the future. Eight major objectives and 163 actions were identified in the CAISMP.
Aquatic Invasive Species Draft California Rapid Response Plan	No	**Yes**	No	CDFW	The CAISMP (described above) proposes an Aquatic Invasive Species Rapid Response Plan for the State. The plan establishes a draft general procedure for rapid response following detection of a new aquatic invasive species infestation. It provides a framework for developing and implementing a rapid response plan. It is preliminary in that it describes types of information, resources, and decisions necessary to finalize the plan. To finalize, fund, and implement the draft Rapid Response Plan, CDFW expects that cooperating agencies will assign staff to participate. CDFW Invasive Species Program staff will provide coordination for the interagency activities listed in the agreement(s).
Zebra Mussel Rapid Watch Program and Response Plan for California	No	**Yes**	No	CDFW	As part of the Zebra Mussel Early-Detection Monitoring and Outreach Program and the California Zebra Mussel Watch Program, this rapid response plan was developed to outline necessary actions and resources needed to respond to confirmed introductions of Zebra Mussels into the state. The plan outlines available options for eradication and/or control of Zebra Mussels (and Quagga Mussels) and provides guidance for resource managers and agency personnel. The plan includes a list of potential Zebra Mussel infestation scenarios, with possible treatment and post-treatment monitoring techniques. The Zebra Mussel Rapid Response Plan for California is a working document that requires additional information (which will be incorporated as it becomes available) regarding funding sources, permitting requirements, specific roles of agency personnel, legal information, and infestation site specific information. The draft plan will serve as the template for a statewide plan that staff from DWR will continue to develop.

Table 4.6-1 e. List of Cumulative Projects – Area-Wide Plans and Programs

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Bay-Delta Water Quality Control Plan Update	No	**Yes**	No	SWRCB	The SWRCB is updating the 2006 Bay-Delta WQCP in two phases (SWRCB 2018): • Phase I: The first Plan amendment is focused on San Joaquin River flows and South Delta salinity and modifies water quality objectives (i.e., establishes minimum flows) on the Lower San Joaquin River and Stanislaus, Tuolumne, and Merced rivers, to protect the beneficial use of fish and wildlife, and modifies the water quality objectives in the South Delta to protect the beneficial use of agriculture. The proposed final amendments to the Bay-Delta Plan and the Final Supplemental Environmental Document for Phase I was released in July 2018, with some additional minor changes released in August 2018. • Phase II: Phase II is focused on the Sacramento River and its tributaries, Delta eastside tributaries (including the Calaveras, Cosumnes, and Mokelumne rivers), Delta outflows, and interior Delta flows.
Delta Plan	No	**Yes**	No	Delta Stewardship Council (Council)	In November 2009, the California Legislature enacted SBX7 1, which took effect on February 3, 2010. One portion of this legislation is known as the Sacramento–San Joaquin Delta Reform Act of 2009 (the Delta Reform Act). The Delta Reform Act requires development of a legally enforceable, comprehensive, long-term management plan for the Delta, which is referred to as the Delta Plan. The Delta Reform Act also created the Delta Stewardship Council (Council), which is an independent State agency. One of the Council's primary responsibilities is to adopt the Delta Plan. The Delta Reform Act requires the Council to adopt a Delta Plan that achieves the State's coequal goals. The Delta Reform Act also specifies the following: (1) eight objectives that are "inherent" in the co-equal goals (see Water Code Section 85020), (2) a related statewide policy to reduce reliance on the Delta in meeting the State's future water supply needs through improved regional water self-reliance (Water Code Section 85021); and (3) certain specific subjects and strategies that must be included in the Delta Plan (see Water Code Sections 85301–85309). The Delta Plan must include Bay Delta Conservation Plan (BDCP)if the BDCP is completed and approved by DFW as a Natural Communities Conservation Plan and by federal agencies as a Habitat Conservation Plan. In September 2013, the Delta Plan was adopted by the Council and subsequently was amended in 2016 and 2018 (Delta Stewardship Council 2018).
Hatchery and Stocking Program	No	**Yes**	No	CDFW and USFWS	CDFW operates a statewide system of fish hatchery facilities that rear and subsequently release millions of trout, salmon, and steelhead of various age and size classes into State waters. These fish are reared and released for recreational and commercial fishing, for conservation and restoration of fish species that are native to California waters, for mitigation of habitat losses caused by construction of dams on the state's major rivers, and for mitigation of fish lost at State-operated pumping facilities in the Delta. (CDFG and USFWS 2010). CDFW's Hatchery Program includes: • operation of 14 trout hatchery facilities owned by CDFW and the related stocking of fish; • operation of eight salmon and steelhead hatchery facilities owned by others and the related stocking of fish; • operation of two salmon and steelhead hatchery facilities owned by CDFW and the related stocking of fish; • providing education staff and fish for stocking under the Fishing in the City program; • issuing authorizations and providing fish eggs for the Classroom Aquarium Education Project (CAEP); • issuing permits for stocking public and private waters with fish reared at private aquaculture facilities; and • implementing the fish production and native trout conservation requirements contained in California Fish and Game Code Section 13007. The fundamental objectives of CDFW's Hatchery Program are to continue the rearing and stocking of fish from its existing hatchery facilities for the recreational use of anglers, for mitigation of habitat loss from dam construction and blocked access to upstream spawning areas, for mitigation of fish losses caused by operation of the State-operated Delta pumps, and for conservation and species restoration.
Hatchery and Stocking Program Proposed Changes	No	**Yes**	No	CDFW and USFWS	CDFW has been rearing and stocking fish in the inland waters of California since the late 1800s. CDFW currently stocks trout in high mountain lakes, low elevation reservoirs, and various streams and creeks throughout California. Salmon have been planted mostly in rivers and direct tributaries to the Pacific Ocean, with the exception of inland kokanee, coho, and Chinook Salmon populations that have been planted in reservoirs for recreational fishing. In 2006, a lawsuit was filed against CDFW, claiming that CDFW's fish stocking operation did not comply with CEQA. In July 2007, CDFW was ordered by the Sacramento Superior Court to comply with CEQA regarding its fish stocking operations. CDFW completed a Final EIR to comply with the court order in July 2010 (CDFG and USFWS 2010). The USFWS served as the co-lead for the joint EIR/EIS.
Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes	**Yes**	No	No	USFWS	The recovery plan addresses the recovery needs for eight fish species that occupy the Delta, including Delta Smelt, Sacramento Splittail, Longfin Smelt, Green Sturgeon, Chinook Salmon (Spring-run, Late Fall-run, and San Joaquin Fall-run), and Sacramento Perch (believed to be extirpated). The objective of the plan is to establish self-sustaining populations of these species that will persist indefinitely. This would be accomplished by managing the estuary, to provide better habitat for aquatic life in general and for the fish addressed by the plan. Recovery actions include tasks such as increasing freshwater flows; reducing entrainment losses to water diversions; reducing the effects of dredging, contaminants, and harvest; developing additional shallow-water habitat, riparian vegetation zones, and tidal marsh; reducing effects of toxic substances from urban non-point sources; reducing the effects of introduced species; and conducting research and monitoring.

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Public Draft Recovery Plan for Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Chinook Salmon and Central Valley Steelhead	**Yes**	No	No	NMFS	The Draft Recovery Plan provides a roadmap that describes the steps, strategy, and actions that should be taken to return Winter-run Chinook Salmon, Spring-run Chinook Salmon, and Steelhead to viable status in the Central Valley. California thereby is ensuring their long-term persistence and evolutionary potential. The general near-term strategic approach to recovery includes methods to: secure all extant populations, monitor for *O. mykiss* in habitats accessible to anadromous fish, and minimize straying from hatcheries to natural spawning areas. Actions will include conducting critical research on fish passage and reintroductions with climate change and developing a recovery plan for sustainable populations that will have minimal susceptibility to catastrophic events. The recovery plan for Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Chinook Salmon, and Central Valley Steelhead was released in July 2014.
Sacramento Valley Salmon Resiliency Strategy	No	**Yes**	No	CNRA, CDFW, DWR, Reclamation	The Sacramento Valley Salmon Resiliency Strategy is a science-based document that has been prepared to address specific near- and long-term needs of Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Chinook Salmon, and California Central Valley Steelhead. The Strategy is science-driven, focused, and designed to provide resource agencies, the public, Congress, and the California State Legislature with information critical to collaborative approaches to species resiliency. The Strategy aims to improve species viability and resiliency by promoting actions that address specific life stage stressors by implementing specific habitat restoration actions.
Delta Smelt Resiliency Strategy	No	**Yes**	No	CNRA, CDFW, DWR, and Division of Boating and Waterways	The Delta Smelt Resiliency Strategy is a science-based prepared to address both immediate and near-term needs of Delta Smelt, to promote their resiliency to drought conditions as well as future variations in habitat conditions. Several of the actions identified in this Strategy could also benefit other species, and coordination across various resource management agencies as appropriate may allow for benefits beyond Delta Smelt. Although the feasibility and effectiveness of each action included in the Strategy requires further exploration and study, the Strategy is an aggressive approach to implementing any actions that can be implemented in the near term, can be implemented by the State with minimal involvement of other entities, and have the potential to benefit Delta Smelt.

Table 4.6-1 f. List of Cumulative Projects – Other Projects

Project	Past Project	Present or Ongoing	Future Project	Primary Agencies	Description
Rio Vista Estuarine Research Center Station	No	No	**Yes**	USFWS and DWR	The planned Delta Research Station (DRS) would consist of two facilities, a proposed Estuarine Research Station (ERS) and a Fish Technology Center (FTC). Collectively, these facilities are intended to serve as an aquatic research and monitoring facility that is located in a centralized area of the Bay-Delta. The project reflects the outcome of a multiyear collaboration between DWR, USFWS, California Department of Fish and Wildlife, and other agencies involved in the IEP. The DRS would consolidate ongoing Interagency Ecological Program (IEP) research and monitoring activities throughout the Bay-Delta and provide facilities for study and production of endangered Delta fishes

Notes for Tables 4.6-1 a through f
AF = acre feet
AFSP = Anadromous Fish Screen Program
AFY = acre-feet per year
BDCP = Bay Delta Conservation Plan
BMPs = best management practices
BiOp = Biological Opinion
CAEP = Classroom Aquarium Education Project
CAISMP = California Aquatic Invasive Species Management Plan
CCWD = Contra Costa Water District
CDFG = California Department of Fish and Game
CDFW = California Department of Fish and Wildlife
cfs = cubic feet per second
CNRA = California Natural Resources Agency
COA = Coordinated Operations Agreement
Council = Delta Stewardship Council
CV RWQCB = Central Valley Regional Water Quality Control Board
CVP = Central Valley Project
CVPIA = Central Valley Project Improvement Act
DBW = California Department of Boating and Waterways
Delta = Sacramento–San Joaquin Delta
DMC = Delta-Mendota Canal
DO = dissolved oxygen
DEIR = Draft Environmental Impact Report
DRS = Delta Research Station
DWR = California Department of Water Resources
EBMUD = East Bay Municipal Utility District
EchoWater = Sacramento Regional Wastewater Treatment Plant Facility Upgrade Project
EDCP = The Egeria Densa Control Program
EID = El Dorado Irrigation District

EIR = environmental impact report
EIS = Environmental Impact Statement
EPA = U.S. Environmental Protection Agency
ERP = Ecosystem Restoration Program
ERS = Estuarine Research Station
ESA = Endangered Species Act
FERC = Federal Energy Regulatory Commission
FMS = Flow Management Standard
FTC = Fish Technology Center
GSPs = Groundwater Sustainability Plans
ID = Merced Irrigation District
IEP = Interagency Ecological Program
IS = initial study
LMP = Land Management Plan
LSIWA = The Lower Sherman Island Wildlife Area
LTO = Long-Term Operations
mg/L = milligrams per liter
mgd = million gallons per day
MID = Modesto Irrigation District
MND = mitigated negative declaration
Natomas Mutual = Natomas Central Mutual Water Company
NMFS = National Marine Fisheries Service
NOD = Notice of Determination
NPDES = National Pollutant Discharge Elimination System
NSJCGBA = Northeastern San Joaquin County Groundwater Banking Authority
OCAP = Operations Criteria and Plan
PG&E = Pacific Gas and Electric Company
Reclamation = U.S. Bureau of Reclamation
RWQCB = Regional Water Quality Control Board
RHJV = Riparian Habitat Joint Venture
ROC = Reinitiation of Consultation
ROD = Record of Decision
Sacramento County RSD = Sacramento County Regional Sanitation District
SFCWA = State and Federal Contractors Water Agency
SGM = Sustainable Groundwater Management
SGMA = Sustainable Groundwater Management Act
SLDMWA = San Luis and Delta–Mendota Water Authority
SSQP = Sacramento Stormwater Quality Partnership
SWP = State Water Project
SWRCB = State Water Resources Control Board
TCCA = Tehama-Colusa Canal Authority
TCD = temperature control device
TID = Turlock Irrigation District
USACE = U.S. Army Corps of Engineers
USFWS = U.S. Fish and Wildlife Service
WQCP = Water Quality Control Plan

The impacts of past projects on surface water quality, including past operation of the SWP, have been included in the description of the baseline environmental conditions provided in Section 4.3. The cumulative impact of these past projects has resulted in a baseline that has altered Delta outflows and degraded surface water quality in the Delta. In particular, Delta waterways are listed on Section 303(d) for impairment by EC, a measure of salinity. Several factors have contributed to this impairment, and it is difficult to quantify the proportion of salinity impairment attributable to a specific project action or event.

Projects that contribute to these cumulative impacts that involve construction and operation of infrastructure facilities could have temporary adverse impacts on surface water quality during construction and also could result in longer-term impacts on surface water quality by altering surface water flows. Projects involving invasive species management actions would have short-term adverse impacts on surface water quality through application of herbicides or pesticides, or from disturbance of streambeds from mechanical removal. Projects involving water diversions or transfers (e.g., CVP long-term operations) would affect hydrology and water flow, and therefore would have secondary impacts on salinity levels in the Delta.

Present and future projects affecting surface water quality in the Delta, including the proposed long-term SWP operations, would be subject to a variety of laws and regulatory processes that would require management of flows in these water bodies to maintain surface water quality indicators and limit potential impacts on aquatic resources. However, because of the existing altered surface water quality conditions in the Delta, the overall cumulative impact from past, present, and reasonably foreseeable projects on surface water quality in the Delta would be **potentially significant**.

The incremental contribution of the Proposed Project to the cumulative impact on surface water quality would not be cumulatively considerable. As explained in Section 4.3, the Proposed Project would not increase concentrations of nutrients, mercury, organic matter, or other human-made water quality constituents. The Proposed Project would have the potential to increase salinity in late fall and winter.

Discussion of Cumulative Impact to Water Quality

DWR operates the SWP in accordance with obligations under D-1641. D-1641 includes water right permit terms and conditions to implement water quality objectives to protect agricultural and M&I beneficial uses in the Delta, as well as water quality objectives to protect fish and wildlife beneficial uses in the Delta and Suisun Marsh. DWR and Reclamation will continue to operate the SWP and CVP in compliance with the provisions of D-1641, including maintaining salinity levels corresponding to the location of X2, as required. DWR, in coordination with Reclamation, is required to meet these standards even if other projects result in changes to salinity so that the cumulative water quality conditions are consistent with the salinity standards of D-1641 and protect the beneficial uses.

Therefore, the contribution of the Proposed Project to Delta water quality **would not be cumulatively considerable.**

4.6.1.5 Aquatic Biological Resources

The baseline for evaluating cumulative impacts on aquatic resources is the same environmental setting as that described for the Proposed Project in Section 4.4, and the relevant threshold of impact significance is as follows:

(a) Would the project, in combination with other past, present, or reasonably foreseeable future projects, have a substantial adverse impact (either directly, through habitat modifications, by interfering with the movement of native fish species, or by impeding use of native fish nursery/rearing sites) on any species of primary management concern, including species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game, National Marine Fisheries Services, or U.S. Fish and Wildlife Service?

As discussed in Section 3.4, this threshold is a combination of the two thresholds taken from Appendix G of the CEQA Guidelines that are applicable to aquatic biological resources. Thresholds from Appendix G relating to terrestrial biological resources are not addressed in this cumulative analysis because the Initial Study determined that the Proposed Project would have no impact on terrestrial biological resources.

As described in Section 4.4, the Proposed Project would result in less-than-significant impacts on the aquatic species evaluated and on habitats for these species that are influenced by SWP operations, including the Sacramento River (from its confluence with the Feather River downstream to the Delta), the Delta, and Suisun Marsh and Bay. Species evaluated include:

- Delta Smelt
- Longfin Smelt
- Winter-run Chinook Salmon
- Spring-run Chinook Salmon
- Central Valley Steelhead
- Fall-/Late Fall-run Chinook Salmon
- Green Sturgeon
- White Sturgeon
- Pacific Lamprey
- River Lamprey
- Sacramento Splittail
- Hardhead
- Central California Roach
- Striped Bass
- American Shad

- Largemouth Bass, Smallmouth Bass, and Spotted Bass

Although the direct and indirect project impacts on these species are limited to the Sacramento River, Delta, and Suisun Marsh and Bay, the geographic context for cumulative impact analysis of aquatic biological resources extends beyond the limits of project-specific impacts and would vary depending on the existing range and habitat of each of the affected species.

The Delta has undergone dramatic change over the last 160 years, rendering its early nature virtually unrecognizable. Many fundamental alterations occurred within the first few decades since 1848. Waterways were leveed, wetlands drained, tidal sloughs dammed, riparian forests cut, and flows altered. Today, the many layers of change and unintended consequences and long-lasting repercussions of actions make it challenging to comprehend the natural ecosystem form, process and function (SFEI 2012, SFEI and DSC 2019).

Before the transformation of wetlands to farms and towns, distinct patterns of native habitats were expressed along the Delta’s broad physical gradients. The arrangement of habitats was driven by variations in dominant physical processes. The historical Delta habitat patterns and ecological functions reflected the transition between dominant riverine processes upstream and tidal processes downstream. At the Delta mouth, the salinity gradient shifted with interannual and seasonal variability. It was also affected by the differences in the hydrologic regimes of the Sacramento and San Joaquin rivers, as well as other tributaries that feed into it. Landscape patterns were influenced by these and other interacting physical processes and organized within the context of three primary components: the subtidal channels, the intertidal and non-tidal wetlands, and the elevated, infrequently flooded natural levees.

The existing Delta is one of the most significantly modified deltas in the world. The most significant change in the Delta region has been the replacement of the historically large expanse of perennial wetland by an even greater expanse of agriculture and urban development. Another important observation is that much of the existing areas of “natural” habitat types in the Delta patches of alkali seasonal wetlands, seasonal wetlands, grassland, or willow-lined artificial levees has been converted from the freshwater emergent wetlands that historically occupied those locations. The remnant natural areas in the Delta today are also often not of the same quality as similar types historically, as they are significantly compromised in the ecological functions they can provide and often highly disturbed, fragmented, or disconnected from other habitat types (SFEI 2012).

In addition to the direct physical changes that have occurred in the Delta, the establishment of agriculture, urban areas, and associated infrastructure in the Central Valley has further contributed to altering conditions in the Delta by introducing agricultural runoff and urban pollutants, and modifying Delta hydrology by diverting and managing surface water at upstream locations.

The impacts of past projects, including past operation of the SWP, have been included in the description of the baseline environmental conditions provided in Section 3.4. The cumulative impact of these past projects has resulted in a baseline consisting of a trending decline of listed-species population within the Delta and other waterways used by anadromous fish populations in northern

California. As noted, multiple factors have contributed to this trending decline, and it is difficult to quantify the proportion of the decline attributable to a specific project, action, or event
Existing federal statutes and regulatory requirements on federal actions provide protective measures to avoid jeopardizing those species listed in accordance with the federal ESA. Specifically, BiOps were prepared to allow the SWP and CVP to continue operating without causing jeopardy to listed species or adverse modification to designated critical habitat. In addition, California requires an incidental take permit for the long-term operation of the SWP facilities in the Delta for the protection of state-listed species.

Despite these protections, the cumulative impact of past Delta modifications and other past and present projects has contributed to the continuing decline in Delta fish populations and habitat of protected species. This overall cumulative impact is significant.

Table 4.6-1 lists past, present, and probable future projects capable of producing related or cumulative impacts in combination with the Proposed Project. This list does not include those historical actions or events that have contributed to the existing conditions in the Delta, as previously described. The projects listed in Table 4.6-1 are divided into six categories corresponding to their respective similarities, impacts on similar resources, and potential impacts on Delta fish species.

The defined categories include the following:

- Water Supply, Water Management, and Water Quality Projects and Actions
- Habitat Improvement Projects and Actions
- Fish Passage and Diversion Screening Projects and Actions
- Invasive Species Control Programs and Actions
- Area-Wide Plans and Programs
- Other Projects

The majority of past, present, and reasonably foreseeable projects that are shown in Table 4.6-1 may have impacts on the same aquatic species and/or habitats as the Proposed Project. Specific quantifiable details regarding the biological impacts of every one of these projects were not available, and therefore this analysis is conducted qualitatively. Many of these projects would be subject to the federal and state protective laws and regulatory processes that require avoidance or mitigation of impacts on listed fish addressed in this document.

Present and future projects could affect Delta conditions and Delta fish populations. Each of these projects would be subject to its own permitting analyses and, if necessary, mitigation to less-than-significant levels under CEQA and, potentially, full mitigation to meet CESA requirements. The following discussion addresses the potential cumulative impact for each of the categories previously listed.

Water Supply, Water Management, and Water Quality Projects and Actions

Projects that could contribute to these cumulative impacts, which involve construction and operation of infrastructure facilities that affect Delta waterways, could have temporary adverse impacts on water quality during construction that affect aquatic species and could cause a permanent reduction in fish habitat. The operation of such projects could also result in longer-term impacts on aquatic habitat quality and quantity by altering surface water flows, water temperature, migratory routes, and streambed characteristics, to name a few variables.

Projects, such as the Shasta Lake Resources Investigation (Shasta Dam), have the potential to substantially alter aquatic species habitat, while other projects, such as the Sacramento Regional Wastewater Treatment Plant Upgrade Project (EchoWater), have the ability to substantially improve Delta water quality by treating and removing constituents harmful to aquatic biological resources.

In addition, Reclamation evaluated the impacts of the Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project in a Draft Environmental Impact Statement issued in July 2019 (Reclamation 2019). As reported by Reclamation (2019) long-term operation of the CVP facilities upstream of the Sacramento River confluence with the Feather River, on the American River, and upstream of the Delta on the San Joaquin and Stanislaus rivers could potentially affect species evaluated in this EIR. Long-term operation of the CVP facilities has the potential to affect instream flows and water temperatures for anadromous species, including Chinook Salmon, Central Valley Steelhead, Green Sturgeon, White Sturgeon, lamprey species, Striped Bass, and American Shad, that would enter the Sacramento River reach potentially affected by long-term SWP operations (i.e., from the confluence with the Feather River to the Delta) and the Delta during their immigration and emigration life stages.

The EIS for the long-term operation of the CVP identified limited impacts on these species (see Section 5.9 in Reclamation 2019). Specifically, habitat conditions in the Sacramento River upstream of the Feather River would remain similar or improve for anadromous species. Habitat conditions in the American River would remain similar or improve for anadromous species. Habitat conditions in the Stanislaus River would be similar, although conditions could be slightly warmer. However, habitat restoration included in the Proposed Project would benefit anadromous species in the river. Habitat conditions in the San Joaquin River would be similar for anadromous species. Entrainment-related impacts in the Delta would be offset by improved conditions in the Sacramento River for the Sacramento River basin anadromous fishes evaluated. Negative impacts on Delta fishes, including Delta Smelt and Longfin Smelt, could occur as a result of CVP operation but are anticipated to be offset with the reintroduction efforts for Delta Smelt and habitat restoration proposed in the EIS. Conservation measures, including habitat restoration, are described in the Proposed Action in Reclamation (2019) to minimize potential effects on aquatic species. The measures that are anticipated to minimize impacts on aquatic species by region include:

Sacramento River Region Conservation Measures

- Rice Decomposition Diversion Coordination and Smoothing
- Spring Water Temperature Management to Identify Effects on Spawning Locations

- Develop Updated Water Temperature Modeling Platform
- Shasta Temperature Control Device Performance Evaluation
- Battle Creek Salmon and Steelhead Restoration Project and Battle Creek Reintroduction Plan
- Lower Intakes near Wilkins Slough
- Spawning Habitat Restoration
- Rearing Habitat Restoration
- Deer Creek Irrigation District Dam (DCID) Fish Passage
- Small Screen Program
- Knights Landing Outfall Gates
- Winter-Run Chinook Salmon Conservation Hatchery Production
- Adult Rescue
- Trap and Haul
- Reclamation, NMFS, DWR, and CDFW Directors Meetings to Address Multiple Years of Low Egg-to-Fry Survival (if needed)

American River Region Conservation Measures

- Spawning and Rearing Habitat Restoration
- Nimbus Hatchery Genetic Management Plans
- Drought Water Temperature Management

Delta Region Conservation Measures

- San Joaquin Basin Steelhead Telemetry Study
- Steelhead Life Cycle Monitoring Program
- San Joaquin Basin Steelhead Collaborative
- San Joaquin River Scour Hole Predation Reduction
- Tidal Habitat Restoration
- Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
- Predator Hot Spot Removal
- Delta Cross-Channel Gate Improvements
- Tracy Fish Facility Improvements
- Clifton Court Forebay Mortality Reduction
- Skinner Fish Facility Performance Improvements
- Salvage Release Site Evaluation
- Small Screen Program
- Reintroduction Efforts for Delta Smelt

- Delta Fish Species Conservation Hatchery
- Sediment Supplementation Feasibility Study

Stanislaus River Conservation Measures

- Spawning Habitat Restoration
- Rearing Habitat Restoration
- Water Temperature Management Study

San Joaquin River Conservation Measures

- Lower SJR Rearing Habitat Restoration

In addition to the evaluation of SWP impacts conducted in Section 4.4 above, analyses of entrainment at the CVP export facility in the South Delta was conducted using the salvage density method and the results are provided in Appendix E. The analysis of entrainment at the CVP export facility in the South Delta was conducted using the CalSim II modeling provided in Appendix H. These analyses suggest that that entrainment loss of juvenile Winter-run Chinook Salmon, Central Valley Steelhead, Late Fall-run Chinook Salmon, Green Sturgeon, lamprey species, and White Sturgeon at the CVP South Delta export facility would be similar under both the Existing Conditions and Proposed Project scenarios. However, the salvage-density method suggested that modeled entrainment loss of juvenile Spring-run Chinook Salmon, Fall-run Chinook Salmon, Hardhead (during wet years), and Sacramento Splittail at the CVP South Delta export facility could be appreciably greater under the Proposed Project scenario compared to the Existing Conditions scenario. Although these analyses suggest greater potential for entrainment for some species, the CVP facility is subject to the risk assessment-based approach to OMR management included in the NMFS and USFWS Biological Opinions on Long-term Operation of the Central Valley Project and State Water Project (NMFS 2019; USFWS 2019) for the protection of ESA-listed species. The risk assessment-based approach, particularly the implementation of cumulative loss thresholds and real-time implementation of individual year loss thresholds for Winter-run Chinook Salmon and steelhead are not included in the CalSim modeling, and therefore are not included in the salvage-density entrainment analysis. The risk assessment-based OMR management included in the biological opinions could provide ancillary protection for Spring-run Chinook Salmon, Fall-run Chinook Salmon, Hardhead (during wet years), and Sacramento Splittail at the CVP South Delta export facility.

A number of other water supply and water management projects could potentially affect Delta conditions, including long-term and short-term water transfers and the Sites Reservoir Project, for example. Each of these would be subject to their own permitting analyses and, if necessary, full mitigation to meet CESA requirements. A number of habitat restoration projects, many under the California EcoRestore program, have the potential to positively affect aquatic resources. Projects involving construction of fish protection facilities, such as those established by the Anadromous Fish Restoration Program or the American Basin Fish Screen and Habitat Improvement Project, may have temporary adverse impacts on water quality (and associated short-term impacts on aquatic species), but in the longer term, would have beneficial impacts on fish species by reducing entrainment and fish loss.

~~Voluntary Agreements would implement a combination of flow and non-flow projects. The largest change in outflow due to the Proposed Project would occur in April and May of most years and occasionally in November following wet and above-normal years. Voluntary Agreements would augment Delta outflow, particularly in spring, which, cumulatively with the proposed long-term SWP operations, may result in Delta outflow similar to or greater than baseline conditions in April and May of most water year types except wet water year types. Cumulatively, the Voluntary Agreements would contribute to improving conditions for special-status species in the Delta.~~

Impacts of SWP and CVP facilities in the Delta on special-status species inhabiting and traversing the Delta also have been evaluated in Section 4.4, above. As described in these species-specific analyses, many of the impacts are reported as joint SWP and CVP impacts because the models used provide outputs for the SWP and CVP combined. Analyses of impacts on special-status fish species in the Delta show that the Proposed Project would result in less-than-significant impacts. In consideration of the conclusions in Section 5.9 of Reclamation (2019) and Section 4.4., above, the Proposed Project's contribution to cumulative impacts associated with the Reinitiation of Consultation of the CVP and SWP would not be cumulatively considerable. The cumulative impact of the Proposed Project would therefore be **Less Than Significant**.

WQCP Update and Voluntary Agreements

As discussed above, the Bay-Delta Water Quality Control Plan (WQCP) for the Sacramento and San Joaquin rivers serves as the basin plan for much of the area that provides the water supplies for the SWP. The SWRCB is updating the 2006 Bay-Delta WQCP in two phases: the first focusing on San Joaquin River flows and South Delta salinity and the second focused on the Sacramento River and its tributaries, Delta eastside tributaries, Delta outflows, and interior Delta flows. In December of 2018, the SWRCB adopted WQCP amendments under phase one to update water quality objectives for San Joaquin River flows and Southern Delta salinity. The phase one update established an objective to maintain unimpaired flow of 40%, within an adaptive range of 30% to 50%, for San Joaquin River tributaries from February through June of each year. The SWRCB has not yet adopted WQCP updates under phase two but issued a framework in July 2018 for potential phase two WQCP amendments proposing a 55% average unimpaired flow, within a range of 45%–65%, for the Delta and the Sacramento River and its tributaries.

The Voluntary Agreement process is intended to provide an alternate approach to unimpaired flow that would implement a combination of flow and non-flow actions to support the viability of native fishes in the Bay-Delta watershed and achievement of related objectives in the WQCP. Voluntary Agreements, if implemented, would augment Delta outflow, particularly in spring, which, in combination with the proposed long-term SWP operations, will result in Delta outflow greater than Existing Conditions in most water year types. On February 4, 2020, the California Natural Resources Agency and CalEPA outlined a "Framework of Voluntary Agreements," identifying additional flow above Existing Conditions in Above Normal, Below Normal, and Dry Years as well as funding sources and habitat improvements. Appendix K includes slides from the Secretaries of the Natural Resources Agency and CalEPA describing the "Framework for Voluntary Agreements." As described in Chapter 5.3, it is anticipated that spring outflow made available through SWP export reductions developed as a part of Voluntary Agreements would act as a substitute for~~,~~ the spring maintenance flows described in Refined Alternative 2b.

Cumulatively, both the WQCP update and the Voluntary Agreements would contribute to improving conditions for special-status species in the Delta.

~~Voluntary Agreements would implement a combination of flow and non-flow projects. The largest change in outflow due to the Proposed Project would occur in April and May of most years and occasionally in November following wet and above-normal years. Voluntary Agreements would augment Delta outflow, particularly in spring, which, cumulatively with the proposed long-term SWP operations, may result in Delta outflow similar to or greater than baseline conditions in April and May of most water year types except wet water year types. Cumulatively, the Voluntary Agreements would contribute to improving conditions for special-status species in the Delta.~~

~~Impacts of SWP and CVP facilities in the Delta on special-status species inhabiting and traversing the Delta also have been evaluated in Section 4.4, above. As described in these species-specific analyses, many of the impacts are reported as joint SWP and CVP impacts because the models used provide outputs for the SWP and CVP combined. Analyses of impacts on special-status fish species in the Delta show that the Proposed Project would result in less-than-significant impacts. In consideration of the conclusions in Section 5.9 of Reclamation (2019) and Section 4.4., above, the Proposed Project's contribution to cumulative impacts associated with the Reinitiation of Consultation of the CVP and SWP would not be cumulatively considerable. The cumulative impact of the Proposed Project would therefore be Less Than Significant.~~

Habitat Improvement Projects and Actions

Habitat restoration projects could also have temporary adverse impacts on aquatic species through short-term diminishment of water quality but would have beneficial long-term impacts through restoration of habitat areas. Many of the numerous habitat restoration projects that have and are planned to be implemented, including Cache Slough Area Restoration and the Prospect Island Tidal Habitat Restoration Project are intended to increase the area of subtidal and intertidal habitat that would directly benefit Delta fish species. Other habitat restoration projects being developed by California EcoRestore have the potential to substantially increase aquatic species habitat to benefit region-wide fish populations.

Fish Passage and Diversion Screening Projects and Actions

The projects included in this category consist of replacing and improving existing water diversion intakes to minimize loss of fish and improving passage of migrating anadromous fish while improving the reliability of agricultural water supplies. These projects have the potential to contribute to reducing anadromous fish loss at various intake locations on the Sacramento and San Joaquin rivers, in the Delta, and in Suisun Marsh and Bay.

These projects would have a beneficial impact on fish populations and would contribute to improving environmental conditions that act in a cumulative manner with other projects listed in Table 4.6-1.

Invasive Species Control Programs and Actions

Projects involving invasive species management actions, such as the Invasive Species Program and the Zebra Mussel Rapid Watch Program and Response Plan for California, would have beneficial impacts on the listed aquatic species by reducing the presence of competing or predating invasive aquatic species, minimizing their extent and potential impact on water quality and food sources for Delta fish, and/or improving fish habitat by removing invasive plant species. However, localized short-term adverse impacts could occur depending on the type of management action.

Area-Wide Plans and Programs

The plans and program identified in Table 4.6-1 address a wide range of actions. Several plans, such as the Bay-Delta Water Quality Control Plan Update and the California Stewardship Delta Plan, consist of area-wide plans specifically addressing Delta water quality and other Delta resources. These plans include provisions for maintaining water quality objectives; protecting and restoring the Delta ecosystem; protecting unique cultural, recreational, natural resources, and agricultural values; and establishing a more reliable water supply for California.

The implementation of these plans has acted to limit adverse impacts on respective environmental resources and values for which the plans were developed. In this manner, these plans have acted to protect environmental values in the Delta from continued decline associated with past and present activities.

Delta Smelt Resiliency Strategy

The Delta Smelt Resiliency Strategy proposes several actions, including aquatic weed control, North Delta food web adaptive management projects, Delta outflow augmentation, reoperation of the Suisun Marsh Salinity Control Gates, sediment supplementation in the low salinity zone, spawning habitat augmentation, Roaring River Distribution System food production, coordinated managed wetland flood and drain operations in Suisun Marsh, adjusted fish salvage operations, stormwater discharge management, Rio Vista Research Station and Fish Technology Center, near-term Delta Smelt habitat restoration, and the Franks Tract restoration feasibility study. Several of these actions are also proposed as part of the Proposed Project and as separate projects, as listed in Table 4.6-1. The implementation of these actions would contribute to improving conditions for Delta Smelt and would promote the species abundance and distribution.

Other Projects

The Rio Vista Estuarine Research Center Station is a project classified as a unique from the other projects listed in Table 4.6-1. This project would establish an aquatic research and monitoring facility to consolidate efforts by DWR, USFWS, and other agencies involved in the Interagency Ecological Program. The construction of the station would involve site disturbance that can be readily mitigated. The operation of the facility would contribute to improving the understanding of Delta fish, their life history, and habitat requirements.

Discussion of Cumulative Impact to Aquatic Biological Resources

The incremental contribution of the Proposed Project to the cumulative impact on aquatic resources would not be cumulatively considerable because the proposed SWP operations are subject to the same regulatory framework promulgated by the federal and state resource agencies, and include environmental commitments, conservation, or protective measures specifically intended to offset, reduce, or otherwise limit potential impacts on aquatic species, and therefore the Proposed Project would essentially "self-mitigate" for its proportional share of its contribution to the cumulative impact. Therefore, the Proposed Project's contribution to cumulative impacts **would not be cumulatively considerable**. The cumulative impact of the Proposed Project would therefore be **Less Than Significant**.

4.6.1.6 TRIBAL CULTURAL RESOURCES

As discussed in Section 4.5, DWR consulted with numerous Tribal groups, including Fernandeño Tataviam Band of Mission Indians, the Karuk Tribe, United Auburn Indian Community of the Auburn Rancheria, Wilton Rancheria, and the Yocha Dehe Wintun Nation, to determine if TCRs would be adversely affected with implementation of the Proposed Project. No TCRs were identified during this consultation process. Therefore, the Proposed Project's contribution to potential cumulative impacts on TCRs **would not be cumulatively considerable.**

4.6.1.7 HABITAT RESTORATION

DWR is implementing habitat restoration that was identified under the current ESA and CESA authorizations for SWP operations. Some of this restoration is also identified as a part of the Delta Smelt Resiliency Strategy and the Sacramento Valley Salmon Resiliency Strategy. These habitat restoration projects are identified in Table 4.6-1 to the extent that the projects are known and CEQA review has been completed. Other restoration projects are in the planning stages and ~~If any additional habitat restoration targets are incorporated as a requirement of the ITP that DWR seeks for the Proposed Project, DWR will subsequently comply with the requirement and the specific individual projects needed to achieve such restoration targets~~ will be subject to separate future CEQA review once such specific individual projects have been identified and adequate information is available to carry out environmental analysis.

As explained above in the Introduction and in Section 3.2.3, the 2008 USFWS and 2009 NMFS Biological Opinions included RPAs that were designed to allow for continued operations without causing jeopardy to listed species or adverse modification to designated critical habitat, provided the RPAs were implemented. Among those RPAs were requirements to implement ecosystem restoration to benefit listed species. Specifically, RPA Component 4 of the 2008 USFWS Biological Opinion directed DWR to implement a program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh. The 2009 NMFS Biological Opinion included RPA Action I.6.1 directing DWR and Reclamation to restore 17,000 to 20,000 acres of seasonal floodplain rearing habitat in the Lower Sacramento River Basin; it also included Action I.7 requiring the reduction of migratory delays and loss of salmon, steelhead, and sturgeon at the Fremont Weir and other structures in the Yolo Bypass. In addition, the 2009 LFS ITP directed DWR to restore 800 acres of intertidal and associated subtidal wetland habitat in the mesohaline part of the Bay Delta Estuary for the benefit of Longfin Smelt.

The restoration requirements in the 2008 USFWS and 2009 NMFS Biological Opinions were carried forward into the new Biological Opinions that the USFWS and NMFS issued on October 21, 2019, as baseline conditions and were discussed at a programmatic level. DWR ~~intends to~~ identified~~y~~ this restoration as well as the 800 acres of intertidal and associated subtidal wetland habitat as mitigation for the ongoing long-term SWP operations in its ~~forthcoming~~ December 13, 2019 application to CDFW for an ITP pursuant to CESA. The ITP application also proposed a conservative estimate of 396.3 acres of new mesohaline tidal habitat restoration to provide full CESA mitigation for Longfin Smelt take. The actual amount of the additional acreage requirement, if any, will be identified by CDFW in the ITP. As noted in DWR's ITP application, the calculation of 396.3 acres is conservative because it does not account for additional curtailment of exports during spring, which is proposed as part of the Adaptive Management Planning process. If the ITP ultimately includes a requirement for new acreage for mesohaline tidal habitat restoration, the requirement may not necessitate any additional restoration projects beyond those that have already been approved or are in the planning process. Characteristics of existing or planned projects, that would have exceeded the previous 800-acre requirement for mesohaline tidal habitat, may already satisfy any additional acreage requirement. If existing or planned projects do not fully satisfy a new acreage requirement in the ITP, any additional restoration projects will be subject to separate future CEQA review once the projects have been identified and adequate information is available to carry out environmental analysis, which is consistent with how DWR has satisfied CEQA for its current restoration projects.

DWR has been pursuing various projects to meet tidal restoration acreage requirements. Table 4.6-2, below, identifies the tidal restoration projects for which CEQA review has already been completed and regulatory approvals have been granted.

The projects listed in Table 4.6-2 would be credited toward the restoration requirement identified in 2008 USFWS BiOp RPA Component 4, and at least ~~one~~ two of the projects, Winter Island and Tule Red, would be credited toward the wetland acreage requirement in the 2009 LFS ITP. The particular impacts of each individual project differ and are discussed in detail in the individual CEQA documents. The CEQA documents show that there could be impacts on biological resources, such as plants or terrestrial species, associated with landscape changes or on aquatic species associated with in-water work during construction. In-water work could negatively impact water quality, such as by increasing turbidity or from applying herbicides. Other impacts include hazardous material impacts associated with the use of chemicals, such as diesel fuel and oil in machinery during construction; potential impacts on cultural resources if human remains are found during earth moving; and hydrological changes. In addition, some projects could have impacts on short- and long-term aesthetics, and could also have construction-related noise, air quality, and greenhouse gas impacts. In many cases, these impacts were less than significant, or mitigation measures were included to reduce the impacts to a less-than-significant level.

Table 4.6-2. List of Tidal Habitat Restoration Projects Implemented to Date

Project Name	Creditable Acreage[1]	CEQA Document	Estimated Completion Date
Decker Island	114	Mitigated Negative Declaration for Decker Island Restoration Project, approved April 20, 2017	~~2018~~Construction Completed
Prospect Island	1360	Environmental Impact Report for the Prospect Island Tidal Habitat Restoration Project, certified August 2019	2022
Winter Island	553	Mitigated Negative Declaration for Winter Island Tidal Habitat Restoration Project, approved January 9, 2019	~~2019~~Construction Completed
Tule Red	610	CEQA Addendum to Suisun Marsh Habitat Management, Preservation, and Restoration Plan EIS/EIR for Tule Red Restoration Project, dated February 2016	Construction Completed~~2019~~
Lower Yolo Ranch	1680	Environmental Impact Report for Lower Yolo Restoration Project, certified July 2013 Addendum to the Lower Yolo Restoration Project Final Environmental Impact Report, dated September 2018	2020
Yolo Flyway Farms	294	Final Supplemental Environmental Impact Report for Yolo Flyway Farms Restoration Project, certified March 2016	Construction Completed~~2018~~

Note: [1] Acreage suitable for accredited habitat calculation to comply with regulatory requirements.
Source: DWR 2019

DWR is in the process of planning additional projects for at least 3,389 creditable acres toward the remaining tidal restoration that was identified in the 2008 Biological Opinion. In addition to exploring other restoration opportunities, DWR is the lead agency for an EIR that is underway for the Lookout Slough Tidal Habitat Restoration and Flood Improvement Project, which would involve restoring approximately 3,000 acres of tidal marsh habitat toward RPA Component 4 in the 2008 USFWS BiOp and would also provide salmonid rearing habitat. Implementation of these future projects has the potential to result in environmental impacts that would likely be similar to the impacts identified in the final CEQA documents identified above, although the impacts of any particular restoration project would depend on a variety of factors, including the location, acreage, volume of earthmoving, and equipment needed to make landscape modifications.

DWR, in partnership with Reclamation, has also developed the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (YBSHRFPP) consistent with 2009 NMFS BiOp RPA Actions I.6.1 and I.7 to improve fish passage and increase floodplain fisheries rearing habitat in the Yolo Bypass. The Final EIS/EIR for the YBSHRFPP was released on June 7, 2019, and construction is anticipated to begin in 2021 (DWR and Reclamation 2019). As explained in the EIR/EIS, the YBSHRFPP involves creating an opening in the Fremont Weir that is deeper than the Fremont Weir, with operable gates to allow increased flow from the Sacramento River to enter the Yolo Bypass in certain conditions. The

YBSHRFPP would also involve the construction of fish passage improvements on the Fremont Weir and within the Yolo Bypass. These actions would increase the availability of floodplain fisheries rearing habitat for target fish species and improve fish passage. The Final EIS/EIR identified the following impacts as significant and unavoidable:

- Water quality impacts associated with increased methylmercury (MeHg) loads into the Delta during operations of the YBSHRFPP
- Cultural resources impacts associated with the potential to discover and damage previously unknown archaeological and historic-era resources
- Air quality impacts associated with emissions of PM_{10} and nitrogen oxides (NO_X).
- Construction-related noise impacts associated with vibrations from loaded haul trucks along the haul route
- Construction- and maintenance-related noise impacts associated with the temporary or periodic increase in ambient noise levels in the project vicinity

In addition, the Final EIS/EIR identified cumulatively considerable impacts associated with MeHg in the Yolo Bypass, loss of archeological sites that may not be identified through inventory efforts, and the emissions of PM_{10} and NO_X.

As explained above, these mitigation projects have been included in Table 4.6-1 and in the cumulative impact analysis. The Proposed Project would not contribute in a cumulative manner to the effects of these projects. Because no construction or land-disturbing activities would occur, the Proposed Project would not considerably contribute to cumulative impacts on fish and aquatic resources, air quality, water quality, noise, traffic, or conversion of agricultural land or other upland habitats to aquatic habitat. Furthermore, changes in flows and Delta hydrodynamics would not substantially alter water quality in the Delta and therefore would not contribute considerably to cumulative water quality impacts associated with restoration projects. In addition, these restoration projects would result in long-term beneficial effects on Delta fish species resulting from increased frequency and duration of inundation of floodplain habitat, conversion of non-tidal and upland habitat to high-quality fish habitat, and increased fish passage opportunities. Therefore, the Proposed Project, which would result in differences in flows and Delta hydrodynamics under the Proposed Project that would not be expected to significantly impact Delta fishes, the Proposed Project would not considerably contribute to cumulative impacts. **No considerable contribution** to cumulative impacts associated with these projects would occur.

4.6.1.8 Sacramento Valley Salmon Resiliency Strategy

In June 2017, the State of California, through the California Natural Resources Agency, issued the Sacramento Valley Salmon Resiliency Strategy (SRS). The SRS is a science-based document that addresses near- and long-term needs of Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Chinook Salmon, and California Central Valley Steelhead. The Strategy identifies habitat restoration actions aimed at improving species viability and resiliency.

DWR is committed to participating in the SRS and to partnering with other federal, state, and local agencies to pursue salmonid restoration efforts. DWR is already implementing multiple projects, such as the McCormack Williamson Tract Restoration Project, which involves restoring natural floodplains and tidal marsh habitats in the Delta as well as reducing flood risk. DWR is also implementing the Lower Elkhorn Basin Levee Setback Project, a multi-benefit flood risk management project that adds 900 acres of floodplain habitat to the Yolo Bypass, one of California's important floodplain ecosystems.

In addition to projects that are already underway, DWR has begun processes to pursue additional actions. For example, DWR is preparing an EIR analyzing the Tisdale Weir Rehabilitation and Fish Passage Project, which would involve installation of fish passage facilities in the weir to allow upstream migrating salmon and sturgeon access to the Sacramento River. Also, as discussed above in section 4.6.1.7, "Habitat Restoration," DWR is undertaking environmental review for the Lookout Slough Tidal Habitat Restoration and Flood Improvement Project, which would be a multi-benefit project that would benefit salmon, among other species. DWR is also exploring opportunities to partner with local entities to improve adult fish passage and floodplain rearing habitat throughout the Sutter Bypass. These projects and any future restoration projects identified in the SRS will be subject to full CEQA review before any project approvals.

No considerable contribution to cumulative impacts associated with the SRS or projects pursued consistent with the SRS would occur under the Proposed Project. Specifically, because no construction or land-disturbing activities would occur under the Proposed Project, no considerable contribution to cumulative impacts associated with the SRS would occur to air quality, water quality, noise, traffic, or conversion of agricultural land or other upland habitats to aquatic habitat. Further, changes in flows and Delta hydrodynamics would not substantially alter water quality in the Delta and, therefore, would not contribute considerably to cumulative water quality impacts associated with the SRS or projects implemented to support the SRS. In addition, implementation of projects consistent with the SRS would result in beneficial effects on emigrating juvenile and immigrating adult Chinook Salmon and steelhead by increasing frequency and duration of inundation of floodplain habitat and increasing fish passage opportunities. Juvenile Chinook Salmon and steelhead exhibit increased growth and greater survival when rearing on floodplain habitats, and improving fish passage throughout the Central Valley reduces the likelihood of immigration delays at flood control structures (e.g., Tisdale Weir) and increases the likelihood of adult migrants reaching spawning areas. Although the Proposed Project would result in differences in Sacramento River flows below the confluence with the Feather River and would alter Delta hydrodynamics, these differences would not result in significant impacts on Chinook Salmon, steelhead, or other special-status fish species, and would not considerably contribute to cumulative impacts associated with construction of projects consistent with the SRS.

4.6.2 Growth-Inducing Impacts

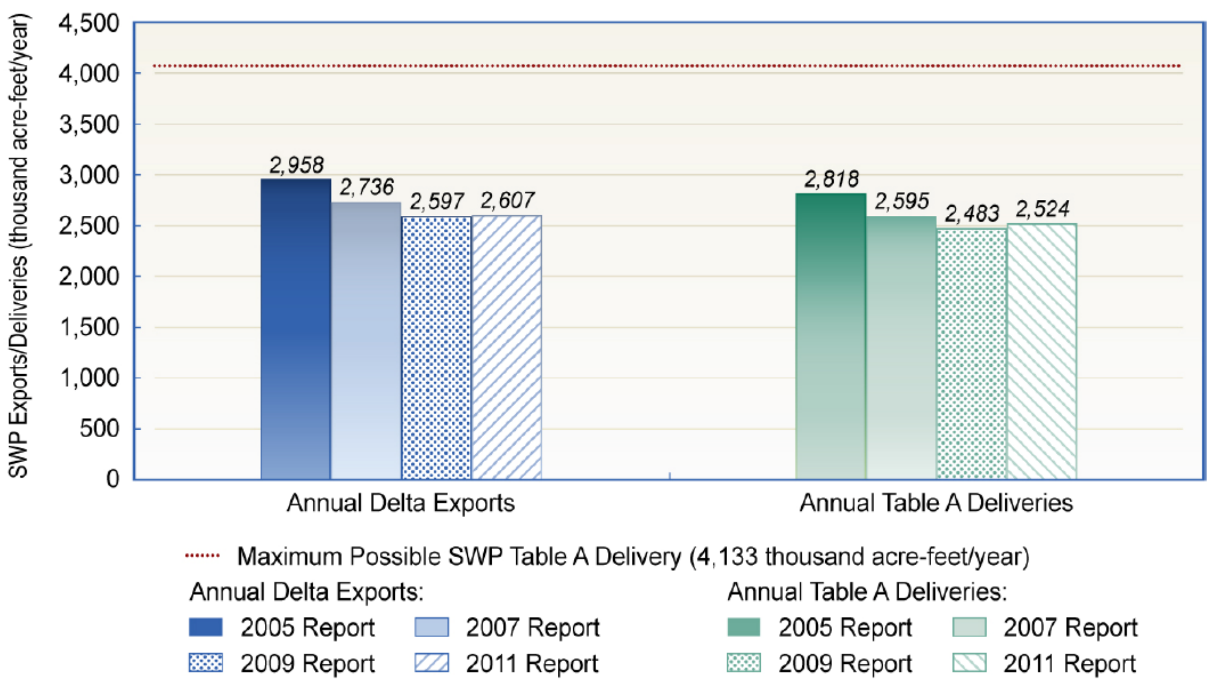
Section 15126.2(e) of the State CEQA Guidelines requires that an EIR discuss the ways in which a Proposed Project could foster economic or population growth, or construction of additional housing, either directly or indirectly, in the surrounding environment. In addition, an EIR should discuss whether the characteristics of a project may encourage and facilitate other activities that could significantly affect the environment. It must not be assumed that growth is beneficial, detrimental, or of little significance to the environment.

4.6.2.1 DIRECT IMPACTS OF THE PROPOSED PROJECT

The Proposed Project would not include any of the following:

- New construction of water facilities, infrastructure, or other land disturbance
- Expansion of the SWP service area
- Economic or population growth due to construction-related activities in the vicinity of the existing SWP facilities in the Delta or other portions of the SWP service area
- Construction of new facilities or modification to existing facilities that could increase the capacity of the SWP
- Modification or increase to the maximum volume of existing contracted water supplies with the 29 public water agencies receiving SWP supplies

As shown in Figure 4.6-1, SWP exports decreased from the historically higher deliveries that occurred from 2005 through 2011. Therefore, the volume of SWP water deliveries has historically been greater than the volume under Existing Conditions and has been subject to declines resulting from a combination of drier hydrologic conditions and regulatory restrictions.



Source: DWR 2011

Figure 4.6-1. Trends in Estimated Average Annual Delta Exports and SWP Table A Water Deliveries 2005 2011

Implementation of the Proposed Project would enable improved management of South Delta pumping facilities in response to real-time monitoring. This level of monitoring would enable the SWP to manage facility operations in the Delta to minimize potential impacts on special-status aquatic species when the risk of impact is higher and to relax operational constraints when the risk of impact is lower.

The increased precision of information to manage the SWP would result in improved fish protection and increase SWP water deliveries during periods when pumping would have less impact on special-status aquatic species. As discussed in Section 4.2, implementation of the Proposed Project scenario would potentially increase annual SWP deliveries by 219 TAF (6%) compared to the Existing Conditions scenario. Relative delivery increases would be greatest in above-normal, below-normal, and dry years. In the dry and critical water years, proposed long-term average annual SWP deliveries would increase by 193 TAF (8%), compared to the Existing Conditions scenario. Figure 4.6-2 compares the potential future deliveries under the Proposed Project scenario to those under the Existing Conditions scenario.

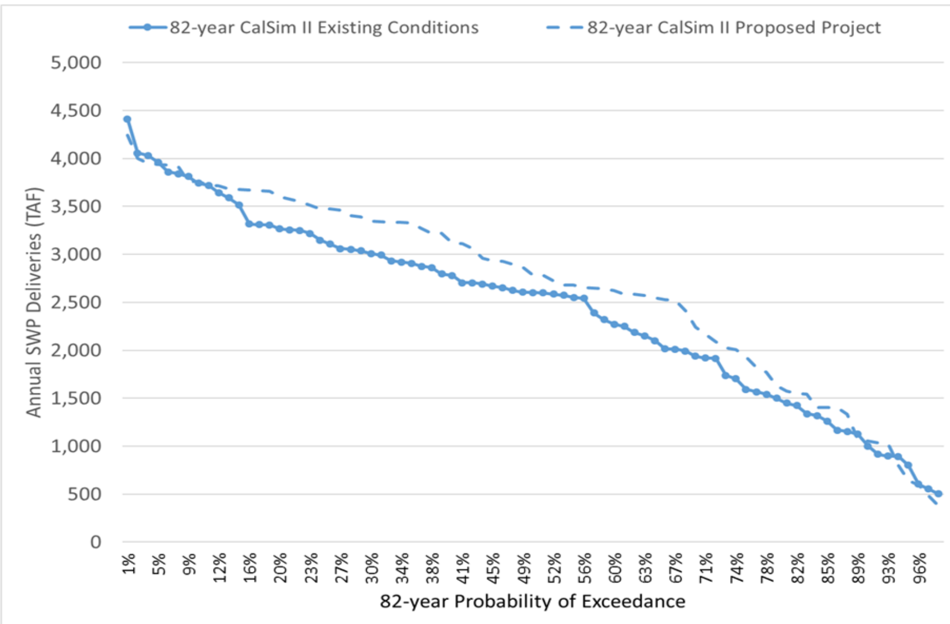


Figure 4.6-2. Probability of Exceedance for Annual SWP Deliveries for Existing Conditions and Proposed Project During 82-Year Model Simulation Period

Figure 4.6-2 presents the 82-year probability of exceedance for annual SWP deliveries for both Existing Conditions and Proposed Project modeled conditions for the 82-year model simulation period. The results of the model show that, during most years, deliveries would increase.

As shown in Figure 4.6-3, actual SWP historical water deliveries between 1996 and 2018 have ranged from less than 500 TAF to more than 3,500 TAF in 2005 and 2006. The CalSim model results shown in Figure 4.6-2 indicate that deliveries would increase with implementation of the proposed long-term SWP operations. However, in many years, SWP deliveries would continue to be limited by drier hydrologic conditions and continuing regulatory restrictions.

In most years, the additional water supply would augment existing limited supplies that routinely are reduced by drier hydrologic conditions or regulatory restrictions. The total south of Delta SWP deliveries would not exceed the contracted maximum water volume of the individual public water agencies. In addition, under the Proposed Project, deliveries are projected to remain within the range of historical deliveries (Figures 4.6-2 and 4.6-3).

4.6.2.2 Potential of the Proposed Project to Induce Growth

To determine direct growth-inducement potential, the Proposed Project was evaluated to verify whether an increase in population or employment, or the construction of new housing would occur as a direct or indirect result of the long-term SWP operations. If either of these scenarios occurred, the Proposed Project could result in direct growth-inducement within the Public Water Agency (PWA) service areas.

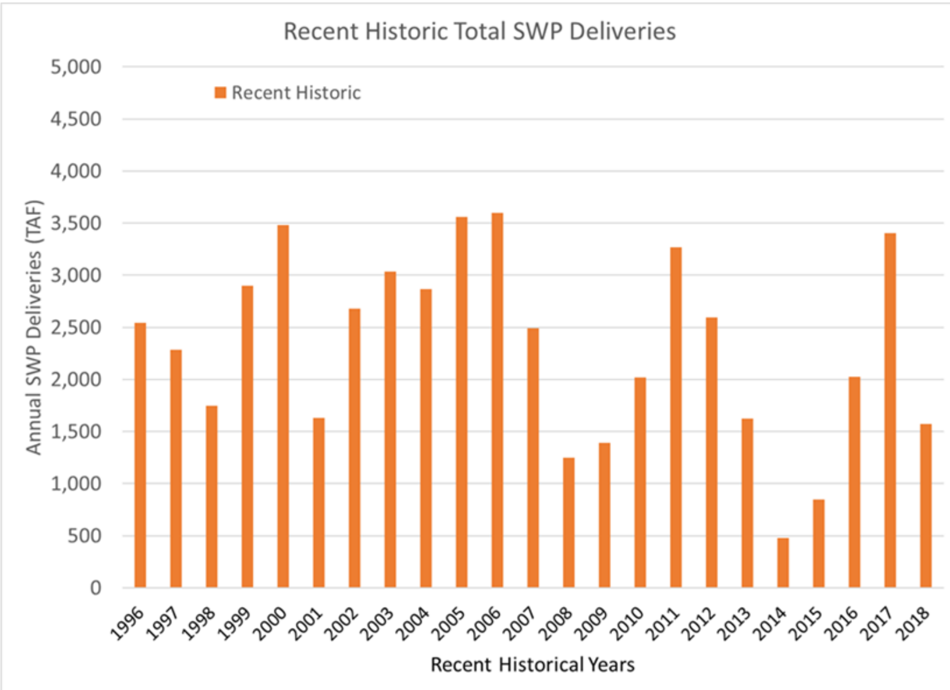


Figure 4.6-3. Historical SWP South of Delta Water Deliveries

The potential increase in future project deliveries is the only project element that might be linked to future growth because the other project elements have only localized impacts. Increased water deliveries would be spread across 24 contracted public water agency service areas south of the Delta. These service areas include both agricultural uses as well as M&I uses. Additional water deliveries could be used for urban growth in areas dependent on this water supply, but these deliveries would not be the single impetus behind such growth. Other important factors influencing growth include:

- financial factors, such as the cost of housing;
- economic factors, such as employment opportunities;
- capacity of public services and infrastructure, such as available services, including wastewater, public schools, and roadways;
- local land use policies; and
- use constraints, such as floodplains, sensitive habitat areas, and seismic risk zones.

Cities and counties have primary authority over land use decisions, and water suppliers (such as the PWAs) are expected and usually required to provide water service if water supply is available. Approval or denial of development proposals is the responsibility of the cities and counties in the study area, and not DWR. Availability of water is only one of the many factors that land use planning agencies consider when making decisions about growth.

While the Proposed Project would increase the potential delivery of water from the Delta, the amount of water available to the individual PWAs would be small relative to the portfolio of water available and would not be enough to indirectly support population growth. The Metropolitan Water District (MWD) is the largest contractor on the State Water Project system. MWD is a regional water wholesaler that provides water for 26 member public agencies to deliver, either directly or through their sub-agencies, to nearly 19 million people living in Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties—an area that supports a $1 trillion-per-year economy. MWD's member agencies serve residents in 152 cities and 89 unincorporated communities. Throughout MWD's service area, approximately 250 retail agencies supply water to the public. MWD imports water via the SWP and from the Colorado River via its Colorado River Aqueduct. About 45% of Southern California's water supply comes from these two sources. Southern California relies on various local sources to make up the difference. MWD receives about 50% of SWP's exports, roughly 1.2 MAF in an average year (MWD 2015, 2016a, 2016b). The modeled increase in exports received by MWD, less than 100 TAF (40% to 50% of total exports), would represent less than 5% of MWD's annual water portfolio of approximately 2 to 2.4 MAF in an average year, and MWD's imported supplies from the SWP and Colorado River Aqueduct are only 45% of Southern California's supplies. This illustrates why the potential increase in water delivery is not expected to have a direct or indirect effect on future growth in the PWA service areas.

During the time period from 2006 through 2018, average water deliveries from the SWP have generally been lower than they were in the previous decade due to changes in regulatory requirements and below-normal water years. Despite reductions in water delivery, urban growth within the service areas of the 24 water contractors that receive water from Delta has continued, as shown in Figure 4.6-4 below.

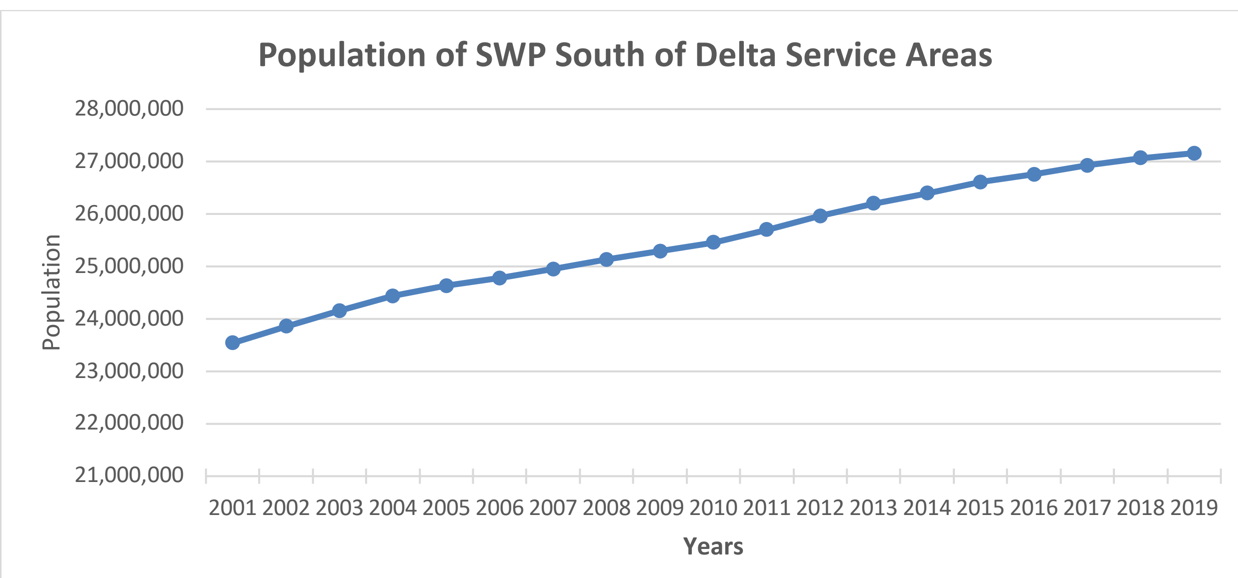


Figure 4.6-4. Population of SWP South of Delta Service Areas

The steady population growth illustrated by Figure 4.6-4 has not been appreciably affected by the annual changes in SWP deliveries shown in Figure 4.6-3. These two figures demonstrate that changes in the supply of water would have had little, if any, impact on population growth in the south of Delta service areas. Based on the absence of a discernable link between water delivery from the SWP and population growth based on historic data, the Proposed Project is not likely to result in a direct or indirect increase in population or employment. Therefore, the Proposed Project is not growth-inducing and would not induce secondary impacts of growth.

5 ALTERNATIVES TO THE PROPOSED PROJECT

Section 21100(b)(4) of the Public Resources Code states that an EIR shall include a detailed statement setting forth alternatives to the project. The range of alternatives to the proposed project should include those that could feasibly accomplish most of the basic objectives of the project and could avoid or substantially lessen one or more significant effects. In this DEIR, however, the proposed project does not result in significant effects, thus the need to lessen does not exist. This DEIR still discusses four alternatives, in addition to the "no project" alternative:

- **Alternative 2a~~A~~** - Proposed Project with Additional Spring Delta Outflow
- **Refined Alternative 2b~~B~~** – Proposed Project with Dedicated Water for Delta Outflow from SWP
- **Alternative 3** – Installation of Spring Head of Old River Barrier and Non-Physical Barrier at Georgiana Slough
- **Alternative 4** – Alternative Summer-Fall Action

The following sections summarize the effects of the Proposed Project as identified in Chapter 4 and describes the potential effects of each alternative. The discussion then compares the difference between the effects identified for the Proposed Project and the alternative in relation to the Existing Conditions (i.e., baseline). The analysis of the alternatives presented below, is expected to cover the range of actions that may be considered as a part of the CESA ITP process.

5.1 NO PROJECT ALTERNATIVE

CEQA requires that the specific alternative of "No Project" shall be evaluated in an EIR along with its impact. (CEQA Guidelines, Section~~§~~ 15126.6(b).) The purpose of describing the No Project Alternative is to allow decisionmakers to compare the impacts of approving the proposed project with the impacts of not approving the proposed project. When the proposed project is a revision to an existing operation, the No Project alternative will typically be a continuation of the existing operation into the future.

The No Project Alternative would include continuation of SWP operations in compliance with the 2008 United States Fish and Wildlife Service (USFWS) Biological Opinion and the 2009 National Marine Fisheries Service (NMFS) Biological Opinion, SWRCB Water Rights Decision 1641, and other regulatory requirements as of (April 22, 2019). The Existing Condition assumption includes existing facilities and ongoing programs that existed as of April 22, 2019, publication date of the Notice of Preparation (NOP). The No Project Alternative assumptions also include facilities and programs that received approvals and permits and permits by April 2019.

Overall the relative changes due to the proposed project as compared to the Existing Conditions under the future climate and sea level rise scenarios are similar to that described under the current climate scenario. The No Project Alternative is the same as Existing Conditions. Based on this analysis, it is concluded that the hydrologic characteristics of the Delta and other waters affected by SWP operations would not substantially change between Existing Conditions and the two future climate change scenarios estimated in the Year 2030.

Because the hydrologic characteristics would remain similar, the analysis of water quality in the Delta and other waters affected by SWP operations, as influenced by hydrology, would also remain similar between Existing Conditions and the two future climate change scenarios estimated in the Year 2030.

Based on the similarities of hydrology and water quality, the analysis of aquatic biological resources in the Delta and other waters affected by SWP operations, as influenced by hydrology, would also remain similar between Existing Conditions and the two future climate change scenarios estimated in the Year 2030. Proposed operations would reduce Sacramento River flow in September and November in years following a wet water year. In years following above normal water years, estimated Sacramento River flow at Freeport would increase in September and decrease in November. The range of the estimated SWP contribution to these changes is about 20% to 65%. In below normal, dry, and critical water years, Sacramento River flow under the proposed project will remain similar to the flow under Existing Conditions.

The No Project Alternative is the same as Existing Conditions. A description of the existing SWP facilities is provided in EIR Chapter 3, Section 3.1.3~~3.1.2~~. A description of the existing regulatory framework is provided at Chapter 3, Section 3.2. A description of the existing SWP Water Service Contracts is provided in Chapter 3, Sections 3.1.4 through 3.1.6~~3.1.3 through 3.1.5~~. Daily operations are described in Chapter 3, Section 3.1.7~~3.1.6~~. The modeling assumptions used to represent the No Action Alternative are provided in Appendix H~~1~~, Attachment 1-1.

5.1.1 Hydrology

As described in Chapter 4.2, implementation of the Proposed Project could affect surface water resources through the proposed changes in operation of the SWP. Changes to SWP operations may result in changes to surface water hydrology in the lower Sacramento River, downstream of the Feather river confluence, the Delta and Suisun Bay, and water deliveries to south of Delta SWP water users.

Compared to the Proposed Project, the No Project Alternative would not modify existing operations and associated reservoir storage, downstream surface water flows, and diversions at SWP facilities and related waterways. Surface water hydrology would be the same as Existing Conditions.

5.1.2 Surface Water Quality

As described in Chapter 4.3, implementation of the Proposed Project could affect surface water quality through the proposed changes in operation of the SWP. Changes to SWP operations may result in potential effects on salinity and chloride, mercury, and nutrients. Existing conditions of these constituents in the study area are summarized in Chapter 4.3. As described previously, these effects were determined to be less than significant relative to Existing Conditions.

The No Project Alternative would not modify existing operations. Therefore, the No Project Alternative would not result in adverse changes to salinity and chloride, mercury, and nutrients compared to Existing Conditions. As the No Project Alternative would not result in adverse changes to salinity and chloride, D-1641 compliance under the No Project Alternative would be similar to Existing Conditions.

5.1.3 AQUATIC RESOURCES

As described above, implementation of the Proposed Project could affect surface water hydrology and water quality through proposed changes in operation of the SWP. Changes to SWP operations may result in potential effects to sensitive aquatic resources including Delta Smelt, Longfin Smelt, Winter-run Chinook Salmon, Spring-run Chinook Salmon and other special status fish species. Existing Conditions of these resources in the project study area are summarized in Chapter 4.4. Potential effects of the Proposed Project on these resources were determined to be less than significant relative to Existing Conditions. Project environmental commitments include facility operations, facility and habitat improvement actions, funding for studies that reduce uncertainty about SWP effects on Delta fishes, and an adaptive management framework that, individually and collectively are intended to minimize effects of the Proposed Project and improve conditions for Delta fishes.

The No Project Alternative would not include the actions included in the Proposed Project that could minimize effects of SWP long term operation on aquatic resources. Potential effects of the No Project Alternative on special status aquatic resources are discussed below.

5.1.3.1 DELTA SMELT

The Proposed Project includes measures that are intended to improve Delta Smelt food supply and habitat, thereby contributing to the recruitment, growth, and survival of the species. The No Project Alternative would not change the existing habitat conditions for Delta Smelt compared to Existing Conditions.

Although the Proposed Project modeling suggests an increase in entrainment relative to Existing Conditions, the OMR measures included in the proposed project would reduce entrainment based on real-time monitoring and adaptive management. Therefore, the No Project Alternative is unlikely to result in substantially different levels of entrainment of Delta Smelt relative to Existing Conditions or the Proposed Project.

5.1.3.2 LONGFIN SMELT

Model results presented in Chapter 4.4 suggest that there generally would be relatively minor differences in the potential for entrainment of Longfin Smelt between the proposed project and Existing Conditions. Actual differences would be less when the proposed project is implemented because real-time operational measures are included that would manage OMR flows for the protection of Longfin Smelt. The No Project Alternative would result in levels of entrainment of Longfin Smelt that would be comparable to Existing Conditions. Although real-time operations under the Proposed Project would protect Longfin Smelt, the potential for entrainment under the No Project Alternative would be slightly less than the levels anticipated for the Proposed Project. Delta outflow-related effects on Longfin Smelt abundance would be expected to be similar between Existing Conditions and the no project alternative because Delta outflow would be essentially the same.

5.1.3.3 Winter-Run Chinook Salmon

As discussed in Chapter 4.4, most Winter-run Chinook salmon entrainment occurs prior to the April–May period when the modeled south Delta exports under the Proposed Project would be slightly larger than the modeled Existing Condition. Based on the April-May timing of the modeled change in south Delta exports, entrainment loss of juvenile Winter-run Chinook salmon at the SWP south Delta export facility would be similar between the Proposed Project and Existing Conditions (Table 4.4-18).

Under the No Project Alternative, a smaller proportion of Winter-run Chinook salmon would likely move toward the South Delta export facilities at the Railroad Cut junction and at the SWP intake junction, in April and May of most years compared to the Proposed Project. However, the Proposed Project includes compliance with cumulative and single-year loss thresholds, implementation of real-time OMR management actions, improvement of salvage operations and genetic identification of salvaged fish that would reduce any increases in entrainment associated with altered flows at key junctions in the Delta. Therefore, the No Project Alternative is expected to have effects that would be similar to both Existing Conditions and the Proposed Project.

5.1.3.4 Spring-Run Chinook Salmon

The No Project Alternative would result in entrainment losses of juvenile Spring-run Chinook salmon at the SWP south Delta export facility comparable to Existing Conditions. The potential entrainment losses would be less than the levels shown in the modeled results for the Proposed Project. The potential reduction in entrainment losses compared to the Proposed Project would be concentrated in April and May. However, the difference would be reduced by ancillary protection from OMR management for other species and improvement of salvage operations under the Proposed Project. Entrainment losses of juvenile Spring-run Chinook salmon would be similar to Existing Conditions under the No Action Alternative, and potentially somewhat lower than the Proposed Project.

5.1.3.5 Fall-Run and Late Fall-Run Chinook Salmon

The No Project Alternative would result in entrainment losses of juvenile Fall-run and Late Fall-run Chinook salmon at the SWP south Delta export facility comparable to Existing Conditions. The potential entrainment losses would be less than the levels shown in the modeled results for the Proposed Project scenario. The potential reduction in entrainment losses under the No Action Alternative compared to the Proposed Project would be concentrated in April and May. However, the difference would be reduced by ancillary protection from OMR management for other species and improvement of salvage operations under the Proposed Project. Entrainment losses of juvenile Fall-run and Late Fall-run Chinook salmon would be similar to Existing Conditions under the No Action Alternative, and potentially somewhat lower than the Proposed Project.

5.1.3.6 Central Valley Steelhead

The No Project Alternative would result in entrainment losses of Central Valley Steelhead at the SWP south Delta export facility comparable to Existing Conditions. The potential entrainment losses would be less than the levels shown in the modeled results for the Proposed Project. The potential reduction in entrainment losses compared to the Proposed Project would be concentrated in April and May. However, the difference would be reduced by compliance with cumulative and single-year loss thresholds, implementation of real-time OMR management actions, and improvement of salvage operations under the Proposed Project. Therefore, entrainment losses of Central Valley Steelhead would be similar to Existing Conditions under the No Action Alternative, and somewhat less than the Proposed Project.

5.1.3.7 Central California Coast Steelhead

As described in Chapter 4.4, CCC Steelhead do not occur in the Delta. Changes in Delta Outflow are the only mechanism by which SWP operations could affect CCC Steelhead or their Designated Critical Habitat. Operation of the SWP would not substantially alter Delta Outflow on an annual basis (Figure 4.4-86), or on a monthly basis (Figure 4.4-87) under the No Project Alternative. This conclusion is comparable to the conclusion for the Proposed Project.

No changes in outflows are expected under the No Project Alternative or the Proposed Project that would affect CCC steelhead rearing and migration habitat attributes in the San Francisco or San Pablo bays, including salinity distribution, food availability, migration cues, dilution of toxins, or other habitat attributes, compared to Existing Conditions.

5.1.3.8 North American Green Sturgeon and White Sturgeon

North American Green Sturgeon and White Sturgeon inhabit areas of the Delta that could be affected by the No Project Alternative throughout the year as adults and juveniles. Potential effects are likely to be comparable to the effects of the Proposed Project based on modeling of salvage suggesting little difference between scenarios.

5.1.3.9 Pacific Lamprey and River Lamprey

Pacific Lamprey inhabit areas of the Delta that could be affected by the No Project Alternative during winter/spring for migration, and throughout the year as larvae. River Lamprey inhabit areas of the Delta that could be affected by the No Project Alternative from September through May for adult migration, May through July for juvenile migration, and throughout year as larvae. Effects of the No Project Alternative on lampreys would be comparable to the Proposed Project and Existing Conditions based on modeling of salvage suggesting little difference between scenarios.

5.1.3.10 Other Special Status Native Fish Species

The No Project Alternative is expected to have effects on other special status fish species that are comparable to Existing Conditions and the effects of the Proposed Project, as operational criteria do not differ between Existing Conditions and the No Project Alternative. However, several avoidance and minimization measures with beneficial effects on entrainment and survival of native fish species included in the Proposed Project would not be implemented under the No Project Alternative.

5.2 ALTERNATIVE 2A – PROPOSED PROJECT WITH ADDITIONAL SPRING DELTA OUTFLOW

The objective of Alternative 2a~~A~~ would be to provide spring outflow based on the hypothesis that longfin smelt abundance can be improved with increased spring outflow. This spring outflow action would be subject to the AMP described in Section 3.3.16. This increase in Delta outflow would be met by reducing the amount of SWP exports that could occur under the Proposed Project. The increase in Delta outflow under this Alternative may or may not match the amount of SWP export reductions, depending on the CVP operations.

Alternative 2a~~A~~ consists of operations as described for the Proposed Project with the addition of the SWP export curtailments by operating to its proportional share of San Joaquin River Inflow to Export Ratio (SJR I:E ratio) defined by the 2009 NMFS BiOp RPA Action IV.2.1 from April 1 – May 31. The SWP proportional share will be based on applicable COA split, which is currently 40% of the total potential SWP-CVP export reduction required under the SJR I:E ratio constraint during excess conditions in the Delta. The potential impacts and benefits of this alternative would be proportional to the 40% share provided by the actions proposed by the SWP. However, as discussed under Other Considerations, below, the SJR I:E ratio was not included in the NMFS BiOp that was issued on October 21, 2019, and therefore it is not a requirement for CVP operations. Consequently, the benefits of reduced exports by the SWP may be diminished if the CVP operations are not bound by the same constraint.

While the 2009 NMFS BiOp at p. 641 explains that the purpose of the SJR I:E ratio is for reducing the risk of entrainment of CV steelhead into the south Delta channels, this export constraint resulted in incidental Delta outflow over and above the outflow required during April and May. Alternative 2A relies on the SJR i:e ratio to provide spring outflow through SWP export curtailments.

The 2009 NMFS BiOp identifies the SJR I:E ratio to be measured at Vernalis for combined CVP and SWP operations, as shown in Table 5.2-1 (see NMFS BiOp RPA Action IV.2.1, pp. 643-644).

Table 5.2-1. Vernalis Flow CVP/SWP Combined Export Ratios

San Joaquin Valley Classification	Vernalis Flow (cfs): CVP/SWP Combined Export Ratio
Critically dry	1:1
Dry	2:1
Below normal	3:1
Above normal	4:1
Wet	4:1
Vernalis flow equal to or greater than 21,750 cfs	Unrestricted exports until flood recedes below 21,750 cfs

Notes:
cfs = cubic foot per second
CVP = Central Valley Project
SWP = State Water Project

Exception for high Delta outflow: If the 3-day average Delta outflow is greater than 44,500 cfs, then this action will be suspended until the flows drop below 44,500 cfs on a 3-day average. The off-ramp at Delta outflow greater than 44,500 cfs is consistent with recent permits issued by CDFW. The AMP described in Section 3.3.16 will be used to test the extent that outflow (or associated X2) can affect Longfin Smelt abundance.

Exception procedure for multiple dry years: If the previous 2 years plus current year of the San Joaquin Valley “60-20-20” Water Year Hydrologic Classification and Indicator as defined in D-1641 and provided in following table (Table 5.2-2), is 6 or less, AND, the New Melones Index is less than 1 MAF, SWP shall be limited to its proportional share of a 1:1 ratio with San Joaquin River inflow, as measured at Vernalis.

Table 5.2-2. Water Year Hydrologic Classification and Indicator

San Joaquin Valley Classification	Indicator
Critically dry	1
Dry	2
Below normal	3
Above normal	4
Wet	5

Exception for Health and Safety: DWR predicts that it will not be able to achieve these ratios while meeting health and safety needs. Current estimate of health and safety needs is an SWP export of 600 cfs. SWP export is defined under D-1641 as CCF diversions minus Byron Bethany Irrigation District demand.

The following sections present an evaluation of the impacts that would occur under Alternative 2a~~A~~ compared to the Proposed Project.

5.2.1 HYDROLOGY

Under Alternative 2a~~A~~, April-May Delta outflow would be less than the No Project Alternative but greater than the Proposed Project. Delta outflow results of Existing Conditions, Proposed Project and Alternative 2a~~A~~ are presented in Figures 5.2-1 and 5.2-2. Alternative 2a~~A~~ would result in reduced south of Delta exports in April-May compared to the Proposed Project, as shown in Figures 5.2-3 and 5.2-4. Reduction in south of Delta exports leads to an increase in April-May OMR flows under Alternative 2a~~A~~ compared to the Proposed Project. OMR flow results of Existing Conditions, Proposed Project and Alternative 2a~~A~~ are presented in Figures 5.2-5 and 5.2-6.

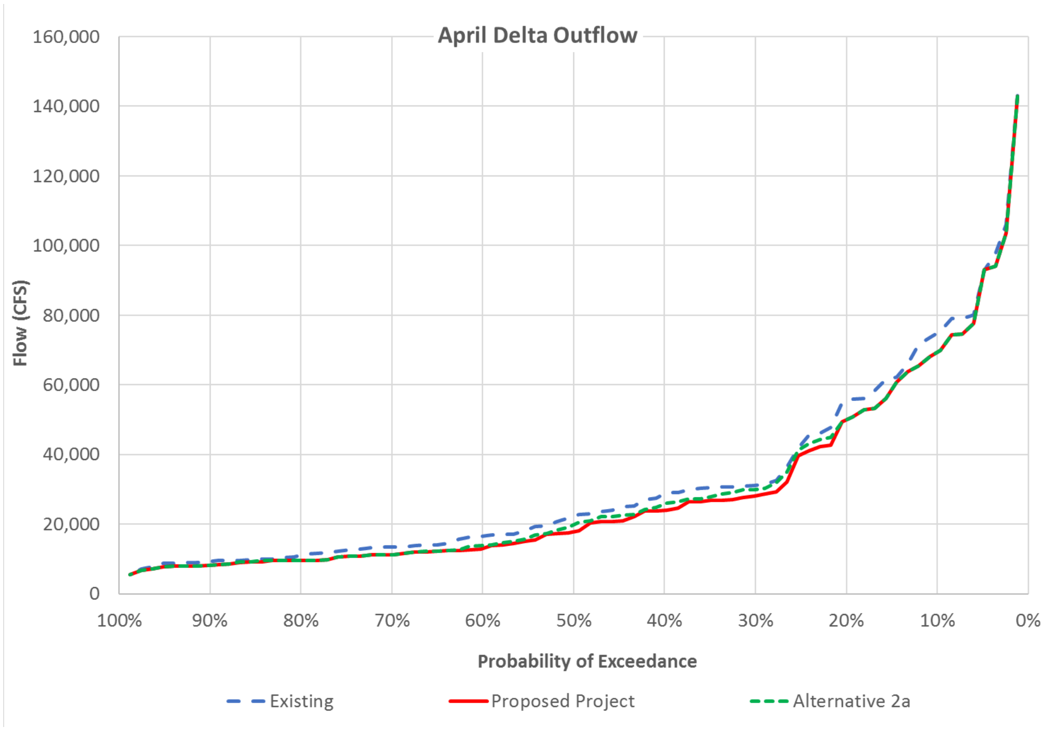


Figure 5.2-1. Exceedance Probability of April Delta Outflow

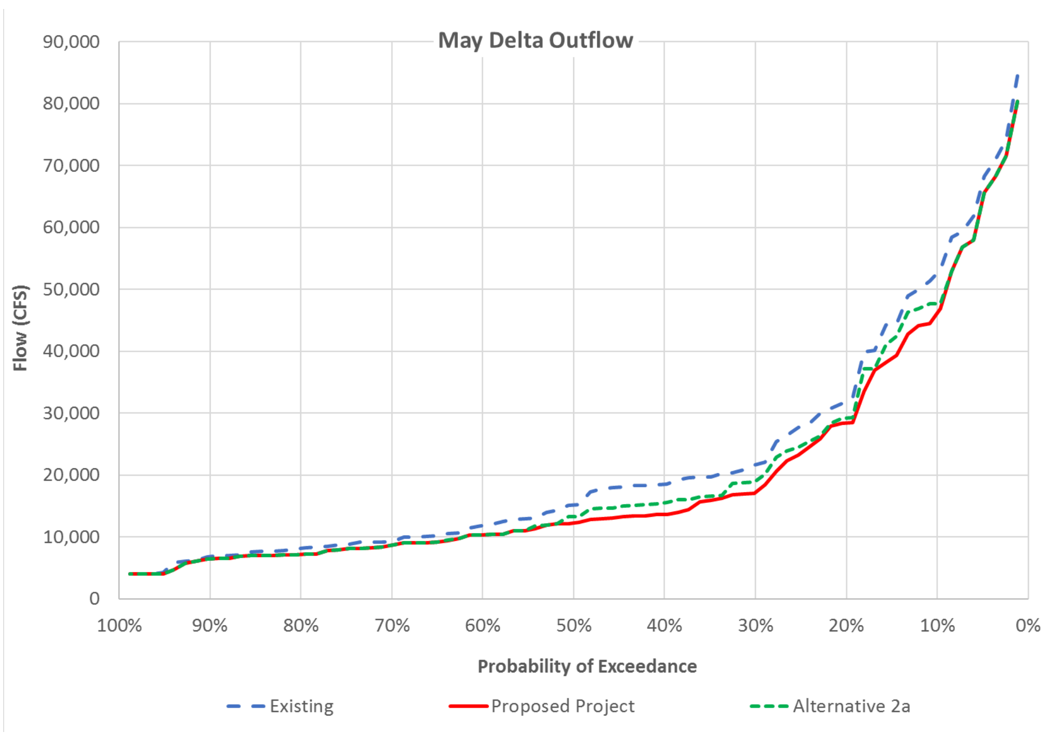


Figure 5.2-2. Exceedance Probability of May Delta Outflow

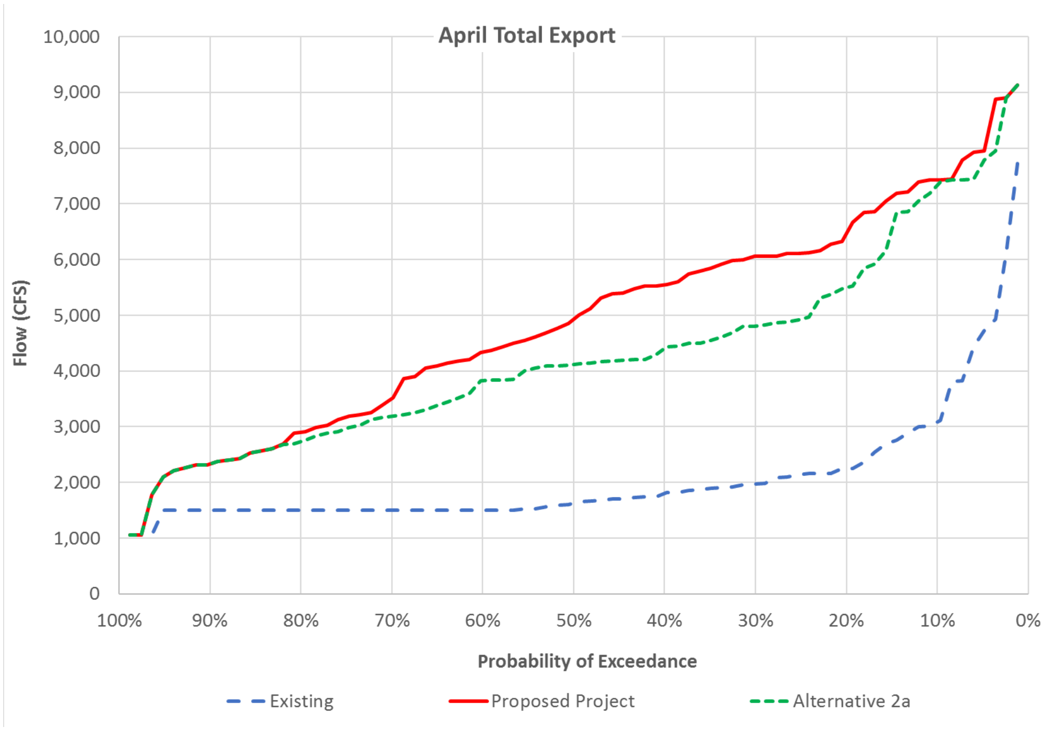


Figure 5.2-3. Exceedance Probability of April Total Exports

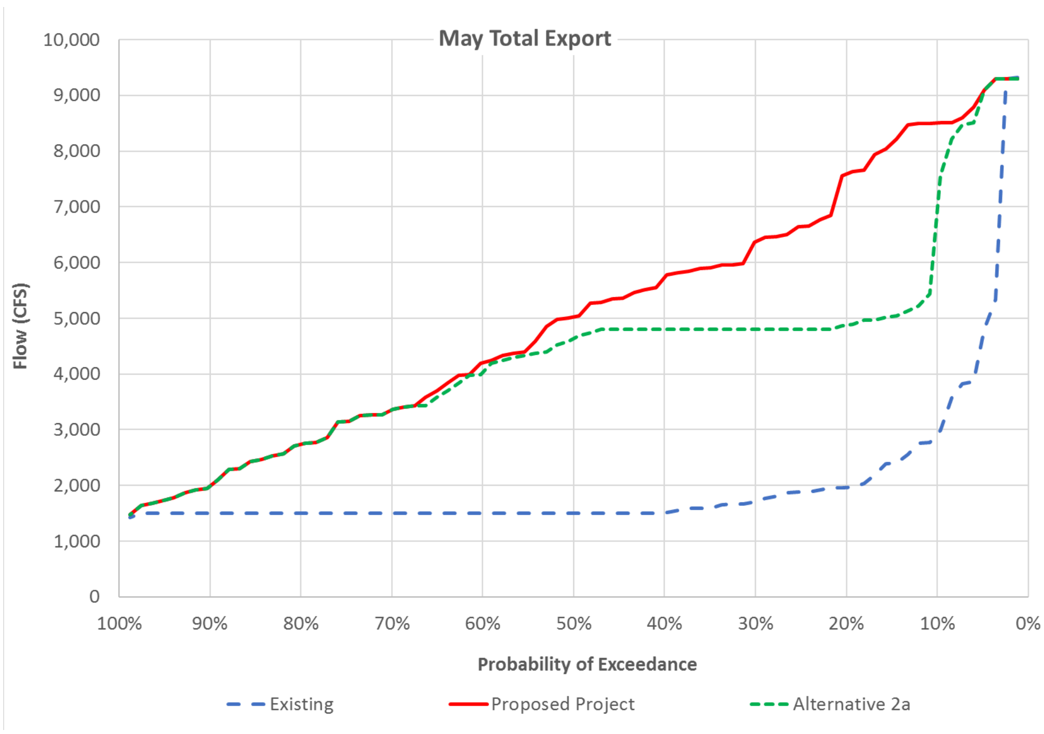


Figure 5.2-4. Exceedance Probability of May Total Exports

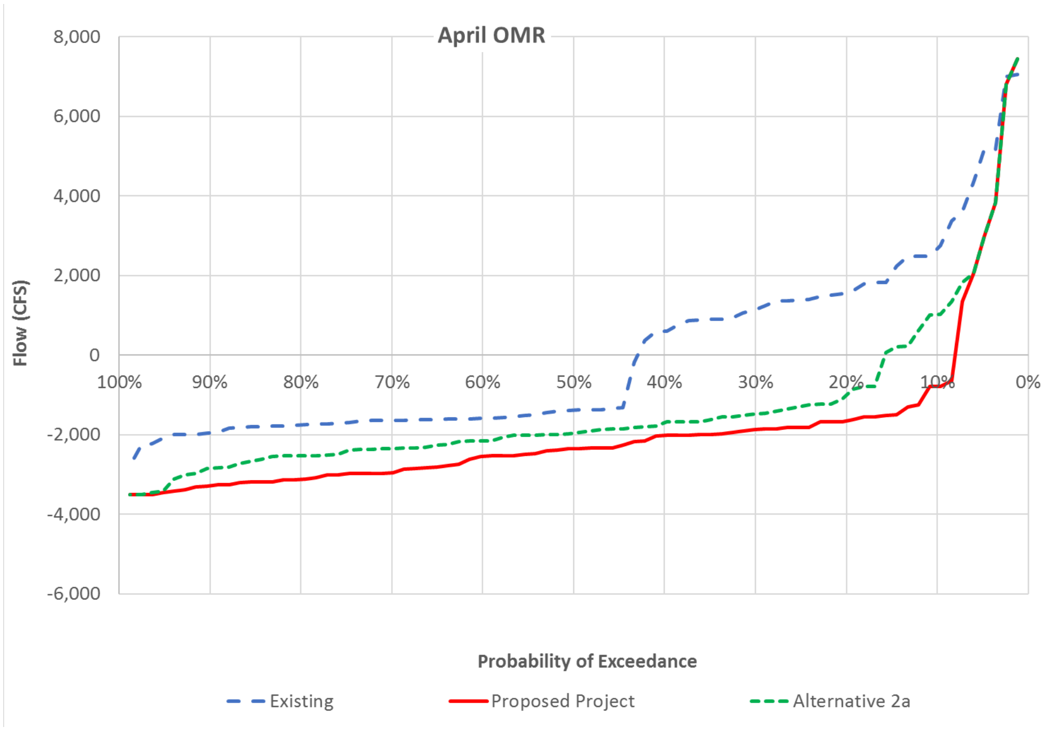


Figure 5.2-5. Exceedance Probability of April OMR Flow

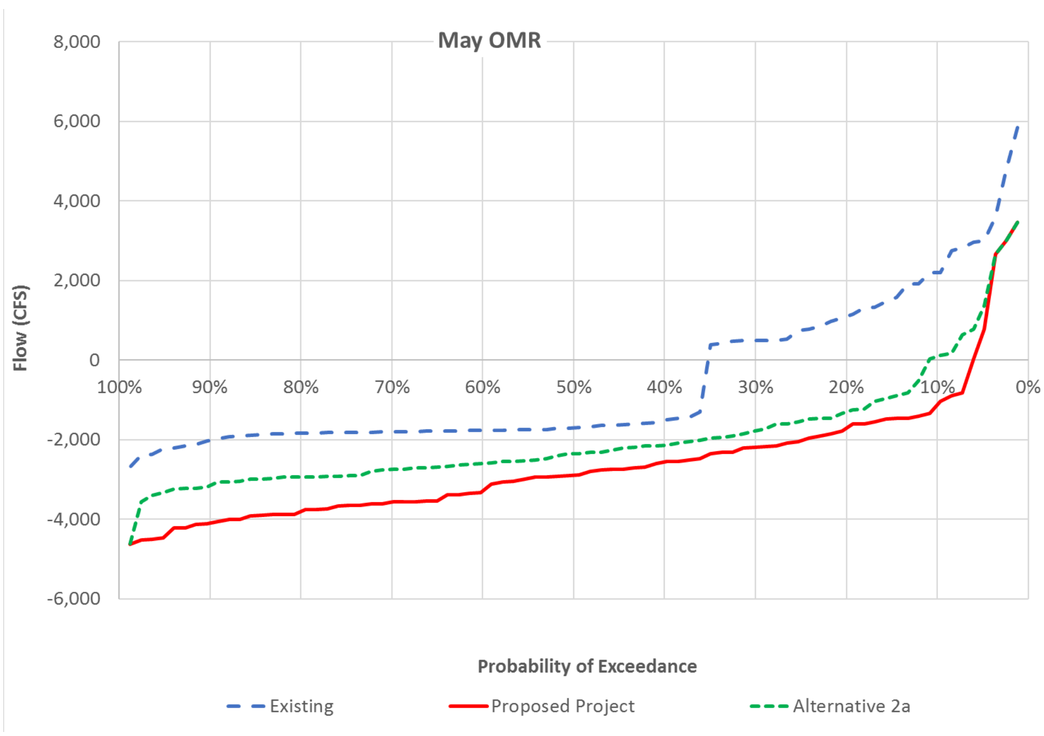


Figure 5.2-6. Exceedance Probability of May OMR Flow

5.2.2 Surface Water Quality

The predicted differences in surface water quality estimated for Alternative 2a~~A~~ when compared to Existing Conditions are due to the changes in Delta outflow and exports described in Section 5.2.1 above. Similar to the Proposed Project, Alternative 2a~~A~~ operations generally would increase salinity during the late fall and early winter in years following wet and above normal water years, as a result of the proposed Summer-Fall Delta Smelt habitat action. Modeling of Proposed Project suggests the potential for D-1641 compliance exceedances, but these modeled exceedances are attributable to hydrologic modeling assumptions and limitations and are not expected to occur in real-time operations (Nader-Tehrani, 2016). Historically, SWP and CVP have a high degree of success in meeting D-1641 requirements (Leahigh, 2016). Operations to meet D-1641 requirements would be similar to the Proposed Project under Alternative 2a~~A~~, and the impacts to surface water quality would remain **less than significant**.

5.2.3 Aquatic Resources

The differences in surface water quality and hydrology estimated for Alternative 2a when compared to Existing Conditions and the Proposed Project are driven by the changes in exports and Delta outflow described in Section 5.2.1 above, which result in differences between Delta outflow and Old and Middle River flows in April and May (Tables 5.2-3, 5.2-4, 5.2-5, and 5.2-6). Table 5.2-7 provides a qualitative summary of the main operations-related effects by analytical component to illustrate the similarities and differences between the Proposed Project and Alternative 2a. The differences between Alternative 2a and the Proposed Project are entirely dependent on whether the analytical components overlap the April–May period when outflow would be increased compared to the Proposed Project. The main analytical components for which differences are expected, by species/life stage, include: Delta Smelt—potential effects on larvae from less *Eurytemora affinis* larval prey, changes to silverside predation, and greater south Delta entrainment; Longfin Smelt—potential effects on abundance from less Delta outflow and on juveniles from greater south Delta entrainment; Winter-run Chinook Salmon—potentially greater juvenile south Delta entrainment during spring overlap; Spring-run Chinook Salmon—potentially greater juvenile south Delta entrainment and lower through-Delta survival; Fall-run and Late fall-run Chinook Salmon—potentially greater juvenile south Delta entrainment lower through-Delta survival; Central Valley Steelhead—potentially greater juvenile south Delta entrainment; White Sturgeon—potential effects on year-class strength from less Delta outflow; Pacific and River Lamprey—potentially greater juvenile south Delta entrainment; Sacramento Splittail—potentially greater juvenile south Delta entrainment; Striped Bass—potentially greater juvenile south Delta entrainment; American Shad—potentially greater juvenile south Delta entrainment; and Largemouth Bass—potentially greater juvenile south Delta entrainment. The extent of the difference between Alternative 2a and Existing Conditions would be less than the extent of difference between the Proposed Project and Existing Conditions, and the impact conclusions for all impacts remain less than significant. Table 5.2-7 summarizes the main differences that may be expected to occur under Alternative 2a when compared with Existing Conditions, with rationale based on the context provided by the analyses comparing the Proposed Project to Existing Conditions. The notable impacts of Alternative 2a would include an increase in CVP water diversions, and entrainment at CVP facilities. As shown in Table 5.2-7, the effects of Alternative 2a could be **less than significant** for all analyzed aquatic resources, the same as the impact conclusions for the Proposed Project.

Table 5.2-3. Average Delta Outflow by Alternative and Water Year Type, April.

Water Year Type	Existing	Proposed Project	Alternative 2a	Existing vs. Alternative 2a	Proposed Project vs. Alternative 2a
Wet	56,933	53,084	53,750	-3,184 (-6%)	666 (1%)
Above Normal	33,562	29,851	31,135	-2,427 (-7%)	1,284 (4%)
Below Normal	23,217	20,278	21,261	-1,957 (-8%)	983 (5%)
Dry	15,097	13,225	13,310	-1,787 (-12%)	85 (1%)
Critically Dry	9,410	8,916	8,916	-494 (-5%)	0 (0%)
Average	31,618	28,870	29,455	-2,163 (-7%)	586 (2%)

Table 5.2-4. Average Delta Outflow by Scenario and Water Year Type, May.

Water Year Type	Existing	Proposed Project	Alternative 2a	Existing vs. Alternative 2a	Proposed Project vs. Alternative 2a
Wet	39,709	35,402	36,630	-3,079 (-8%)	1,228 (3%)
Above Normal	24,582	20,521	21,466	-3,116 (-13%)	945 (5%)
Below Normal	15,806	13,073	14,001	-1,806 (-11%)	928 (7%)
Dry	9,920	8,909	8,993	-927 (-9%)	84 (1%)
Critically Dry	5,821	5628	5,628	-194 (-3%)	0 (0%)
Average	21,916	19,239	19,944	-1,972 (-9%)	705 (4%)

Table 5.2-5. Average Old and Middle River Flow by Scenario and Water Year Type, April.

Water Year Type	Existing	Proposed Project	Alternative 2a	Existing vs. Alternative 2a	Proposed Project vs. Alternative 2a
Wet	1,945	-1,208	-602	-2,547 (-131%)	606 (50%)
Above Normal	104	-2,740	-1,570	-1,674 (-1,602%)	1,170 (43%)
Below Normal	-415	-2,495	-1,600	-1,185 (-285%)	895 (36%)
Dry	-1,586	-2,300	-2,209	-623 (-39%)	91 (4%)
Critically Dry	-1,748	-1,592	-1,592	156 (9%)	0 (0%)
Average	-43	-1948	-1,412	-1,369 (-3,199%)	536 (28%)

Table 5.2-6. Average Old and Middle River Flow by Scenario and Water Year Type, May.

Water Year Type	Existing	Proposed Project	Alternative 2a	Existing vs. Alternative 2a	Proposed Project vs. Alternative 2a
Wet	812	-2,388	-1,269	-2,081 (-256%)	1,119 (47%)
Above Normal	-383	-3,585	-2,724	-2,341 (-611%)	861 (24%)
Below Normal	-695	-3,268	-2,350	-1,655 (-238%)	917 (28%)
Dry	-1,773	-2,548	-2,472	-699 (-39%)	76 (3%)
Critically Dry	-1,881	-1,522	-1,522	359 (19%)	0 (0%)
Average	-582	-2,622	-1,968	-1,386 (-238%)	654 (25%)

Table 5.2-7. Estimated Impacts on Aquatic Resources Occurring Under Alternative 2a Compared to Existing Conditions and the Proposed Project.

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Delta Smelt	Adult to Eggs and Larvae	Food Availability	Similar flow through the Yolo Bypass	Similar food production and input to the Delta under both scenarios. This is a combined SWP and CVP result.	Less than Significant	Similar food production and input to the Delta under both scenarios. This is a combined SWP and CVP result.	Less than Significant	No difference between the Proposed Project and Alternative 2a. Yolo Bypass is not affected by south Delta exports
Delta Smelt	Adult to Eggs and Larvae	Predation	Similar Rio Vista Flows from December through May	Similar suspended sediment input to the Delta and low sediment removal from the Delta therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	Similar suspended sediment input to the Delta and low sediment removal from the Delta therefore similar predation potential under both scenarios. This is a combined SWP and CVP result	Less than Significant	Rio Vista flow is not affected by south Delta exports
Delta Smelt	Eggs and Larvae to Juveniles	Food Availability	Delta outflow from March through June is lower under the Proposed Project, and predicted *Eurytemora affinis* density is 2% to 4% lower under the Proposed Project.	Food availability might be slightly reduced under the Proposed Project, but uncertainty is high SWP responsibility for the impact is between approximately 40% to 60%	Less than Significant	Food availability might be slightly reduced under Alternative 2a, but uncertainty is high	Less than Significant	Delta outflow in April-May would be greater under Alternative 2a than Proposed Project, but less than Existing Conditions
Delta Smelt	Eggs and Larvae to Juveniles	Predation	Similar Rio Vista Flows from December through May. South Delta exports are higher from March through May under the Proposed Project. Delta inflow from June through September is slightly lower under the Proposed Project.	Similar predation potential associated with turbidity Potentially lower silverside cohort strength with high uncertainty, based on greater March–May south Delta exports Potentially higher silverside cohort strength with high uncertainty, based on lower June–September Delta outflow SWP contribution between approximately 40% to 60% during March May SWP responsibility for the June-September impact is between approximately between 20-50%	Less than Significant	Similar predation potential associated with turbidity Potentially lower silverside cohort strength with high uncertainty, based on greater March–May south Delta exports Potentially higher silverside cohort strength with high uncertainty, based on lower June–September Delta outflow	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project but greater than Existing Conditions
Delta Smelt	Juveniles to Subadults	Food Availability	Delta outflow from July through September is similar most of the time (75% of the time) but is lower about 25% of the time, suggesting slightly lower predicted *Pseudodiaptomus forbesi* density. Similar QWEST under both scenarios in July and August. Higher (positive more often) QWEST in September under the Proposed Project.	Slightly lower *P. forbesi* density under the Proposed Project as a result of lower Delta outflow some of the time. Analysis has high uncertainty Similar *P. forbesi* subsidy to the LSZ from the San Joaquin River most of the time under both scenarios, but potentially slightly higher *P. forbesi* subsidy in September under the Proposed Project. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. This is a combined SWP and CVP result SWP responsibility for the change in Delta Outflow and QWEST that could affect *P. forbesi* subsidy to the LSZ is between approximately 23-28% in wet and above-normal water year types (when X2 requirements are not in place under the Proposed Project)	Less than Significant	Slightly lower *P. forbesi* density could occur under the Alternative 2a as a result of lower Delta outflow some of the time. Analysis has high uncertainty Similar *P. forbesi* subsidy to the LSZ from the San Joaquin River most of the time under both scenarios, but potentially slightly higher *P. forbesi* subsidy in September under Alternative 2a. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty.	Less than Significant	No operational differences between Proposed Project and Alternative 2a in July-September

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Delta Smelt	Juveniles to Subadults	Predation	Similar Rio Vista Flows from December through May.	Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and summer predation potential is unknown. Wind and water temperature, which are drivers of turbidity would be similar therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and summer predation potential is unknown. Wind and water temperature, which are drivers of turbidity would be similar therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	Rio Vista flow is not affected by south Delta exports
Delta Smelt	Juveniles to Subadults	Harmful Algal Blooms	Similar probability of remaining below 1 foot per second (ft/sec) velocity Microcystis threshold at each of the 8 Delta locations.	Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations Similar potential for velocity conditions to affect harmful algal blooms under both scenarios This is a combined SWP and CVP result	Less than Significant	Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations Similar potential for velocity conditions to affect harmful algal blooms under both scenarios This is a combined SWP and CVP result	Less than Significant	No operational differences between Proposed Project and Alternative 2a in June-November
Delta Smelt	Juveniles to Subadults	~~Summer/Fall~~Summer-Fall Habitat Qualitative Discussion	N/A	Manage overlapping suitable habitat based on the latest conceptual model of suitable habitat for Delta Smelt in summer-fall using multiple tools including outflow augmentation, Suisun Marsh Salinity Control Gates (SMSCG) operation, and food actions. LSZ would tend to be further upstream following wet years, without detailed consideration of SMSCG operation. Evidence from 2018 SMSCG pilot action showed that Delta Smelt had access to suitable low salinity habitat during the action.	Less than Significant	Manage overlapping suitable habitat based on the latest conceptual model of suitable habitat for Delta Smelt in summer-fall using multiple tools including outflow augmentation, Suisun Marsh Salinity Control Gates (SMSCG) operation, and food actions. LSZ would tend to be further upstream following wet years, without detailed consideration of SMSCG operation. Evidence from 2018 SMSCG pilot action showed that Delta Smelt had access to suitable low salinity habitat during the action.	Less than Significant	No operational differences between Proposed Project and Alternative 2a in ~~summer/fall~~Summer-Fall
Delta Smelt	Juveniles to Subadults	~~Summer/Fall~~Summer-Fall Habitat–SCHISM WY 2012 (salinity alone)	Limited benefits in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation period. Reduced habitat area in Suisun Bay.	Modeled benefits are greater when gates are operated starting in August rather than June Lower salinity in Suisun Marsh has the potential to increase habitat for Delta Smelt during the summer and fall.	Less than Significant	Modeled benefits are greater when gates are operated starting in August rather than June Lower salinity in Suisun Marsh has the potential to increase habitat for Delta Smelt during the summer and fall.	Less than Significant	No operational differences between Proposed Project and Alternative 2a in ~~summer/fall~~Summer-Fall
Delta Smelt	Juveniles to Subadults	~~Summer/Fall~~Summer-Fall Habitat–SCHISM WY 2012 (salinity, temperature, and turbidity)	Limited benefits overall in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation.	Potentially beneficial overall because of improved Suisun Marsh Conditions	Less than Significant	Potentially beneficial overall because of improved Suisun Marsh Conditions	Less than Significant	No operational differences between Proposed Project and Alternative 2a in ~~summer/fall~~Summer-Fall

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Delta Smelt	Juveniles to Subadults	~~Summer/Fall~~Summer-Fall Habitat–SCHISM WY 2017 (salinity alone)	Limited benefits overall in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation.	Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under the Proposed Project	Less than Significant	Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under the Proposed Project from modeling of that scenario	Less than Significant	No operational differences between Proposed Project and Alternative 2a in ~~summer/fall~~Summer-Fall
Delta Smelt	Juveniles to Subadults	~~Summer/Fall~~Summer-Fall Habitat–SCHISM WY 2017 (salinity, temperature, and turbidity)	Limited benefits in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation.	Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under the Proposed Project.	Less than Significant	Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under the Proposed Project from modeling of that scenario	Less than Significant	No operational differences between Proposed Project and Alternative 2a in ~~summer/fall~~Summer-Fall
Delta Smelt	Subadults to Adults	Food Availability	Higher (positive more often) QWEST in September under the Proposed Project, although Delta outflow is lower.	Potentially slightly higher *P. forbesi* subsidy in September under the Proposed Project based on net flow on the San-Joaquin River at Jersey Point (QWEST), but slightly lower based on Delta outflow. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. Overall density of calanoid copepods in the low salinity not shown to be related to Delta outflow (X2) by other analyses. This is a combined SWP and CVP result	Less than Significant	Potentially slightly higher *P. forbesi* subsidy in September under Alternative 2a based on net flow on the San-Joaquin River at Jersey Point (QWEST), but slightly lower based on Delta outflow. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. Overall density of calanoid copepods in the low salinity not shown to be related to Delta outflow (X2) by other analyses. This is a combined SWP and CVP result	Less than Significant	No operational differences between Proposed Project and Alternative 2a in July-September
Delta Smelt	Subadults to Adults	Predation	Similar Rio Vista Flows from December through May.	Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and fall predation potential is unknown. However, wind and water temperature, which are drivers of predation would be similar therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and fall predation potential is unknown. However, wind and water temperature, which are drivers of predation would be similar therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	Rio Vista flow is not affected by south Delta exports
Delta Smelt	Subadults to Adults	Harmful Algal Blooms	Similar velocity conditions at 8 Delta locations Similar probability of remaining below 1 ft/sec threshold at each of the 8 Delta locations	Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations Similar potential for velocity conditions to affect harmful algal blooms under both scenarios This is a combined SWP and CVP result	Less than Significant	Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations Similar potential for velocity conditions to affect harmful algal blooms under both scenarios This is a combined SWP and CVP result	Less than Significant	No operational differences between Proposed Project and Alternative 2a in June-November

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Delta Smelt	Entrainment	Consideration of OMR	During the March–June period of concern for larval/juvenile Delta Smelt entrainment risk, OMR flows would generally be lower (more negative) under the Proposed Project in April and May but would be similar under both scenarios in March and June. During this period, flows under both scenarios would be at or less negative than the -5,000 cfs inflection point at which entrainment tends to sharply increase.	Based on CalSim modeling estimated entrainment could increase for larvae/early juveniles (March – June) under the Proposed Project however there are number of measures that will keep entrainment risk at protective levels: • OMR flows during April and May under the Proposed Project are less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk. • Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts • Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles • SWP responsibility for the impact is between approximately 30-60%	Less than Significant	Estimated entrainment could increase for larvae/early juveniles (March – June) under Alternative 2a however there are number of measures that will keep entrainment risk at protective levels: • OMR flows during April and May under Alternative 2a would be less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk. • Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts • Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles • SWP responsibility for the impact is between approximately 30-60%	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project but greater than Existing Conditions
Delta Smelt	Entrainment	Particle Tracking Modeling	DSM2 PTM showed increases in Delta Smelt entrainment in April and May.	Based on DSM2 PTM modeling estimated entrainment is appreciably greater under the Proposed Project in April and May. However, there are number of measures that will keep entrainment risk at protective levels: • OMR flows during April and May under the Proposed Project are less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk. • Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts • Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles	Less than Significant	Entrainment has the potential to be greater under Alternative 2a in April and May. However, there are number of measures that will keep entrainment risk at protective levels: • OMR flows during April and May under Alternative 2a would be less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk. • Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts • Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project but greater than Existing Conditions
Delta Smelt	All Life Stages	Annual O&M Activities	N/A	Annual O&M activities likely would have limited impacts on Delta Smelt because work windows and best management practices (BMPs) would be implemented. Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	Annual O&M activities likely would have limited impacts because work windows and best management practices (BMPs) would be implemented. Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2a.	Less than Significant	Annual O&M activities would be the same for the Proposed project and Alternative 2a.

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Delta Smelt	All Life Stages	Project Environmental Protective Measures including: • Clifton Court Forebay (CCF) predator relocation and aquatic weed control; • Skinner Fish Facility performance improvements; • Longfin Smelt Science Program; • Continue Studies to Establish a Delta Fish Hatchery; and • Conduct further Studies to Prepare for Delta Smelt Reintroduction from the FCCL (see Table 3-3)	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Delta Smelt reintroduction and Delta Fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics, and perhaps increase the options to improve smelt management. Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival	Less than Significant	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Delta Smelt reintroduction and Delta Fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed project and Alternative 2a.
Longfin Smelt	Population Abundance	Delta Outflow-Abundance	The results of the Nobriga and Rosenfield (2016) model application suggested that differences in the predicted fall midwater trawl abundance index between scenarios would be very small, with mean indices slightly lower under the Proposed Project and with some uncertainty, especially when considered in relation to the confidence intervals, as a result of high uncertainty in the outflow–abundance relationship.	Recruitment under the Proposed Project is modeled to slightly decrease under good survival (2% max difference) and poor survival (1% max difference) scenarios when confidence intervals are accounted for. The following measures should help reduce any potential small effects in real-time: • Increased measures to reduce entrainment losses for all Longfin Smelt life stages • A commitment to a Longfin Smelt Science program to understand mechanisms underlying flow-abundance relationships, and to identify and test additional options for Longfin Smelt management. • A commitment to support the Fish Culture Facility for Longfin Smelt culture for future study and adaptive management application. • This is a combined SWP and CVP result with the SWP responsibility of approximately 40% to 60%	Less than Significant	Recruitment under Alternative 2a has the potential to slightly decrease. The following measures should help reduce any potential small effects in real-time: • Increased measures to reduce entrainment losses for all Longfin Smelt life stages • A commitment to a Longfin Smelt Science program to understand mechanisms underlying flow-abundance relationships, and to identify and test additional options for Longfin Smelt management. • A commitment to support the Fish Culture Facility for Longfin Smelt culture for future study and adaptive management applications. • This is a combined SWP and CVP result with the SWP responsibility of approximately 40% to 60%	Less than Significant	Delta outflow in April-May would be greater under Alternative 2a than proposed project, but less than Existing Conditions
Longfin Smelt	Adult	Entrainment	Similar OMR flow from December February.	Modeled entrainment under the Proposed Project is similar to the existing project. Other measures should reduce real-time entrainment risk, including: • OMR management Dec-Feb • OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt • Existing adult Longfin Smelt entrainment is less than 1% of the population (all years except 2008 @ 3%) • SWP responsibility for slight differences in OMR is between approximately 40% to 60%	Less than Significant	Entrainment under Alternative 2a would be expected to be similar to Existing Conditions. Other measures should reduce real-time entrainment risk, including: • OMR management Dec-Feb • OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt • Existing adult Longfin Smelt entrainment is less than 1% of the population (all years except 2008 @ 3%) • SWP responsibility for slight differences in OMR is between approximately 40% to 60%	Less than Significant	No operational differences between Proposed Project and Alternative 2a in December-February

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Longfin Smelt	Larvae	Entrainment	DSM2-PTM results suggested that entrainment potential of Longfin Smelt larvae is similar between scenarios.	Modeled entrainment of larval Longfin Smelt does not increase under the Proposed Project. Other measures should reduce real-time entrainment risk, including: • OMR management Jan-Mar • OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt, shifting spawning seaward of interior Delta. • Adult Longfin Smelt presence as detected by the surveys and salvage suggests spawning is limited in interior Delta, which reduces subsequent larval entrainment risk. • This is a combined SWP and CVP result	Less than Significant	Entrainment of larval Longfin Smelt would not be expected to increase under Alternative 2a. Other measures should reduce real-time entrainment risk, including: • OMR management Jan-Mar • OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt, shifting spawning seaward of interior Delta. • Adult Longfin Smelt presence as detected by the surveys and salvage suggests spawning is limited in interior Delta, which reduces subsequent larval entrainment risk. • This is a combined SWP and CVP result	Less than Significant	No operational differences between Proposed Project and Alternative 2a in January-March
Longfin Smelt	Juvenile	Salvage	Based on the Grimaldo et al. (2009) salvage-Old and Middle River flow regression, the potential exists for large relative increases in entrainment under the Proposed Project.	Modeled juvenile Longfin Smelt salvage is increased under the Proposed Project. However, the following measures/considerations are expected to minimize entrainment: • OMR flows during April and May under the Proposed Project are less negative than the -5000 cfs inflection point deemed protective of entrainment risk for Longfin Smelt and other ESA species. • Real-time OMR management, PTM models and CDFW Smelt Larval Survey (SLS) monitoring will be used to assess entrainment risk in real-time. • Increased first flush protection actions should lead to less movement and spawning in the interior Delta, subsequently decreasing entrainment risk of larvae and juveniles • SWP responsibility for differences in OMR flows is between approximately 40-50%	Less than Significant	Juvenile Longfin Smelt salvage has the potential to increase Alternative 2a. However, the following measures/considerations are expected to minimize entrainment: • OMR flows during April and May under the Proposed Project are less negative than the -5000 cfs inflection point deemed protective of entrainment risk for Longfin Smelt and other ESA species. • Real-time OMR management, PTM models and CDFW Smelt Larval Survey (SLS) monitoring will be used to assess entrainment risk in real-time. • Increased first flush protection actions should lead to less movement and spawning in the interior Delta, subsequently decreasing entrainment risk of larvae and juveniles • SWP responsibility for differences in OMR flows is between approximately 40-50%	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project but greater than Existing Conditions
Longfin Smelt	All Life Stages	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	Annual O&M activities likely would have limited impacts because work windows and best management practices (BMPs) would be implemented. Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2a.	Less than Significant	Annual O&M activities would be the same for the Proposed project and Alternative 2a.

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Longfin Smelt	All Life Stages	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; • Skinner Fish Facility performance improvements; • Longfin Smelt Science Program; and • Continue Studies to Establish a Delta Fish Hatchery (see Table 3-3)	N/A	Longfin Smelt Science Program would improve understanding of Longfin Smelt ecology, population distribution, and abundance to better inform management decisions. Delta fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival	Less than Significant	Longfin Smelt Science Program would improve understanding of Longfin Smelt ecology, population distribution, and abundance to better inform management decisions. Delta fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed project and Alternative 2a.
Winter-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during most months of the immigration period.	Similar flow conditions would likely result in similar habitat conditions including SAIL Conceptual Model habitat attributes of water temperature, dissolved oxygen concentrations, and other attributes that influence the timing, condition, and survival of adult Winter-run Chinook Salmon during their upstream migration. This is a combined SWP and CVP result	Less than Significant	Similar flow conditions would likely result in similar habitat conditions including SAIL Conceptual Model habitat attributes of water temperature, dissolved oxygen concentrations, and other attributes that influence the timing, condition, and survival of adult Winter-run Chinook Salmon during their upstream migration. This is a combined SWP and CVP result	Less than Significant	Freeport flow is not affected by south Delta exports
Winter-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment	Changes in hydrodynamic conditions (velocity distributions) indicate that juvenile winter run entering the interior Delta from Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor may be more likely to become entrained under the Proposed Project, if exports are greater at the time they are present. There is little difference during the main December-February period when Winter-Run are most abundant in the Delta.	Although Chinook Salmon in the Old-Middle River Corridor could become entrained more often under the Proposed Project, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of winter run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile winter run Chinook salmon encounter the South Delta salvage facilities. Velocity changes that could occur in the Spring and Fall under the proposed project are less t likely to affect Winter-run Chinook Salmon because most Winter-run Chinook Salmon are expected to have exited the Delta by April and May and are generally present in low abundance in September and November. This is a combined SWP and CVP result Implementing OMR management, including factors such as cumulative loss thresholds, would limit entrainment of Winter-run Chinook Salmon that do enter the Old-Middle River corridor. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF could reduce pre-screen losses, which could increase observed salvage. Skinner Fish Facility Improvements also have the potential to improve survival of salvaged winter-run Chinook Salmon.	Less than Significant	Although Chinook Salmon in the Old-Middle River Corridor could become entrained more often under Alternative 2a, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers for the Proposed Project modeling indicate that probabilities of moving south from that point are similar. Thus, Alternative 2a would be unlikely to increase the proportion of winter run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile winter run Chinook salmon encounter the South Delta salvage facilities. Velocity changes that could occur in the Spring and Fall under Alternative 2a are less likely to affect Winter-run Chinook Salmon because most Winter-run Chinook Salmon are expected to have exited the Delta by April and May and are generally present in low abundance in September and November. This is a combined SWP and CVP result Implementing OMR management, including factors such as cumulative loss thresholds, would limit entrainment of Winter-run Chinook Salmon that do enter the Old-Middle River corridor. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF could reduce pre-screen losses, which could increase observed salvage. Skinner Fish Facility Improvements also have the potential to improve survival of salvaged winter-run Chinook Salmon.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project; the difference in entrainment loss would be small because there is little temporal overlap of Winter-Run with April-May

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Winter-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Winter-run Chinook Salmon at the SWP south Delta export facility would be similar between the scenarios.	Entrainment loss would be similar under both scenarios, but the analysis is uncertain because it is not scaled by population size and there is uncertainty about the true racial identity of Chinook Salmon in salvage. The model does not include real-time management operations, which would reduce entrainment. The model does not include the genetic identity of salvaged Chinook salmon, and some fish in historical salvage could be misidentified, which would artificially increase the estimated salvage in the analysis.	Less than Significant	Entrainment loss would be similar under both scenarios, but the analysis is uncertain, and the models run for the Proposed Project do not include real-time management operations or genetic identity of salvaged Chinook salmon.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project; the difference in entrainment loss would be small because there is little temporal overlap of Winter-Run with April-May
Winter-run Chinook Salmon	Juvenile	Salvage based on Zeug and Cavallo (2014)	Winter-run Chinook Salmon salvage is similar under both scenarios. Median salvage of the juvenile population at the SWP was 0.149% under the existing condition and 0.140% under the proposed project (≈ 0.01% lower under the proposed project). Median salvage at both the SWP and CVP combined was 0.353% under the proposed project and 0.380% under the existing condition.	The maximum annual proportion of juvenile Winter-run Chinook Salmon production predicted to be salvaged is low (<1.2%) for both the proposed project and the existing condition. Differences between scenarios in individual years were small (<0.5%). Additionally, small differences in predicted salvage occurred in certain months and water year types. However, there was high overlap in interquartile ranges and the scenario with greater salvage was not consistent across these comparisons.	Less than Significant	The maximum annual proportion of juvenile Winter-run Chinook Salmon production that would be predicted to be salvaged would low (<~1.2%) for both Alternative 2a and the existing condition. Differences between scenarios in individual years would be expected to be small (<0.5%).	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project; the difference in entrainment loss would be small because there is little temporal overlap of Winter-Run with April-May
Winter-run Chinook Salmon	Outmigrant Survival	Delta Passage Model	Across the 82-year simulation period, mean through-Delta survival was 0.1% greater for the Proposed Project. Survival followed water year-type for both scenarios with the highest values in wet years and lowest values in critical years. Differences in individual model years were generally small (≤ 1.6%) as were differences within individual water year-types.	Through Delta survival of Winter-run Chinook Salmon was similar under both scenarios with some uncertainty. These results are similar to those of the STARS analysis described below which does not include an export-survival function which is included in the DPM. Together, these results suggest changes in export operations under the proposed project had little influence on through-Delta survival of winter run Chinook Salmon. Uncertainty in the modeled result will be addressed by implementing cumulative loss thresholds as part of OMR management would limit entrainment SWP responsibility for differences in Delta operations is between approximately 40% to 60%	Less than Significant	Through Delta survival of Winter-run Chinook Salmon would be expected to be similar under both scenarios with some uncertainty. Modeling results for the Proposed Project suggest changes in export operations under the proposed project would have little influence on through-Delta survival of winter run Chinook Salmon. Uncertainty in the modeled result will be addressed by implementing cumulative loss thresholds as part of OMR management, which would limit entrainment. SWP responsibility for differences in Delta operations is between approximately 40% to 60%	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project; the difference in entrainment loss would be small because there is little temporal overlap of Winter-Run with April-May

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Winter-run Chinook Salmon	Outmigrant Survival	STARS	Generally similar proportions of Winter-run Chinook Salmon entered the interior Delta via Georgiana Slough and the DCC, resulting in similar through Delta survival under both scenarios except during November, when survival was predicted to be lower under the Proposed Project as a result of less river flow and greater Delta Cross Channel (DCC) opening as a result of model assumptions. However, abundance of Winter-run Chinook Salmon is generally low in November.	During most months of the outmigration period (October through June for this analysis) Winter-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the central Delta and reduced survival could occur in November. However, abundance of Winter-run Chinook Salmon is generally low in November. This is a combined result. During November when the largest differences in routing occur, the SWP is responsible for approximately 50-60% of operations-related impacts but note that the DCC is a CVP facility.	Less than Significant	During most months of the outmigration period (October through June for this analysis) Winter-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the central Delta and reduced survival could occur in November. However, abundance of Winter-run Chinook Salmon is generally low in November. This is a combined result. During November when the largest differences could occur, the SWP is responsible for approximately 50-60% of operations-related impacts but note that the DCC is a CVP facility.	Less than Significant	Freeport flow is not affected by south Delta exports
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	Annual O&M activities likely would have limited impacts because work windows and best management practices (BMPs) would be implemented. Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2a.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival.	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.
Spring-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the January through June immigration period.	Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. SWP responsibility for differences in Delta operations is between approximately 30-60%.	Less than Significant	Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration.	Less than Significant	Freeport flow is not affected by south Delta exports

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Spring-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	For juvenile spring-run Chinook Salmon migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the Old and Middle River corridors during April and May suggest entrainment of fish entering Old River at HOR would be higher. For juvenile spring-run Chinook Salmon originating from the Sacramento River, changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor in April and May are more likely to become entrained under the Proposed Project.	Greater frequency of routing San Joaquin-origin spring-run into Old River increases entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under the proposed project (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River. For Sacramento River-origin spring-run, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of spring run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May This is a combined SWP and CVP result. OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Greater frequency of routing San Joaquin-origin spring-run into Old River would increase entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under the proposed project (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River. For Sacramento River-origin spring-run, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers for modeling of the proposed project indicate that probabilities of moving south from that point are similar. Thus, Alternative 2a would be unlikely to increase the proportion of spring run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May This is a combined SWP and CVP result. OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Spring-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Spring-run Chinook Salmon at the SWP south Delta export facility could be appreciably greater under the Proposed Project.	Entrainment loss of Spring-run Chinook Salmon could be higher under the Proposed Project, but the analysis is uncertain, and the model does not include genetic identity of salvaged Chinook salmon or account for the total number of juveniles that could potentially be salvaged (data are not scaled). Coded wire tag studies indicate that small fractions of Sacramento River Chinook Salmon encounter the South Delta salvage facilities, so entrainment-related impacts on the ESU would be small. OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Entrainment loss of Spring-run Chinook Salmon could be higher under Alternative 2a. Coded wire tag studies indicate that small fractions of Sacramento River Chinook Salmon encounter the South Delta salvage facilities, so entrainment-related impacts on the ESU would be small. OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions
Spring-run Chinook Salmon	Outmigrant Survival	Delta Passage Model	Across the 82-year simulation period, mean through-Delta survival was 0.6% lower under the Proposed Project. Differences in individual years were generally small (< 1.5%), with the largest difference occurring in the 1995 model year when survival under the Proposed Project was 1.6 % lower than the Existing Condition.	Through Delta survival of Spring-run Chinook Salmon was similar under both scenarios with some uncertainty. The Delta Passage Model contains an export-survival relationship. Thus, higher exports in April and May did not result in substantial changes in through-delta survival. Only a small fraction of Sacramento River-origin Spring-run enter the interior Delta and most of the juvenile population is not exposed to the hydrodynamic effect of exports. This is a combined SWP and CVP result	Less than Significant	Through Delta survival of Spring-run Chinook Salmon would be expected to be similar under both scenarios with some uncertainty. This is a combined SWP and CVP result.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions
Spring-run Chinook Salmon	Outmigrant Survival	San Joaquin River Structured Decision Model	Across the 82-year simulation period, through-Delta survival was low (< 4%) under both scenarios. Survival was higher under the Proposed Project for all years, but the magnitude of the difference between scenarios was variable in specific years. Survival was more similar between scenarios in drier year types relative to wetter year types.	Survival of San Joaquin River-origin Spring-run Chinook Salmon has the potential to be higher under the Proposed Project. Although exports will be higher under the proposed project in April and May, the SDM includes the latest acoustic tagging data from the CVP and south Delta. These data and the model suggest that volitional migration survival from the facilities north can be lower than entrainment at CVP and trucking to the West Delta. Thus, more fish being routed into Old River and higher exports lead to a higher survival under the proposed project. However, overall through-delta survival for San Joaquin River-origin Chinook Salmon is low regardless of scenario (<4%).	Less than Significant	Survival of San Joaquin River-origin Spring-run Chinook Salmon has the potential to be higher under Alternative 2a. Although exports will be higher under the Alternative 2a in April and May, the SDM includes the latest acoustic tagging data from the CVP and south Delta. These data and the model suggest that volitional migration survival from the facilities north can be lower than entrainment at CVP and trucking to the West Delta. Thus, more fish being routed into Old River and higher exports lead to a higher survival under the proposed project. However, overall through-delta survival for San Joaquin River-origin Chinook Salmon would be low regardless of scenario.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Spring-run Chinook Salmon	Outmigrant Survival	STARS	The STARS model results suggest little difference in predicted through-Delta survival of Spring-run Chinook Salmon between the scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December.	During most months of the outmigration period (November through May for this analysis) Spring-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the Delta and reduced survival could occur in November. Although the STARS model does not include an export-survival function, results generally followed those of the DPM which does. Only small fractions of Sacramento River Chinook Salmon encounter the South Delta facilities as indicated by coded wire tag studies. This likely explains the minor effect of increased exports during April and May on total through-Delta survival. The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40–60% depending on the month and water year type.	Less than Significant	During most months of the outmigration period (November through May for this analysis) Spring-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the Delta and reduced survival could occur in November. Although the STARS model run for the Proposed Project does not include an export-survival function, results generally followed those of the DPM which does. Only small fractions of Sacramento River Chinook Salmon encounter the South Delta facilities as indicated by coded wire tag studies. This likely explains the minor effect of increased exports during April and May on total through-Delta survival. The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40–60% depending on the month and water year type.	Less than Significant	Freeport flow is not affected by south Delta exports
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2a.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.
Fall-run and Late Fall-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the July through December Fall-run Chinook Salmon and October through April Late Fall-run Chinook Salmon adult immigration periods. No SWP influence on DCC operations.	Similar flow conditions would likely result in similar habitat conditions in the Sacramento River including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. SWP responsibility for differences in Freeport flows is between approximately 20-60% during the Fall-run Chinook Salmon Immigration Period. SWP responsibility for differences in Freeport flows is between approximately 40% to 60% during the Late Fall-run Chinook Salmon Immigration Period. There is no difference in straying rates of Mokelumne River Fall-run Chinook Salmon because there is no SWP influence on DCC operations.	Less than Significant	Similar flow conditions would likely result in similar habitat conditions in the Sacramento River including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. There would be no difference in straying rates of Mokelumne River Fall-run Chinook Salmon because there is no SWP influence on DCC operations.	Less than Significant	Freeport flow is not affected by south Delta exports

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Fall-run and Late Fall-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	For juvenile fall-run Chinook Salmon migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the Old and Middle River corridors during April and May suggest entrainment of fish entering Old River at HOR would be higher. For juvenile fall-run and late-fall run Chinook Salmon originating from the Sacramento River, Changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor in April and May (primarily fall run) and November (late-fall run) are more likely to become entrained under the Proposed Project.	Greater frequency of routing San Joaquin-origin fall-run into Old River increases entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under the proposed project (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River. For Sacramento River-origin fall-run, and late fall-run that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of fall and late-fall run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May (fall run) or November (late fall-run). This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the period evaluated for San Joaquin River basin Fall-run Chinook Salmon is approximately 40% to 60%. OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements would improve survival of salvaged fish.	Less than Significant	Greater frequency of routing of San Joaquin-origin fall-run into Old River under Alternative 2a would increase entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model undertaken for the Proposed Project incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under the proposed project (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River. For Sacramento River-origin fall-run, and late fall-run that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers for Proposed Project modeling indicate that probabilities of moving south from that point are similar. Thus, Alternative 2a would be unlikely to increase the proportion of fall and late-fall run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May (fall run) or November (late fall-run). This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the period evaluated for San Joaquin River basin Fall-run Chinook Salmon is approximately 40% to 60%. OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements would improve survival of salvaged fish.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions
Fall-run and Late Fall-run Chinook Salmon	Juvenile	Mokelumne River Fall-run Chinook Salmon Qualitative Discussion	N/A	Coded wire tag analysis suggests that very small percentages of Mokelumne River Fall-run Chinook Salmon would be expected to be entrained, ranging from 0.4-0.6% of outmigrants.	Less than Significant	Coded wire tag analysis suggests that very small percentages of Mokelumne River Fall-run Chinook Salmon would be expected to be entrained, ranging from 0.4-0.6% of outmigrants.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Fall-run and Late Fall-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Fall-run Chinook Salmon at the SWP south Delta export facility could be appreciably greater under the Proposed Project. Entrainment loss of Late Fall-run Chinook Salmon is similar between scenarios.	Entrainment loss could be higher under the Proposed Project, but the analysis is uncertain, and the model does not include genetic identity of salvaged Chinook salmon. Small percentages of juvenile Sacramento River Fall-run and Late Fall-run Chinook Salmon are estimated to encounter the south Delta, export facilities, so entrainment-related impacts on the ESU would be small. Entrainment losses likely to be higher for San Joaquin River-origin fall run. However, the SDM model indicated higher survival under the proposed project due to poor volitional survival through Old River relative to salvage and trucking OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Entrainment loss could be higher under Alternative 2a, but the analysis is uncertain, and the modeling done for the Proposed Project does not include genetic identity of salvaged Chinook salmon. Small percentages of juvenile Sacramento River Fall-run and Late Fall-run Chinook Salmon are estimated to encounter the south Delta export facilities, so entrainment-related impacts on the ESU would be small. Entrainment losses likely to be higher for San Joaquin River-origin fall run. However, the SDM model indicated higher survival under the Proposed Project due to poor volitional survival through Old River relative to salvage and trucking OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	Delta Passage Model CV Fall-run and Late Fall-run Chinook Salmon	Across the 82-year simulation period, mean Fall-run Chinook Salmon through-Delta survival was 0.5% lower under the Proposed Project. Differences in individual years were generally small (< 1.5%). Across the 82-year simulation period, mean Late Fall-run Chinook Salmon through-Delta survival was 0.3% lower under the Proposed Project. Differences in individual years were generally small (< 1.0%).	Through Delta survival of Fall-run and Late Fall-run Chinook Salmon was similar under both scenarios with some uncertainty. These results were similar to those from the STARS model which does not include an export-survival relationship like to DPM. This suggests changes to exports did not have a substantial effect on through-Delta survival. This is a combined SWP and CVP result.	Less than Significant	Through Delta survival of Fall-run and Late Fall-run Chinook Salmon would be expected to be similar under both scenarios with some uncertainty. This is a combined SWP and CVP result.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	San Joaquin River Structured Decision Model	Across the 82-year simulation period through-Delta survival was low (< 4%) under both scenarios. Survival was higher under the Proposed Project for all years, but the magnitude of the difference between scenarios was variable. Survival was higher under the Proposed Project in all water year types.	Greater proportions of fish would be routed into Old River relative to the San Joaquin River under the proposed project and exports will be higher in April and May when fall run are migrating. However, survival of San Joaquin River-origin Fall-run Chinook Salmon has the potential to be higher under the Proposed Project. The SDM uses the most recent survival data from acoustic tagging studies in the South Delta and at the CVP. This indicates survival is higher for fish in Old River that are salvaged and trucked rather than volitional migration.	Less than Significant	Survival of San Joaquin River-origin Fall-run Chinook Salmon has the potential to be higher under Alternative 2a because data from acoustic tagging studies in the South Delta and at the CVP indicate survival is higher for fish in Old River that are salvaged and trucked rather than volitional migration.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	STARS	The STARS model results suggest little difference in predicted through-Delta survival of Chinook Salmon between the scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December.	During most months of the outmigration period (January through June) Fall-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Late Fall-run Chinook Salmon could be exposed to increased routing into the Delta and reduced survival in November, although this is because of DCC operational assumptions related to Freeport flow. Small percentages of Sacramento River Fall-run Chinook Salmon and Late Fall-run Chinook Salmon enter the South Delta, so entrainment-related impacts on the ESU would be small. This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 40% to 60%, depending on the month and water year type.	Less than Significant	During most months of the outmigration period (January through June) Fall-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Late Fall-run Chinook Salmon could be exposed to increased routing into the Delta and reduced survival in November, although modeling of this for the Proposed Project reflects DCC operational assumptions related to Freeport flow. Small percentages of Sacramento River Fall-run Chinook Salmon and Late Fall-run Chinook Salmon enter the South Delta, so entrainment-related impacts on the ESU would be small. This is a combined SWP and CVP result.	Less than Significant	Freeport flow is not affected by south Delta exports
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2a.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Central Valley Steelhead	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the July through March immigration period.	Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. SWP responsibility for differences in OMR flows is between approximately 20-60%.	Less than Significant	Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration.	Less than Significant	Freeport flow is not affected by south Delta exports
Central Valley Steelhead	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	For juvenile steelhead migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile fish approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the Old and Middle River corridors during April and May suggest entrainment of fish entering Old River at HOR would be higher. For juvenile steelhead originating from the Sacramento River, Changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor in April and May are more likely to become entrained under the Proposed Project	Greater frequency of routing San Joaquin-origin steelhead into Old River increases entrainment risk for these fish but it is unknown if this would translate into a population-level effect on survival. For Sacramento River-origin steelhead, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of steelhead entering the Old-Middle River corridor. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May This is a combined SWP and CVP result. Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Greater frequency of routing San Joaquin-origin steelhead into Old River under Alternative 2a would increase entrainment risk for these fish but it is unknown if this would translate into a population-level effect on survival. For Sacramento River-origin steelhead, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers based on modeling for the Proposed Project indicate that probabilities of moving south from that point are similar. Thus, Alternative 2a would be unlikely to increase the proportion of steelhead entering the Old-Middle River corridor. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May This is a combined SWP and CVP result. Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project; the difference in entrainment loss would be small because there is little temporal overlap of Steelhead with April-May

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Central Valley Steelhead	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Central Valley steelhead at the SWP south Delta export facility could be greater under the Proposed Project.	Entrainment loss of steelhead could be higher under the Proposed Project, but the analysis is uncertain. Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Entrainment loss of steelhead could be higher under Alternative 2a, but the analysis is uncertain. Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions
Central Valley Steelhead	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	Annual O&M activities likely would have limited impacts because work windows and best management practices (BMPs) would be implemented. Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2a.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
Central Valley Steelhead	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to increase pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Delta Outflow	Similar under both scenarios.	Similar Delta outflow during most of the year would result in similar impacts under both scenarios. This is a combined SWP and CVP result. SWP responsibility for differences in Delta operations is between approximately 20-60%.	Less than Significant	Similar Delta outflow during most of the year would result in similar impacts under both scenarios. This is a combined SWP and CVP result.	Less than Significant	Delta outflow in April-May would be greater under Alternative 2a than Proposed Project, but less than Existing Conditions
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Annual O&M Activities	N/A	Annual O&M activities would not occur within the habitats occupied by Central California Coast Steelhead.	Less than Significant	Annual O&M activities would not occur within the habitats occupied by Central California Coast Steelhead.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Project Environmental Protective Measures)	N/A	No project environmental protective measures occur in San Francisco Bay and San Pablo Bay, and no impacts on Central California Coast Steelhead would occur.	Less than Significant	No project environmental protective measures occur in San Francisco Bay and San Pablo Bay, and no impacts on Central California Coast Steelhead would occur.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Green Sturgeon	Immigrating Adults and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on Green Sturgeon habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November would not be expected to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on Green Sturgeon habitat attributes. This is a combined SWP and CVP result.	Less than Significant	Freeport flow is not affected by south Delta exports
Green Sturgeon	Juvenile	Daily Salvage Loss Density	Green Sturgeon salvage is low and is similar under both scenarios.	Green Sturgeon salvage would be expected to be similar under both scenarios.	Less than Significant	Green Sturgeon salvage would be expected to be similar under both scenarios.	Less than Significant	Little expected salvage during April-May period of export differences.
Green Sturgeon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
Green Sturgeon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.
White Sturgeon	Immigrating Adults and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions and during April and May.	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on White Sturgeon habitat attributes. Reductions in Delta outflow in April/May have the potential to reduce year-class strength based on observed correlations, although there is uncertainty in the mechanism and differences would be expected to be small relative to variability in estimates that may reflect hydrological conditions as opposed to operations. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%, and for Delta outflow in April/May is approximately 40-50%.	Less than Significant	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on White Sturgeon habitat attributes. Reductions in Delta outflow in April/May have the potential to reduce year-class strength based on observed correlations, although there is uncertainty in the mechanism and differences would be expected to be small relative to variability in estimates that may reflect hydrological conditions as opposed to operations. This is a combined SWP and CVP result.	Less than Significant	Freeport flow is not affected by south Delta exports; Delta outflow in April-May would be greater under Alternative 2a than Proposed Project, but less than Existing Conditions

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
White Sturgeon	Juvenile	Daily Salvage Loss Density	White Sturgeon salvage is low and is similar under both scenarios.	White Sturgeon salvage is low and is similar under both scenarios.	Less than Significant	White Sturgeon salvage would be expected to be low and similar under both scenarios.	Less than Significant	Little expected salvage during April-May period of export differences.
White Sturgeon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
White Sturgeon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.
Pacific Lamprey and River Lamprey	Immigrating Adults, Ammocoetes, and Migrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on lamprey habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on lamprey habitat attributes. This is a combined SWP and CVP result.	Less than Significant	Freeport flow is not affected by south Delta exports
Pacific Lamprey and River Lamprey	Juvenile	Daily Salvage Loss Density	Lamprey salvage is similar under both scenarios in wet and above-normal water years but is higher under the Proposed Project in below-normal, dry, and critical water years.	Lamprey salvage is similar under both scenarios in wet and above-normal water years but is higher under the Proposed Project in below-normal, dry, and critical water years. Real-time OMR management for other listed species, particularly first flush protections for Delta Smelt, may incidentally limit lamprey salvage. Actions to improve survival in the CCF including aquatic weed control and continued evaluation of predator reduction in the CCF, could limit pre-screen loss. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Lamprey salvage would be expected to be similar under both scenarios in wet and above-normal water years but may be higher under Alternative 2a in below-normal, dry, and critical water years. Real-time OMR management for other listed species, particularly first flush protections for Delta Smelt, may incidentally limit lamprey salvage. Actions to improve survival in the CCF including aquatic weed control and continued evaluation of predator reduction in the CCF, could limit pre-screen loss. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.
Native Minnows	Native Minnow Residence	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident native minnow habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident native minnow habitat attributes. This is a combined SWP and CVP result.	Less than Significant	Freeport flow is not affected by south Delta exports
Native Minnows	Splittail Spawning Hardhead Spawning Central California Roach Spawning	Flow Analysis	Similar flow conditions at Freeport during the native minnow spawning periods and into the Yolo Bypass during the Splittail spawning period.	Similar flows would not result in substantial long-term impacts on native minnow spawning habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 30-60%.	Less than Significant	Freeport flow is not affected by south Delta exports.	Less than Significant	Freeport flow and Yolo Bypass flow are not affected by south Delta exports

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Native Minnows	Juvenile	Splittail Salvage Loss Density	Appreciable increases in entrainment of Sacramento Splittail could occur under the Proposed Project.	Although salvage could be higher under the Proposed Project, the main driver of Sacramento Splittail population dynamics appears to be inundation of floodplain habitat, such as the Yolo Bypass, which would not change. Sacramento Splittail may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in the Proposed Project that would be implemented to protect listed salmonids and smelts. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in CCF, would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Although salvage could be higher under Alternative 2a, the main driver of Sacramento Splittail population dynamics appears to be inundation of floodplain habitat, such as the Yolo Bypass, which would not change. Sacramento Splittail may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in Alternative 2a that would be implemented to protect listed salmonids and smelts. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in CCF, would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions
Native Minnows	Juvenile	Hardhead Salvage Loss Density	Hardhead salvage is similar under both scenarios and is low.	Similar and low salvage loss would not be expected to substantially affect Hardhead.	Less than Significant	Similar and low salvage loss would not be expected to substantially affect Hardhead.	Less than Significant	Very few Hardhead were salvaged historically, so operational differences between scenarios would not be expected to result in differences in entrainment loss.
Native Minnows	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
Native Minnows	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Striped Bass	Immigrating and Spawning Adults, Rearing and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, particularly during the immigration, spawning, and larvae dispersal period (April through June). Less Delta outflow (greater fall X2) in fall following wet years; greater fall outflow (lower fall X2) in fall following above-normal years.	Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on Striped Bass. Differences in young-of-the-year abundance as a result of differences in fall Delta outflow/X2 may result in potentially limited population-level impacts because of density dependence later in the life cycle. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on Striped Bass. Differences in young-of-the-year abundance as a result of differences in fall Delta outflow/X2 may result in potentially limited population-level impacts because of density dependence later in the life cycle. This is a combined SWP and CVP result.	Less than Significant	Freeport flow is not affected by south Delta exports; fall operations do not differ between Alternative 2a and the Proposed Project.
Striped Bass	Juvenile Entrainment	Entrainment Loss Density	Similar salvage of juvenile Striped Bass under both scenarios.	Similar and low salvage loss would not be expected to substantially affect Striped Bass. Potential for greater entrainment loss of early life stages (eggs/larvae) during spring may be limited by ancillary protection for listed salmonids and smelts, with limited population-level impacts because of density dependence later in the life cycle.	Less than Significant	Similar and low salvage loss would not be expected to substantially affect Striped Bass. Potential for greater entrainment loss of early life stages (eggs/larvae) during spring may be limited by ancillary protection for listed salmonids and smelts, with limited population-level impacts because of density dependence later in the life cycle.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions
Striped Bass	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
Striped Bass	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.
American Shad	Immigrating and Spawning Adults	Flow Analysis	Similar flow conditions at Freeport during most months of the year, particularly during the immigration, spawning, and larvae dispersal period (April through June).	Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on American Shad. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on American Shad. This is a combined SWP and CVP result.	Less than Significant	Freeport flow is not affected by south Delta exports

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
American Shad	Juvenile Entrainment	Entrainment Loss Density	Similar salvage of juvenile American Shad under the both scenarios during most years, with higher salvage occurring under the Proposed Project during critical water years.	Similar salvage loss would not be expected to result in substantial impacts on American Shad under the Proposed Project. Loss of earlier life stages may be limited because most early rearing is upstream of the Delta, and there may be ancillary protection from OMR management for listed fish in spring.	Less than Significant	Similar salvage loss would not be expected to result in substantial impacts on American Shad under Alternative 2a. Loss of earlier life stages may be limited because most early rearing is upstream of the Delta, and there may be ancillary protection from OMR management for listed fish in spring.	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions
American Shad	All Life Stages Present in the Delta	Annual O&M Activities	N/A	Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
American Shad	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.
Non-Native Freshwater Bass	Resident Adults and Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident non-native freshwater bass habitat attributes This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%	Less than Significant	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident non-native freshwater bass habitat attributes This is a combined SWP and CVP result.	Less than Significant	Freeport flow is not affected by south Delta exports
Non-Native Freshwater Bass	Juvenile Entrainment	Entrainment Loss Density	The salvage-density method suggested the potential for entrainment of Largemouth Bass to moderately increase under the Proposed Project, particularly in intermediate water years. Similar salvage of juvenile Spotted Bass and Smallmouth Bass under the both scenarios.	Increased salvage loss of Largemouth Bass could occur but may be mediated because Grimaldo et al. (2009) did not find a significant relationship between Largemouth Bass salvage and OMR flows. Similar, very low salvage of juvenile Spotted Bass and Smallmouth Bass would be expected under both scenarios	Less than Significant	Increased salvage loss of Largemouth Bass could occur under Alternative 2a but may be mediated because Grimaldo et al. (2009) did not find a significant relationship between Largemouth Bass salvage and OMR flows. Similar, very low salvage of juvenile Spotted Bass and Smallmouth Bass would be expected under both scenarios	Less than Significant	South Delta exports in April-May would be less under Alternative 2a than Proposed Project, but greater than Existing Conditions

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Expected Effects of Alternative 2a Relative to Existing Conditions	Impact Conclusion (Alternative 2a)	Rationale
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	Annual O&M activities would be the same for the Proposed Project and Alternative 2a.
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2a.
Killer Whale	All Life Stages	Food Source Discussion	See model results for Fall-run and Late Fall-run Chinook Salmon.	Because impacts on Fall-run and Late Fall-run Chinook Salmon are less than significant, impacts on killer whales resulting from prey reductions would be minimal	Less Than Significant	Because impacts on Fall-run and Late Fall-run Chinook Salmon are less than significant, impacts on killer whales resulting from prey reductions would be minimal	Less Than Significant	See discussion for Fall-run and Late Fall-run Chinook Salmon

Sources: Nobriga and Rosenfield 2016; Grimaldo et al. 2009 ;Zeug and Cavallo 2014

Notes:
BMPs = best management practices
CCF = Clifton Court Forebay
CDFW = California Department of Fish and Wildlife
cfs = cubic feet per second
CVP = Central Valley Project
DCC = Delta Cross Channel
Delta = Sacramento–San Joaquin Delta
DPM = Delta Passage Model
DSM2 = Delta Simulation Model II
DWR = California Department of Water Resources
EDSM = Enhanced Delta Smelt Monitoring
ESU = Evolutionary Significant Unit
FCCL = Fish Conservation and Culture Laboratory
ft/sec = foot per second
HOR = Head of Old River
LCM = USFWS Life Cycle Model
LSZ = low salinity zone
N/A = not applicable
O&M = operations and maintenance
OMR = Old and Middle River
PTM = Particle Tracking Modeling
QWEST = Net flow on the San-Joaquin River at Jersey Point
SAIL = Salmon and Sturgeon Assessment of Indicators by Life Stage
SCHISM = Semi-implicit Cross-scale Hydroscience Integrated System Model
SDM = Structured Decision Model
SLS = Smelt Larval Survey
SMSCG = Suisun Marsh Salinity Control Gates
STARS = Survival, Travel Time, and Routing Simulation
SWP = State Water Project
USFWS = United States Fish and Wildlife Service
WY = water year

5.2.4 Other Resources

As described in Section 1.4 *Summary of Environmental Consequences* and the information and analyses presented in the Initial Study, Appendix A, the Proposed Project would result in no impacts to the following resource topics:

- Aesthetics
- Agriculture and Forestry Resources
- Air Quality
- Biological Resources (Terrestrial)
- Cultural Resources
- Energy
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards and Hazardous Materials
- Land Use and Planning
- Mineral Resources
- Noise
- Population and Housing
- Public Services
- Recreation
- Transportation/Traffic
- Tribal Cultural Resources
- Utilities and Service Systems
- Wildfire

The only difference between the Proposed Project and Alternative 2(a) is that Alternative 2(a) includes an additional export reduction in April and May. The export reduction would offset the modeled increase in exports associated with the proposed project. Therefore, the effect on exports would be negligible compared to Existing Conditions, which would further reduce any changes identified in the Initial Study for the resources listed above.

5.2.5 Other Considerations

The 2009 NMFS BiOp imposed a reasonable and prudent alternative (RPA) for an I:E ratio to be met by combined CVP and SWP operations. The 2019 project description for Long-Term Operations (LTO) does not include an I:E ratio requirement. Instead, export restrictions for the protection of steelhead (federally listed species) in April and May and earlier in the year are provided through restrictions on OMR flows. Moreover, since the proposed April-May flows in Alternative 2(a) are intended to benefit Longfin Smelt, a state-listed species, it is not anticipated that the CVP would be jointly operating to meet the I:E ratio.

If the SWP reduced water diversions without a prior agreement with the CVP, the CVP would be expected to increase water diversions up to their permitted capacity within federal regulatory requirements. Therefore, Alternative 2a~~2(a)~~ would be expected to increase CVP diversions compared to the Proposed Project, which could reduce the potential for increased outflows consistent with the objectives of the action. However, as CVP exports under Alternative 2a~~2(a)~~ have not been quantified, it is unclear how much additional CVP pumping would be possible. The potential benefits of Alternative 2a for Longfin Smelt abundance compared to the Proposed Project are not completely understood because the modeled differences in Longfin Smelt abundance are very small relative to the variability in the predicted values.

5.3 REFINED ALTERNATIVE 2B~~B~~ – PROPOSED PROJECT WITH DEDICATED WATER FOR DELTA OUTFLOW FROM SWP

Refined Alternative 2b~~B~~ includes elements of the operations described in the Proposed Project~~ and Alternative 2A~~, but also consists of a dedicated "block" of water for summer or fall Delta outflow and additional spring maintenance flows, which through the AMP could be shifted for use in Summer-Fall period of the current or subsequent year. ~~i~~In addition to the Summer-~~/~~Fall Delta Smelt Habitat Action in the Proposed Project, Refined Alternative 2b includes an additional salinity target in the Suisun Marsh to guide SMSCG operations in Wet, Above Normal, and Below Normal Years. The additional spring through fall water dedicated for Delta outflow would be used to test hypotheses through scientific studies and narrow the uncertainty surrounding the effect of Delta outflow on spring Longfin Smelt abundance and Summer-Fall Delta Smelt habitat. The details of the scientific studies will be developed by DWR in coordination with CDFW and SWC as described in the AMP.

Additional Delta Outflow in Spring (Spring Maintenance Flows). Refined Alternative 2b would curtail exports to maintain the current SWP spring outflow contribution. The additional outflow would be developed by operating to the SWP proportional share of the spring (April and May) maintenance flows consistent with flows that would occur from continued implementation of the 2008 and 2009 Biological Opinions. ~~Alternative 2B spring operations are the same as those described above for Alternative 2A and would provide additional Delta outflow in Spring through SWP export curtailments by operating to its proportional share of SJR I:E ratio during April 1 – May 31. The details of SWP export curtailment for spring outflow using SJR I:E ratio are described in Alternative 2A.~~

Development and Redeployment of Spring Maintenance Flows Reserved for Spring, Summer, or Fall. As described in the Adaptive Management Plan proposed for Refined Alternative 2b, DWR would provide for up to 150 TAF of water to be developed through shifting of spring maintenance flows for use in the summer-fall period of the current year through discretionary export reductions (if those are forecasted to occur later in the year) or spring-fall of the following year, except if the following year is Critical. This water could be used to test the efficacy of providing additional spring, summer, and fall outflow for the benefit of Longfin and Delta Smelt. CDFW would define when this volume of water would be developed and deployed for use each year for a given year, but it is anticipated that this option will only be exercised under wet conditions. In March of each year, DWR will coordinate with DFW, and provide a preliminary SWP operations outlook that includes projected operations and conditions for the spring maintenance flow action. Once approved by DFW, the proposed operations will be implemented starting April 1 of each year. As determined by DWR and DFW, the outlook may be revised to include changing hydrology or operational conditions. Figure 5.3-1 shows decision points for Spring Maintenance Flow and potential use for development up to 150 TAF for deferred flow actions.

Alternate Voluntary Agreement Approach to Spring Maintenance Flows. If the voluntary agreement is achieved through early implementation or through final approval by the SWRCB, spring maintenance flows will alternatively be provided through SWP export reductions pursuant to the voluntary agreement.

Additional 100 TAF "Block" of Delta Outflow in Summer or Fall. Refined Alternative 2b~~B~~ provides an additional volume of water to supplement Delta outflow in summer or fall months of wet and above normal years as defined by the Sacramento Valley Index informed by the May 1 snow survey. In coordination with CDFW through the AMP, an additional 100 TAF of water would be provided for the purposes of testing and evaluating some components identified in the Delta smelt resiliency strategy, or other purposes as identified in the AMP ~~by studying the Delta outflow effects on Delta Smelt habitat~~. The 100 TAF would be available for use during June through November from water purchases or SWP project water. In the event that this water originates from Oroville storage, the management of Oroville would remain unchanged, and the water would be made available as Delta outflow in lieu of being exported for south-of-Delta beneficial uses.

Initially, the 100 TAF will be used in August of wet and above normal years to maintain a monthly average X2 of 80 km to the extent possible to test hypotheses and narrow uncertainty surrounding the Delta outflow effects on Delta smelt habitat. However, CDFW may define an alternate purpose for this volume of water within the June through ~~November~~ October time period of wet and above normal years through the AMP. In addition, CDFW has the option to apply this water in the subsequent non-Critical years. If the water is successfully carried over without spilling from storage, the timing of the deployment in the subsequent year will be at CDFW's discretion in coordination with DWR. Water carried over to the following year could be applied between March and October. If another time period is desired to be tested through the AMP process, then additional environmental review would be required to implement the action. Figure 5.3-2 shows decision points for additional 100 TAF Summer-Fall water and potential use for deferred actions.

Dedication of Water for Additional Delta Outflow. DWR shall ensure that the water provided by the SWP is dedicated for outflow purposes and may do this through any of the following in order of preference: agreements with downstream water users, a term-limited Section 1707 dedication as provided under the California Water Code, reliance on Term 91 conditions as enforceable by the SWRCB, or other means to ensure the water is not diverted for any intended use other than Delta outflow.

Under Refined Alternative 2b, DWR may seek agreements to protect water provided by the SWP for Delta outflow as described above. Agreements with downstream water users could potentially be sought with water users such as Reclamation and downstream diverters that could otherwise divert DWR's water meant for Delta outflow under this Alternative.

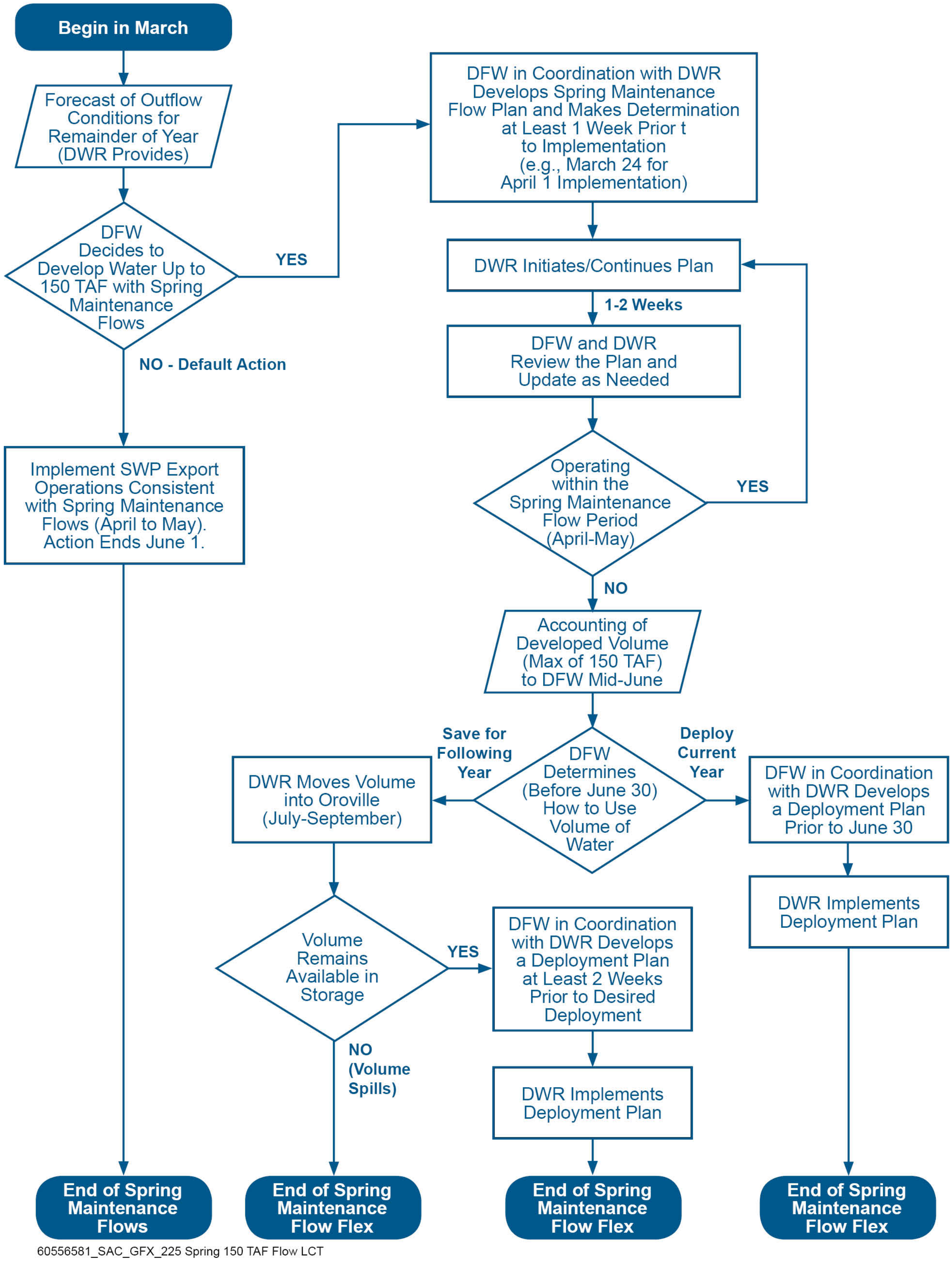


Figure 5.3-1 - Decision Points for Spring Maintenance Flow and Potential Use for Development up to 150 TAF for Deferred Flow Actions

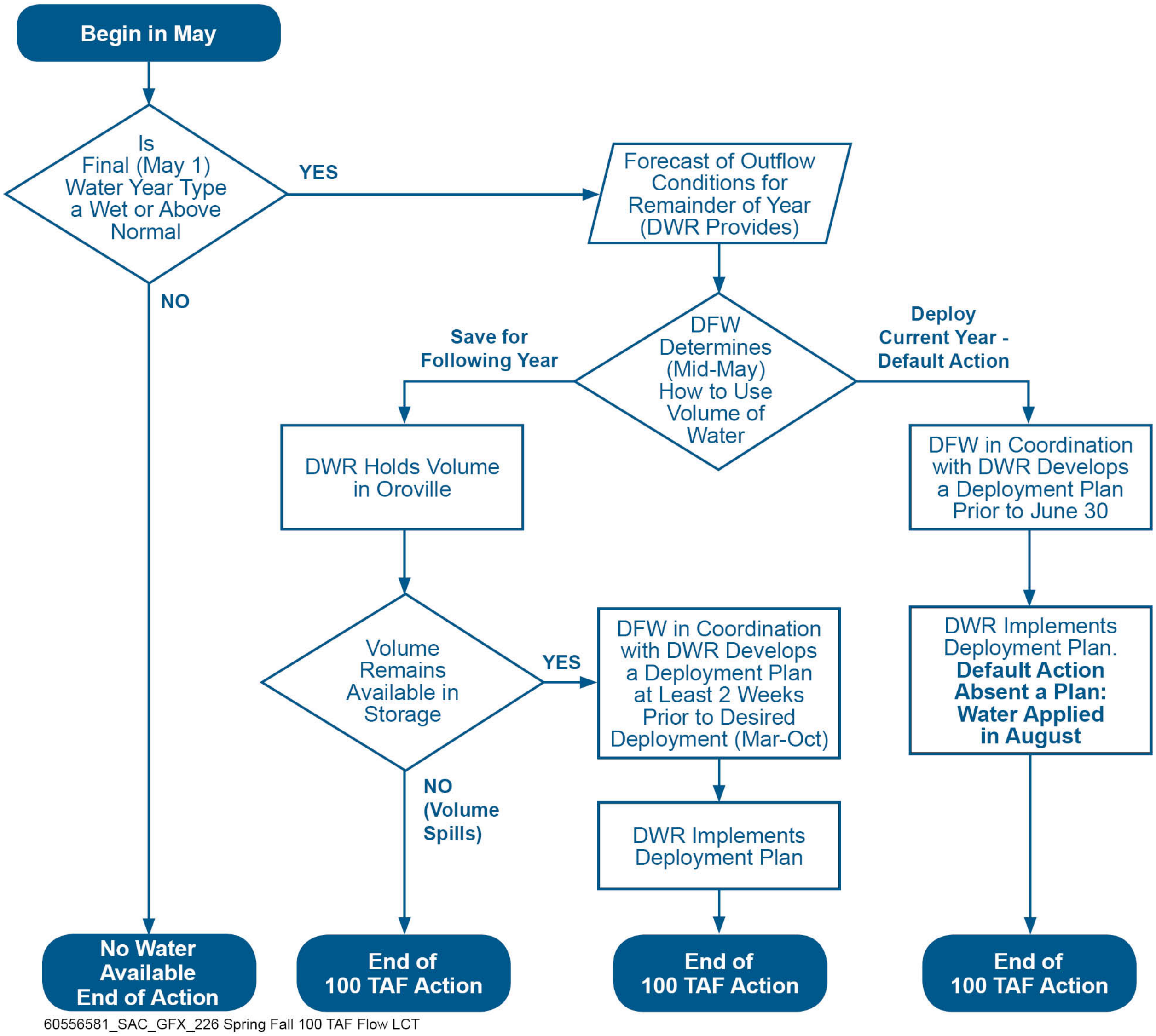


Figure 5.3-2 - Decision Points for Additional 100 TAF Summer-Fall Water and Potential Use for Deferred Actions

Under Refined Alternative 2b~~B~~, DWR would pursue an instream flow dedication under Section 1707 of the California Water Code to protect flow provided by the SWP for Delta outflow during the term of the permit and would pursue agreements with other downstream water users. If DWR can achieve satisfactory agreement to protect the water made available under this alternative, DWR may withdraw its 1707 petition at its discretion.

Term 91[15] is a condition imposed on water rights junior to the SWP and CVP that is designed to interrupt diversions under such junior water rights when conditions in the Delta watershed threaten certain water quality objectives.

[15] For more information on Term 91 see https://www.waterboards.ca.gov/water_issues/programs/delta_watermaster/docs/term_91_faq_111618.pdf

Under Section 1707 of the California Water Code, water that is reallocated for Delta outflow for the benefit of listed species would not be diverted by other water users downstream:

> "Any person entitled to the use of water, whether based upon an appropriative, riparian, or other rights, may petition the board… for a change for purposes of preserving or enhancing wetlands habitat, fish and wildlife resources, or recreation in, or on, the water."

As an appropriate water right holder, DWR would petition the SWRCB under a 1707 process to change the terms of its water rights for the SWP for the term of the ITP to recognize the instream dedication to benefit listed species. The water right holder may petition the SWRCB pursuant to Chapter 6.6 of the California Water Code, *Temporary Urgency Changes,* or Chapter 10.5, *Change of Point of Diversion, Place of Use, or Purpose of Use, Involving the Transfer of Water*, as appropriate. Among the various steps under the SWRCB petition process, DWR would submit a change petition form and accompanying environmental information. The petition would be noticed as directed by the SWRCB and interested persons would have the opportunity to protest. The parties would seek to resolve protests, if any, during the process and the resolution of protests could include a public hearing. Before granting DWR's petition, the SWRCB would need to find that the proposed changes would not injure any other legal users of water and would be in the public interest. The SWRCB could rely on this DEIR for its CEQA purposes. If the SWRCB ultimately grants DWR's petition, no other water users could divert the water subject to the instream dedication because leaving the instream would be recognized as a beneficial use of water under DWR's water rights.

DWR may also seek agreements with other water users, such as Reclamation and downstream diverters, could divert DWR's water meant for Delta outflow under this Alternative. These agreements would include similar assurances as those included in the 1707 findings.

The following sections present an evaluation of the impacts that would occur under Refined Alternative ~~2B~~ 2b compared to the Proposed Project.

5.3.1 Additional Components of Refined Alternative 2b

The OMR Management, Adaptive Management Plan, and Georgiana Slough Behavior Modification Barrier sections below describe updated elements of Refined Alternative 2b that would differ from the Proposed Project as described in DEIR Chapter 3. Refined Alternative 2b includes an updated Collaborative Real-Time Assessment, which differs from the decision-making process as described in the Proposed Project, an updated Adaptive Management Plan, and inclusion of the Georgiana Slough behavioral modification barrier. These elements of Refined Alternative 2b are presented in the subsections below.

5.3.2 OMR Management

DWR, in coordination with Reclamation, proposes to operate the SWP in a manner that maximizes exports while minimizing direct and indirect impacts on state and federally listed fish species. Old and Middle River (OMR) flow is a surrogate indicator of the influence of export pumping at Banks and Jones Pumping Plants, as well as other south Delta diversions, on hydrodynamics in the South Delta. The management of OMR flow, in combination with other environmental variables, can minimize or avoid entrainment of fish in the South Delta and at the SWP salvage facilities. DWR proposes to manage OMR flow by incorporating all available information into decision support for the management of OMR flow. The available information includes real-time monitoring of fish distribution, turbidity, temperature, hydrodynamic models, and entrainment models. The objective of the OMR management will be to provide focused protection for fish when necessary and to provide flexibility where possible. DWR, in coordination with existing multi-agency Delta-focused technical teams, will use estimates of species distribution and other environmental variables based on ongoing monitoring.

From the onset of OMR management to the end, DWR, in coordination with Reclamation, will operate to an OMR index that is no more negative than a 14-day moving average of -5,000 cfs unless Delta excess conditions occur (described below). Grimaldo et al. (2017) indicated that -5,000 cfs OMR flow is an inflection point for fish entrainment. OMR flow could be more positive than -5,000 cfs if additional real-time OMR restrictions are triggered (described below) or constraints other than OMR flow control exports. The OMR flow index would be computed using an equation presented in Hutton (2008). An OMR flow index allows for shorter-term operational planning and real-time adjustments. DWR, in coordination with Reclamation, will make a change to exports within 3 days of the trigger when monitoring, modeling, and operational criteria indicate protection for fish is necessary. The 3-day period is consistent with the 2008 and 2009 Biological Opinions and allows for efficient power scheduling.

5.3.2.1 Collaborative Real-time Risk Assessment

During the OMR Management period for species listed under CESA, DWR and CDFW technical staff, as part of the Smelt Monitoring Group and Salmon Monitoring Group, will meet weekly to consider survey data, salvage data and other pertinent biological and abiotic factors. Refined Alternative 2b would include decision points that would trigger, or off-ramp, an OMR flow requirement or an export constraint. These decision points may require a risk assessment to determine whether or not a requirement is triggered or can be off-ramped. Under those circumstances, DWR and CDFW technical staff will jointly develop a risk assessment and supporting documentation based on the monitoring data and operations forecast. DWR, in coordination with Reclamation, will recommend the OMR operations for species listed under CESA species based on the jointly developed risk assessment with WOMT. The WOMT will then confer and attempt to reach a resolution. If a resolution is reached, DWR will operate to the decision from WOMT. If the WOMT does not reach a resolution, then CDFW Director may require DWR to implement CDFW’s operational decision and DWR will implement the decision required by CDFW. CDFW will provide its decision in writing. DWR will ensure that its proportional share of the OMR flow requirement described herein is satisfied. Figure 5.3-3 shows the collaborative real-time risk assessment decision-making process.

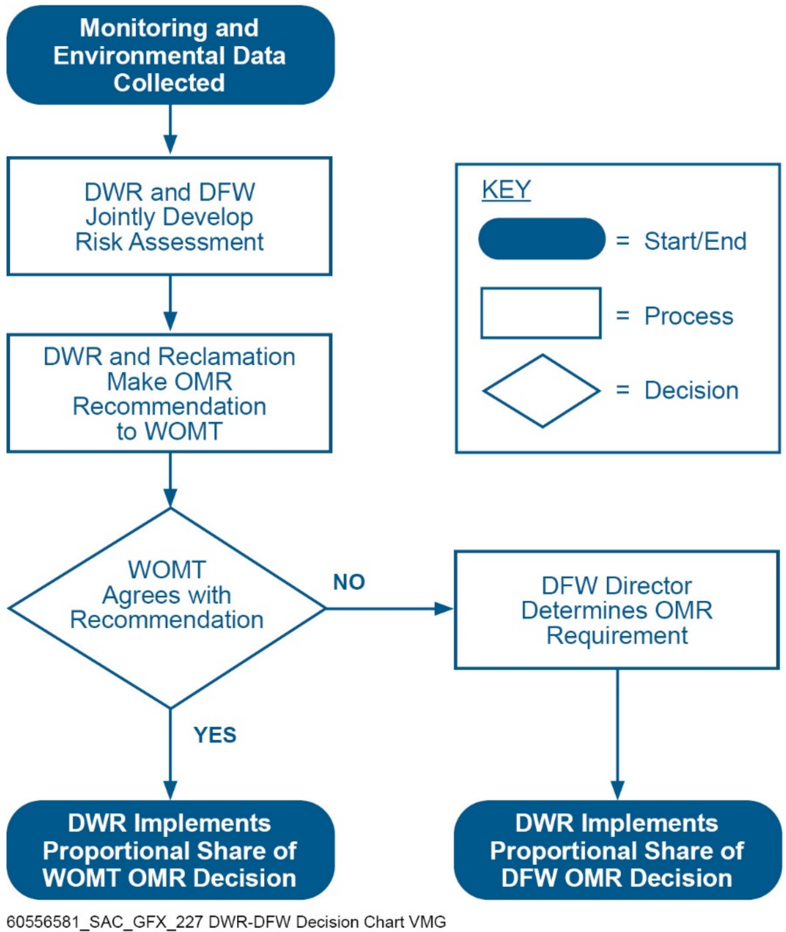


Figure 5.3-3. Collaborative real-time risk assessment decision-making process for OMR management

5.3.2.2 Early Season OMR Management Events for Winter-run Chinook Salmon

If discrete daily loss criteria for Winter-run Chinook Salmon[16] are exceeded during November-December prior to early winter pulse protection DWR will maintain a five-day average OMR index that is no more negative than -5000 cfs and DWR would seek advice from the Salmon Monitoring Team. Daily loss criteria for older juveniles (natural older juvenile Chinook salmon) and yearling spring-run Chinook Salmon (used as surrogates for winter-run Chinook Salmon) are as follows:

- 6 older juvenile Chinook Salmon in November
- 26 older juvenile Chinook Salmon in December

All natural older juvenile Chinook salmon juveniles will be identified based on the Delta Model length-at-date criteria. Loss shall be calculated for the South Delta Export Facilities using the equation provided in CDFW (2003). This would not be an event that leads to the onset of OMR management as described below.

[16] Chinook Salmon observed during salvage operations are classified as “fry/smolt” or “older juvenile Chinook Salmon” based on length when they are salvaged. For purposes of this FEIR, 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 criteria used to assign individuals to race.

5.3.2.3 Mid- and Late-Season OMR Management Events for Winter-run Chinook Salmon

To minimize entrainment, salvage, and take of natural Winter-run Chinook Salmon during the peak and end of their migration through the Delta, DWR will restrict south of Delta exports for five days to achieve a five-day average OMR index no more negative than -3,500 cfs when daily loss of natural juveniles at the SWP and CVP salvage facilities exceeds the following thresholds based on the Juvenile Production Estimate (JPE) reported in January of the same calendar year:

- January 1 - January 31: **0.00635 %** of the Winter-run Chinook Salmon JPE
- February 1 -February 28: **0.00991 %** of the Winter-run Chinook Salmon JPE
- March 1 - March 31: **0.0146 %** of the Winter-run Chinook Salmon JPE
- April 1 -April 30: **0.00507 %** of the Winter-run Chinook Salmon JPE
- May 1 - May 31: **0.0077 %** of the Winter-run Chinook Salmon JPE

All natural older juvenile Chinook Salmon juveniles shall be identified based on the Delta Model length-at-date criteria. Loss shall be calculated for the South Delta Export Facilities using the equation provided in CDFW (2018)[17].

5.3.2.4 Onset of Annual OMR Management

DWR, in coordination with Reclamation, would start OMR management when one or more of the following conditions have occurred, as shown in Figure 5.3-4.

- Integrated Early Winter Pulse Protection (First Flush Turbidity Event): To minimize project influence on migration (or dispersal) of Delta Smelt, DWR and Reclamation would reduce exports for 14 consecutive days so that the 14-day averaged OMR index for the period would not be more negative than −2,000 cfs, in response to “First Flush” conditions in the Delta. The population-scale migration of Delta Smelt is believed to occur quickly in response to inflowing freshwater and turbidity (Grimaldo et al. 2009; Sommer et al. 2011). Thereafter, best available scientific information suggests that fish make local movements, but there is no evidence for further population-scale migration (Polansky et al. 2018). The “First Flush” action may be triggered between December 1 and January 31. The triggers include a running 3-day average of the daily flows at Freeport that is greater than 25,000 cfs and a running 3-day average of the daily turbidity at Freeport that is 50 Nephelometric Turbidity Units (NTU) or greater; or, real-time monitoring indicates a high risk of migration and dispersal into areas at high risk of future entrainment.
    - This “First Flush” action may only be initiated once during the December through January period.

[17] Chinook Salmon Loss Estimation for the Skinner Delta Fish Protective Facility and Tracy Fish Collection Facility, July 9, 2018. Unpublished document provided by CDFW via e-mail on March 17, 2020.

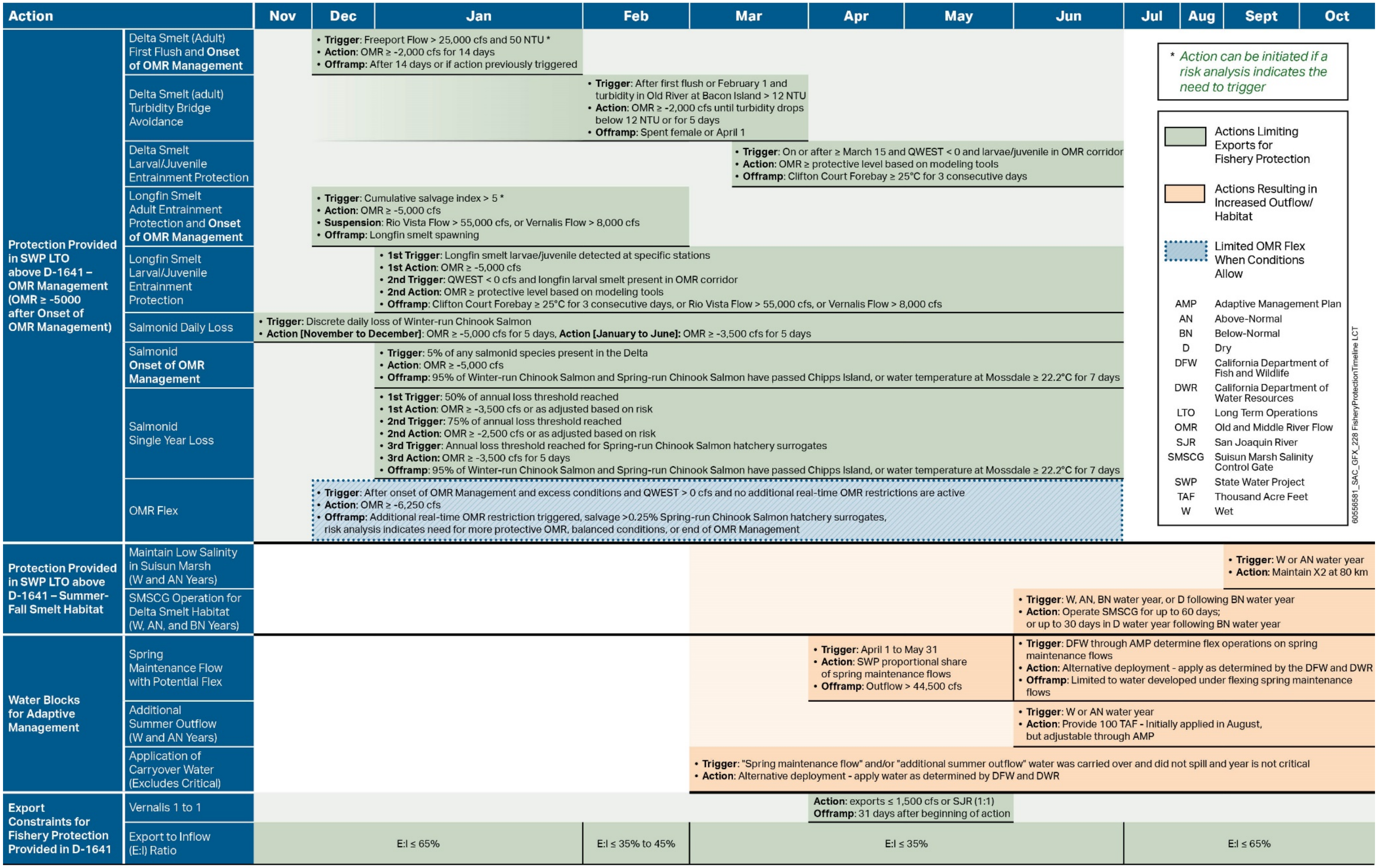


Figure 5.3-4. Fish Protection Timeline

- Salmonids Presence: After January 1, if more than 5% of any one or more salmonid species (wild young-of-the-year (YOY) Winter-run, wild YOY Spring-run, or wild California Central Valley Steelhead) are estimated to be present in the Delta, as determined by their appropriate monitoring working group based on available real-time data, historical information, and modeling (e.g., SAC PAS).

- Longfin Smelt protection: After December 1, trigger adult Longfin Smelt entrainment protection, if:
  - The cumulative salvage index (defined as the total estimated Longfin Smelt salvage at the CVP and SWP in the December 1 through February 28 period) exceeds the immediately previous Fall Midwater Trawl (FMWT) Longfin Smelt annual abundance[18] index divided by 10,[19] or
  - Real-time monitoring of abiotic and biotic factors indicates a risk of Longfin Smelt movement into areas that at high risk of future entrainment, as determined by DWR and CDFW Smelt Monitoring Group staff.

5.3.2.5 Real-time OMR Limits and Performance Objectives

DWR, in coordination with Reclamation, would operate to an OMR flow requirement that is more positive than a -5,000 cfs OMR flow based on conditions that would protect the following fish species and groups of species from entrainment:

- Longfin Smelt
- Delta Smelt
- Salmonids

The conditions for each of these species and species groups (salmonids) are described below.

Longfin Smelt Entrainment Protections

Additional Real-time Consideration for Adult Longfin Smelt

From onset of OMR protections for Adult Longfin Smelt through February 28, using the Collaborative Real-time Risk Assessment process described in Section 5.3.1.1 above, DWR and CDFW will decide whether a more restrictive OMR flow requirement than -5,000 cfs is needed for adult Longfin Smelt protection.

After onset of OMR protections for Adult Longfin Smelt through February 28, DWR, in coordination with Reclamation, will ensure that the OMR flow 14-day running average is no more negative than -5,000 cfs unless:

[18] The Fall Midwater Trawl (FMWT) Survey annual abundance index for Longfin Smelt is calculated as the sum of September through December monthly abundance indices and is typically reported at about the same date as adult salvage begins in December. Early December salvage can be compared to September through November abundance as an approximation of the salvage index.

[19] Cumulative salvage index criteria may be modified as part of the adaptive management program in coordination with CDFW.

1. During any time, OMR flow restrictions for Delta Smelt are being implemented, this measure will not result in additional OMR flow requirements for protection of adult Longfin Smelt, or
2. When Longfin Smelt spawning has been detected in the system, adult Longfin Smelt migration and spawning action will terminate and Larval Longfin Smelt Entrainment Protection will be implemented, or
3. Adult Longfin Smelt migration and spawning action, including the OMR flow requirement, is not required or would cease if previously required when river flows are (a) greater than 55,000 cfs in the Sacramento River at Rio Vista or (b) greater than 8,000 cfs in the San Joaquin River at Vernalis, or
4. If subsequent to the high flows identified in number 3 above, flows go below 40,000 cfs in the Sacramento River at Rio Vista or below 5,000 cfs in the San Joaquin River at Vernalis, the OMR flow in the adult Longfin Smelt migration and spawning action may resume if triggered previously and not precluded by another adult Longfin Smelt migration and spawning action off-ramp. In the implementation of this resumption, in addition to river flows, the Collaborative Real-time Risk Assessment described in Section 5.3.1.1 above, will be used to determine relaxation or cessation of this OMR flow requirement.

Larval and Juvenile Longfin Smelt

From January 1 through June 30, when a single Smelt Larva Survey (SLS) or 20 mm Survey (20 mm) sampling period results in one of the following triggers, DWR in coordination with Reclamation will ensure the OMR flow 14-day running average is no more negative than -5,000 cfs:

- Longfin Smelt larvae or juveniles found in eight or more of the 12 SLS or 20 mm stations in the Central Delta and South Delta (Stations 809, 812, 815, 901, 902, 906, 910, 912, 914, 915, 918, 919), or
- Longfin Smelt catch per tow exceeds 15 Longfin Smelt larvae or juveniles in four or more of the 12 stations in the Central Delta and South Delta (Stations 809, 812, 815, 901, 902, 906, 910, 912, 914, 915, 918, 919).

If QWEST is negative and larval or monitoring detects juvenile Longfin Smelt within the corridors of the Old and Middle rivers, DWR will assess potential entrainment impacts of fish in the corridors of the Old and Middle rivers relative to their estuarine-wide distribution from monitoring data (e.g., SLS and Enhanced Delta Smelt Monitoring Program [EDSM] for larvae; 20 mm Survey and EDSM for juveniles) using Particle Tracking Model (PTM) runs weighted by the distribution in the surveys. In addition to PTM outputs, DWR will use real-time hydrological conditions, salvage data, forecast models (e.g., statistics-based models of historical data), other potential hydrodynamic models, and water quality to assess entrainment risk and to determine appropriate OMR flow targets to minimize entrainment or entrainment risk, or both. In coordination with CDFW, DWR will determine the best available models, the model inputs, and the assessment methods for determining larval and juvenile Longfin Smelt entrainment risk.

The Collaborative Real-time Risk Assessment process described in Section 5.3.1.1 above, will be used to determine if an OMR flow protection target is warranted and determine the timing (e.g., days or weeks) and magnitude of the action. Implemented OMR flow management actions will continue until it is determined that the risk is abated based on changes in real-time conditions or until the off-ramp has been met as described in the "End of OMR Management" section below.

Off-Ramps for Larval and Juvenile Longfin Smelt Entrainment Protection

DWR will continue to manage OMR flows for the protection of Longfin Smelt until the off-ramp criteria have been met, as described in the "End of OMR Management" section below or until one of the following off-ramp criteria are met:

1. During periods when OMR flow restrictions for larval and juvenile Delta Smelt are being implemented, this measure shall not result in additional OMR flow requirements for protection of larval and juvenile Longfin Smelt, or
2. When river flows meet one of the following requirements, larval and juvenile Longfin Smelt protections would not trigger, or would be relaxed if triggered previously:
   - Greater than 55,000 cfs in the Sacramento River at Rio Vista
   - Greater than 8,000 cfs in the San Joaquin River at Vernalis
3. If subsequent to the high flows identified in (2), flows drop below 40,000 cfs in the Sacramento River at Rio Vista or below 5,000 cfs in the San Joaquin River at Vernalis, larval and juvenile Longfin Smelt protection will resume if triggered previously. In implementing this resumption, in addition to river flows, the Collaborative Real-time Risk Assessment process described in Section 5.3.1.1 above, will be used to determine relaxation or cessation of this OMR flow requirement.

As Longfin Smelt are not a federally listed species and because DWR has limited control over OMR flows, DWR can take actions to make OMR flows more positive, but there are circumstances when the actual OMR flow may not respond to DWR's actions, particularly if the CVP is operating differently. DWR will make efforts to coordinate with Reclamation, but it is anticipated that Reclamation's operations would not include protective measures for Longfin Smelt. DWR will ensure that its proportional share of the OMR flow requirements described for Longfin Smelt are satisfied.

Delta Smelt Entrainment Protections

Turbidity Bridge Avoidance (South Delta Turbidity)

After the Integrated Early Winter Pulse Protection (above) or February 1 (whichever comes first), until when a spent female is detected or April 1 (whichever is first), DWR, in coordination with Reclamation, would manage exports in order to maintain daily average turbidity in Old River at Bacon Island (OBI) at a level of less than 12 NTU. The purpose of this action is to minimize the risk to adult Delta Smelt in the corridors of the Old and Middle rivers, where they are subject to high entrainment risk. This action seeks to avoid the formation of a turbidity bridge from the San Joaquin River shipping channel to the South Delta fish facilities, which historically has been associated with elevated salvage of pre-spawning adult Delta Smelt. If the daily average turbidity at Bacon Island could not be maintained at less than 12 NTU, DWR, in coordination with Reclamation, would manage exports to achieve an OMR flow that is no more negative than -2,000 cfs until the daily average turbidity at Bacon Island drops below 12 NTU. However, if 5 consecutive days of OMR flow that is less negative than -2,000 cfs does not reduce daily average turbidity at Bacon Island below 12 NTU in a given month, DWR, in coordination with Reclamation, may determine that OMR restrictions to manage turbidity are infeasible and will instead implement an OMR flow target that is deemed protective based on turbidity and adult Delta Smelt distribution and salvage, but will not a more negative OMR flow than -5,000 cfs.

DWR and Reclamation recognize that readings at individual sensors can generate spurious results in real time. Such changes could be incorrectly interpreted as a full turbidity bridge, when in fact the cause a result of local conditions or sensor error. To avoid excessive OMR restrictions during a sensor error or a localized turbidity spike, DWR, in coordination with Reclamation, will consider and review data from other locations and sources. Additional information that will be reviewed include regional visualizations of turbidity, alternative sensors, and boat-based turbidity mapping, particularly if there was evidence of a local sensor error.

The Collaborative Real-time Risk Assessment process described in Section 5.3.1.1 will be used to determine if the OMR requirement could be off-ramped after 5-days of implementation of the Turbidity Bridge Avoidance action or to determine that this action is not warranted.

Larval and Juvenile Delta Smelt Protection

DWR, in coordination with Reclamation, will use results produced by life cycle models approved by CDFW and USFWS to manage the annual entrainment levels of larval and juvenile Delta Smelt. The USFWS models will be publicly vetted and peer reviewed prior to March 15, 2020. CDFW and USFWS will coordinate with the Delta Fish Monitoring Working Group to identify a Delta Smelt recruitment level that Reclamation and DWR can use in OMR flow management. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment such as OMR flows. In this context, recruitment is defined as the estimated number of post-larval Delta Smelt in June per number of spawning adults in the prior February-March period.

DWR, in coordination with Reclamation, CDFW, and USFWS will operationalize the life cycle model results through the use of real-time monitoring for the spatial distribution of Delta Smelt. On or after March 15 of each year, if QWEST is negative and larval or juvenile Delta Smelt are detected within the corridors of the Old and Middle rivers based on real-time sampling of spawning adults or YOY life stages, Reclamation and DWR, or both, will run hydrodynamic models and forecasts of entrainment informed by the EDSM or other relevant survey data to estimate the percentage of larval and juvenile Delta Smelt that could be entrained. If necessary, DWR and Reclamation will manage exports to limit entrainment to be protective, based on the modeled recruitment levels. DWR, in coordination with Reclamation, will re-run hydrodynamic models when operational changes or new sampling data indicate a potential change in entrainment risk. This process will continue until the off-ramp criteria have been met, as described in the “End of OMR Management” section below. In the event the life cycle models cannot be operationalized in a manner that can be used to inform real-time operations, Reclamation, DWR, CDFW, and USFWS will coordinate to develop an alternative plan to provide operational actions protective of this life stage.

If CDFW does not agree with the operational actions determined above, the Collaborative Real-time Risk Assessment process described in Section 5.3.1.1 above, will be used to determine the appropriate action.

In addition to the measure described above, DWR will implement SMG evaluation and recommendation within specified range of OMRs (-1,250 through -5,000) for 5 days if salvage triggers are met.

Salmonid Entrainment Loss Protections

Daily Loss Thresholds

Daily loss criteria would be implemented as a proactive action to avoid exceeding 50% or 75% of the annual loss threshold. DWR will restrict south Delta exports for five days to achieve a five-day average OMR index no more negative than -3,500 cfs when daily loss of natural older juveniles at the SWP and CVP salvage facilities exceeds the JPE thresholds summarized in Section 5.3.1.3.Additionally, each year between February 1 and June 30, DWR will restrict south Delta exports for five days to achieve a five-day average OMR index no more negative than -3,500 cfs when:

- Daily loss of Feather River Hatchery coded wire tagged (CWT) Spring-run Chinook Salmon surrogates (includes both spring- and fall-run hatchery release groups) cumulative loss at the at the CVP and SWP salvage facilities is greater than 0.25% for each release group, OR
- Coleman National Fish Hatchery and Nimbus Fish Hatchery CWT fall-run release groups cumulative loss at the at the CVP and SWP salvage facilities is greater than 0.25% of the total in-river releases for each release group.

The hatchery surrogates will be young-of-the-year Spring-run Chinook Salmon from the Feather River Hatchery (Cavallo et al. 2009), to be released at times and locations representative of wild young-of-the-year Spring-run Chinook Salmon based on coordination with CDFW and in consideration of relevant historical information (e.g., Ward et al. 2004a,b,c; Cordoleani et al. 2018, 2019; Notch et al. 2020).

Cumulative Loss Thresholds

DWR, in coordination with Reclamation, would target exceedance of cumulative loss thresholds over the duration of the ITP for natural Winter-run Chinook Salmon, hatchery Winter-run Chinook Salmon, natural Central Valley Steelhead from December through March, natural Central Valley Steelhead from April 1 through June 15, and hatchery Spring-run Chinook Salmon surrogates.

DWR, in coordination with Reclamation, proposes to avoid exceeding cumulative loss thresholds by 2030 as follows:

- Natural Winter-run Chinook Salmon (cumulative loss = 8,738)
- Hatchery Winter-run Chinook Salmon (cumulative loss = 5,356)
- Natural Central Valley Steelhead from December through March (cumulative loss = 6,038)
- Natural Central Valley Steelhead from April 1 through June 15 (cumulative loss = 5,826).

Natural Central Valley Steelhead would be separated into two time periods to protect San Joaquin-origin fish that historically appear in the Mossdale trawls later than Sacramento-origin fish. The loss threshold and loss tracking for hatchery Winter-run Chinook Salmon do not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook Salmon is based on length-at-date criteria.

The cumulative loss thresholds would be based on the cumulative historical loss from 2010 through 2018. DWR and Reclamation's performance objectives are intended to avoid loss such that the cumulative loss threshold (measured as the 2010-2018 average cumulative loss multiplied by 10 years) will not be exceeded by 2030.If at any time prior to 2024, DWR, in coordination with Reclamation, were to exceed 50% of the cumulative loss threshold, DWR, in coordination with Reclamation, would convene an independent panel to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the cumulative loss threshold, if any.

In the year 2024, DWR, in coordination with Reclamation, would convene an independent panel to review the first 5 years of actions and determine whether continuing these actions is likely to reliably maintain the trajectory associated with this performance objective for the duration of the period.

If during real-time operations, DWR, in coordination with Reclamation, were to exceed the cumulative loss threshold, DWR, in coordination with Reclamation, would immediately seek technical assistance from CDFW and NMFS, as appropriate, on the coordinated operation of the SWP and CVP, respectively for the remainder of the OMR management period. In addition, prior to the next OMR management season, DWR in coordination with Reclamation would convene an independent review panel to review the actions contributing to this loss trajectory and make recommendations for modifications or additional actions to stay within the permitted take.

Single-Year Loss Thresholds

In each year, DWR, in coordination with Reclamation, would avoid exceeding an annual loss threshold equal to 90% of the greatest salvage loss that occurred in the historical record from 2010 through 2018 for each of the following:

- Natural Winter-run Chinook Salmon (loss = 1.17% of JPE)
- Hatchery Winter-run Chinook Salmon (loss = 0.12% of JPE)
- Natural Central Valley Steelhead from December through March (loss =1,414)
- Natural Central Valley Steelhead from April through June 15 (loss = 1,552)

Natural Central Valley Steelhead would be separated into two time periods to protect San Joaquin-origin fish that historically appear in the Mossdale trawls later than Sacramento-origin fish. The loss threshold and loss tracking for hatchery Winter-run Chinook Salmon does not include releases into Battle Creek. Loss (for development of thresholds and ongoing tracking) for Chinook Salmon is based on length-at-date criteria.

During the year, if SWP and CVP operations were to exceed the average annual loss threshold, DWR in coordination with Reclamation would review recent fish distribution information and operations with the fisheries agencies at the Water Operations Management Team (WOMT) and seek technical assistance on future planned operations. DWR, Reclamation, USFWS, NMFS, and CDFW could elevate an issue from WOMT to a Directors' discussion, as appropriate.

During the year, if SWP and CVP operations exceed 50% of the annual loss threshold, DWR, in coordination with Reclamation, would restrict OMR to a 14-day moving average OMR index that is no more negative than −3,500 cfs, unless the Collaborative Real-time Risk Assessment process described in Section 5.3.1.1 determines that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.

The -3,500 OMR flow operational criteria adjusted and informed by this risk assessment would remain in effect for the rest of the season. DWR and Reclamation would seek CDFW and NMFS technical assistance on the risk assessment and real-time operations.

During the year, if Reclamation and DWR exceed 75% of the annual loss threshold, Reclamation and DWR will restrict OMR to a 14-day moving average OMR flow index that is no more negative than -2,500 cfs unless the Collaborative Real-time Risk Assessment process described in Section 5.3.1.1 determines that further OMR restrictions are not required to benefit fish movement because a risk assessment shows that the risk is no longer present based on real-time information.

The -2,500 OMR flow operational criteria adjusted and informed by this risk assessment will remain in effect for the rest of the season. DWR and Reclamation will seek CDFW and NMFS technical assistance on the risk assessment and real-time operations.

Regarding the risk assessments (identified above), the Collaborative Real-time Risk Assessment process described in Section 5.3.1.1 will be used to evaluate and adjust OMR restrictions under this section by preparing a risk assessment that considers several factors, including but not limited to, real-time monitoring, historical trends of salmonids exiting the Delta and entering the South Delta, fish detected in salvage, and relevant environmental conditions. Risks will be measured against the potential to exceed the next single-year loss threshold.

If during real-time operations, Reclamation and DWR were to exceed the single-year loss threshold, Reclamation and DWR would immediately seek technical assistance from CDFW, USFWS, and NMFS, as appropriate, on the coordinated operation of the CVP and SWP for the remainder of the OMR management period. In addition, Reclamation and DWR would, prior to the next OMR management season, convene an independent panel to review the OMR Management Action. The purpose of the independent review would be to review the actions contributing to this loss trajectory and make recommendations on modifications or additional actions to stay within the annual loss threshold, if any.

DWR, in coordination with Reclamation, would continue monitoring and reporting salvage at the Jones and Tracy fish facilities. DWR and Reclamation would continue the release and monitoring of yearling Coleman National Fish Hatchery (NFH) Late Fall-run and yearling Spring-run Chinook Salmon surrogates. DWR, in coordination with Reclamation, would use the reported real-time salvage counts along with qualitative and quantitative tools such as the "Salmonid Entrainment Model" to inform operations.

Off-Ramps for Salmonid Annual Loss Threshold Entrainment Protection

DWR will continue to manage OMR flows for the protection of salmonids until the off-ramp criteria have been met, as described in the "End of OMR Management" section below or until the following off-ramp criteria are met:

1. After exceeding the 50% or 75% annual loss thresholds and 14 days of restricted OMR, risk of entrainment is determined to be minimal based on risk analysis conducted by the Salmon Monitoring Team and as described in Section 5.3.1.1.

OMR Flexibility During Delta Excess Flow Conditions

DWR, in coordination with Reclamation, may operate to a more negative OMR flow but no more negative than -6,250 cfs on a 5-day average to capture excess flows in the Delta when QWEST is positive. Excess flows occur typically from storm-related events and are defined as flows in excess of that required to meet water quality control plan flow and salinity requirements and other applicable regulations. DWR, in coordination with Reclamation, would continue to monitor fish in real time and would operate in accordance with the "Additional Real-time OMR Restrictions," previously described.

Figure 5.3-5 shows the physical checks that would preclude implementation of an OMR flexibility action. As shown, if any other OMR flow limit is active, an OMR flexibility action would be precluded.

Unless the following species protections occur, DWR has the discretion to capture excess flows if:

1. Integrated Early Winter Pulse Protection or additional real-time OMR restrictions are triggered and the required OMR flow is more positive or less negative than -5,000 cfs. Under such conditions, DWR and Reclamation have already determined that a more restrictive OMR flow is required.
2. An evaluation of environmental and biological conditions by DWR, in coordination with Reclamation, indicates more negative OMR would likely trigger an additional real-time OMR restriction.
3. Salvage of yearling Coleman NFH Late Fall-run (as yearling Spring-run Chinook Salmon surrogates) exceeds 0.5% within any of the release groups.
4. DWR, in coordination with Reclamation, identifies changes in spawning, rearing, foraging, sheltering, or migration behavior beyond those anticipated to occur under OMR management.

DWR, in coordination with Reclamation, would continue to monitor conditions and could resume management of OMR flows to levels no more negative than −5,000 cfs if conditions indicate the defined off-ramps are necessary to avoid additional adverse impacts.

End of OMR Management

OMR flow criteria may control operations until June 30 or when both of the following species-specific off-ramps have occurred, whichever is earlier.

- Longfin Smelt and Delta Smelt: When the daily mean water temperature at the CCF reaches 77 degrees Fahrenheit (°F) (25 degrees Celsius [°C]) for 3 consecutive days.

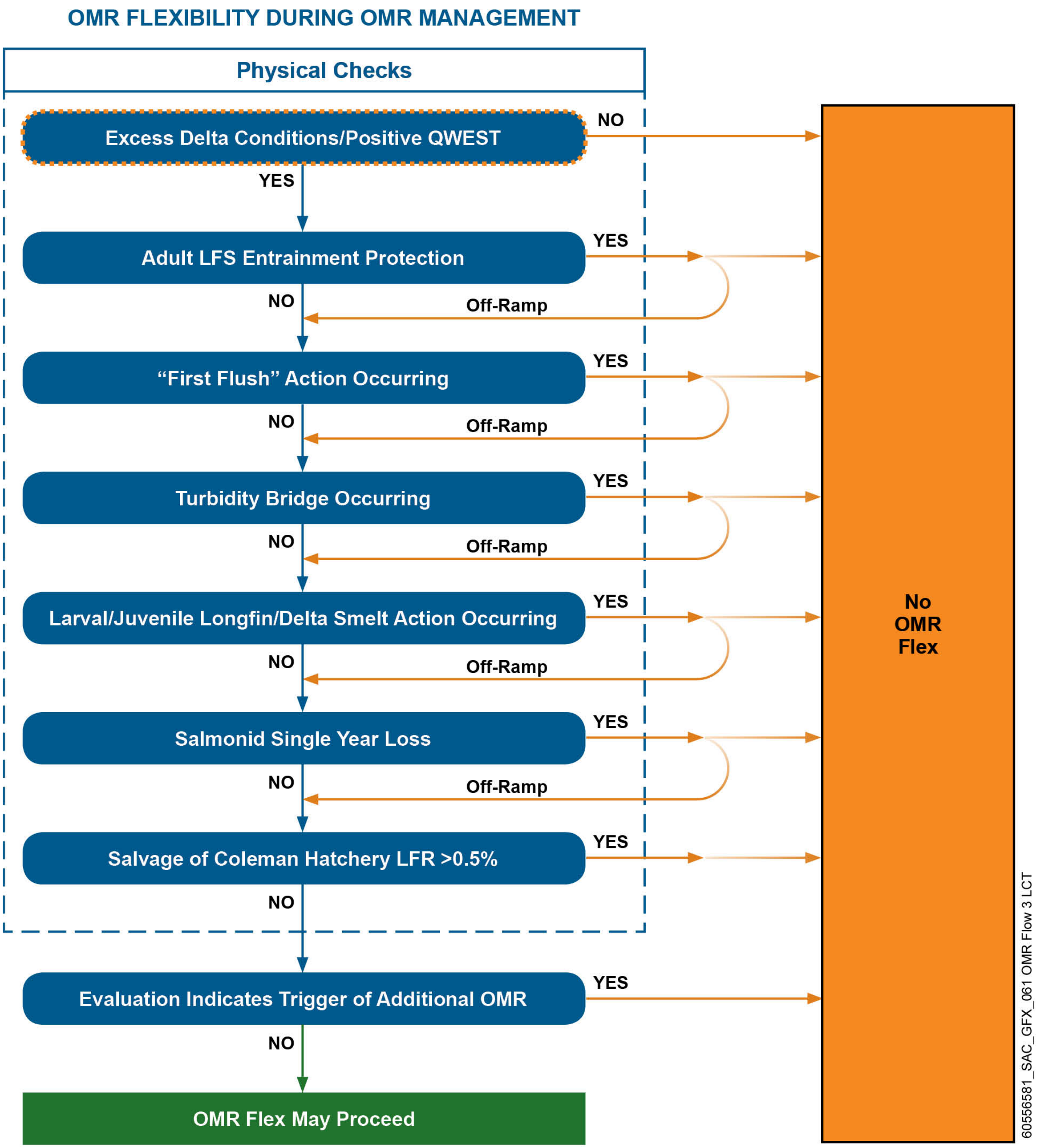


Figure 5.3-5. OMR Flexibility During OMR Management

- Salmonids: When more than 95% of Winter-run Chinook Salmon and Spring-run Chinook Salmon have migrated past Chipps Island, as determined by DWR and Reclamation's monitoring working group, or after daily average water temperatures at Prisoner's Point exceed 72°F (22.2 °C) for 3 consecutive days and Mossdale exceed 72°F (22.2 °C) for 7 days (the 7 days do not have to be consecutive) during June AND when no salvage of spring-run surrogates for 5 consecutive days

Real-Time Decision-Making and Loss Thresholds

When real-time monitoring demonstrates that criteria in "Additional Real-Time OMR Restrictions and Performance Objectives" are not supported, then Reclamation and DWR may confer with the Directors of NMFS, USFWS, and CDFW if they desire to operate to a more negative OMR flow than what is specified in "Additional Real-Time OMR Limits and Performance Objectives." Upon mutual agreement, the Directors of NMFS and USFWS may authorize DWR and Reclamation to operate to a more negative

OMR flow than the "Additional Real-Time OMR Restrictions," but no more negative than -5,000 cfs. The Director of CDFW may authorize DWR to operate to a more negative OMR flow than the "Additional Real-Time OMR Restrictions," but no more negative than -5,000 cfs. This process would be separate from the risk analysis process described above.

The Collaborative Real-time Risk Assessment process described in Section 5.3.1.1 will be used to determine the DWR's operational action.

5.3.3 Delta Smelt Summer-Fall Habitat Action

The Delta Smelt Summer-Fall Habitat Action is intended to improve Delta Smelt food supply and habitat, thereby contributing to the recruitment, growth, and survival of Delta Smelt. The current conceptual model states that Delta Smelt habitat should include low-salinity conditions of 0 to 6 parts per thousand (ppt), turbidity of approximately 12 NTU, temperatures below 25°C, food availability, and littoral or open water physical habitats (FLaSH Synthesis:15–25). The Delta Smelt Summer-Fall Habitat Action is being undertaken recognizing that the highest-quality habitat in this large geographical region includes areas with complex bathymetry, in deep channels close to shoals and shallows, and in proximity to extensive tidal or freshwater marshlands and other wetlands. The Delta Smelt Summer-Fall Habitat Action is to provide the aforementioned habitat components in the same geographic area through a range of actions to improve water quality and food supplies.

DWR and Reclamation propose to implement Delta Smelt habitat actions. In the summer and fall (June through October) of below-normal, above-normal and wet years, based on the Sacramento Valley Index, the environmental and biological goals are, to the extent practicable, the following:

- Maintain low-salinity habitat in Suisun Marsh and Grizzly Bay.
- Manage the low salinity zone to overlap with turbid water and available food supplies.
- Establish contiguous low-salinity habitat from Cache Slough Complex to Suisun Marsh.

The action will initially include modifying project operations to maintain a monthly average 2 ppt isohaline at 80 km (X2) from the Golden Gate in above-normal and wet water years in September and

October. DWR and Reclamation will also implement additional measures that are expected to achieve additional benefits. These measures include, but are not limited to:

- Suisun Marsh Salinity Control Gates (SMSCG) operations for up to 60 days (not necessarily consecutive) in June through October of below-normal and above-normal years. This action may also be implemented in wet years, if preliminary analysis shows expected benefits. The SMSCG would be operated to achieve the longest continuous duration of a salinity at Belden's Landing of 4 ppt on a 3-day running average. During operation of the SMSCG, DWR, Reclamation and CDFW will monitor habitat conditions and confer as needed.
- SMSCG operations for 30 days during June through October of dry years that follow a below normal water year to achieve the longest continuous duration of a salinity at Belden's Landing of 6 ppt on a 3-day running average. Refer to the section below, Export Curtailments for Spring Maintenance Flows, for additional detail regarding the water used to offset the cost of this action.
- Food enhancement action (for example, those included in the Delta Smelt Resiliency Plan to enhance food supply). These projects include the North Delta Food Subsidies and Colusa Basin Drain project, and Suisun Marsh Food Subsidies (Roaring River distribution system reoperation). DWR and Reclamation will monitor dissolved oxygen at Roaring River distribution system drain location(s) during Delta Smelt food distribution actions.

These considerations (listed above) and implementation of other actions will be more fully defined and developed through the structured decision-making or other review process. The review will include selection of appropriate models, sampling programs, and other information to be used. The process will be completed prior to implementation and may be improved in subsequent years as additional information is synthesized and reviewed, as described below.

Reclamation and DWR will develop a Delta Smelt Summer-Fall Habitat Action Plan to meet the environmental and biological goals in years when summer-fall habitat actions are triggered. In above normal and wet years, operating to a monthly average X2 of 80 km in September and October is the initial operation. In every action year, Reclamation and DWR will propose, based on discussions with the USFWS and CDFW, a suite of actions that would meet the action's environmental and biological goals. This action would be coordinated with Reclamation and categorized as an in-basin use for COA purposes. In the event that Reclamation does not meet its share of the Delta outflow to meet 80 km X2, DWR will implement its share of this action.

5.3.3.1 Food Enhancement Summer-Fall Actions

North Delta Food Subsidies and Colusa Basin Drain Project: DWR proposes to implement actions to improve flow conditions in the North Delta in summer and fall, thereby facilitating downstream transport of phytoplankton and zooplankton. While the Cache Slough Complex and the lower Yolo Bypass are known to have relatively high levels of food resources, local water diversions create net negative flows during summer and fall that may inhibit downstream food transport. By enhancing summer and fall flows through the Yolo Bypass, downstream transport of food could be improved.

DWR and partners would test two different ways to improve flow conditions in the North Delta. For the first approach, water would be provided by Sacramento River water districts, such as Reclamation District 108 and Glenn Colusa Irrigation District. The water districts would use their facilities to move freshwater into Colusa Drain. By adjusting the operations of Knights Landing Outfall Gates and Wallace Weir, much of this water would be routed into the Yolo Bypass.

The second approach would use agricultural drain water in fall, which is available in fall when valley rice fields discharge irrigation water at the end of the growing season. Agricultural drain water would be routed into the Yolo Bypass via Knights Landing Ridge Cut.

DWR proposes flow pulses would include summer actions using fresh Sacramento River water and fall actions using agricultural drain water from Colusa Drain. Initial results suggest that a target pulse of 27 TAF over a 4-week period would improve downstream transport of phytoplankton. This flow volume is not sufficient to inundate the floodplain in the Yolo Bypass, nor would it constitute a consumptive use of water because the water used for this action would be allowed to move through the North Delta and contribute to Delta outflow.

This food subsidy action is an adaptive management action that relies on monitoring and evaluation in order to optimize its efficacy. Similarly, the action depends on partnerships with local water users including Reclamation District 108, Glenn Colusa Irrigation District, Conaway Ranch, and Swanston Ranch. All actions should be developed in consultation with the needs of local water users and landowners. Food enhancement action design and implementation would be determined through the Summer-Fall Adaptive Management process. Note that DWR is not requesting take under the ITP for this action because it is designed to avoid negative effect on listed species.

Roaring River Distribution System Reoperations: Infrastructure in the Roaring River Distribution System may help drain food-rich water from the canal into Grizzly Bay to augment Delta Smelt food supplies in that area. This effort remains a programmatic concept, so DWR is not specifically requesting take for this potential project.

5.3.3.2 Delta Smelt Summer-Fall Habitat Action Adaptive Management Planning

Conceptual Model

The Delta Smelt Summer-Fall Habitat Action is intended to improve Delta Smelt food supply and habitat, thereby contributing to improved Delta Smelt habitat conditions. The current conceptual model is that Delta Smelt habitat should include low salinity conditions of 0 to 6 ppt, turbidity of approximately 12 NTU, temperatures below 25°C (77 °F), food availability, and littoral or open water physical habitats (FLaSH Synthesis, pp. 15-25). The Delta Smelt Habitat Action is being undertaken recognizing that the highest quality habitat in this large geographical region includes areas with complex bathymetry, in deep channels close to shoals and shallows, and in proximity to extensive tidal or freshwater marshlands and other wetlands. The Delta Smelt Habitat Action is to provide these habitat components in the same geographic area through a range of actions to improve water quality and food supplies.

Planning Process

The adaptive management process would be investigating the way in which SWP-CVP operations interact with the full range of components of Delta Smelt habitat. The process would be investigating the extent that providing flow and/or low salinity conditions of various volumes and locations improves the quality and quantity of Delta Smelt habitat in the summer and fall, and whether Delta Smelt survival, viability, and/or abundance improves in relation to the Delta Smelt Habitat Actions. The planning process will also consider other tradeoffs, including effects on other species.

The framework for the Adaptive Management Plan (AMP) (Appendix J) is as follows:

- DWR and Reclamation shall form a Delta Coordination Group (Reclamation, DWR, USFWS, NMFS, CDFW, and representatives from federal and state water contractors).
- The Delta Coordination Group would use one of the existing structured decision-making models or adopt a new model to analyze proposed summer-fall habitat actions, making predictions regarding the potential outcomes for various implementation scenarios. This structured decision-making process would inform each year's Habitat Action Plan.
- Within 6 months of signing the NOD, the Delta Coordination Group would meet to select a structured decision-making model and complete initial model runs (and annual model runs thereafter) testing various approaches to satisfying the environmental and biological goals, using the available tool box of approaches.
- Each year, the Delta Coordination Group would develop a Habitat Action Plan accounting for forecasted hydrology and temperatures over the summer and fall. The Habitat Action Plan would describe how the proposed action would meet the environmental and biological goals of the action. The Habitat Action Plan would include the hypotheses to be tested, the suite of actions and operations to test the hypotheses, and the expected outcomes. The Habitat Action Plan would be informed by the annual results of the structured decision-making process. In recognition of the time required for annual planning, the Habitat Action Plan process would occur every year so the Plan would be prepared in time for review by the USFWS and CDFW in the event the action is triggered.
- CDFW and USFWS would review the Habitat Action Plan in each year in which an action is triggered and confirm that the impacts of the action are within what was analyzed in the BiOp and the California Fish and Game Code Section 2081 permit, and that the action is consistent with the project description.
- After the completion of each summer-fall habitat action, DWR and Reclamation will share preliminary monitoring results through the Delta Coordination Group. At the beginning of the next water year, DWR and Reclamation would provide a synthesis of the monitoring results to the Delta Coordination Group. The Delta Coordination Group would review the synthesis of results and use the results of the monitoring to inform a subsequent structured decision-making modeling exercise using the tool box of available approaches.

- The Delta Smelt Summer-Fall Habitat Action would be included in the Four-Year Reviews described in the AMP (Appendix J). The structured decision-making model and the multi-year science and monitoring plan would be part of this Four-Year Review.

5.3.4 Adaptive Management Plan

The Adaptive Management Plan (AMP) (Appendix J) will be carried out to evaluate the efficacy of the operations and activities stated below. An Adaptive Management Team (AMT), composed of one designated representative and one designated alternate each from DWR, CDFW, and a SWP contractor. In addition, the AMT will use input from DSP in order to organize and guide the activities. The AMT will oversee efforts to monitor and evaluate the operations and related activities. In addition, the AMT will use tools such as structured decision-making to assess the relative costs and benefits of those operations and activities. The AMT will also identify proposed adaptive management changes to those operations and activities. The AMP could be incorporated into the ITP that DWR is seeking for CESA coverage for the Proposed Project. Any proposed adaptive management changes should provide equivalent or superior conservation benefits to the listed species at equal or lesser societal costs. The objectives of the AMP are to: (i) continue the long-term operation of the SWP in a manner that improves water supply reliability and water quality consistent with applicable laws, contractual obligations, and agreements and (ii) use the knowledge gained from the scientific study and analysis described in the AMP to avoid, minimize and fully mitigate the adverse effects of SWP operations on CESA-listed aquatic species.

Overall, the intent of this AMP is to:

- Provide a common definition of adaptive management and explain how it links to the incidental take permit for long-term operations of the SWP (SWP ITP).
- Describe how adaptive management for ongoing SWP operations, as it operates in coordination with the CVP that will assist DWR in complying with applicable California law, including CESA.
- Identify the key uncertainties about how combined SWP and CVP water operations and other management actions to benefit CESA-listed species can be implemented to meet regulatory standards applicable to CESA.
- Develop and implement a science program necessary to address uncertainties and support implementation of adaptive management, working in coordination with CSAMP, IEP, other adaptive management programs and the DSP as appropriate.
- Identify the SWP operations and activities that will be subject to adaptive management.
- Describe the decision-making and governance structure that will be used to implement the AMP including adaptive management changes.
- Describe the structure for communication among the Implementing Entities and with the broader stakeholder community regarding implementation of the AMP.
- Describe funding for the AMP.
- Describe the relationship between the AMP and real-time operations.

Each existing operation and activity and each adaptive management change must be accompanied by (1) a set of criteria that the implementing entities can use to determine whether the action is having the anticipated impacts (e.g., take limits derived from salvage data) and (2) monitoring that will provide the data necessary in order to determine whether the performance measures are being met. It may be necessary to undertake additional monitoring and research that builds on existing efforts in order to carry out this adaptive management program. The AMP would draw upon the Collaborative Science and Adaptive Management Program (CSAMP) and the Delta Science Program (DSP), where appropriate, to assist with these monitoring and research efforts as well as program evaluation.

The AMP extends to specified SWP operations and activities undertaken by DWR concomitant to those operations. They include the following:

- SWP operations to comply with OMR flow requirements
- Daily and annual loss thresholds restricting OMR
- Delta Smelt Summer-Fall Habitat Action, including food enhancement actions
- Cultured Delta Smelt studies
- Spring maintenance flows actions
- Additional summer-fall actions
- Role of habitat restoration in improving conditions for listed fish species
- Efficacy of Delta Smelt supplementation
- Installation of the South Delta temporary barriers, including installation of other seasonal barriers, as determined necessary by the AMT
- Installation of the Georgiana Slough Behavioral Modification Barrier to minimize entrainment of out-migrating Sacramento River salmonids into the central and South Delta
- Evaluation of behavioral modification barriers to route emigrating Sacramento River into Sutter and Steamboat Sloughs to improve through Delta survival to Chipps Island
- Clifton Court Forebay predator management
- Development of a JPE Science Plan (by Sept 1, 2020)
- Development of a JPE index for Spring-run Chinook Salmon (within 5 years of ITP issuance)
- Development of predictive tools for management of entrainment
- Longfin Smelt Science Program monitoring and Lifecycle Modeling
- Monitoring associated with all of the foregoing

While the AMP described in this document pertains only to specified SWP operations and activities undertaken by DWR concomitant to those operations and will be used to support the 2081 permit issued for operation of the SWP, upon unanimous agreement among the Implementing Entities, it may be (1) expanded in the future to include other operations and activities, or (2) implemented in a coordinated manner with other adaptive management programs covering such operations and activities. These may include ongoing operations of the CVP and implementation of voluntary agreements or other activities associated with the SWP operations.

5.3.4.1 Adaptive Management Across Wetter and Drier Years

DWR intends to better understand how the management of water and habitat across various hydrologic conditions. The real-time operations of Banks Pumping Plant are one important component of this concept, allowing for exports when impacts to fish can be avoided, minimized or fully mitigated. The other important aspect of this concept is improving conditions during drier periods, and the SWP can contribute to that through the shifting of exports to wetter conditions. To that end, DWR proposes to maintain its current spring outflow contribution across most water year types, allow for increased exports during some wet conditions per the real-time operations described in 5.3.1 *OMR Management*, and to provide additional water for outflow in some dry Summer-Fall periods.

Export Curtailments for Spring Maintenance Flows

DWR will provide spring maintenance flows to better understand how the management of water and habitat across various hydrologic conditions would benefit listed fish species, including the extent that outflow (or associated X2) can affect Longfin Smelt abundance. The spring maintenance flows would be provided through SWP export curtailment equivalent to what would occur under the 2009 NMFS Biological Opinion in April and May (2009 permit). Although the spring maintenance flows would initially be provided in April and May, through the AMP, the SWP could alternatively provide a block of water equivalent in volume to the spring maintenance flows but limited to 150 TAF. This block of water could be provided either (1) later that same year in the summer or fall to augment Delta outflow, or in the event of a dry year, provide salinity standard maintenance flows to accommodate extended SMSCG operations; or (2) the following year to be deployed in spring, summer, or fall to augment Delta outflow or to facilitate an extended SMSCG operation that summer. The following paragraphs detail the process for determining the proposed operations each year and the amount of water that could be deployed.

In March of each year, DWR will coordinate with CDFW, and provide a preliminary SWP operations outlook that includes forecasted operations. DWR and CDFW will develop one or more spring maintenance flow operational alternatives identified in the preceding paragraph and determine the most beneficial alternatives for implementation under various forecasted outcomes. Once approved by CDFW, the proposed operations will begin implementation by April 1 of each year. The outlook may be revised as determined by DWR and CDFW to include changing hydrology or operational conditions.

The amount of spring maintenance flows available for direct deployment, or that can be developed and deferred to a later period, will be dependent on the specific conditions of that year. Table 5.3-1 shows the average and the range of April and May volumes, as estimated by the Refined Alternative 2b hydrologic modeling[20], that the SWP would be contributing toward spring maintenance flows. At the discretion of CDFW, up to 150 TAF of these flows could be shifted and redeployed to another time, but the total amount would depend on how much could actually be developed. Table 5.3-1 shows that the

[20] The SJR I:E, with a 44,500 cfs off-ramp, was simulated in the model to guide the SWP export reduction needed in order to maintain the SWP share of Spring Outflow.

volume provided by SWPs proportion of the Spring Maintenance flows, as estimated by the modeling, can vary between 0 and 405 TAF.

Table 5.3-1: Average April to May SWP Export Reductions for Spring maintenance flows

Water Year Type	Average Volume (TAF)	Volume Range (TAF)
All	132	0 to 405
Wet	138	0 to 332
Above Normal	208	124 to 405
Below Normal	188	64 to 360
Dry	95	9 to 217
Critical	32	0 to 98

In some years, as determined by CDFW, spring maintenance flows would be used to develop up to 150 TAF of water for deployment at a later time. In order to develop this volume of water, real-time operations of SWP exports in April and May would be greater than what would occur under the 2009 permit but would be limited to export levels as described in Section 5.3.1 *OMR Management*. If the increase in exports occurs, an equivalent amount[21] of up to 150 TAF would be stored for environmental use in the summer – fall (June – October) of the current year, or the following year (March – October), except if the following year is Critical. In wet water years, prior to either directly deploying or developing the 150 TAF block of water, the SWP will first export up to 30 TAF for SWP supply above what could occur under the 2009 permit and beyond the additional water that could be exported under the 44,500 cfs exception as noted below. This 30 TAF block of water will offset the water required to operate SMSCG for 30 days during summers of dry years that follow a below normal water year.

If a spring maintenance flows block is deferred for use in the following year, it will be subject to spill and will not be available for discretionary deployment if spilled. The spring maintenance flows block cannot be deferred beyond the following year. This water would be dedicated to Delta outflow for the term of the permit through agreements with downstream water users, a term-limited Section 1707 dedication as provided under the California Water Code, reliance on Term 91 conditions as enforceable by the SWRCB, or other means to ensure the water is not diverted for any intended use other than Delta outflow.

Exception for high Delta outflow: If the 3-day average Delta outflow is greater than 44,500 cfs, then export curtailments for spring maintenance flows will be suspended until the flows drop below 44,500 cfs on a 3-day average.

Exception for Health and Safety: Operating to the spring maintenance flows will not prohibit DWR from achieving its minimum SWP health and safety export needs, of 600 cfs. SWP export is defined under D-1641 as CCF diversions minus Byron Bethany Irrigation District demand.

[21] Increased SWP export amount is difference between actual April – May SWP exports and SWP exports under its share of SJR I:E ratio with an off-ramp when the 3-day average outflow is greater than 44,500 cfs.

Additional Summer – Fall Actions for Adaptive Management

Historically, the long-term trend in Delta outflow in the summer is positive (Hutton et. al., 2017a p. 8). Since the 1950s, Delta outflow in July and August has increased, with June and September outflow showing no long-term trend (Hutton et. al., 2017b p. 7). The positive outflow change is attributed primarily to the effects of the SWP and CVP operations, which have more than fully attenuated impacts of diversions by non-SWP/CVP diversion (Hutton et. al., 2017b p 7). Moreover, the Refined Alternative 2b, like the Proposed Project, is not expected to decrease June through August outflow as compared to baseline. Therefore, there is no mitigation required for SWP related changes in summer outflow.

However, there is a recognized lack of understanding of factors influencing Delta smelt survival in the summer. To study habitat effects on Delta Smelt survival, DWR may take additional summer-fall actions as described below. This water would also be for the purposes of testing and evaluating components identified in the Delta Smelt Resiliency Strategy by studying outflow effects on Delta smelt habitat.

DWR will provide an adaptively-managed 100 TAF block of Delta outflow in June through October in Wet and Above Normal years, as managed through the AMP. This 100 TAF block for Wet and Above Normal years may instead be used:

- As additional outflow in March – October of the following year, except if the following year is Critical, OR
- To offset impacts to the Delta water quality standards in June – October while operating the SMSCG for up to 60 days in the following year to target a salinity of 4 ppt at Belden's Landing on a 3-day running average, if it is a Dry year.

If the 100 TAF block is deferred for use in the following year, it will be subject to spill and will not be available if spilled. The water block from Wet or Above-Normal year can be deferred only to the following year.

Initially, this water will be used in August of wet and above normal years to maintain a monthly average X2 of 80 km to the extent possible to test hypotheses and narrow uncertainty. However, subject to the AMP, CDFW may define an alternative purpose of this volume of water within the June through October period of the identified year types. DWR shall ensure that the water provided by the SWP is dedicated for outflow purposes and may do this through any of the following in order of preference: agreements with downstream water users, a term-limited Section 1707 dedication as provided under the California Water Code, reliance on Term 91 conditions as enforceable by the SWRCB, or other means to ensure the water is not diverted for any intended use other than Delta outflow. This water could be provided through water purchases or SWP project water.

5.3.5 Continuation of Existing Monitoring

Existing monitoring programs through the Interagency Ecological Program (IEP) and FWS (Enhanced Delta Smelt Monitoring [EDSM] program) includes monitoring to track the status of listed species of fish, and also monitoring to ascertain performance of minimization measures associated with operations of the South Delta export facilities and their fish salvage programs. Existing monitoring programs and proposed modifications to existing IEP programs will facilitate tracking status of listed species of fish and evaluating effectiveness of minimization measures. Incidental take associated with the IEP monitoring programs is authorized via ESA Section 10(a)(1)(A) Research and Enhancement Permits and state FGC Section 2081(a) permits. Monitoring to track performance of the South Delta export facilities and their fish salvage programs is authorized through the existing biological opinions (NMFS 2009 [Section 13.4]; USFWS 2008). 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.

Monitoring will be centered on a core set of long-term IEP monitoring elements. Under the ITP, DWR would provide continued support for each of these elements at our current level of cost-share with USBR (50%). Note that the budgets and scope for IEP elements will change over time in response to management needs, input from periodic scientific reviews, innovation, and inflation. Some of the key expected changes to support management are summarized below. These elements are in addition to the EDSM program, which is funded by USBR.

5.3.5.1 Proposed Modifications to IEP Sampling Programs

As noted above, IEP's sampling program will continue to evolve to support specific management needs. Some of the specific changes will include the following. Budgets for each are provided in Table 8-1.

Changes to Longfin Smelt Sampling Program: Through IEP's science management plan review process (IEP 2014), DWR will undertake a review of existing IEP fish monitoring programs to propose modifications to CDFW SLS and 20 mm programs given new information showing that longfin smelt have a more robust distribution, both temporally (i.e., spawning window) and spatially (i.e., habitat and regions) than what is monitored by these programs (MacWilliams et al. 2016; Grimaldo et al. 2017; Lewis et al. 2019; Grimaldo et al. submitted manuscript). This review and associated monitoring changes will be completed within one year of ITP issuance.

Longfin Smelt Science Program: As described previously, there are substantial uncertainties about the biology and management of longfin smelt. Efforts over the last several years under the Longfin Settlement Agreements have helped to address this gap. DWR therefore proposes to continue applied work on longfin distribution, abundance, and limiting factors as part of a new Longfin Smelt Science Program that will continue for the duration of the ITP. This program will be developed by DWR, SWC and CDFW with the input and guidance of IEP.

Longfin Smelt Life Cycle Model: One of the key gaps for longfin smelt management is the need for a life cycle model to help understand the effects of different management actions, and to evaluate potential impacts of different stressors including entrainment. DWR proposes to fund the development of a new longfin smelt life cycle model to support management of that species.

Facilities: As part of the mitigation program, the construction of RVERS is included, which should improve IEP's sampling program. This facility has been permitted through a separate state and federal environmental review process.

Adaptive Management: Refined Alternative 2b includes an Adaptive Management Plan that will be developed in conjunction with CDFW and other partners. It is expected that the Adaptive Management Plan will require substantial additional IEP resources to support the required evaluations. The specific level of support remains to be determined and will likely vary substantially depending on the adaptive management actions conducted each year. Based on recent experience with pilot North Delta Food Web and Suisun Marsh Salinity Control Gate flow actions, it is anticipated that the required annual cost for monitoring and adaptive management support would be approximately $2 million/year. However, additional changes to the budget are expected when the program is reduced or expanded.

5.3.5.2 Monitoring Addressing Habitat Restoration Sites

DWR will develop monitoring plans to assess environmental characteristics of restored habitat (e.g., salinity and zooplankton abundance) and evaluate the benefit to listed fish, lower trophic consumers, water quality, and effects on listed botanical and wildlife species. Aquatic monitoring will focus on regional and site-specific habitat characteristics associated with listed fish species.

Monitoring plans will be developed as part of each restoration action that will include both pre- and post-project monitoring requirements. These plans will be independently reviewed and evaluated by technical teams or a science panel. Monitoring will rely as much as possible on data from existing regional monitoring efforts under the IEP. In addition, site-specific monitoring data will be collected within each project site prior to restoration action. Expansion of long-term Delta-wide monitoring efforts will assist with the fulfillment of monitoring requirements.

5.3.6 Georgiana Slough Behavioral Modification Barrier

DWR would install and operate a behavioral modification barrier (BMB) at the confluence of Georgiana Slough and the Sacramento River as originally described in the DEIR Chapter 5.4.2 as the Georgiana Slough Non-Physical Barrier (NPB). This component is analyzed based on the available information. Additional design details will be developed and evaluated through future permitting and consultation with resource agencies.

The proposed barrier would be located between river mile 26.4 and river mile 26.7 near the community of Walnut Grove (Figure 5.3-6). The behavioral modification barrier, also referred to as a bio-acoustic fish fence (BAFF), would be operated from approximately January through May each year.

The Georgiana Slough BMB would be a behavioral deterrent to prevent emigrating Sacramento River juvenile salmonids from entering Georgiana Slough during the period when wild juvenile salmonids are present (primarily between October 1 through June 1). DWR has previously conducted evaluations of a potential barrier at Georgiana Slough, which demonstrated the effectiveness of the barrier as described here.

The Georgiana Slough BMB consists of the following components:

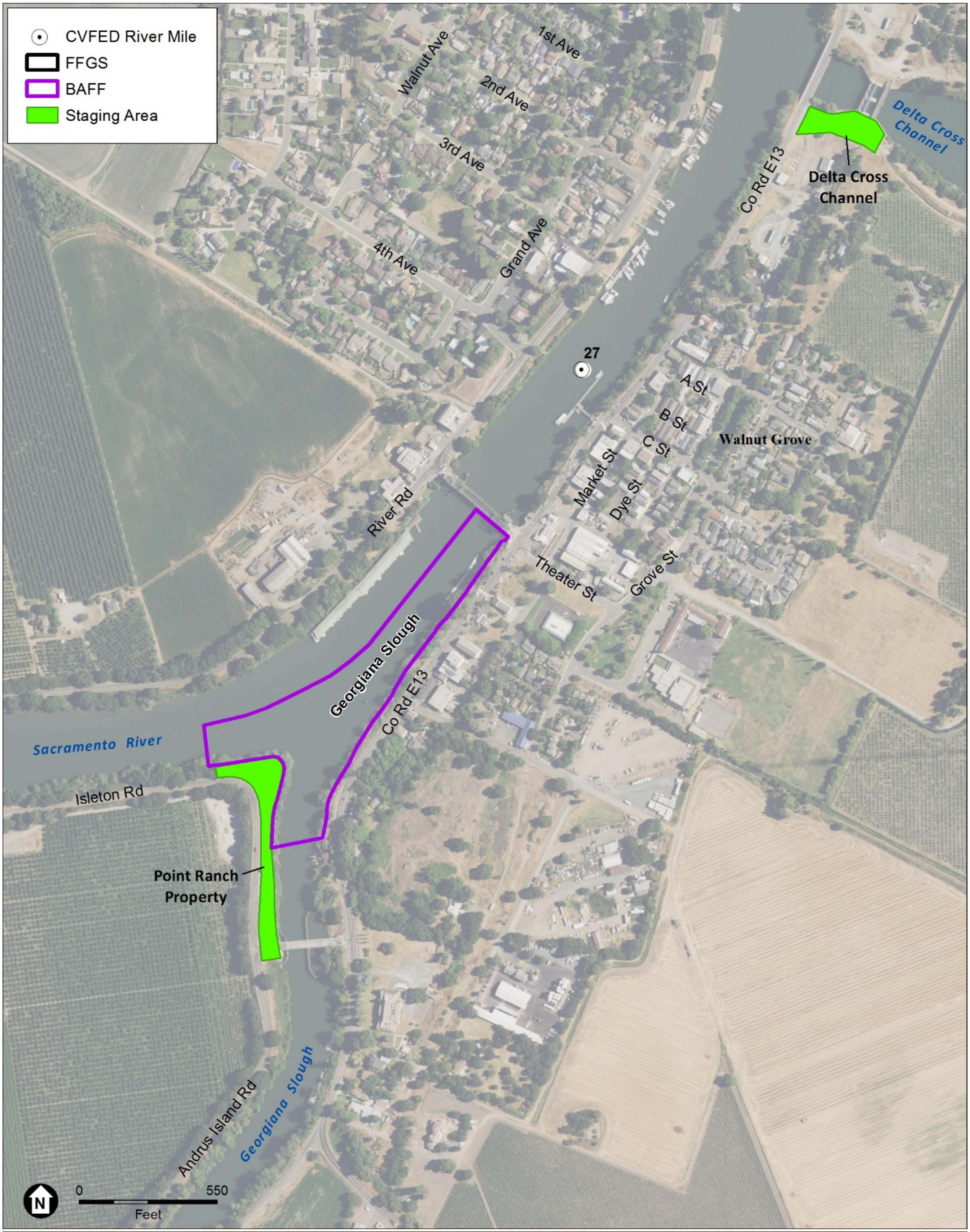


Figure 5.3-6. Location of Georgiana Slough Behavioral Modification Barrier and Associated Staging Areas

- Bio-Acoustic Fish Fence (BAFF): Install up to 31 steel piles (up to 24-inch-diameter) and 4 concrete pier blocks (up to 24-inch-diameter). Installation of the BAFF and data collection equipment, including fish tagging station and hydrophone installation, is anticipated to take up to 30 days and would typically occur between December 1–January 31. The BAFF is anticipated to be operational between January 1 and April 30 of each year.
- Navigation Aids: Install up to 40 concrete anchor blocks for navigation aids, such as buoys and signs at the Sacramento River/Georgiana Slough location.
- Fish Tracking and other Data Collection Monitoring Equipment: Install up to 18 steel piles at Georgiana Slough (up to 24-inch-diameter) to attach equipment for hydroacoustic and hydrodynamic barrier operational monitoring.
- Barrier Construction and Operation Window: In-water construction, including pile driving and installation of anchors and pier blocks, would last approximately 30 days between August 1 and September 30 of each year to avoid or minimize the potential for impacting Delta Smelt and salmon/steelhead migrating through the Delta. All pile driving will be conducted with a vibratory hammer to minimize potential in-water acoustic levels. The BAFF would be installed as early as December through January (conditions permitting) and be operational between January through April of each year. Removal of the barrier components would occur as early as May through September, with August and September being the optimal period for marine construction, each year. Mobilization, both land- and water-based, would occur within 15 days prior to and after each activity. Supporting infrastructure, including piles, would remain in place for use in subsequent years.
- Dolphin Structures (structures for docking and securing boats): Each dolphin structure consists of three piles driven into the riverbed that anchor other elements of the barrier. DWR proposes to retain the two dolphin structures that were installed at the Georgiana Slough junction as part of a 2014 feasibility study. DWR may utilize the existing dolphin structures to anchor the BAFF; attach monitoring equipment; and temporarily moor work boats. Current authorization of the existing dolphin structures at Georgiana Slough by the U.S. Army Corps of Engineers (USACE) includes removal by March 17, 2022. DWR would request an amendment to the current Incidental Take Permit term.
- Staging Area Improvements: To prepare, install, and operate the BAFF at Georgiana Slough, DWR may need to conduct improvements, such as adding gravel and grading at the staging area near the Delta Cross Canal. To provide electricity to the Point Ranch Property staging area (adjacent to Georgiana Slough), DWR may install a new power pole.
- Construction workers will participate in an annual environmental awareness program that will provide an overview of the sensitive resources at the site and identify specific avoidance and minimization measures required for project implementation.
- DWR will implement standard construction best management practices, including implementation of an erosion control plan and hazardous materials management program, and monitoring of turbidity levels, with adjustment of work to ensure turbidity remains within basin plan thresholds. Other best management practices would include dust control during site preparation and grading,

removing track-out mud/dirt, limiting vehicle speed on unpaved roads to less than 15 mph for safety of wildlife and workers, and keeping all construction equipment in proper working condition.

The annual cost of installing the BAFF is approximately $6,600,000 per year for a total cost over the ten-year anticipated Incidental Take Permit duration of $66,000,000.

5.3.6.1 Sutter and Steamboat Slough Studies

In addition to implementing the Georgiana Slough Behavior Modification Barrier, DWR would conduct studies to determine the efficacy of placing behavioral guidance barriers in the Sacramento River near the mouths of Sutter and Steamboat sloughs for the purpose of directing emigrating salmonids into these sloughs. DWR and CDFW hypothesize that salmonid emigration through these sloughs would be beneficial, relative to emigration in the mainstem Sacramento River because there is less likelihood of entry into the Central Delta from Sutter and Steamboat sloughs. DWR also would conduct studies to identify survival rates through both migratory pathways (Sutter and Steamboat Sloughs or the Sacramento River). Implementation of these studies would require additional permitting and environmental review under CEQA.

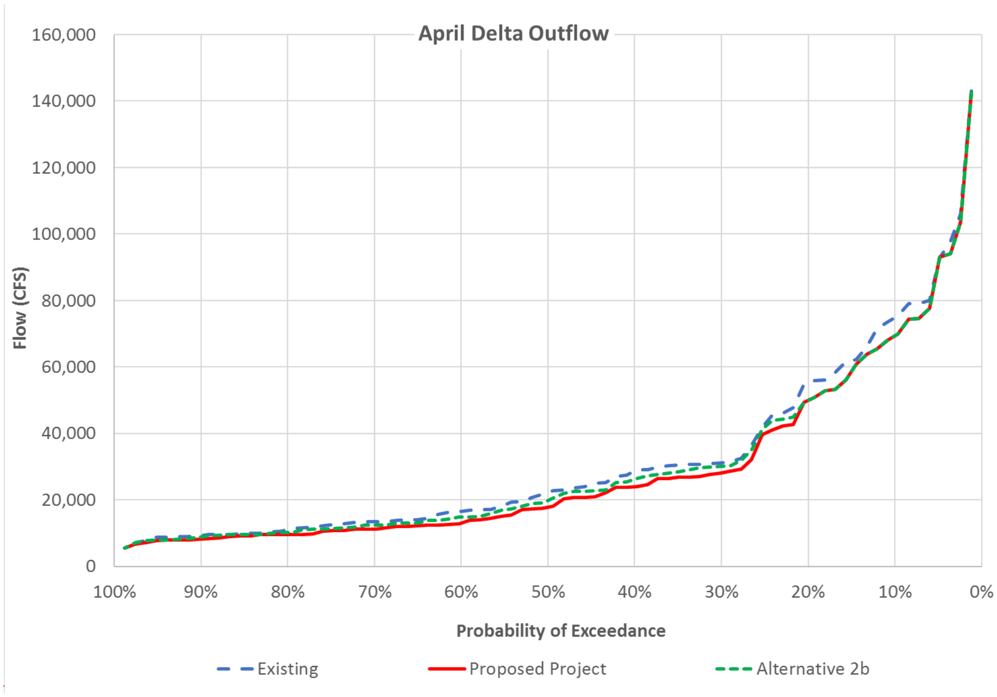
Impact Discussion

The following sections present an evaluation of the impacts that would occur under Refined Alternative 2b, compared to the Proposed Project. Due to the refinements made to Refined Alternative 2b, and selection of this alternative as the preferred alternative for the long-term operations of the SWP, a more detailed impact analysis is being presented in this FEIR. The complete analysis for Refined Alternative 2b, as provided in this FEIR, has been supplemented with additional modeling and analysis, which support the DEIR impact conclusions for the alternative.

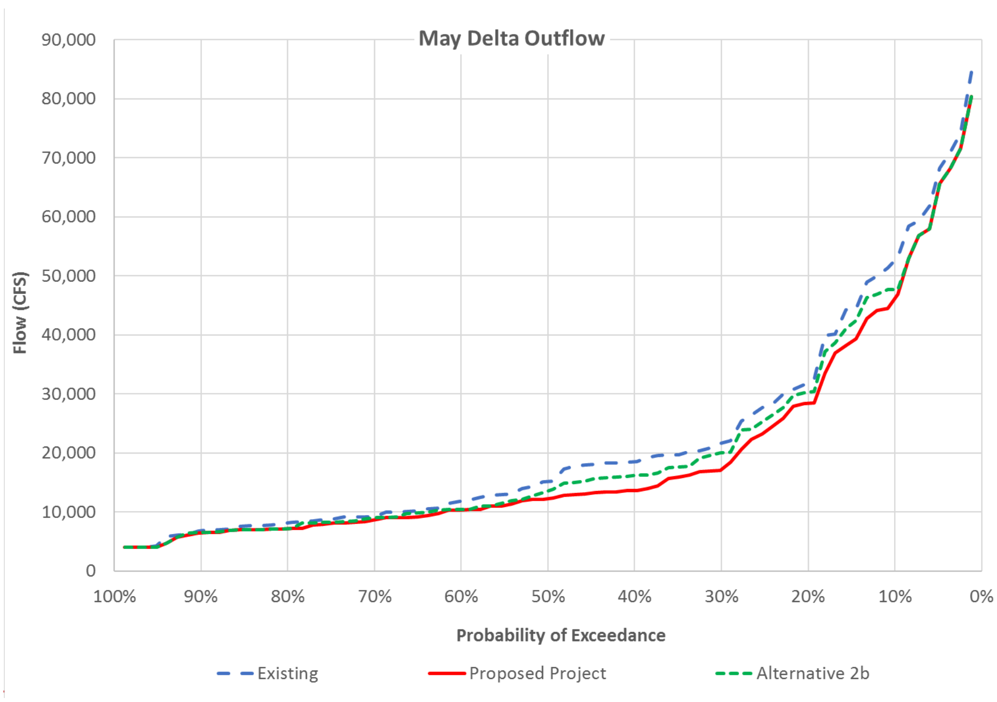
~~5.3.1~~5.3.7 Hydrology

~~Under Alternative 2B, April-May Delta outflow would be less than the No Project Alternative but greater than the Proposed Project. Modeled Delta outflow for Existing Conditions, Proposed Project and Alternative 2B are presented in Figures 5.3-1 and 5.3-2. Alternative 2B would result in reduced south of Delta exports in April-May compared to the Proposed Project, as shown in Figures 5.3-3 and 5.3-4. Reduction in south of Delta exports leads to an increase in April-May OMR flows under Alternative 2B compared to the Proposed Project. OMR flow results of Existing Conditions, Proposed Project and Alternative 2B are presented in Figures 5.3-5 and 5.3-6. Summer Delta outflow under Alternative 2B would be greater than the Proposed Project in wet and above normal years. As described in Section 5.3., the 100 TAF increase in Delta outflow would initially occur in August of wet and above normal years. Additional Delta outflow would be made available through reduction in south of Delta exports. Therefore, south of Delta exports in August would decrease by 100 TAF in wet and above normal years under Alternative 2B as compared to the Proposed Project. Reduction in south of Delta exports would result in an increase in OMR flows during August of wet and above normal years under Alternative 2B as compared to the Proposed Project.~~

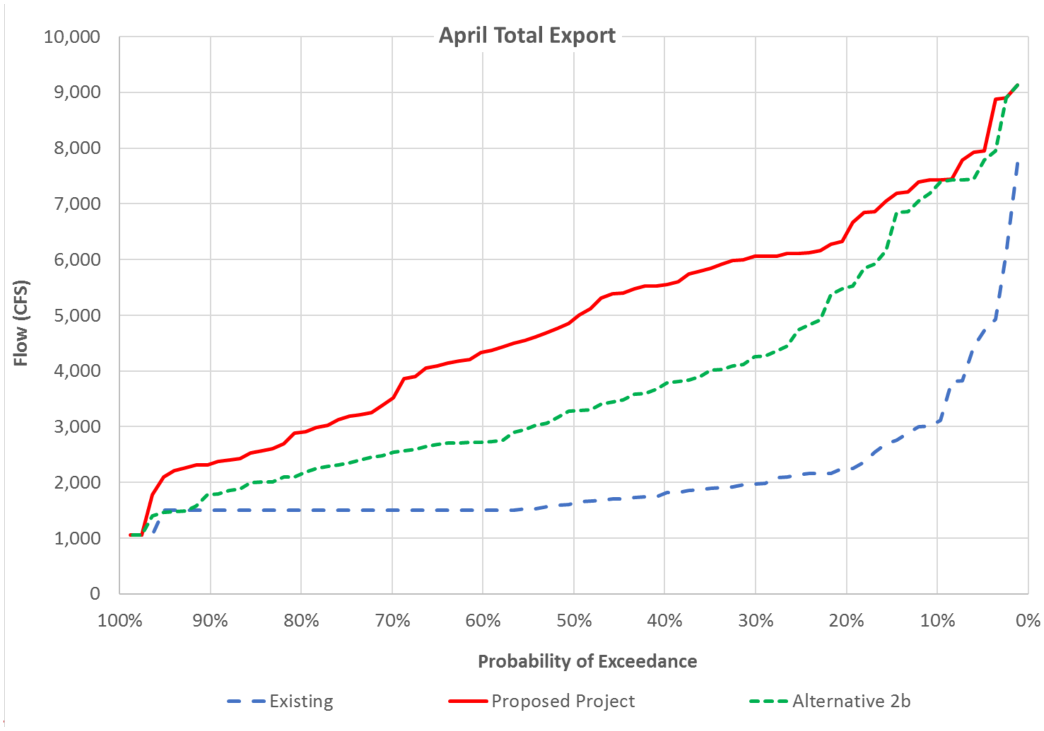
~~CDFW may define an alternate purpose for additional Delta outflow in summer within the June through September time period of wet and above normal years through the AMP. Therefore, incremental differences described above may occur in a different month or may be spread across multiple months during the June through September time period of wet and above normal years.~~



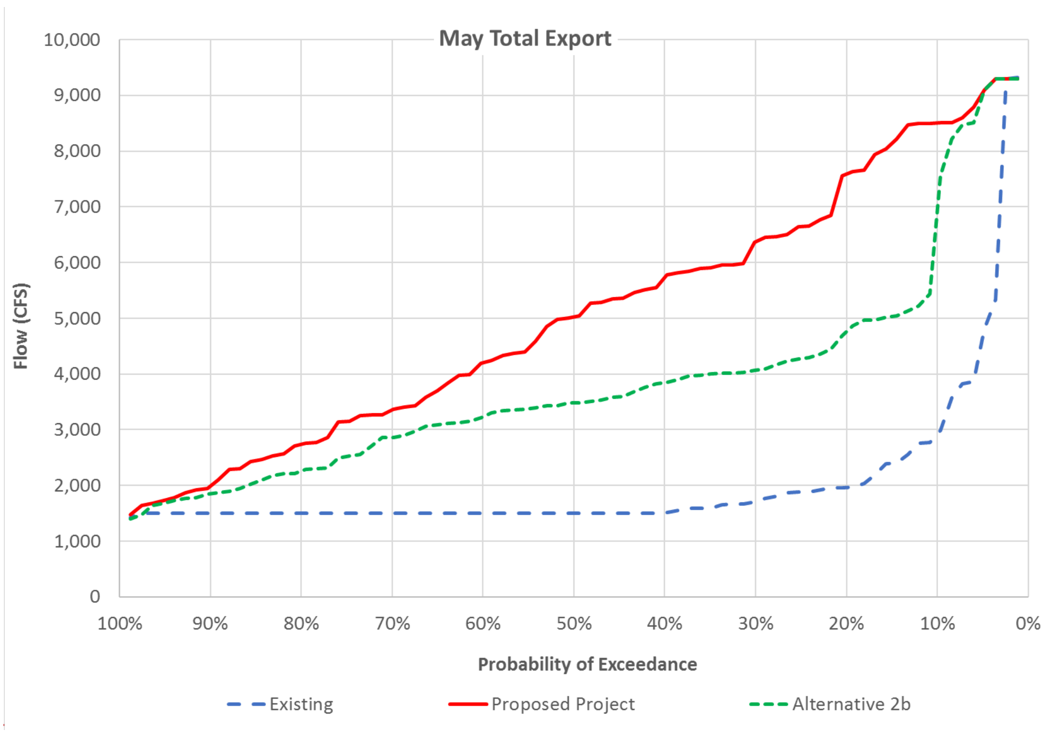
~~**Figure 5.3-1. Exceedance probability of April Delta outflow**~~



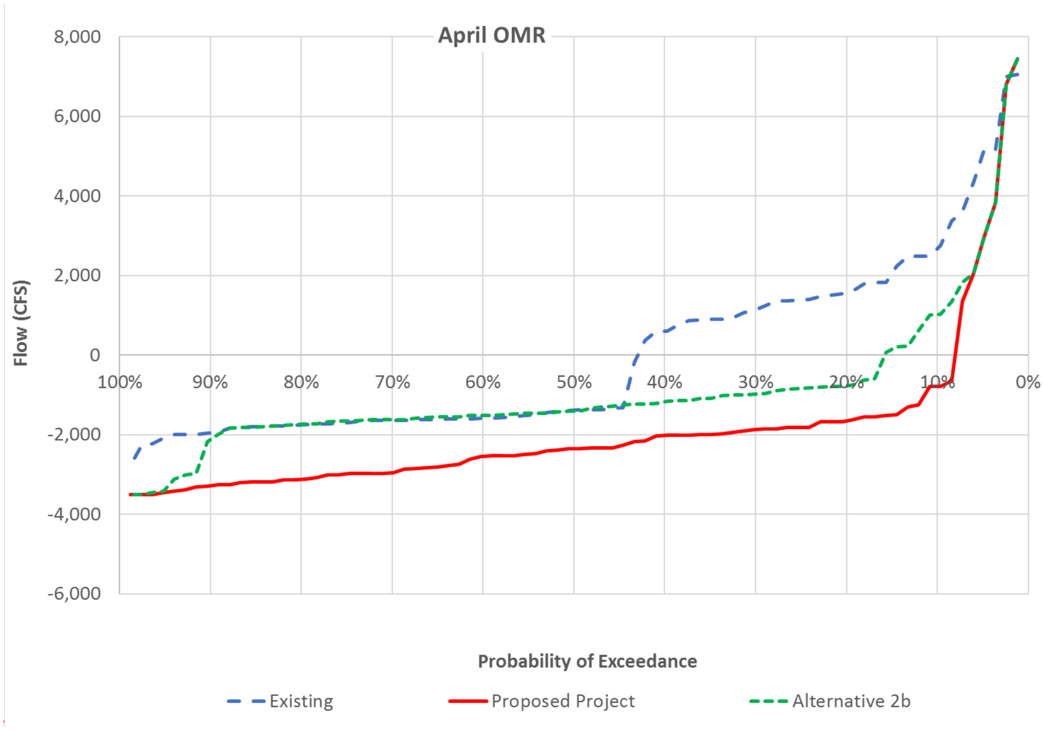
~~**Figure 5.3-2. Exceedance Probability of May Delta Outflow**~~



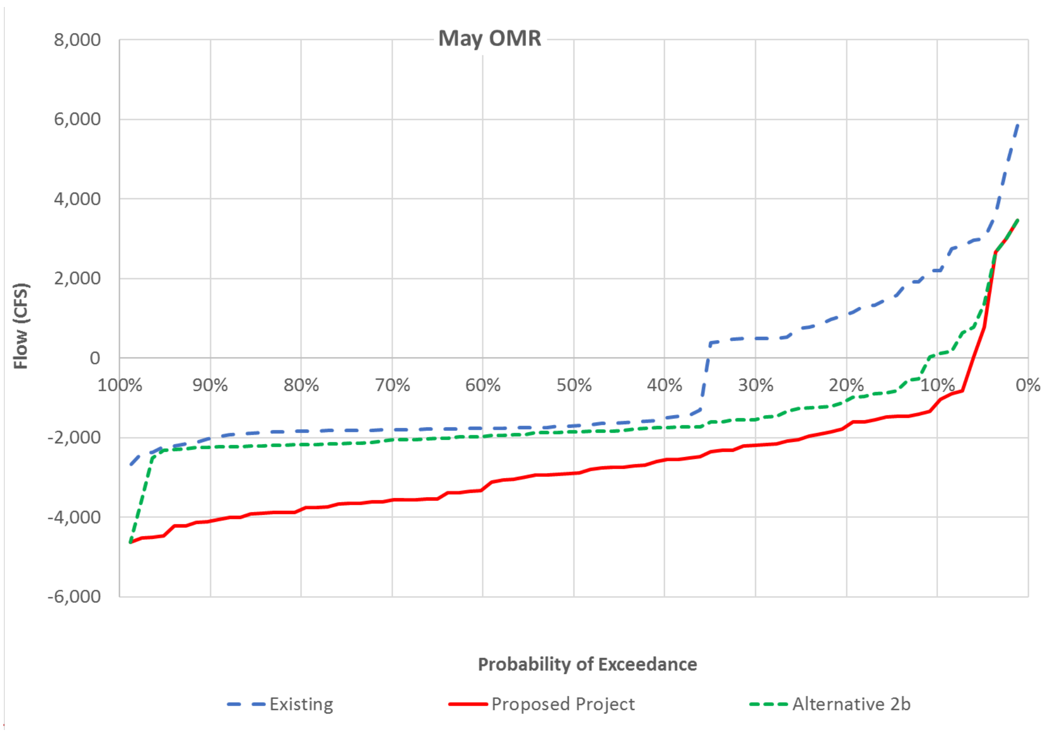
~~Figure 5.3-3. Exceedance Probability of April Total Exports~~



~~Figure 5.3-4. Exceedance Probability of May Total Exports~~



~~Figure 5.3-5. Exceedance Probability of April OMR Flow~~



~~Figure 5.3-6. Exceedance probability of May OMR flow~~

Under Refined Alternative 2b, April-May Delta outflow would be less than the No Project Alternative but greater than the Proposed Project. Modeled Delta outflow for Existing Conditions, Proposed Project and Refined Alternative 2b are presented in Figures 5.3-1 and 5.3-2. Refined Alternative 2b would result in reduced south of Delta exports in April-May compared to the Proposed Project, as shown in Figures 5.3-3 and 5.3-4. Reduction in south of Delta exports leads to an increase in April-May

OMR flows under Refined Alternative 2b compared to the Proposed Project. OMR flow results of Existing Conditions, Proposed Project and Refined Alternative 2b are presented in Figures 5.3-5 and 5.3-6. Summer Delta outflow under Refined Alternative 2b would be greater than the Proposed Project in wet and above normal years. As described in Section 5.3., the 100 TAF increase in Delta outflow would initially occur in August of wet and above normal years. Additional Delta outflow would be made available through reduction in south of Delta exports. Therefore, south of Delta exports in August would decrease by 100 TAF in wet and above normal years under Refined Alternative 2b as compared to the Proposed Project. Reduction in south of Delta exports would result in an increase in OMR flows during August of wet and above normal years under Refined Alternative 2B as compared to the Proposed Project.

CDFW may define an alternate purpose for additional Delta outflow in summer within the June through September time period of wet and above normal years through the AMP. Therefore, incremental differences described above may occur in a different month or may be spread across multiple months during the June through September time period of wet and above normal years.

This section describes the changes to hydrology associated with implementation of Refined Alternative 2b compared to the Existing Conditions scenario. It should be noted that the FEIR Refined Alternative 2b impact analyses were based on modeling conducted after the DEIR was issued in November 2019. The updated analysis is based on detailed modeling results using the CalSim II computer model for all water-year types and long-term averages provided in Appendix C. Appendix H has been updated to present the CalSim II model assumptions that consider the entrainment protections proposed for adult, larval and juvenile Longfin Smelt, and the larval and juvenile Delta Smelt entrainment protection measures.

Refined Alternative 2b would modify existing operations, downstream surface water flows, and diversions at selected SWP facilities and related waterways. As noted in Chapter 4, Section 4.2.2, descriptions of estimated changes in hydrology are presented to provide a basis for understanding potential impacts on designated beneficial uses. Where applicable, estimated SWP contribution to hydrologic changes are provided. Approach and methodology for estimating SWP contribution to change are provided in Appendix H.

Similar to the comparison of Proposed Project with the Existing Conditions, discussions of the potential impacts on designated beneficial uses and other environmental resources are presented in separate sections, as appropriate. For example, estimated changes to Delta outflow could affect surface water quality or aquatic resources, which is further discussed in Sections 5.3.7 and 5.3.8, respectively. Therefore, the changes in Delta outflow are discussed in this section as part of the analysis of hydrology, while the potential influence of the change to Delta outflow on water quality or aquatic resources and associated habitat is presented in Sections 5.3.7 and 5.3.8, respectively.

5.3.7.1 Salinity Target at Belden's Landing

Refined Alternative 2b includes a salinity target at Belden's Landing of 4 ppt. Chapter 5.5, Section 5.5.1.3 analyzes the water supply cost of meeting the 4 ppt at Belden's Landing. Unlike the Below Normal action described in Alternative 4, Refined Alternative 2b would not include additional outflow to meet the action in wet, above normal, and below normal years. The 4 ppt target would be met using up to 60 days of SMSCG operation. It is expected that intermittent operation of the SMSCG would effectively extend the time during which salinity remains at 4 ppt at Belden's Landing. A target of 4 ppt will be used to guide SMSCG operations. This action would not be expected to incur any additional water cost beyond what was analyzed for the Proposed Project.

In addition to the optional SMSCG operations in wet, above normal, and below normal years, through the Summer-Fall habitat action, the AMP framework in Refined Alternative 2b includes the ability to provide SMSCG operations in dry years if water is carried over and deployed for this purpose from AMP water blocks. Water carried over to the following year would be subject to spill and would therefore result in no additional water cost beyond what was analyzed with Refined Alternative 2b CalSim II modeling. Through the AMP, CDFW will have the authority to defer deployment of the 100 TAF of additional summer outflow in wet and above normal years to the subsequent year. If that following year is dry, summer SMSCG operations would likely be facilitated through the use of this water.

In addition to the ability to operate the SMSCG in dry years following wet or above normal years as described above, SMSCG operations would be carried out in dry years following below normal years for 30 days with a salinity target of 6 ppt. As discussed below, the expected impacts of SMSCG operations in dry years following below normal years to water supply will be less than significant.

The operation of the SMSCG for 30 days in dry years following below normal years is expected to cost between 30 and 50 TAF in additional water supply to offset an expected degradation in water quality. This operation would be borne by the SWP. Using the CalSim II analysis for Refined Alternative 2b, simulated exports were evaluated to determine if discretionary exports were available to cover the water cost without relying on stored water. Throughout the 82-year CalSim II record there are 3 instances where dry years follow below normal years (1947, 1949, and 1960) and in these 3 years more than 50 TAF in discretionary exports were available between June and August. This indicates that a 30-day SMSCG operation in dry years following below normal could be fully supported through SWP export cuts alone, but this will have a corresponding water supply impact to the SWP in those years in which an action occurs. Those impacts can be offset with additional exports in wet years as described in the following section.

As described in Section 5.3.4.1, in wet years the SWP will be able to export up to 30 TAF during the Spring Maintenance Flow period, and this water will offset the water cost associated with 30-day SMSCG operations in dry years following below normal water years. CalSim II hydrology indicates that dry years following below normal years occurred 3 out of 82 years (3.7%), versus 26 out of 82 years (32%) that are classified as wet years. An evaluation of the CalSim II output indicates that about 77% (20 out of 26) of those wet years could provide 30 TAF of additional exports during the Spring Maintenance Flow period, which is about 24% of the 82 years simulated. This indicates the chance of a wet year with the ability to provide an additional 30 TAF is about 6 times greater than a dry year SMSCG action following a below normal year. The estimated long-term water volume needed for dry years following below normal years, at a cost of 30 TAF to 50 TAF per action, would be on average 1 to 2 TAF/yr, whereas the additional wet year exports at 30 TAF, would result in an average of about 7 TAF/yr. Supplemental water supplies cost several times more to secure in Dry years than Wet years, so the differences in average volume per year will represent a rough equivalency for the wet year/dry year offset. Such an outcome is consistent with the concept that developing water in dry years for the environment is very beneficial and of greater value to the environment than the same amount in wetter years, but this development comes at a cost to SWP water supplies that are also of greater value in dry years than in wetter years.

The frequency of past hydrology presents the best available information regarding the potential probability of future occurrences, but the actual occurrence of future hydrology could vary during the 10-year term of the ITP. For example, the historical hydrology used in CalSim II indicates that there was a 10-year period (1928 to 1937) that did not have any wet years (0%). In addition, there was a sequence of years in 1947 to 1949 where 2 dry years following below normal years occurred in a 3-year period. Thus, although the actual frequency of hydrologic conditions in the forthcoming 10-year period cannot be predicted with certainty, the above actions were developed with the best available information, which indicate that SMSCG operations would be sufficiently offset through additional SWP water supply increment in wet years.

5.3.7.2 Comparisons of Sacramento River Flows into Delta, Delta Outflow, and OMR Flows

CDFW may define an alternate purpose for additional Delta outflow in summer within the June through September time period of wet and above normal years through the AMP. Therefore, incremental differences described below may occur in a different month or may be spread across multiple months during the June through September time period of wet and above normal years.

Sacramento River at Freeport

As shown in Figure 5.3-7, CalSim II model results indicate that over the 82-year simulation period, Sacramento River inflow to the Delta under the Refined Alternative 2b would decrease by 1,974 cfs (11%) and 1,650 cfs (10%) in September and November, respectively, compared to the Existing Conditions scenario, and remain similar in other months. Estimated SWP contribution to long-term flow changes may range from 25% to 60%, depending on the month. A detailed discussion regarding estimates to SWP contribution of flow changes is provided in Appendix H.

Proposed operations would reduce Sacramento River flow in September and November in years following a wet water year. In years following above-normal water years, the estimated Sacramento River flow at Freeport would increase in September and decrease in November. The range of the estimated SWP contribution to these changes is about 20% to 60%. In below-normal, dry, and critical water years, Sacramento River flow under the Refined Alternative 2b scenario will remain similar to the flow under the Existing Conditions scenario.

Delta Outflow

With implementation of the Refined Alternative 2b scenario, Delta outflow would increase in August and decrease in September and November, when compared to the Existing Conditions scenario. The increase in August Delta outflow results in Delta Smelt habitat benefits, as discussed in Section 5.3.8, above. The SWP's estimated contribution to long-term flow changes ranges from 25% to 60%, depending on the month. Delta outflow would remain similar in all other months. Delta outflow mean monthly flow patterns under the Existing Conditions and the Refined Alternative 2b scenarios over the 82-year simulation period are shown in Figure 5.3-8.

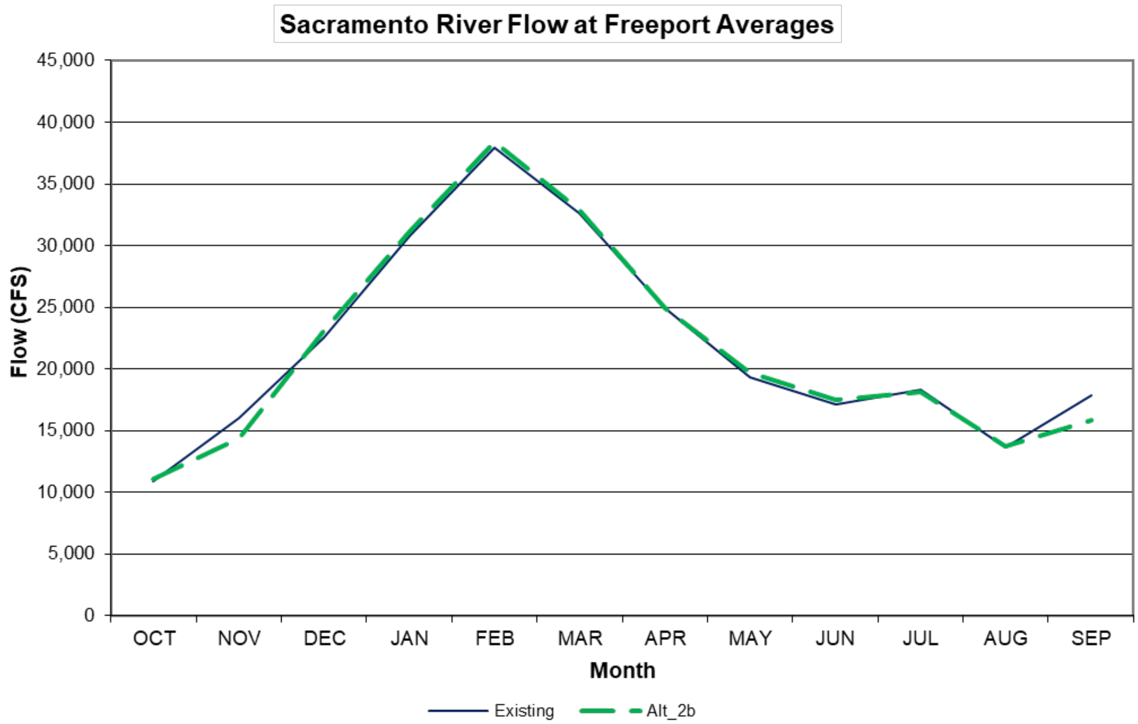


Figure 5.3-7. Sacramento River at Freeport, Comparison of Long-Term Operations

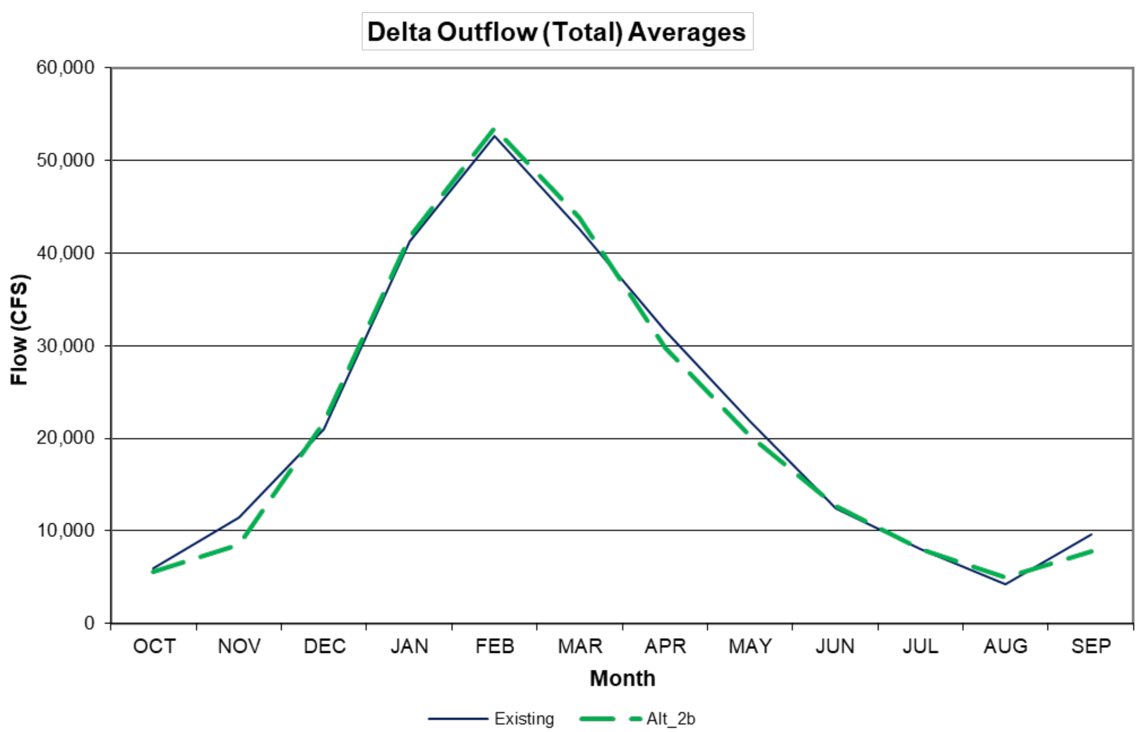


Figure 5.3-8. Delta Outflow, Comparison of Long-Term Operations

Summer Delta outflow under Refined Alternative 2b would be greater than the Existing Conditions in August wet and above normal years. As described in Section 5.3, the 100 TAF increase in Delta outflow would initially occur in August of wet and above normal years. Additional Delta outflow would be made available through reduction in south of Delta exports.

In years following wet water years, Delta outflow decreases in September and November due to the proposed Delta Smelt Summer-Fall Habitat Action. Similarly, in years following above-normal water years, Delta outflow increases in September and decreases in November. Delta outflow in fall months remains similar in all other water year types. Aside from increases in August of wet and above-normal years, Delta outflow under the Refined Alternative 2b scenario in other months remains similar to the Existing Conditions scenario in all water year types.

Old and Middle River Flow

Mean monthly OMR flow would be negative in all months because of South Delta CVP and SWP pumping operations over the 82-year simulation period, as shown in the Figure 5.3-~~8~~9. With implementation of the Refined Alternative 2b, mean monthly OMR flows, as modeled, would increase in March by 788 cfs and decrease by up to 1,000 cfs in late-spring months (April and May).

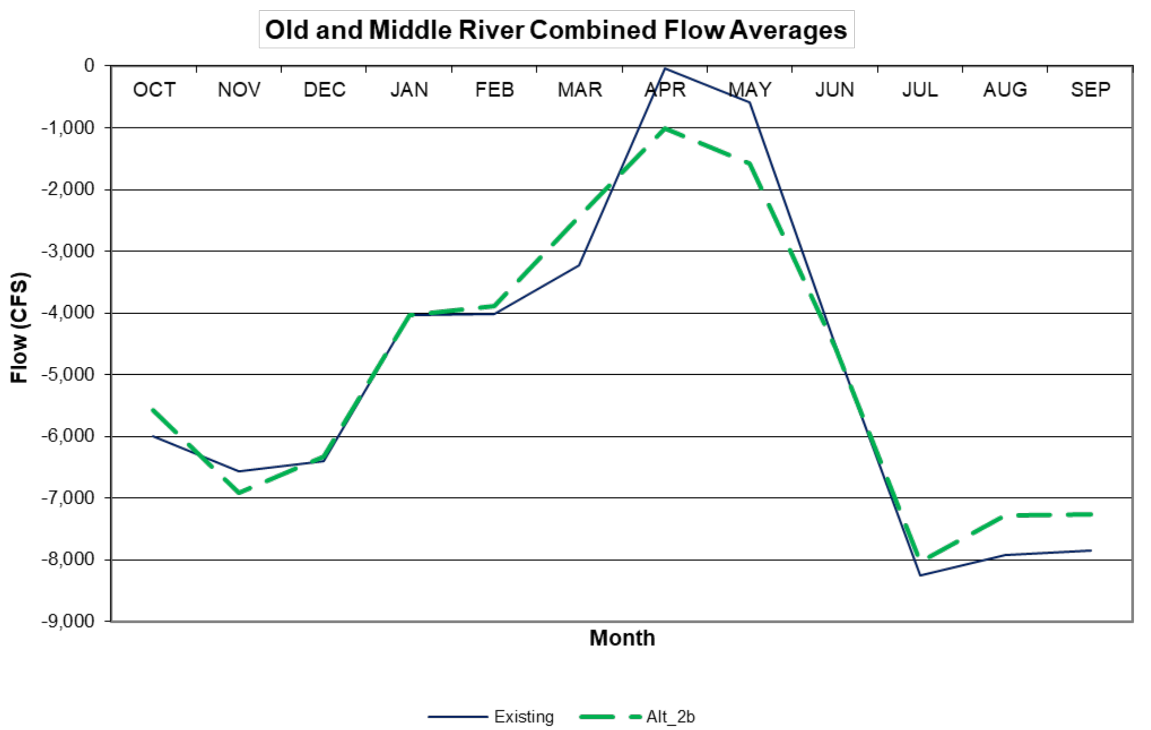


Figure 5.3-9. Old and Middle River Flow, Comparison of Long-Term Operations

In wet, above-normal, below-normal, and dry water years, OMR flows would increase by up to 1,017 cfs in March and decrease by up to 2,325 cfs in April and May when compared to OMR flows under the Existing Conditions scenario. Changes in April and May would result in a large percentage change in the OMR negative flow because OMR flows under the Existing Conditions scenario are nearly zero in these months.

In critical water years, OMR flows would increase by up to 804 cfs in April, May, and October. Conversely, OMR flows would decrease by up to 185 cfs in March and August with implementation of the Refined Alternative 2b. As noted above, estimated SWP contribution to long-term Delta outflow changes may range from 25% to 60%, depending on the month.

5.3.7.3 Comparison of SWP Banks Pumping Plant Exports and SWP Deliveries

With implementation of the Refined Alternative 2b, SWP South Delta exports at Banks Pumping Plant would potentially increase by up to 368 cfs (42%) in April, 235 cfs (29%) in May, and 1,414 cfs (44%) in November. A potential pumping decrease of 673 cfs (18%) in March and 820 cfs (19%) in August would occur with implementation of the Refined Alternative 2b.

In wet and above normal water years, the SWP Banks Pumping Plant exports under the Refined Alternative 2b scenario would potentially increase by up to 1,094 cfs in April, 651 cfs in May, 1,156 cfs in October, and 3,547 cfs in November, and would potentially decrease by up to 921 cfs in March, compared to exports under the Existing Conditions scenario.

In below normal years, Refined Alternative 2b SWP Banks Pumping Plant exports would potentially reduce by up to 919 cfs (25%) in March.

In dry water years, SWP Banks Pumping Plant exports under the Refined Alternative 2b scenario would potentially decrease by 416 cfs (17%) in March and 615 cfs (15%) in July. In critical water years, SWP Banks Pumping Plant exports would potentially increase by 182 cfs (28%) in July, 116 cfs (24%) in August, and 351 cfs (18%) in November and decrease by 148 cfs (21%) in April and 141 cfs (17%) in June compared to exports under the Existing Conditions scenario. Additional details are provided in Appendix C.

Over the long-term, average modeled annual SWP Banks Pumping Plant pumping is increasing by about 24 TAF under the Refined Alternative 2b scenario compared to the Existing Conditions scenario. This modeled difference in alternatives is 1 percent, indicating that deliveries under the Refined Alternative 2b are similar to deliveries under the Existing Conditions.

Table 5.3-2 shows total annual SWP deliveries over the long term, and dry and critical water years over the 82-year simulation period for the Existing Conditions and the Refined Alternative 2b scenarios. Reported values only reflect SWP deliveries and exports and do not include any CVP wheeling or water transfers.

~~5.3.2~~5.3.8 Surface Water Quality

Water quality conditions were analyzed to determine if there were changes in salinity in the Delta due to implementation of the Refined Alternative 2b compared to the Existing Conditions scenario, and these conditions are provided in Appendix C. The joint impacts of CVP and SWP operational changes on salinity conditions in the Delta at Emmaton, Jersey Point, Clifton Court Forebay, CCWD intakes in Rock Slough, Old River and Victoria Canal, and Barker Slough under the Refined Alternative 2b compared to the Existing Conditions scenario are summarized below. The estimated proportional impact of SWP operation will vary from 20% to 60%, depending on month and water year type. More details regarding the estimation of SWP proportional impact are provided in Appendix H.

Emmaton

As compared to the Existing Conditions scenario, modeled electrical conductivity increased average electrical conductivity at Emmaton by 47 µmhos/cm, 269 µmhos/cm, and 175 µmhos/cm in January, November, and December, respectively, with electrical conductivity remaining similar in other months. Increases in salinity are only observed in fall and early winter following a wet or above-normal water year.

Jersey Point

As compared to the Existing Conditions scenario, modeled electrical conductivity increased average electrical conductivity at Jersey Point by 82 µmhos/cm, 373 µmhos/cm and 351 µmhos/cm in January, November, and December, respectively, and remains similar in other months.

Table 5.3-2. Annual SWP Regional Deliveries of the Refined Alternative 2b Compared to Existing Conditions

Region	Delivery Type	Average (Annual)	Existing Conditions (TAF[a])	Refined Alternative 2b (TAF[a])	Change from the Existing Conditions to Refined Alternative 2b (TAF[a]/%)
Sacramento River Hydrologic Region	SWP FRSA Contract Delivery	Long-Term[b] Dry and Critical[c]	952 908	952 908	0 (0%) 0 (0%)
	SWP M&I Contract Delivery	Long-Term Dry and Critical	30 20	32 25	2 (7%) 5 (25%)
San Joaquin River Hydrologic Region (not including Friant-Kern and Madera Canal water users)	SWP Ag Contract Delivery (including Article 21)	Long-Term Dry and Critical	3 2	3 2	0 (0%) 0 (0%)
San Francisco Bay Hydrologic Region	SWP M&I Contract Delivery (including Article 21, includes transfers to SWP contractors)	Long-Term Dry and Critical	202 125	206 146	4 (2%) 21 (17%)
Central Coast Hydrologic Region	SWP M&I Contract Delivery	Long-Term Dry and Critical	40 22	40 25	0 (0%) 3 (14%)
Tulare Lake Hydrologic Region	SWP M&I Contract Delivery	Long-Term Dry and Critical	77 42	77 48	0 (0%) 6 (14%)
	SWP Ag Contract Delivery) (including Article 21	Long-Term Dry and Critical	585 310	574 317	-11 (-2%) 7 (2%)
South Lahontan Hydrologic Region	SWP M&I Contract Delivery (including Article 21)	Long-Term Dry and Critical	260 155	259 173	-1 (0%) 18 (12%)
South Coast Hydrologic Region	SWP M&I Contract Delivery (including Article 21, includes transfers to SWP contractors)	Long-Term Dry and Critical	1,242 763	1,274 912	32 (3%) 149 (20%)
	SWP Ag Contract Delivery (including Article 21)	Long-Term Dry and Critical	7 4	7 5	0 (0%) 1 (25%)
Total for All Regions[d]	Total SWP Supplies Contract Delivery (FRSA, Ag, and M&I from SWP)	Long-Term Dry and Critical	3,399 2,352	3,424 2,561	26 (1%) 210 (9%)

Notes:

e. Based on CALSIM-II modeling over the 82-year simulation period.

f. Long-Term is the average quantity for the period of October 1921 through September 2003.

g. Dry and critical years average is the average quantity for the combination of the SWRCB D-1641 40-30-30 dry and critical years for the period of October 1921 through September 2003.

h. Values do not include deliveries associated with CVP Cross-Valley Canal contracts, CVP JPOD exchanges, and water transfers under the Lower Yuba River Accord (Component 1).
Ag = Agricultural
M&I = Municipal and Industrial

Clifton Court Forebay

As compared to the Existing Conditions scenario, modeled electrical conductivity increased at Clifton Court Forebay by 75 µmhos/cm and 105 µmhos/cm in January and December, respectively. In all other months, electrical conductivity at Clifton Court Forebay would be similar to conductivity under the Existing Conditions scenario.

CCWD Intakes in Rock Slough, Old River and Victoria Canal

Compared to the Existing Conditions scenario, modeled electrical conductivity at Rock Slough under the Refined Alternative 2b scenario would increase by 73 µmhos/cm, 71 µmhos/cm, and 173 µmhos/cm in January, November, and December, respectively. Under the Refined Alternative 2b, modeled electrical conductivity would decrease by 40 µmhos/cm (20%) in May, respectively, and remains similar in all other months.

Compared to the Existing Conditions scenario, modeled electrical conductivity in Old River at State Highway 4 under the Refined Alternative 2b scenario would increase by 72 µmhos/cm and 138 µmhos/cm in January and December, respectively. In all other months, electrical conductivity in Old River at State Highway 4 would be similar to conductivity under the Existing Conditions scenario.

Compared to the Existing Conditions scenario, modeled electrical conductivity at Victoria Canal under the Refined Alternative 2b scenario would increase by 52 µmhos/cm and 57 µmhos/cm in January and December, respectively. In all other months, electrical conductivity at Victoria Canal would be similar to conductivity under the Existing Conditions scenario.

Barker Slough

Modeled long-term average chloride concentrations at the SWP North Bay Aqueduct under the Refined Alternative 2b scenario would be similar to concentrations under the Existing Conditions scenario.

D-1641 Compliance

The Refined Alternative 2b would be operated to meet all D-1641 compliance standards. Changes in the frequency of modeled salinity exceedance between the Refined Alternative 2b and the Existing Conditions scenarios are shown in Tables 5.3-3 and 5.3-4. More detailed D-1641 compliance results are provided in Appendix C.

Table 5.3-3. Modeled Change in Frequency of D1641 Exceedance with CalSim II

Location	Regulation	Change from the Existing Conditions to Refined Alternative 2b
Sacramento River at Emmaton	D1641 AG	0%
Contra Costa Canal at Pumping Plant #1	D1641 M&I	1%
San Joaquin River at Jersey Point	D1641 AG	0%
Spring X2	D1641 FWS	0%

The model results indicate changes between 0% and 2%. Given model assumptions and limitations discussed below, 2% change in modeled frequency of exceedance indicates that the Refined Alternative 2b and the Existing Conditions scenarios are similar.

Although modeling suggests exceedances may occur, these exceedances are an artifact of model assumptions and model limitations, which are primarily related to differences in CALSIM II and DSM2 modeling time steps. Some of the other limitations that may cause modeled exceedances include representation of partial-month D-1641 requirements on a monthly time step, calibration of CalSim II ANN, and the use of CalSim II outputs based on operational decisions on a monthly time step as inputs to DSM2 (Nader-Tehrani 2016).

Table 5.3-4. Modeled Change in Frequency of D1641 Exceedance with DSM2

Location	Regulation	Change from the Existing Conditions to Refined Alternative 2b
Sacramento River at Emmaton	D1641 AG	1%
Sacramento River at Collinsville	D1641 FWS	1%
San Joaquin River at Jersey Point	D1641 AG	0%
San Joaquin River at Jersey Point	D1641 FWS	1%
San Joaquin River at San Andreas Landing	D1641 AG	0%
San Joaquin River at Prisoners Point	D1641 FWS	0%
Contra Costa Canal at Pumping Plant #1	D1641 M&I	1%
Contra Costa Canal at Pumping Plant #1	D1641 M&I No. of Days	1%
South Fork Mokelumne River at Terminus	D1641 AG	0%
Chadbourne Slough at Sunrise Duck Club	D1641 FWS	0%
Montezuma Slough near Belden's Landing	D1641 FWS	0%
Montezuma Slough at National Steel	D1641 FWS	0%
Suisun Slough 300 ft South of Volanti Slough	D1641 FWS	0%
Cache Slough at City of Vallejo	D1641 MI	0%
Barker Slough at North Bay Aqueduct Intake	D1641 MI	0%
West Canal at Mouth of Clifton Court Forebay	D1641 AG	0%
West Canal at Mouth of Clifton Court Forebay	D1641 M&I	0%
Delta-Mendota Canal at Tracy Pumping Plant	D1641 AG	0%
Delta-Mendota Canal at Tracy Pumping Plant	D1641 M&I	0%
Old River at Tracy Road Bridge	D1641 AG	1%
Old River near Middle River	D1641 AG	2%
San Joaquin River at Airport Way Bridge Vernalis	D1641 AG	2%
San Joaquin River at Brandt Bridge Site	D1641 AG	2%

DWR does not anticipate that these exceedances would occur in real time. SWP and CVP have a high degree of success in meeting D-1641 requirements, as demonstrated by the historical record (Leahigh, 2016). Therefore, D-1641 compliance under the Refined Alternative 2b scenario is similar to D-1641 compliance under the Existing Conditions scenario.

The salinity conditions at three south Delta agricultural compliance locations are predominantly controlled by the San Joaquin River inflow salinity and salinity from other localized sources. DWR and Reclamation have reported to the State Water Board that these standards are beyond the reasonable control of the SWP and CVP due to localized impacts and the lack of sufficient circulation within the South Delta channels. The joint obligation to meet the South Delta salinity standards is found in D-1641 and is further addressed as part of Order 2010-0002 (Leahigh, 2016). Pursuant to the order, DWR and Reclamation have been and will continue to report to the SWRCB regarding water quality at these south Delta locations. Refined Alternative 2b operations will not affect actions pursuant to CDO WR 2010-0002.

Finding

The predicted differences in surface water quality estimated for Refined Alternative 2b~~B~~ when compared to Existing Conditions ~~and the Proposed Project~~ are due to the changes in Delta outflow and exports described in Section 5.3.6~~5.3.1~~ above. Similar to the Proposed Project, Refined Alternative 2b~~B~~ operations would generally increase salinity during the late fall and early winter in years following wet and above normal water years, as a result of the proposed Summer-Fall Delta Smelt habitat action. Modeling of ~~Existing Conditions and Proposed Project~~Refined Alternative 2b suggests the potential for D-1641 compliance exceedances, but these modeled exceedances are attributable to hydrologic modeling assumptions and limitations and are not expected to occur in real-time operations (Nader-Tehrani, 2016). Historically, SWP and CVP have a high degree of success in meeting D-1641 requirements (Leahigh, 2016). The Refined Alternative 2b scenario would not result in a violation of any water quality standard or waste discharge requirement, or otherwise degrade water quality. Therefore, changes to water quality are ~~Operations to meet D-1641 requirements would be similar to the Proposed Project under Alternative 2B, and the impacts to surface water quality are expected to remain~~ **less than significant**.

~~5.3.3~~5.3.9 AQUATIC RESOURCES

The analytical approach for analyses of effects on aquatic resources for Refined Alternative 2b is the same as used for the Proposed Project. See Chapter 4.4, Sections 4.4.7.1, 4.4.7.2, 4.4.7.3; and Appendix E Biological Modeling Methods and Selected Results for more details regarding the analytical approach methods utilized in these analyses.

As with the Proposed Project, potential operations-related impacts were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures for each species and are summarized in Table 5.3-5. Detailed discussion and analyses of these impacts on each species are presented in the following sections. Conceptual models and additional background on analyzed impacts for each species are discussed in the corresponding sections of analysis of the Proposed Project (see Chapter 4.4, Section 4.4.7.4). Note that the following analyses of Refined Alternative 2b are conducted relative to Existing Conditions and are not specifically discussed relative to the Proposed Project.

Table 5.3-5. Summary of Impacts and Conclusions Associated with Implementation of Refined Alternative 2b along with Environmental Protective Measures and Other Actions to Offset Impacts Presented by Species and Life Stage

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Delta Smelt	Adult to Eggs and Larvae	Food Availability	Similar flow through the Yolo Bypass	Figures 5.3-16 - 5.3-19	Modeling suggests similar food production and input to the Delta under both scenarios This is a combined SWP and CVP result.	Less than Significant	None Required
Delta Smelt	Adult to Eggs and Larvae	Predation	Similar Rio Vista Flows from December through May	Figures 5.3-98 - 5.3-13	Modeling suggests similar suspended sediment input to the Delta and low sediment removal from the Delta - therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	None Required
Delta Smelt	Eggs and Larvae to Juveniles	Food Availability	Delta outflow from March through June is lower under the Proposed Project, and predicted *Eurytemora affinis* density is 2% to 4% lower under Refined Alternative 2b.	Figure 5.3-20, Figure 5.3-21, Table 5.3-6	Modeling suggests food availability might be slightly reduced under Refined Alternative 2b, but uncertainty is high SWP responsibility for operations during this period is between approximately 40% to 60%	Less than Significant	None Required
Delta Smelt	Eggs and Larvae to Juveniles	Predation	Similar Rio Vista Flows from December through May. South Delta exports are higher from March through May under Refined Alternative 2b. Delta inflow from June through September is slightly lower under Refined Alternative 2b.	Figures 5.3-8 - 5.3-13, Figures 5.3-22 and 5.3-23	Modeling suggests similar predation potential associated with turbidity Modeling suggests potentially lower silverside cohort strength with high uncertainty, based on greater March–May south Delta exports Modeling suggests potentially higher silverside cohort strength with high uncertainty, based on lower June–September Delta outflow SWP responsibility for operations is between approximately 40% to 60% during March – May SWP responsibility for June-September operations is between approximately between 20-50%	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Food Availability	Delta outflow from July through September is similar most of the time (75% of the time) but is lower about 25% of the time, suggesting slightly lower predicted *Pseudodiaptomus forbesi* density. Similar QWEST under both scenarios in July and August. Higher (positive more often) QWEST in September under the Proposed Project.	Figure 5.3-24, Figures 5.3-25 – 5.3-27	Modeling suggests slightly lower *P. forbesi* density under Refined Alternative 2b as a result of lower Delta outflow some of the time. Analysis has high uncertainty Modeling suggests similar *P. forbesi* subsidy to the LSZ from the San Joaquin River most of the time under both scenarios, but potentially slightly higher *P. forbesi* subsidy in September under Refined Alternative 2b. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. This is a combined SWP and CVP result SWP responsibility for operations affecting Delta Outflow and QWEST that could affect *P. forbesi* subsidy to the LSZ is between approximately 20%-55% in wet and above-normal water year types (when X2 requirements are not in place under Refined Alternative 2b)	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Predation	Similar Rio Vista Flows from December through May.	Figures 5.3-7 - 5.3-13	Modeling suggests similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and summer predation potential is unknown. However, wind and water temperature, which are drivers of predation would be similar - therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Delta Smelt	Juveniles to Subadults	Harmful Algal Blooms	Similar probability of remaining below 1 foot per second (ft/sec) velocity Microcystis threshold at each of the 8 Delta locations.	Figures 5.3-28 – 5.3-35	Identical nutrients and water temperatures because these factors that influence harmful algal blooms are not affected by Delta water operations Modeling suggests similar potential for velocity conditions to affect harmful algal blooms under both scenarios This is a combined SWP and CVP result	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat – Qualitative Discussion	N/A	N/A	Manage overlapping suitable habitat based on the latest conceptual model of suitable habitat for Delta Smelt in summer-fall using multiple tools including outflow augmentation, SMSCG operation, and food actions. Low salinity zone would tend to be further upstream following wet years, without detailed consideration of SMSCG operation. Evidence from the pilot 2018 application of the SMSCG action suggests that Delta Smelt had access to more productive habitat, better water quality conditions (lower salinity and higher turbidity), and the benefits extended well beyond the period of gate operations, which are anticipated to continue with implementation of Refined Alternative 2b's SMSCG actions	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2012 (salinity alone)	Limited benefits in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation period. Reduced habitat area in Suisun Bay.	Figure 4.4-43	Modeling suggests benefits are greater when gates are operated starting in August rather than June Lower salinity in Suisun Marsh has the potential to outweigh negative effects of reduced habitat in Suisun Bay because Suisun Marsh is more productive habitat than Suisun Bay.	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2012 (salinity, temperature, and turbidity)	Limited benefits overall in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation.	Figure 4.4-44	Modeling suggests potentially beneficial overall because of improved Suisun Marsh Conditions	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2017 (salinity alone)	Limited benefits overall in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation.	Figure 4.4-45	Modeling suggests potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under Refined Alternative 2b	Less than Significant	None Required
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2017 (salinity, temperature, and turbidity)	Limited benefits in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation.	Figure 4.4-46	Modeling suggests potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under Refined Alternative 2b.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Delta Smelt	Subadults to Adults	Food Availability	Higher (positive more often) QWEST in September under Refined Alternative 2b, although Delta outflow is lower.	Figure 5.3-24, Figure 5.3-27	Modeling suggests potentially slightly higher *P. forbesi* subsidy in September under the Refined Alternative 2b based on QWEST, but slightly lower based on Delta outflow. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. Overall density of calanoid copepods in the low salinity not shown to be related to Delta outflow (X2) by other analyses. This is a combined SWP and CVP result	Less than Significant	None Required
Delta Smelt	Subadults to Adults	Predation	Similar Rio Vista Flows from December through May	Figures 5.3-8 - 5.3-13	Modeling suggests similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and summer predation potential is unknown. However, wind and water temperature, which are drivers of predation would be similar - therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	None Required
Delta Smelt	Subadults to Adults	Harmful Algal Blooms	Similar velocity conditions at 8 Delta locations Similar probability of remaining below 1 ft/sec threshold at each of the 8 Delta locations	Figures 5.3-28 – 5.3-35	Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations Modeling suggests similar potential for velocity conditions to affect harmful algal blooms under both scenarios This is a combined SWP and CVP result	Less than Significant	None Required
Delta Smelt	Entrainment	Consideration of OMR	During the March–June period of concern for larval/juvenile Delta Smelt entrainment risk, OMR flows would generally be lower (more negative) under Refined Alternative 2b in April and May but would be similar under both scenarios in March and June. During this period, flows under both scenarios would be at or less negative than the -5,000 cfs inflection point at which entrainment tends to sharply increase.	Figures 5.3-439 - 5.3-42	Modeling suggests entrainment may be greater for larvae/early juveniles (March – June) under Refined Alternative 2b SWP responsibility for operations during March–June is approximately 20–60%, and 20–40% in April/May. SWP exports overall would be similar to existing conditions during March–June in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than existing conditions. The potential for increases in entrainment at the south Delta export facilities when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period. Refined Alternative 2b includes the use of the USFWS life cycle model for Delta Smelt to limit OMR during this period and use of the model was not included in the modeling assumptions for OMR. Real-time sampling, modeling, and OMR management for larval and juvenile Delta Smelt Protection would limit entrainment.	Less than Significant	None Required
Delta Smelt	Entrainment	Particle Tracking Modeling	DSM2 PTM showed increases in Delta Smelt entrainment in April and May	Table 5.3-7	Modeling suggests entrainment loss of larval Delta Smelt has the potential to be appreciably greater under Refined Alternative 2b in April and May. SWP exports overall would be similar to existing conditions during March–June; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than existing conditions. The potential for increases in entrainment at the south Delta export facilities when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period. Real-time sampling, modeling, and OMR management for larval and juvenile Delta Smelt Protection would limit entrainment.	Less than Significant	None Required
Delta Smelt	All Life Stages	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Delta Smelt	All Life Stages	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Limited potential for effect because of general downstream distribution and weak swimming ability.	Less than Significant	None Required
Delta Smelt	All Life Stages	Annual O&M Activities	N/A	N/A	Annual O&M activities likely would have limited impacts on Delta Smelt because work windows and best management practices (BMPs) would be implemented. Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required
Delta Smelt	All Life Stages	Project Environmental Protective Measures including: • Clifton Court Forebay (CCF) predator relocation and aquatic weed control; • Skinner Fish Facility performance improvements; • Longfin Smelt Science Program; • Continue Studies to Establish a Delta Fish Hatchery; and • Conduct further Studies to Prepare for Delta Smelt Reintroduction from the FCCL (see Table 3-3)	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Delta Smelt reintroduction and Delta Fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival	Less than Significant	None Required
Longfin Smelt	Population Abundance	Delta Outflow-Abundance	The results of the Nobriga and Rosenfield (2016) model application suggested that differences in the predicted fall midwater trawl abundance index between scenarios would be very small, with mean indices slightly lower under Refined Alternative 2b and with some uncertainty, especially when considered in relation to the confidence intervals, as a result of high uncertainty in the outflow–abundance relationship.	Figure 5.3-43, Tables 5.3-8 – 5.3-9	Modeling suggests simulated changes in Delta outflow have limited impacts on Longfin Smelt abundance with high uncertainty. This is a combined SWP and CVP result, SWP responsibility for operations of approximately 20% to 60% (the main differences primarily reflect greater CVP exports in April/May). Longfin Smelt Science Program will implement studies to help understand the mechanisms underlying hydrology-abundance relationships.	Less than Significant	None Required
Longfin Smelt	Adult	Entrainment	Similar OMR flow from December through February.	Figures 5.3-36 – 5.3-38	Modeling suggests similar entrainment potential during the December – February period SWP exports would be similar to existing conditions during this time period and the SWP responsibility for operations is between approximately 40% to 60% Real-time OMR management from December through February would minimize entrainment	Less than Significant	None Required
Longfin Smelt	Larvae	Entrainment	DSM2-PTM results suggested that entrainment potential of Longfin Smelt larvae is similar between scenarios.	Tables 5.3-12 and 5.3-13	Modeling suggests similar entrainment potential for larval Longfin Smelt Real-time OMR management from January through June would minimize entrainment This is a combined SWP and CVP result	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Longfin Smelt	Juvenile	Salvage	Based on the Grimaldo et al. (2009) salvage-Old and Middle River flow regression, the potential exists for increases in entrainment under Refined Alternative 2b.	Figure 5.3-44 and 5.3-45; Table 5.3-12	Modeling suggests entrainment of juvenile Longfin Smelt would have the potential to be higher under Refined Alternative 2b with high uncertainty The number of juvenile Longfin Smelt estimated to be entrained under Refined Alternative 2b is a very small proportion of the population SWP responsibility for operations is between approximately 20-40%. SWP exports generally would be similar to existing conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than existing conditions. The potential for increases in entrainment at the south Delta export facilities when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period. Real-time OMR management from January through June would limit entrainment	Less than Significant	None Required
Longfin Smelt	All Life Stages	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window.	Less than Significant	None Required
Longfin Smelt	All Life Stages	Georgiana Slough Behavioral modification barrier	N/A	N/A	Limited potential for effect because of general downstream distribution and weak swimming ability.	Less than Significant	None Required
Longfin Smelt	All Life Stages	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required
Longfin Smelt	All Life Stages	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; • Skinner Fish Facility performance improvements; • Longfin Smelt Science Program; and • Continue Studies to Establish a Delta Fish Hatchery (see Table 3-3)	N/A	N/A	Longfin Smelt Science Program would improve understanding of Longfin Smelt ecology, population distribution, and abundance to better inform management decisions. Delta fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival	Less than Significant	None Required
Winter-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during most months of the immigration period	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flow conditions would likely result in similar habitat conditions including SAIL Conceptual Model habitat attributes of water temperature, dissolved oxygen concentrations, and other attributes that influence the timing, condition, and survival of adult Winter-run Chinook Salmon during their upstream migration. This is a combined SWP and CVP result	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Winter-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment	Changes in hydrodynamic conditions (velocity distributions) indicate that juvenile winter run entering the interior Delta from Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor may be more likely to become entrained under Refined Alternative 2b, if exports are greater at the time they are present. There is little difference during the December-February period when Winter-Run are most abundant in the Delta.	Figures 5.3-52 and 5.3-53	Modeling suggests that although Chinook Salmon in the Old-Middle River corridor could become entrained more often under Refined Alternative 2b, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, Refined Alternative 2b would be unlikely to increase the proportion of winter run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile winter run Chinook salmon encounter the South Delta salvage facilities. Velocity changes that could occur in the Spring and Fall under Refined Alternative 2b are less likely to affect Winter-run Chinook Salmon because most Winter-run Chinook Salmon are expected to have exited the Delta by April and May and are generally present in low abundance during September and November. This is a combined SWP and CVP result Implementing OMR management, including factors such as cumulative loss thresholds, would limit entrainment of winter run Chinook that do enter the Old-Middle River corridor. The operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Winter-run Chinook Salmon entry into the interior Delta at Georgiana Slough, and therefore reduce entrainment risk. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF could reduce pre-screen losses which would increase salvage. Skinner Fish Facility Improvements also have the potential to improve survival of winter run and increase observed salvage	Less than Significant	None Required
Winter-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Winter-run Chinook Salmon at the SWP south Delta export facility would be similar between the scenarios.	Table 5.3-14	Modeling suggests entrainment loss would be similar under both scenarios, but the analysis is uncertain because it is not scaled by population size and there is uncertainty about the true racial identity of Chinook Salmon in salvage. The model does not include real-time management operations or genetic identity of salvaged Chinook salmon. The operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Winter-run Chinook Salmon entry into the interior Delta at Georgiana Slough, and therefore reduce entrainment risk.	Less than Significant	None Required
Winter-run Chinook Salmon	Juvenile	Salvage based on Zeug and Cavallo (2014)	Winter-run Chinook Salmon salvage is similar under both scenarios. Median salvage of the juvenile population at the SWP was 0.107% under the existing condition and 0.103% under Refined Alternative 2b (≈ 0.04% lower under the proposed project).	Figures 5.3-54 and 5.3-55	The maximum annual proportion of juvenile Winter-run Chinook Salmon production predicted to be salvaged is low (<1%) for both Refined Alternative 2b and the existing condition. Differences between scenarios in individual years were small. Additionally, small differences in predicted salvage occurred in certain months and water year types. However, there was high overlap in interquartile ranges and the scenario with greater salvage was not consistent across these comparisons.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Winter-run Chinook Salmon	Outmigrant Survival	Delta Passage Model	Across the 82-year simulation period, mean through-Delta survival was 0.2% greater for Refined Alternative 2b. Survival followed water year-type for both scenarios with the highest values in wet years and lowest values in critical years. Differences in individual model years were generally small (< 1%) as were differences within individual water year-types.	Figures 5.3-56 – 5.3-57	Modeling suggests through Delta survival of Winter-run Chinook Salmon would be similar under both scenarios with some uncertainty. These results are similar to those of the STARS analysis described below which does not include an export-survival function which is included in the DPM. Together, these results suggest changes in export operations under Refined Alternative 2b had little influence on through-Delta survival of winter run Chinook Salmon. Uncertainty in the modeled result will be addressed by implementing cumulative loss thresholds as part of OMR management that would limit entrainment. SWP responsibility for operations is between approximately 40% to 60%.	Less than Significant	None Required
Winter-run Chinook Salmon	Outmigrant Survival	STARS	Generally similar proportions of Winter-run Chinook Salmon entered the interior Delta via Georgiana Slough and the DCC, resulting in similar through Delta survival under both scenarios except during November, when survival was predicted to be lower under Refined Alternative 2b as a result of less river flow and greater DCC opening as a result of model assumptions. However, abundance of winter-run is generally low in November.	Figure 5.3-58	Modeling suggests during most months of the outmigration period (October through June for this analysis) Winter-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the central Delta and reduced survival could occur in November. However, winter run abundance is typically low in November. This is a combined result. During November when the largest differences in routing occur, the SWP is responsible for approximately 50-60% of operations-related impacts but note that the DCC is a CVP facility.	Less than Significant	None Required
Winter-run Chinook Salmon	Rearing Juveniles	Rearing Effects	Little difference in rearing habitat suggested by CalSim modeling of Freeport and Yolo Bypass flows.	N/A	Available tools are generally focused on rearing habitat as a function of Sacramento River and Yolo Bypass flows, which modeling suggests generally do not differ between Refined Alternative 2b and Existing and combined with results of other analyses suggest little potential for greater effects under Refined Alternative 2b compared to Existing. This is a combined result. SWP responsibility during winter-spring is generally 40-60%.	Less than Significant	None Required
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window and any entrainment counting toward cumulative loss thresholds.	Less than Significant	None Required
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Potential reduced juvenile entry into interior Delta via Georgiana Slough; upstream migrating adults would be able to swim beneath the barrier.	Less than Significant	None Required
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival. If successful, the number of fish observed in salvage would increase as mortality in the pre-screen space is reduced.	Less than Significant	None Required
Spring-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the January through June immigration period	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flow conditions would likely result in similar habitat conditions including SAIL Conceptual Model habitat attributes and olfactory cues for immigration SWP responsibility for operations is between approximately 30-60%	Less than Significant	None Required
Spring-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	For juvenile spring-run Chinook Salmon migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the Old and Middle River corridors during April and May suggest entrainment of fish entering Old River at HOR would be higher. For juvenile spring-run Chinook Salmon originating from the Sacramento River, changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor in April and May are more likely to become entrained under Refined Alternative 2b.	Figures 5.3-52 and 5.3-53; Figure 5.3-59	Modeling suggests greater frequency of routing San Joaquin-origin spring-run into Old River increases entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under Refined Alternative 2b (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River. For Sacramento River-origin spring-run, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, Refined Alternative 2b would be unlikely to increase the proportion of spring run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May. SWP exports generally would be similar to existing conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than existing conditions. The potential for increases in entrainment at the south Delta export facilities when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period. This is a combined SWP and CVP result. OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment. The operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Spring-run Chinook Salmon entry into the interior Delta at Georgiana Slough, and therefore reduce entrainment risk. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish. Facility improvements could potentially increase salvage by reducing mortality in the pre-screen space.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Spring-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Spring-run Chinook Salmon at the SWP south Delta export facility could be greater under Refined Alternative 2b.	Table 5.3-15	Modeling suggests entrainment loss of Spring-run Chinook Salmon could be higher under the Refined Alternative 2b, but the analysis is uncertain, and the model does not include genetic identity of salvaged Chinook salmon or account for the total number of juveniles that could potentially be salvaged (data are not scaled). Coded wire tag studies indicate that small fractions of Sacramento River Chinook Salmon encounter the South Delta salvage facilities, so entrainment-related impacts on the ESU would be small. OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment. The operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Spring-run Chinook Salmon entry into the interior Delta at Georgiana Slough, and therefore reduce entrainment risk. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish. Facility improvements could potentially increase salvage by reducing mortality in the pre-screen space.	Less than Significant	None Required
Spring-run Chinook Salmon	Outmigrant Survival	Delta Passage Model	Across the 82-year simulation period, mean through-Delta survival was 0.4% lower under the Refined Alternative 2b. Differences in individual years were generally small (< 1.5%), with the largest difference occurring in the 1975 model year when survival under Refined Alternative 2b was 1.9 % lower than the Existing Condition.	Figures 5.3-60 and 5.3-61	Modeling suggests through Delta survival of Spring-run Chinook Salmon would be similar under both scenarios with some uncertainty. The DPM contains an export-survival relationship. Thus, higher exports in April and May did not result in substantial changes in through-delta survival. Only a small fraction of Sacramento River-origin Spring-run enter the interior Delta and most of the juvenile population is not exposed to the hydrodynamic effect of exports. SWP exports generally would be similar to existing conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than existing conditions. The potential changes in through-Delta survival when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period. This is a combined SWP and CVP result.	Less than Significant	None Required
Spring-run Chinook Salmon	Outmigrant Survival	San Joaquin River Structured Decision Model	Across the 82-year simulation period, through-Delta survival was low (< 4%) under both scenarios. Survival was higher under Refined Alternative 2b for all years, but the magnitude of the difference between scenarios was variable in specific years.	Figures 5.3-62 and 5.3-63	Modeling suggests survival of San Joaquin River-origin Spring-run Chinook Salmon has the potential to be higher under Refined Alternative 2b. Although exports will be higher under Refined Alternative 2b in April and May, the SDM model includes the latest acoustic tagging data from the CVP and South Delta. These data and the model suggest that volitional migration survival from the facilities north can be lower than entrainment at CVP and trucking to the West Delta. Thus, more fish being routed into Old River and higher exports lead to a higher survival under Refined Alternative 2b. However, overall through-delta survival for San Joaquin River-origin Chinook Salmon is low regardless of scenario (<4%). SWP exports generally would be similar to existing conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than existing conditions. The potential changes in through-Delta survival when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Spring-run Chinook Salmon	Outmigrant Survival	STARS	The STARS model results suggest little difference in predicted through-Delta survival of Spring-run Chinook Salmon between the scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December	Figure 5.3-58	Modeling suggests during most months of the outmigration period (November through May for this analysis) Spring-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the Delta and reduced survival could occur in November. Less than 1% of Sacramento River Spring-run Chinook Salmon enter the central Delta as indicated by coded wire tag studies The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40–60% depending on the month and water year type.	Less than Significant	None Required
Spring-run Chinook Salmon	Rearing Juveniles	Rearing Effects	Little difference in rearing habitat suggested by CalSim modeling of Freeport and Yolo Bypass flows.	N/A	Available tools are generally focused on rearing habitat as a function of Sacramento River and Yolo Bypass flows, which modeling suggests generally do not differ between the Refined Alternative 2b and existing conditions. Combined with results of other analyses, modeling suggests little potential for greater effects under Refined Alternative 2b compared to Existing Conditions.	Less than Significant	None Required
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window.	Less than Significant	None Required
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Potential reduced juvenile entry into interior Delta via Georgiana Slough; upstream migrating adults would be able to swim beneath the barrier.	Less than Significant	None Required
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the July through December Fall-run Chinook Salmon and October through April Late Fall-run Chinook Salmon adult immigration periods No SWP influence on DCC operations	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flow conditions would likely result in similar habitat conditions the Sacramento River including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. SWP responsibility for differences in Freeport flows is between approximately 20-60% during the Fall-run Chinook Salmon Immigration Period. SWP responsibility for differences in Freeport flows is between approximately 40% to 60% during the Late Fall-run Chinook Salmon Immigration Period. There is no difference in straying rates of Mokelumne River Fall-run Chinook Salmon because there is no SWP influence on DCC operations.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Fall-run and Late Fall-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	Changes in hydrodynamic conditions (velocity) and flow proportion toward the Head of Old River indicate juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are much more likely to enter the Old River route and become entrained under Refined Alternative 2b. Similar proportions of flow entering the mouths of Old River and Middle River suggest a similar risk of entering the OMR corridor for Mokelumne River Fall-run Chinook Salmon.	Figures 5.3-52 and 5.3-53; Figure 5.3-59; Figures 5.3-64 and 5.3-65	While this modeled routing increases entrainment risk for San Joaquin River-origin fall-run Chinook Salmon, survival in this region is very poor generally and not adversely influenced by export rates. This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the period evaluated for San Joaquin River basin Fall-run Chinook Salmon is approximately 40% to 60%. OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment. SWP exports generally would be similar to existing conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than existing conditions. The potential for increases in entrainment at the south Delta export facilities when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period. The operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Fall-run and Late Fall-run Chinook Salmon entry into the interior Delta at Georgiana Slough, and therefore reduce entrainment risk. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements would improve survival of salvaged fish. Very few Sacramento River Fall-run and Late Fall-run Chinook Salmon would encounter the Head of Old River (<1% and <2%, respectively).	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Juvenile	Mokelumne River Fall-run Chinook Salmon Qualitative Discussion	N/A	N/A	Coded wire tag analysis suggests that very small percentages of Mokelumne River Fall-run Chinook Salmon would be expected to be entrained ranging from 0.4-0.6% of outmigrants	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Fall-run Chinook Salmon at the SWP south Delta export facility could be greater under Refined Alternative 2b. Entrainment loss of Late Fall-run Chinook Salmon is similar between scenarios.	Tables 5.3-16 and 5.3-17	Modeling suggests entrainment loss could be higher under Refined Alternative 2b, but the analysis is uncertain, and the model does not include genetic identity of salvaged Chinook salmon. Small percentages of Sacramento River Fall-run and Late Fall-run Chinook Salmon (<1% and <2%, respectively) are estimated to occur and potentially be exposed to entrainment in the south Delta, so entrainment-related impacts on the ESU would be small. Entrainment losses are a small percentage of overall mortality (~0.1% of fish from the Sacramento River and ~2% of fish from the San Joaquin River). OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment. The operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Fall-run and Late Fall-run Chinook Salmon entry into the interior Delta at Georgiana Slough, and therefore reduce entrainment risk. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	Delta Passage Model CV Fall-run and Late Fall-run Chinook Salmon	Across the 82-year simulation period, mean Fall-run Chinook Salmon through-Delta survival was 0.3% lower under the Refined Alternative 2b. Differences in individual years were generally small. Across the 82-year simulation period, mean Late Fall-run Chinook Salmon through-Delta survival was 0.3% lower under Refined Alternative 2b. Differences in individual years were generally small (< 1.0%).	Figures 5.3-66 – 5.3.69	Modeling suggests through Delta survival of Fall-run and Late Fall-run Chinook Salmon would be similar under both scenarios with some uncertainty. This is a combined SWP and CVP result.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	San Joaquin River Structured Decision Model	Across the 82-year simulation period through-Delta survival was low (< 4%) under both scenarios. Survival was higher under Refined Alternative 2b for all years, but the magnitude of the difference between scenarios was variable. Survival was higher under Refined Alternative 2b in all water year types.	Figures 5.3-70 and 5.3-71	Modeling suggests survival of San Joaquin River-origin Fall-run Chinook Salmon has the potential to be higher under Refined Alternative 2b. SWP exports generally would be similar to existing conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than existing conditions. The potential changes in through-Delta survival when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	STARS	The STARS model results suggest little difference in predicted through-Delta survival of Chinook Salmon between the scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December	Figure 5.3-58	Modeling suggests during most months of the outmigration period (January through June) Fall-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Late Fall-run Chinook Salmon could be exposed to increased routing into the Delta and reduced survival in November, although this is because of DCC operational assumptions related to Freeport flow. Small percentages of Sacramento River Fall-run Chinook Salmon and Late Fall-run Chinook Salmon enter the South Delta, so entrainment-related impacts on the ESU would be small. This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 40% to 60%, depending on the month and water year type.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	Rearing Juveniles	Rearing Effects	Little difference in rearing habitat suggested by CalSim modeling of Freeport and Yolo Bypass flows.	N/A	Available tools are generally focused on rearing habitat as a function of Sacramento River and Yolo Bypass flows. Modeling suggests these flows generally do not differ between Refined Alternative 2b and Existing Conditions. Combined with results of other analyses, the modeling suggests that there is little potential for greater effects under Refined Alternative 2b compared to Existing Conditions.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Potential reduced juvenile entry into interior Delta via Georgiana Slough; upstream migrating adults would be able to swim beneath the barrier.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
Central Valley Steelhead	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the July through March immigration period	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flow conditions would likely result in similar habitat conditions including SAIL Conceptual Model habitat attributes and olfactory cues for immigration SWP responsibility for operations is between approximately 20-60%	Less than Significant	None Required
Central Valley Steelhead	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	Changes in hydrodynamic conditions (velocity) indicates juvenile steelhead in the South Delta are more likely to become entrained under Refined Alternative 2b.	Figures 5.3-52 and 5.3-53	Velocity changes suggested by modeling that could occur in the spring and fall are not likely to affect Central Valley steelhead because most Central Valley steelhead are expected to have exited the Delta by April and May and generally occur in low numbers in the region between September and November. This is a combined SWP and CVP result. SWP exports generally would be similar to existing conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than existing conditions. The potential changes in through-Delta survival when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period. Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Central Valley Steelhead	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Central Valley steelhead at the SWP south Delta export facility generally would be similar under Refined Alternative 2b compared to Existing Conditions.	Table 5.3-18	Modeling suggests entrainment loss of steelhead could be similar under Refined Alternative 2b, but the analysis is uncertain. Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required
Central Valley Steelhead	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Limited potential for entrainment effect given low overlap with expanded July-November water transfer window.	Less than Significant	None Required
Central Valley Steelhead	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Potential reduced juvenile entry into interior Delta via Georgiana Slough; upstream migrating adults would be able to swim beneath the barrier.	Less than Significant	None Required
Central Valley Steelhead	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required
Central Valley Steelhead	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Delta Outflow	Similar Delta outflow under both scenarios	Figures 5.3-72 and 5.3-76	Modeling suggests similar Delta outflow during most of the year would result in similar impacts under both scenarios. This is a combined SWP and CVP result. SWP responsibility for differences in Delta operations is between approximately 20-60%.	Less than Significant	None Required
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Annual O&M Activities	N/A	N/A	Annual O&M activities would not occur within the habitats occupied by Central California Coast Steelhead.	Less than Significant	None Required
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Project Environmental Protective Measures)	N/A	N/A	No project environmental protective measures occur in San Francisco Bay and San Pablo Bay, and no impacts on Central California Coast Steelhead would occur.	Less than Significant	None Required
Green Sturgeon	Immigrating Adults and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, except during September and November when flows are lower under Refined Alternative 2b. Reductions occur during higher flow conditions.	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on Green Sturgeon habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required
Green Sturgeon	Juvenile	Daily Salvage Loss Density	Green Sturgeon salvage is low and is similar under both scenarios.	Table 5.3-19	Modeling suggests Green Sturgeon salvage would be expected to be similar under both scenarios.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Green Sturgeon	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under Proposed Project's expanded July-November water transfer window but entrainment is limited and would be kept below protective level from NMFS ROC LTO BiOp.	Less than Significant	None Required
Green Sturgeon	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Little potential for effects because of poor hearing ability and upstream migrating adults would be able to swim beneath the barrier.	Less than Significant	None Required
Green Sturgeon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	None Required
Green Sturgeon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
White Sturgeon	Immigrating Adults and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under Refined Alternative 2b. Reductions occur during higher flow conditions and during April and May.	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on White Sturgeon habitat attributes. Reductions in Delta outflow in April/May have the potential to reduce year-class strength based on observed correlations, although there is uncertainty in the mechanism and differences would be expected to be small relative to variability in estimates that may reflect hydrological conditions as opposed to operations. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%, and for Delta outflow in April/May is approximately 40-50%.	Less than Significant	None Required
White Sturgeon	Juvenile	Daily Salvage Loss Density	White Sturgeon salvage is low and is similar under both scenarios.	Table 5.3-20	White Sturgeon salvage is low and is similar under both scenarios.	Less than Significant	None Required
White Sturgeon	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under Proposed Project's expanded July-November water transfer window but entrainment is low and so any effects expected to be limited.	Less than Significant	None Required
White Sturgeon	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Little potential for effects because of poor hearing ability and upstream migrating adults would be able to swim beneath the barrier.	Less than Significant	None Required
White Sturgeon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
White Sturgeon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
Pacific Lamprey and River Lamprey	Immigrating Adults, Ammocoetes, and Migrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under Refined Alternative 2b. Reductions occur during higher flow conditions.	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on lamprey habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required
Pacific Lamprey and River Lamprey	Juvenile	Daily Salvage Loss Density	Lamprey salvage is similar under both scenarios.	Table 5.3-21	Modeling suggests lamprey salvage would be similar under both scenarios. Real-time OMR management for other listed species, particularly first flush protections for Delta Smelt, may incidentally limit lamprey salvage. Actions to improve survival in the CCF including aquatic weed control and continued evaluation of predator reduction in the CCF, could limit pre-screen loss. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Expansion of the water transfer window to include July to November would have limited potential to increase lamprey salvage based on historical patterns in salvage density.	Less than Significant	None Required
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Little potential for effects because of poor hearing ability.	Less than Significant	None Required
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Native Minnows	Native Minnow Residence	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under Refined Alternative 2b. Reductions occur during higher flow conditions	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident native minnow habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required
Native Minnows	Splittail Spawning	Flow Analysis	Similar flow conditions at Freeport during the native minnow spawning periods.	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flows would not result in substantial long-term impacts on native minnow spawning habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 30-60%.	Less than Significant	None Required
Native Minnows	Hardhead Spawning	Flow Analysis	Similar flow conditions at Freeport during the native minnow spawning periods.	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flows would not result in substantial long-term impacts on native minnow spawning habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 30-60%.	Less than Significant	None Required
Native Minnows	Central California Roach Spawning	Flow Analysis	Similar flow conditions at Freeport during the native minnow spawning periods.	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flows would not result in substantial long-term impacts on native minnow spawning habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 30-60%.	Less than Significant	None Required
Native Minnows	Juvenile	Splittail Salvage Loss Density	Increases in entrainment of Sacramento Splittail could occur under Refined Alternative 2b.	Table 5.3-22	Although modeling suggests salvage could be higher under Refined Alternative 2b, the main driver of Sacramento Splittail population dynamics appears to be inundation of floodplain habitat, such as the Yolo Bypass, which would not change. Sacramento Splittail may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in Refined Alternative 2b that would be implemented to protect listed salmonids and smelts. Actions to improve survival in the CCF including aquatic weed control and continued evaluation of predator reduction in CCF, would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	None Required
Native Minnows	Juvenile	Hardhead Salvage Loss Density	Hardhead salvage is similar under both scenarios and is low.	Table 5.3-23	Modeling suggests similar and low salvage loss would not be expected to substantially affect Hardhead.	Less than Significant	None Required
Native Minnows	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under Proposed Project's expanded July-November water transfer window for Splittail (but not Hardhead), but entrainment is not a driver of population dynamics and so any effects expected to be limited.	Less than Significant	None Required
Native Minnows	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Potential reduced juvenile Splittail entry into interior Delta via Georgiana Slough; upstream migrating Splittail adults would be able to swim beneath the barrier.	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Native Minnows	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required
Native Minnows	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	None Required
Striped Bass	Immigrating and Spawning Adults, Rearing and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, particularly during the immigration, spawning, and larvae dispersal period (April through June). Less Delta outflow (greater fall X2) in fall following wet years; greater fall outflow (lower fall X2) in fall following above-normal years.	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on Striped Bass. Differences in young-of-the-year abundance as a result of differences in fall Delta outflow/X2 may result in potentially limited population-level impacts because of density dependence later in the life cycle. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required
Striped Bass	Juvenile Entrainment	Entrainment Loss Density	Similar salvage of juvenile Striped Bass under both scenarios.	Table 5.3-24	Modeling suggests similar and low salvage loss would not be expected to substantially affect Striped Bass. Potential for greater entrainment loss of early life stages (eggs/larvae) during spring may be limited by ancillary protection for listed salmonids and smelts, with limited population-level impacts because of density dependence later in the life cycle.	Less than Significant	None Required
Striped Bass	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under expanded July-November water transfer window, but limited population-level impacts because of density dependence later in the life cycle.	Less than Significant	None Required
Striped Bass	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Upstream migrants would be able to swim beneath the barrier.	Less than Significant	None Required
Striped Bass	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required
Striped Bass	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
American Shad	Immigrating and Spawning Adults	Flow Analysis	Similar flow conditions at Freeport during most months of the year, particularly during the immigration, spawning, and larvae dispersal period (April through June)	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on American Shad. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	None Required
American Shad	Juvenile Entrainment	Entrainment Loss Density	Generally similar salvage of juvenile American Shad under the both scenarios.	Table 5.3-25	Modeling suggests similar salvage loss would not be expected to result in substantial impacts on American Shad under Refined Alternative 2b. Loss of earlier life stages may be limited because most early rearing is upstream of the Delta, and there may be ancillary protection from OMR management for listed fish in spring.	Less than Significant	None Required
American Shad	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under expanded July-November water transfer window but limited because of upstream rearing and low spatial overlap with south Delta.	Less than Significant	None Required
American Shad	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Upstream migrants would be able to swim beneath the barrier.	Less than Significant	None Required
American Shad	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required
American Shad	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	None Required
Non-Native Freshwater Bass	Resident Adults and Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under Refined Alternative 2b. Reductions occur during higher flow conditions	Figures 5.3-46 - 5.3-51; Table 5.3-13	Modeling suggests similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident non-native freshwater bass habitat attributes This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%	Less than Significant	None Required
Non-Native Freshwater Bass	Juvenile Entrainment	Entrainment Loss Density	The salvage-density method suggested the potential for entrainment to be similar under both scenarios	Table 5.3-26 – 5.3-28	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less than Significant	None Required
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Water Transfers	N/A	N/A	Potential for increased entrainment under expanded July-November water transfer window, but limited effect because main period of entrainment of main species (Largemouth Bass) is in summer (i.e., outside the expanded period).	Less than Significant	None Required
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Georgiana Slough Behavioral Modification Barrier	N/A	N/A	Limited potential for effect because of largely resident nature, but migrants would be able to swim beneath the barrier.	Less than Significant	None Required
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Annual O&M Activities	N/A	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	None Required

Species	Life Stage	Analytical Component	Model Results	Exhibit Number	Analytical Discussion	Impact Conclusion	Mitigation Required under CEQA
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (See Table 3-3)	N/A	N/A	Because impacts on Fall-run and Late Fall-run Chinook Salmon are less than significant, impacts on killer whales resulting from prey reductions would be minimal	Less than Significant	None Required
Killer Whale	All Life Stages	Food Source Discussion	See model results for Fall-run and Late Fall-run Chinook Salmon	See exhibits for Fall-run and Late Fall-run Chinook Salmon	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.	Less Than Significant	None Required

Notes:
BMPs = best management practices
CCF = Clifton Court Forebay
CDFW = California Department of Fish and Wildlife
cfs = cubic feet per second
CVP = Central Valley Project
DCC = Delta Cross Channel
Delta = Sacramento–San Joaquin Delta
DPM = Delta Passage Model
DSM2 = Delta Simulation Model II
DWR = California Department of Water Resources
EDSM = Enhanced Delta Smelt Monitoring
ESU = Evolutionary Significant Unit
FCCL = Fish Conservation and Culture Laboratory
ft/sec = foot per second
HOR = Head of Old River
LCM = USFWS Life Cycle Model
LSZ = low salinity zone
N/A = not applicable
O&M = operations and maintenance
OMR = Old and Middle River
PTM = Particle Tracking Modeling
QWEST = Net flow on the San-Joaquin River at Jersey Point
SAIL = Salmon and Sturgeon Assessment of Indicators by Life Stage
SCHISM = Semi-implicit Cross-scale Hydroscience Integrated System Model
SDM = Structured Decision Model
SLS = Smelt Larval Survey
SMSCG = Suisun Marsh Salinity Control Gates
STARS = Survival, Travel Time, and Routing Simulation
SWP = State Water Project
TAF = thousand acre feet
USFWS = United States Fish and Wildlife Service
WY = water year

~~The differences in surface water quality and hydrology estimated for Alternative 2b when compared to Existing Conditions and the Proposed Project are largely driven by the changes in Delta outflow described in Section 5.3.1 above, which consistent with Alternative 2a result in differences between Delta outflow and Old and Middle River flows in April and May (Tables 5.2-3, 5.2-4, 5.2-5 and 5.2-6), as well as differences in Delta outflow in summer (June–September, initially focusing on August of wet and above normal years). Table 5.3-1 provides a qualitative summary of the main operations-related effects by analytical component to illustrate the similarities and differences between the Proposed Project and Alternative 2b. The differences between Alternative 2b and the Proposed Project are dependent on whether the analytical components overlap the April–May period or June–September (initially focusing on August) periods when outflow would be increased compared to the Proposed Project. The main analytical components for which differences are expected, by species/life stage, include: Delta Smelt—potential effects on larvae from less Eurytemora affinis prey, changes to silverside predation, and greater south Delta entrainment, and potential effects on juveniles from changes in Pseudodiaptomus forbesi prey availability and summer-fall habitat; Longfin Smelt—potential effects on abundance from less Delta outflow and on juveniles from greater south Delta entrainment; Winter-run Chinook Salmon—potentially greater juvenile south Delta entrainment during spring overlap; Spring-run Chinook Salmon—potentially greater juvenile south Delta entrainment and lower through-Delta survival; Fall-run and Late fall-run Chinook Salmon—potentially greater juvenile south Delta entrainment lower through-Delta survival; Central Valley Steelhead—potentially greater juvenile south Delta entrainment; White Sturgeon—potential effects on year-class strength from less Delta outflow; Pacific and River Lamprey—potentially greater juvenile south Delta entrainment; Sacramento Splittail—potentially greater juvenile south Delta entrainment; Striped Bass—potentially greater juvenile south Delta entrainment; American Shad—potentially greater juvenile south Delta entrainment; and Largemouth Bass—potentially greater juvenile south Delta entrainment. The extent of the difference between Alternative 2b and Existing Conditions would be less than the extent of difference between the Proposed Project and Existing Conditions, and the impact conclusions for all impacts remain less than significant. Table 5.3-1 summarizes the main differences that may be expected to occur under Alternative 2b when compared with Existing Conditions, with rationale based on the context provided by the analyses comparing the Proposed Project to Existing Conditions. In contrast to Alternative 2a, the cumulative impacts of Alternative 2b would not include an increase in CVP water diversions, and entrainment at CVP facilities. As shown in Table 5.3-1, the effects of Alternative 2b would be less than significant for all analyzed aquatic resources, the same as the impact conclusions for the Proposed Project.~~ Delta Smelt

Operations-Related Impacts

Adults to Eggs and Larvae (December-May)

Predation

As previously noted in the analysis for the Proposed Project, the IEP MAST (2015) conceptual model identifies predation risk as a habitat attribute affecting Delta Smelt egg survival, with flows interacting with erodible sediment supply to affect turbidity. In general, greater turbidity is thought to lower the risk of predation on Delta Smelt (Bennett 2005, Moyle et al 2016). Large amounts of sediment enter the Delta from winter and spring storm runoff, with resuspension by tidal and wind action (Schoellhamer et al. 2014; Bever et al. 2018b). Cloern et al. (2011) identified a relationship between suspended sediment in the Sacramento River at Rio Vista and flows in the Sacramento River at Freeport and through Yolo Bypass. Because simulated flows at Rio Vista under Refined Alternative 2b and Existing Conditions scenarios generally are similar (Figure 5.3-8 to Figure 5.3-13), suspended sediment entering the Delta is not expected to be affected. Therefore, predation risk under Refined Alternative 2b and Existing Conditions scenarios is expected to be similar.

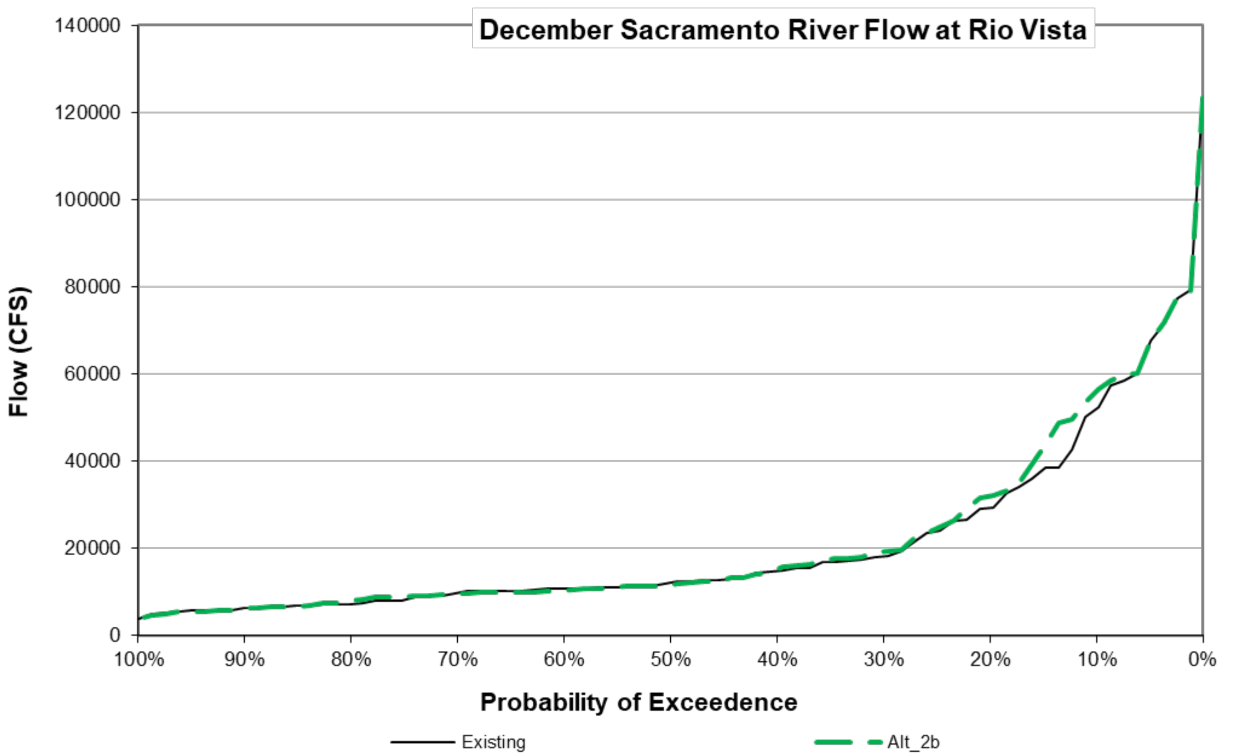


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Figure 5.3-8. Mean Modeled Sacramento River Flow at Rio Vista, December

As previously noted in the analysis for the Proposed Project, available estimates of sediment removal by the south Delta export facilities are low, i.e., ~2% of sediment entering the Delta at Freeport in 1999–2002 (Wright and Schoellhamer 2005). Given the limited expected difference in suspended sediment entering the Delta under Refined Alternative 2b and Existing Conditions scenarios (as suggested by Rio Vista flows discussed above), as well as the small percentage of sediment that would be expected to be removed by the south Delta export facilities, the potential impact of Refined Alternative 2b on turbidity generally would be expected to be low. Per the MAST conceptual model, high turbidity is correlated with low predation risk for Delta Smelt, which suggests that predation risk under both scenarios would be similar. However, there is uncertainty in this conclusion given the complexity of sedimentation mechanisms in the Delta (Schoellhamer et al. 2012, their Figure 7), and the fact that quantitative analyses of the impacts of exports on predation risk and turbidity have not been conducted (IEP MAST 2015, p.52).

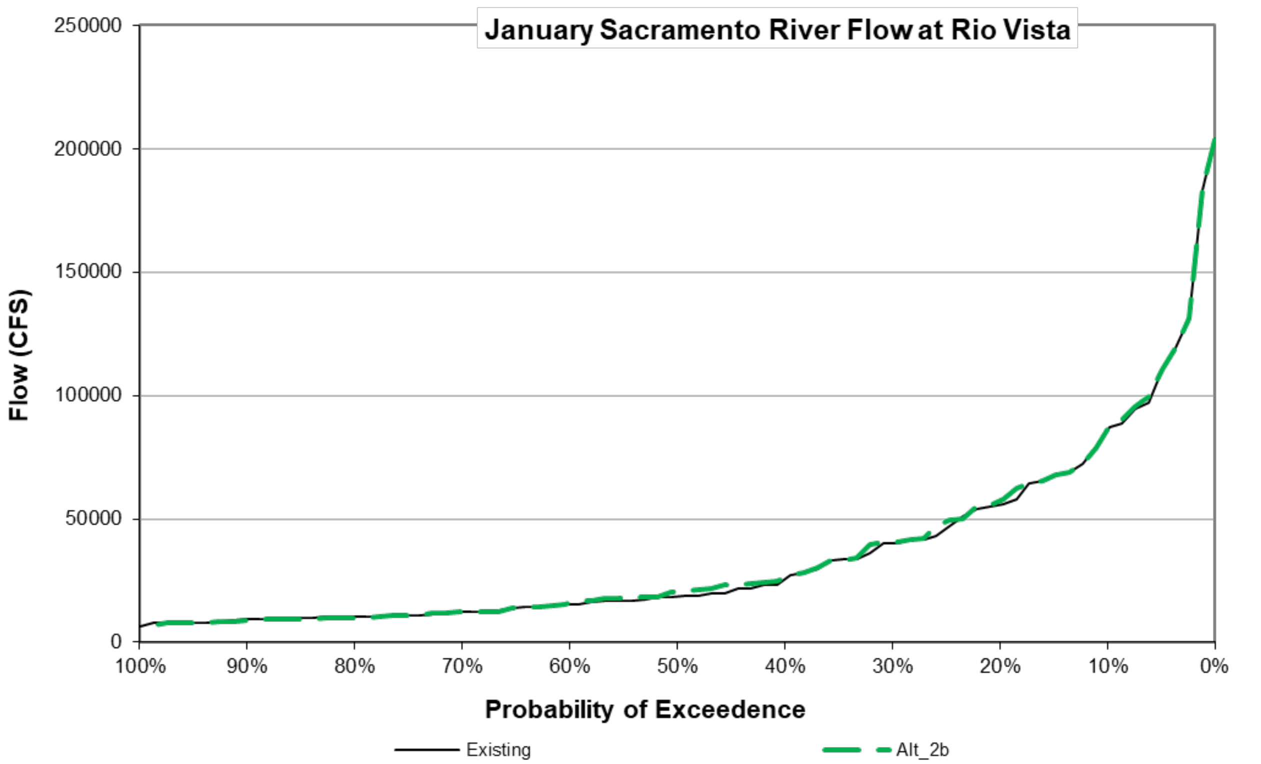

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Figure 5.3-9. Mean Modeled Sacramento River Flow at Rio Vista, January

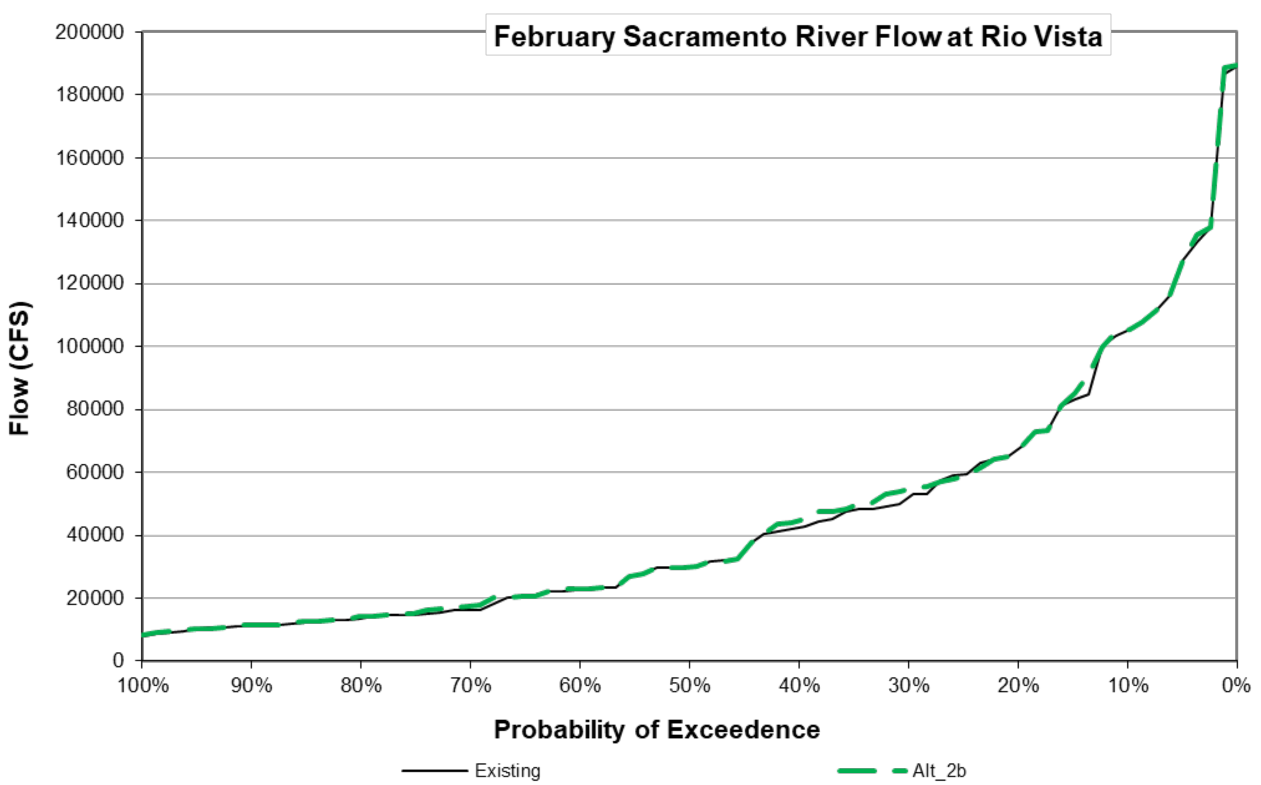

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Figure 5.3-10. Mean Modeled Sacramento River Flow at Rio Vista, February

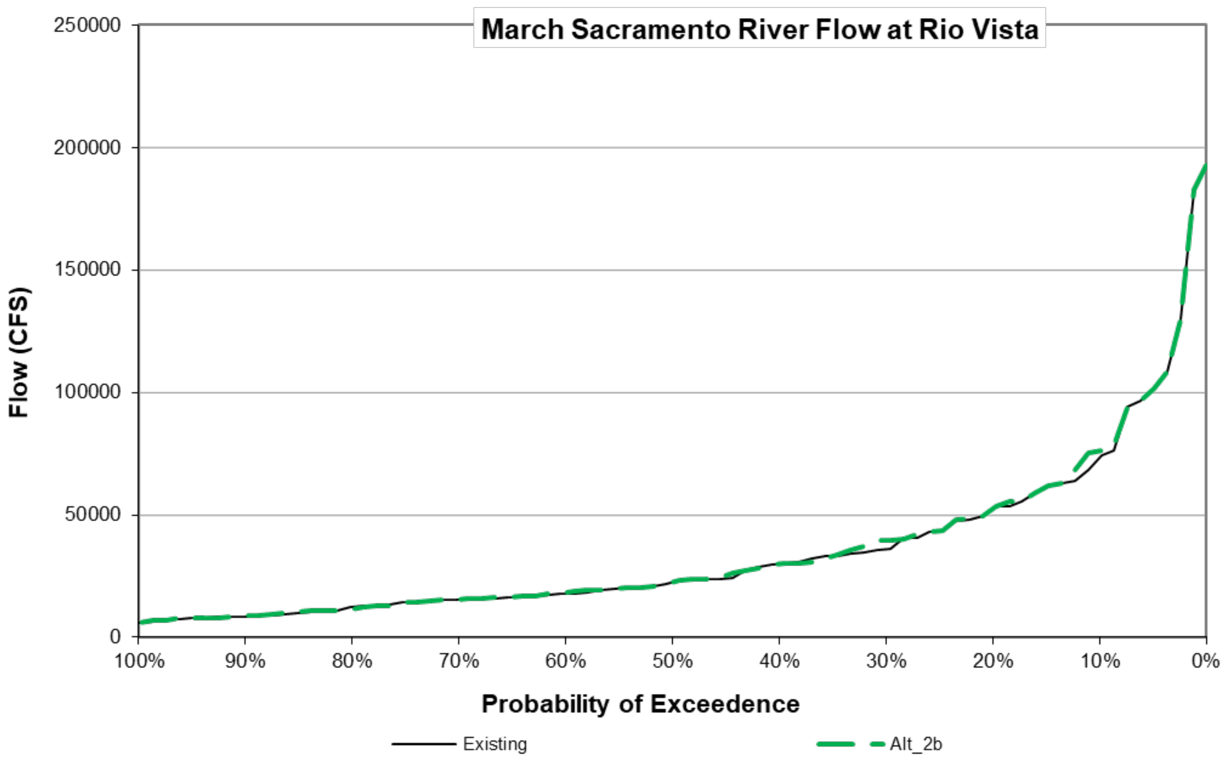

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Figure 5.3-11. Mean Modeled Sacramento River Flow at Rio Vista, March

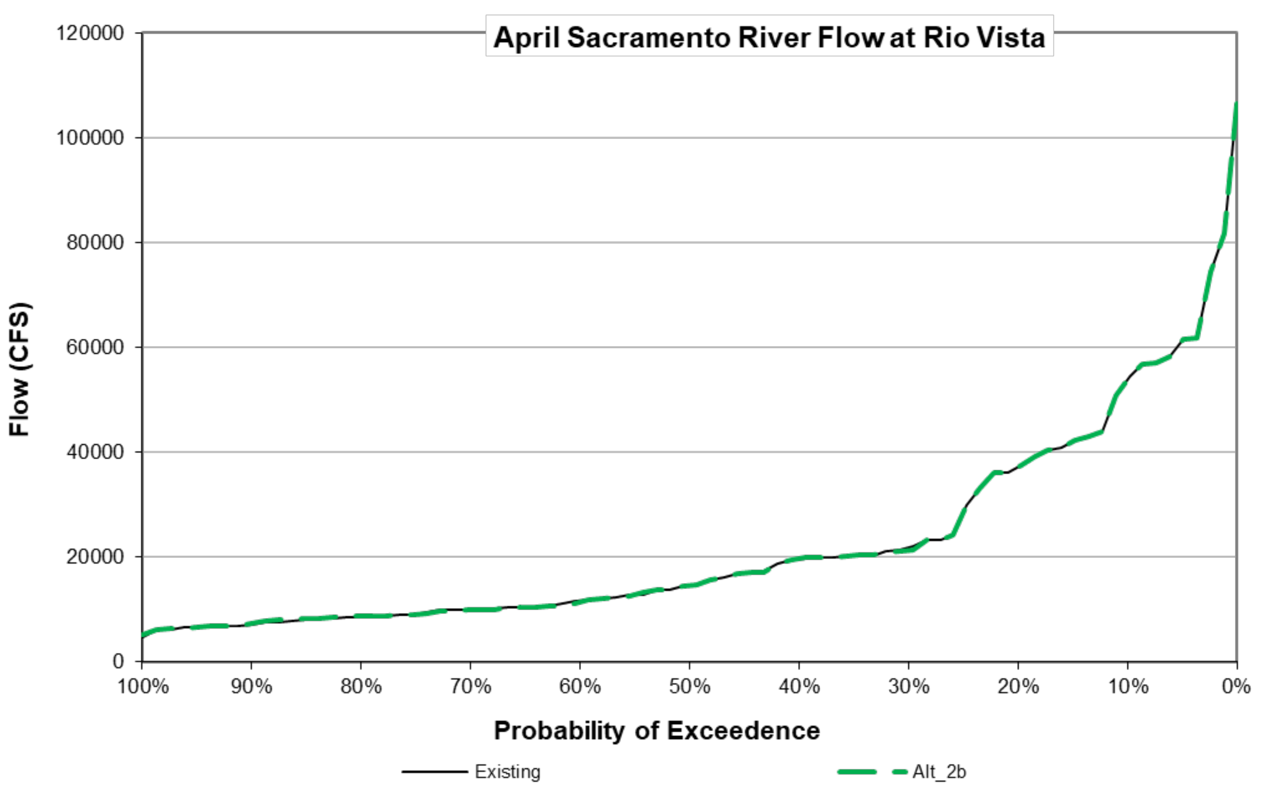

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Figure 5.3-12. Mean Modeled Sacramento River Flow at Rio Vista, April

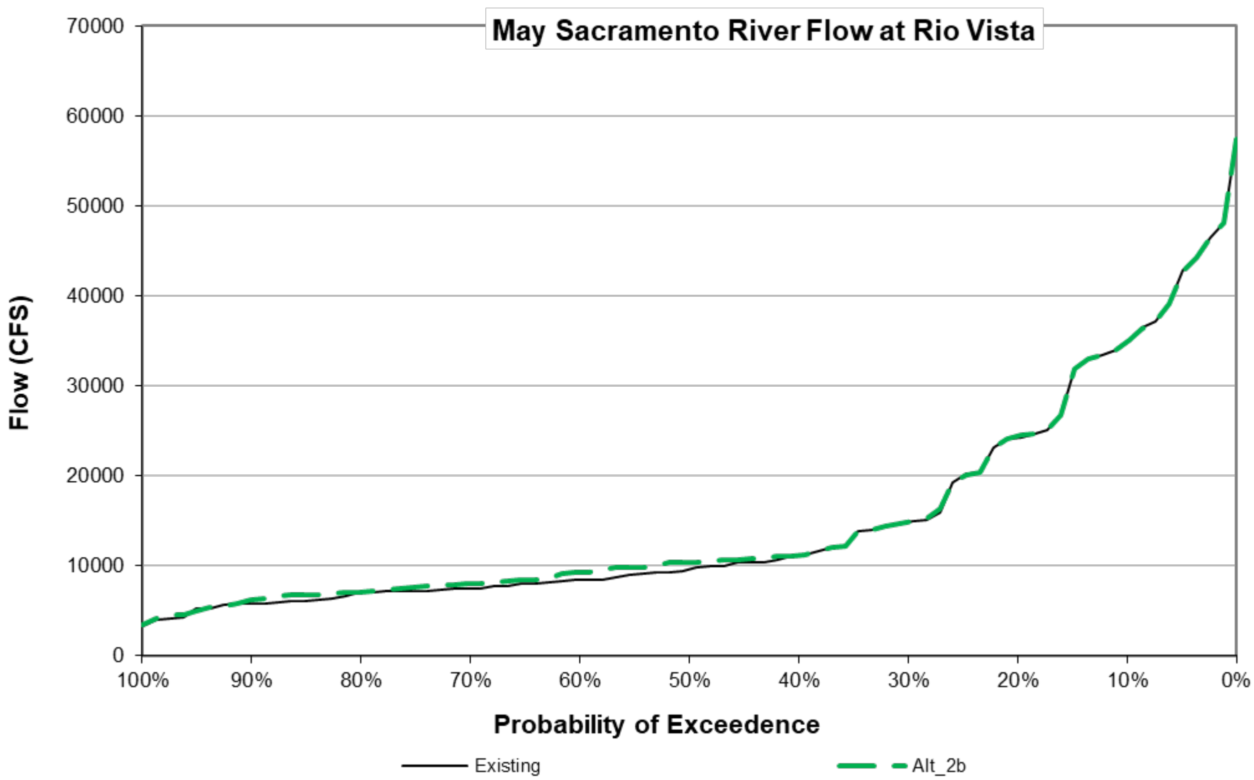

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Figure 5.3-13. Mean Modeled Sacramento River Flow at Rio Vista, May

The potential impacts on Delta Smelt adult predation as a function of Rio Vista flows reflect combined SWP and CVP operations. During December–May, the SWP would be responsible for around 20–60% of Delta water operations under Refined Alternative 2b, depending on water year type and month (see Appendix H).

Food Availability

As previously noted in the analysis for the Proposed Project, food availability is posited by the IEP MAST (2015) conceptual model to affect the probability of Delta Smelt adults spawning and transitioning to egg/larval production, and inundation of the Yolo Bypass could increase food web productivity and benefit growth and survival of Delta Smelt adults occurring downstream of the Yolo Bypass (DWR and Reclamation 2017, p.8-111 to p.8-112). Delta Smelt food sources and availability likely vary by region and the proportion of Delta Smelt food availability originating in the Yolo Bypass is unclear. Therefore, the analysis of Yolo Bypass inundation and resulting impacts of food availability for Delta Smelt is uncertain. Nonetheless, modeling suggests that there would be little difference in flow through the Yolo Bypass between the Refined Alternative 2b and Existing Conditions scenarios (Figure 5.3-14 to Figure 5.3-19), suggesting that food availability would also be similar.

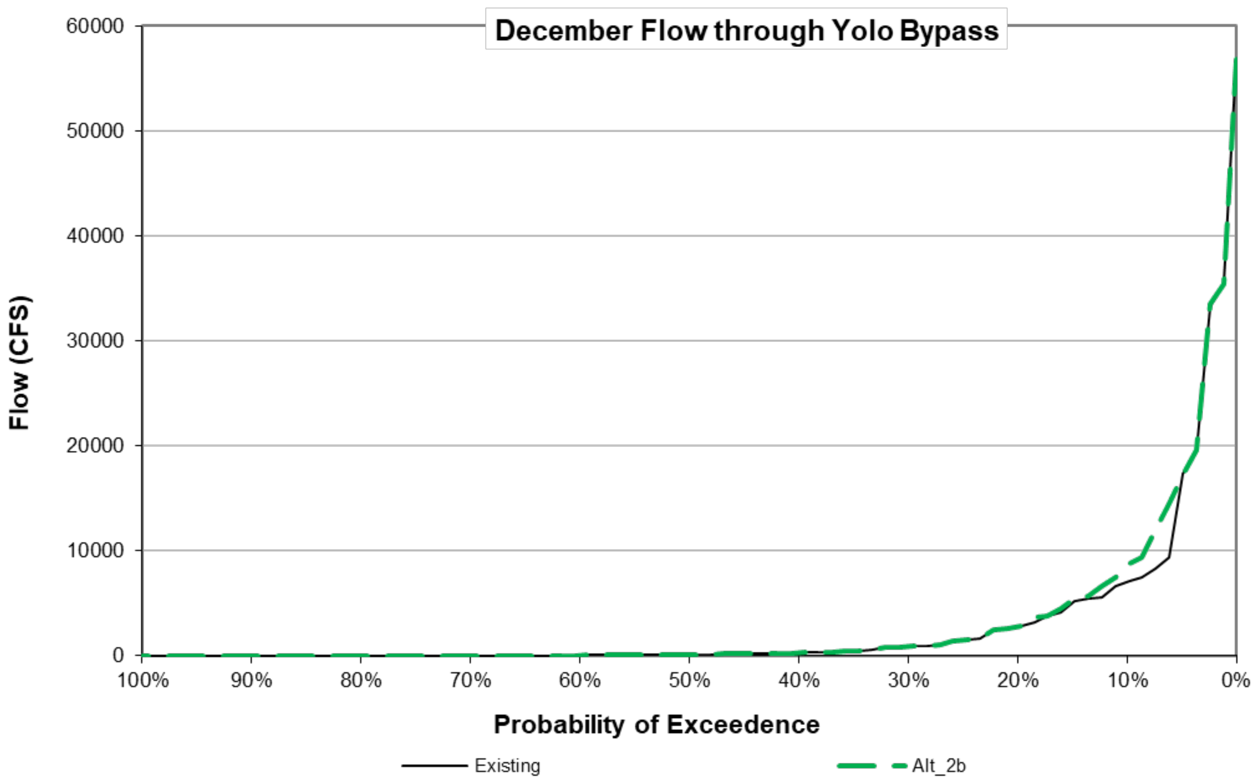

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Figure 5.3-14. Mean Modeled Flow Through Yolo Bypass, December

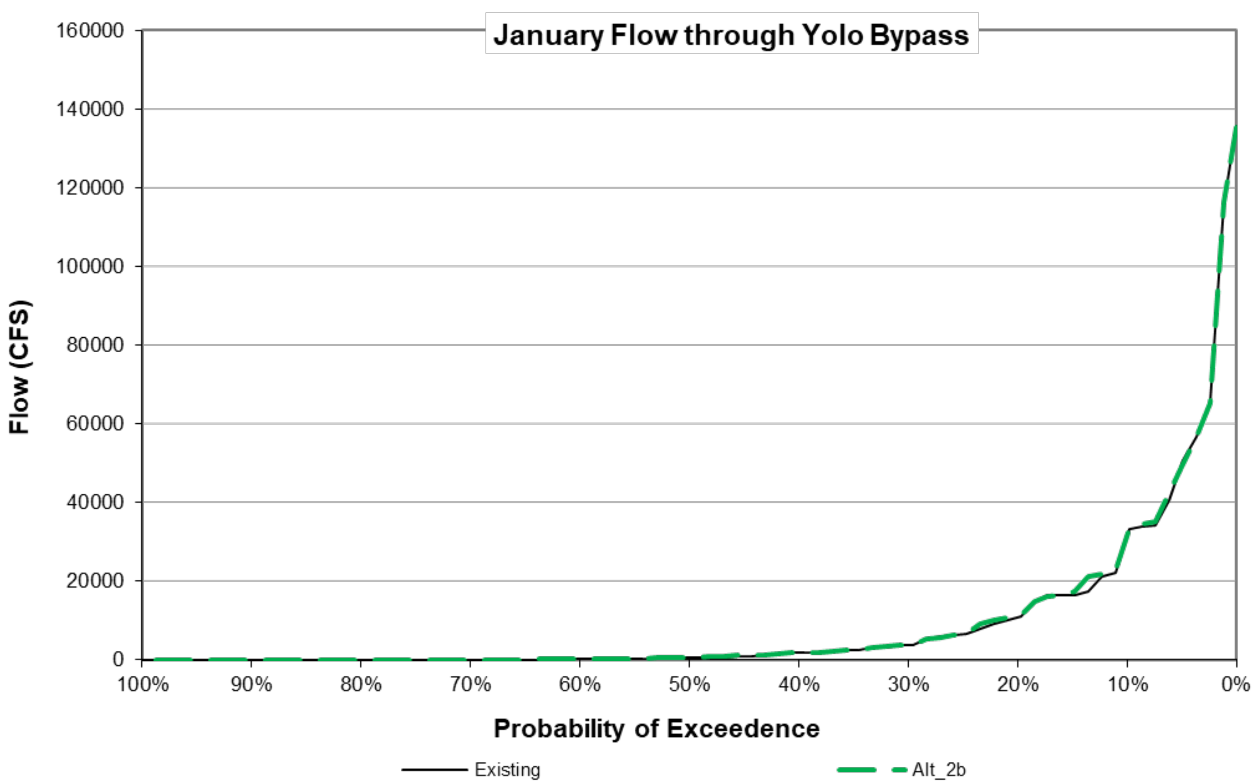

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Figure 5.3-15. Mean Modeled Flow Through Yolo Bypass, January

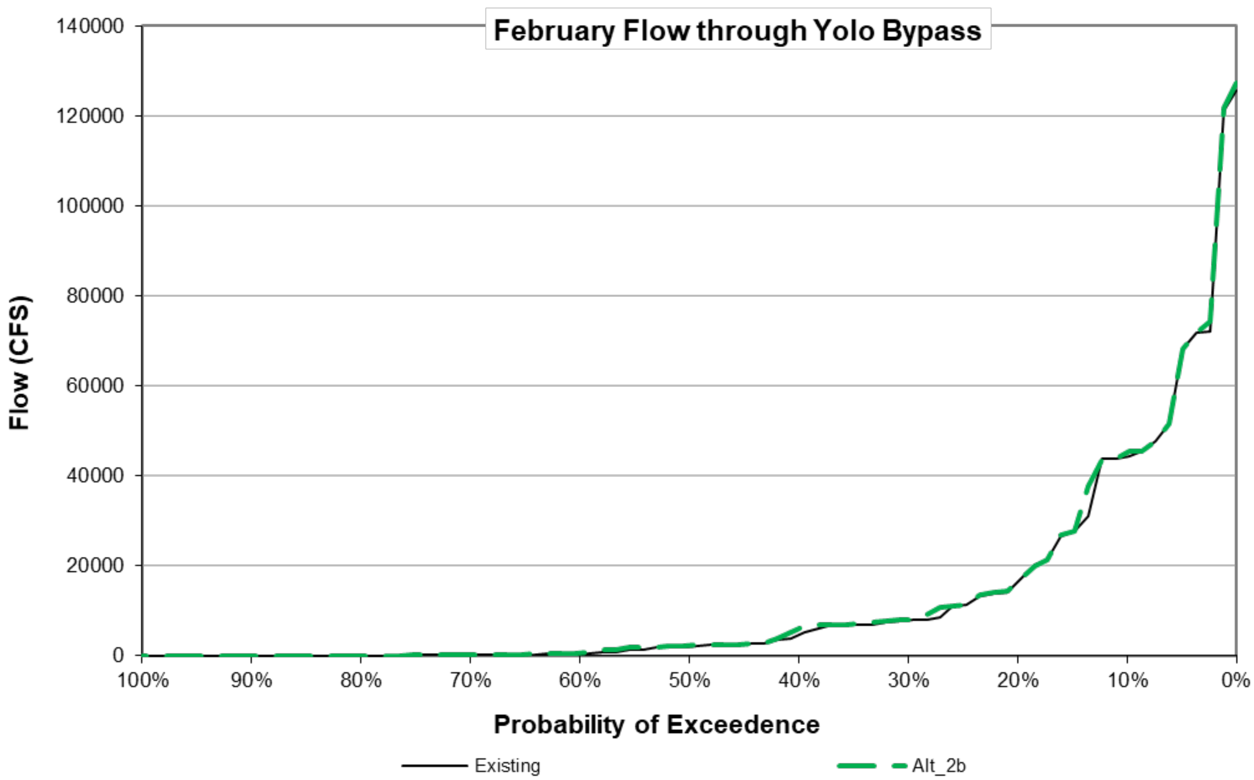

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Figure 5.3-16. Mean Modeled Flow Through Yolo Bypass, February

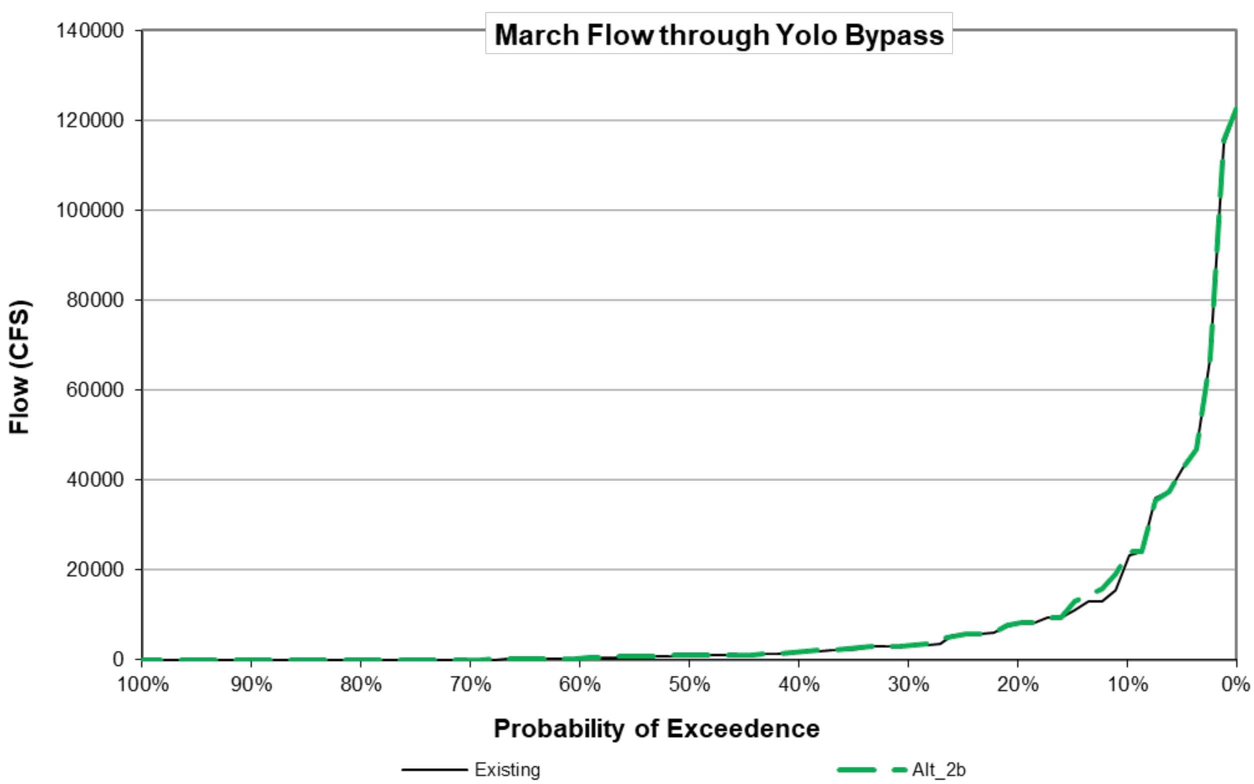

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Figure 5.3-17. Mean Modeled Flow Through Yolo Bypass, March

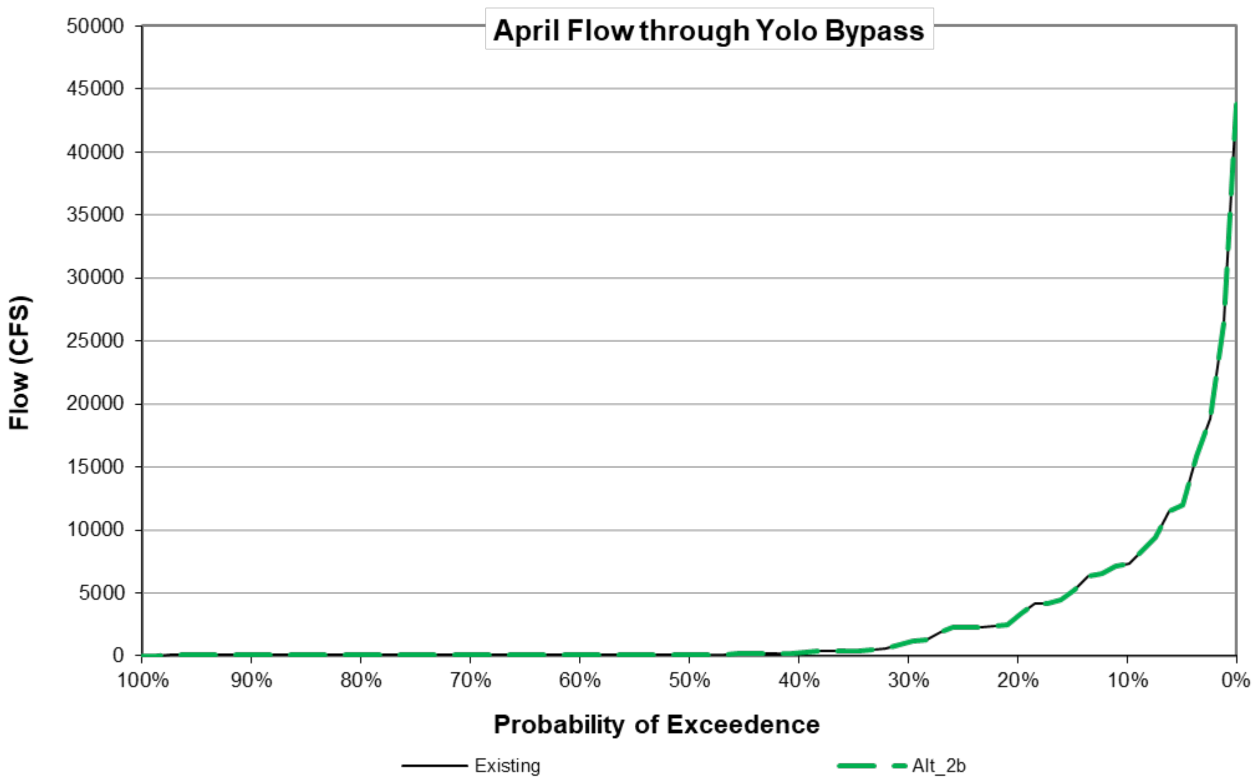

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Figure 5.3-18. Mean Modeled Flow Through Yolo Bypass, April

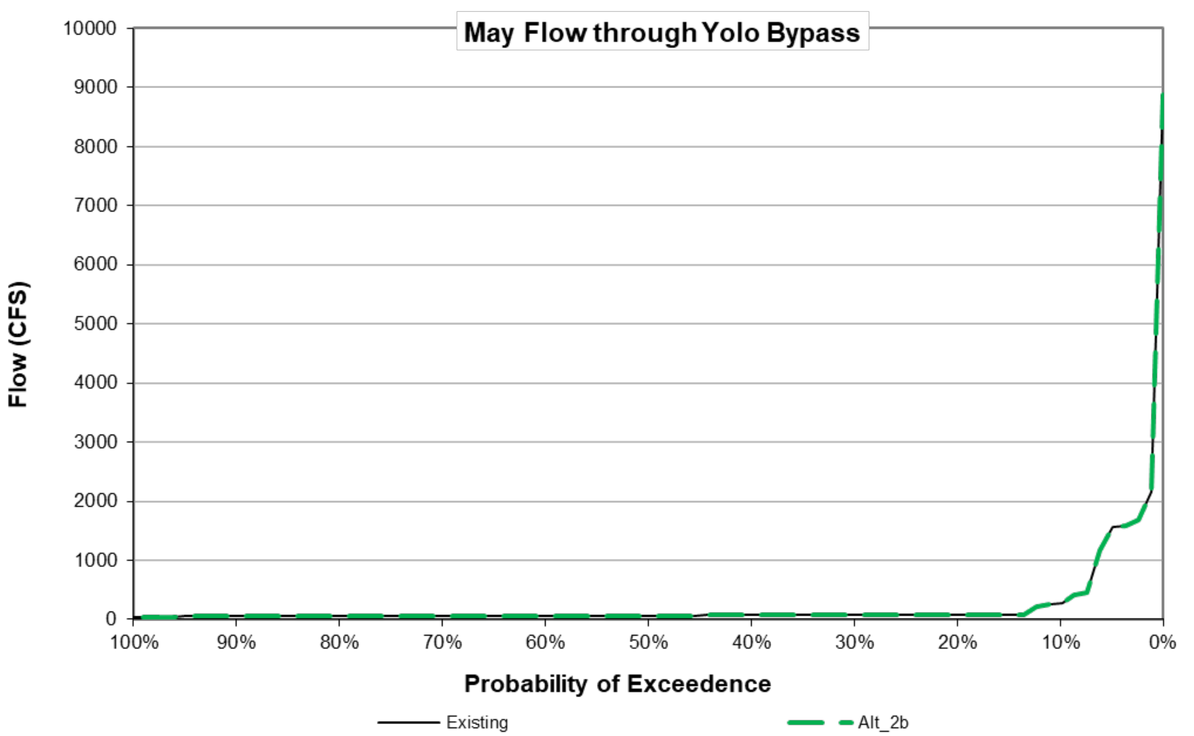

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Figure 5.3-19. Mean Modeled Flow Through Yolo Bypass, May

Eggs and Larvae to Juveniles (March June)

Food Availability

As previously noted in the analysis for the Proposed Project, the IEP MAST (2015) conceptual model suggests that south Delta exports could affect food availability for larval Delta Smelt. The mechanism for the impacts of south Delta exports on food availability could be related to hydrodynamic impacts of Delta outflow because a positive correlation between the density of the important Delta Smelt larval/juvenile zooplankton prey *Eurytemora affinis* in the low salinity zone and Delta outflow (as indexed by X2) during the spring (March–May; Kimmerer 2002a, Greenwood 2018). As shown in Figure 5.3-2~~1~~0, simulated Delta outflow is lower under Refined Alternative 2b than the Existing Conditions scenario in April and May, and X2 would be greater (i.e., further upstream). Therefore, food availability for larval Delta Smelt in April and May could be lower under Refined Alternative 2b.

Consistent with analysis of the Proposed Project, to illustrate the magnitude of potential impact, a regression of March–May X2 versus *E. affinis* density in the low salinity zone was used to compare the Existing Conditions and Refined Alternative 2b scenarios (see methods description in Appendix E). This analysis suggested that there is appreciable uncertainty in the predictions of *E. affinis* density as a function of X2, with 95% prediction intervals spanning several orders of magnitude (Figure 5.3-2~~2~~1). The difference between Refined Alternative 2b and Existing Conditions scenarios in mean estimates of *E. affinis* was small, approximately 2% to 4% (Table 5.3-6). Overall, although this suggests that while there may be the potential for *E. affinis* density in the low salinity zone to be less under Refined Alternative 2b than under the Existing Conditions scenario, this is uncertain, and the predicted mean difference is small.

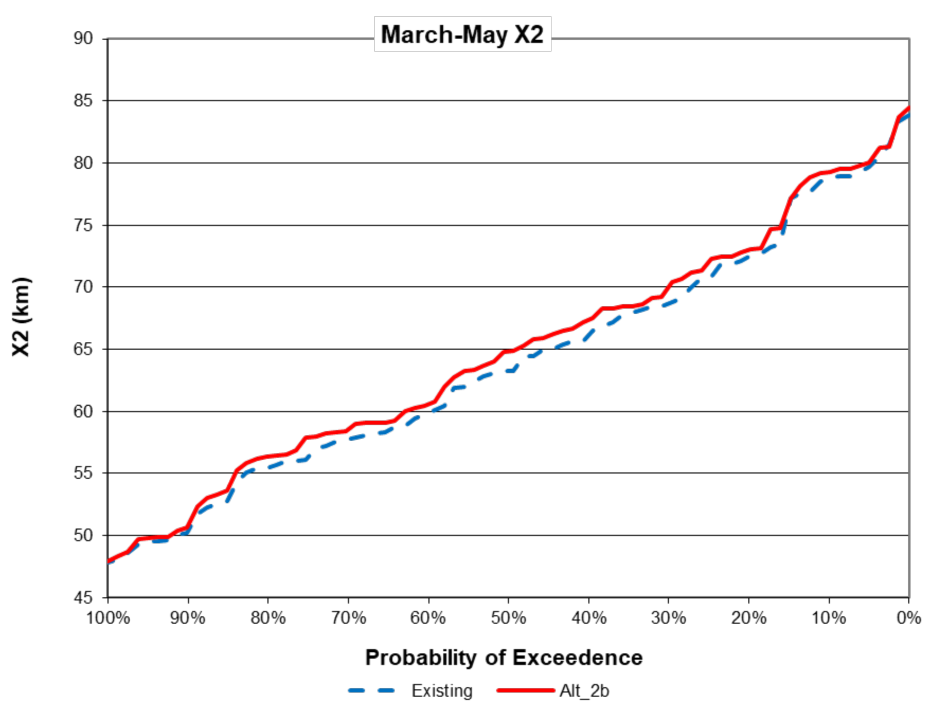

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Figure 5.3-20. Mean Modeled X2, March–May

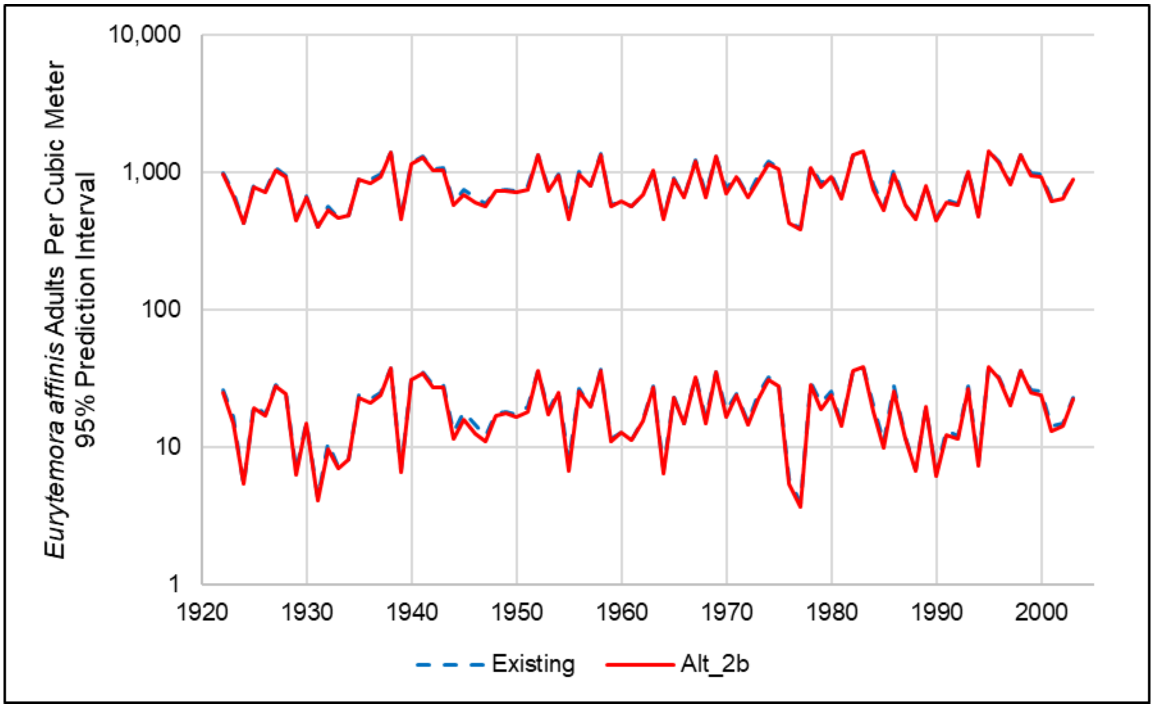

Figure 5.3-21. *Eurytemora affinis* Density in the Low-Salinity Zone 95% Prediction Interval, for the 1922-2003 Modeled Period

Table 5.3-6. Mean Annual Predicted *Eurytemora affinis* Density in the Low Salinity Zone under Refined Alternative 2b and Existing Conditions Modeling Scenarios, and Differences between the Scenarios Expressed as a Numerical Difference and Percentage Difference (parentheses), Grouped by Water Year Type

Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
Wet	204	199	-5 (-2%)
Above Normal	177	171	-6 (-3%)
Below Normal	136	130	-6 (-4%)
Dry	112	108	-3 (-3%)
Critical	82	80	-1 (-2%)

These potential impacts on *E. affinis* as a function of X2 reflect combined SWP and CVP operations from March through May, the period of potential impacts on *E. affinis*. The SWP would be responsible for around 20 to 60% of Delta water operations under Refined Alternative 2b, depending on water year type and month (see Appendix H).

Predation

As previously noted in the analysis for the Proposed Project, the IEP MAST conceptual model (2015) suggests that the probability of egg/larval Delta Smelt surviving to juveniles is influenced by predation risk, which may involve different factors such as turbidity, water temperature, and predators (silversides). SWP operations have limited potential to affect water temperature in the Delta (Wagner et al. 2011), and as discussed for adult Delta Smelt, turbidity would be similar under Refined

Alternative 2b and Existing Conditions scenarios (although this conclusion is uncertain because of the complexity of sedimentation mechanisms in the Delta), so predation risk associated with these factors would be expected to be similar under both Refined Alternative 2b and Existing Conditions.

As previously noted in the analysis for the Proposed Project, detection of predation on Delta Smelt embryos and larvae is rare, which reduces the certainty of any conclusions of analyses of predation, although silversides have been found with Delta Smelt in their guts during the larval period (Schreier et al. 2016). Evaluation of silversides is conducted using multivariate relationships identified by Mahardja et al. (2016) that showed summer (June–September) Delta inflow and spring (March–May) south Delta exports had the strongest correlations with silverside cohort strength. Both relationships were negative. Mahardja et al. (2016, p.12) cautioned that the relationships are not meant to imply causality, given that the mechanisms could not be identified, and that further investigation is merited. Nonetheless, March-May south Delta exports under Refined Alternative 2b are higher than the Existing Conditions scenario (Figure 5.3-22), which could correlate with lower silverside cohort strength under Refined Alternative 2b. However, June-September Delta inflow under Refined Alternative 2b is similar or slightly lower than under the Existing Conditions scenario (Figure 5.3-23), which could correlate with similar or somewhat higher silverside cohort strength. Because simulated exports and inflow suggest opposing impacts on silverside cohort strength under Refined Alternative 2b as well as the uncertainty in the strength of the relationships, the net impact of these changes is uncertain.

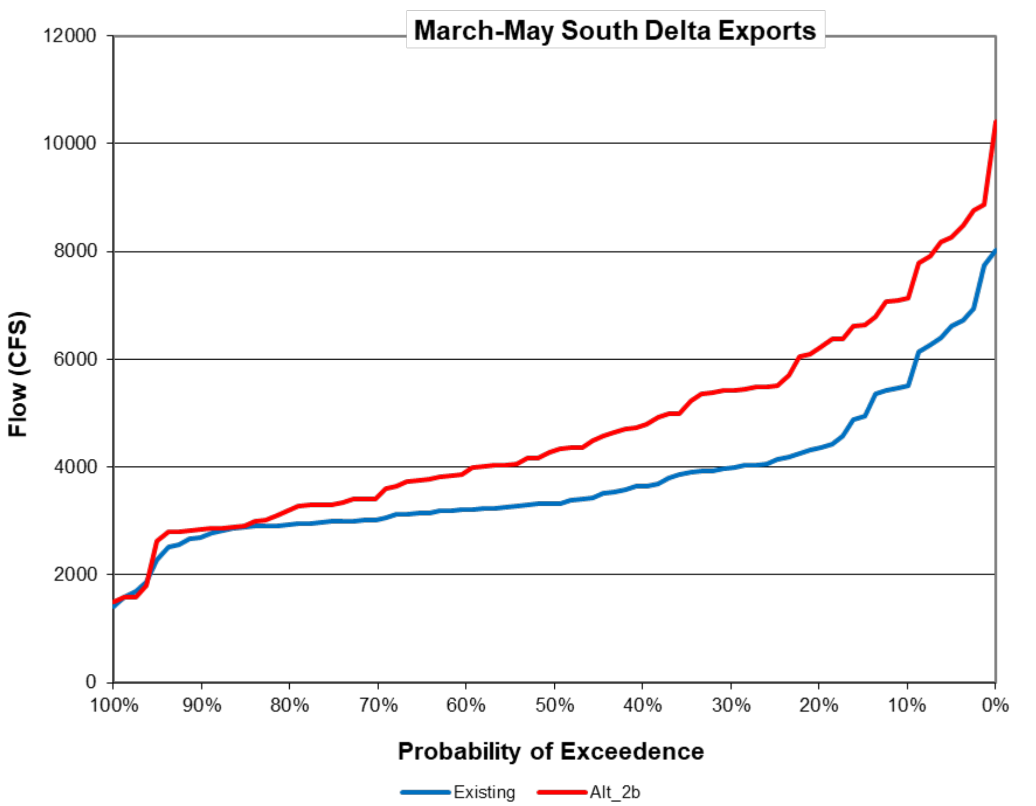

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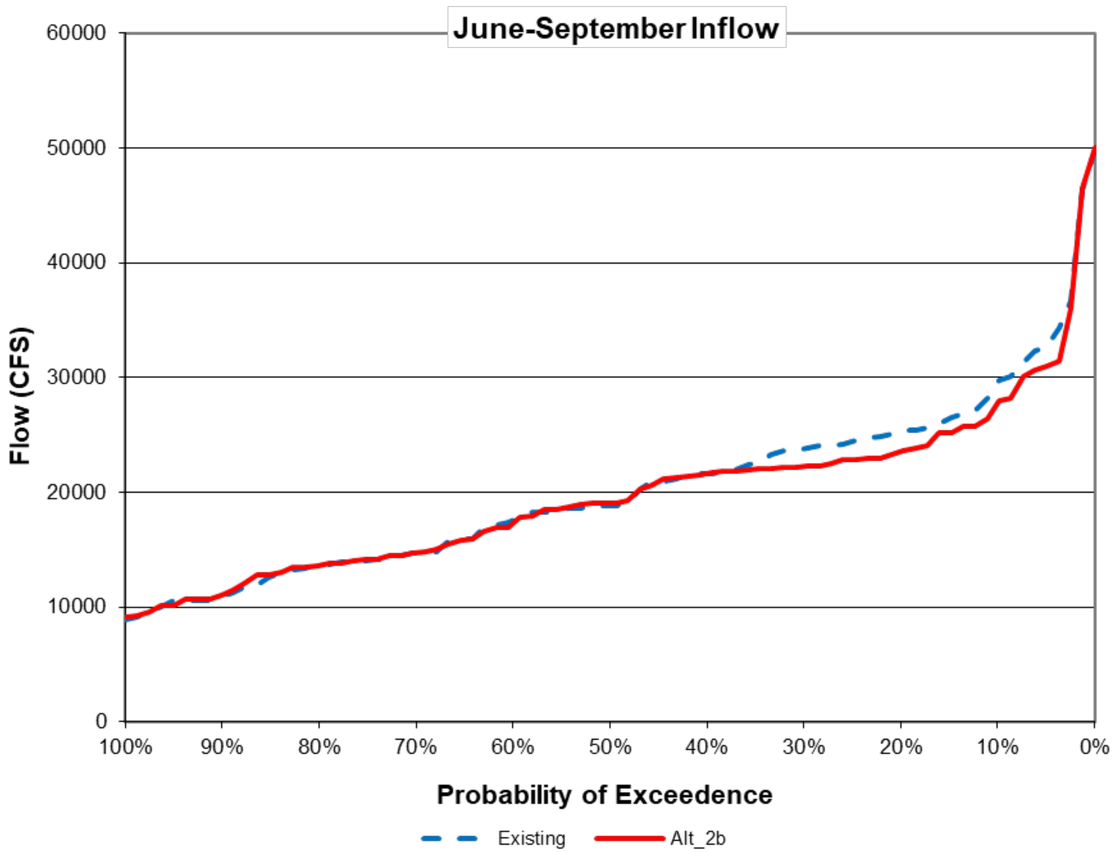
Figure 5.3-22. Mean Modeled South Delta Exports, March–May



Source: <DRAFT_TrendReport_ITP_BL_PP0819_PPALt2B0102.xlsm>.

Note: Delta inflow is represented by flow at Sacramento River at Freeport + through Yolo Bypass + Mokelumne River + San Joaquin River at Vernalis.

Figure 5.3-23. Mean Modeled Delta Inflow, June–September

The potential impacts on silversides and, therefore, Delta Smelt larval predation as a function of Delta inflow and south Delta exports reflect combined SWP and CVP operations. During March–May, the period of potential impacts on silversides from South Delta exports, the SWP would be responsible for around 20% to 60% of Delta water operations under Refined Alternative 2b, depending on water year type and month, whereas from June through September, the period correlated with potential inflow impacts on silversides, the SWP would be responsible for approximately 20% to 50% of Delta water operations (see Appendix H).

Juveniles to Subadults (June September)

Food Availability

As previously noted in the analysis for the Proposed Project, the IEP MAST (2015) conceptual model describes food availability and quality as key components of the June–September transition probability of juvenile Delta Smelt to subadulthood through growth and survival of individuals. Freshwater inflows influence the subsidy of the Delta Smelt zooplankton prey *Pseudodiaptomus forbesi* to the low salinity zone from the freshwater Delta (Kimmerer et al. 2018), with these potential negative impacts probably being of particular importance on the San Joaquin River side of the Delta given the high density of *P. forbesi* in the region (Kimmerer et al. 2019).

As previously noted in the analysis for the Proposed Project, South Delta exports may entrain *P. forbesi* (USFWS 2008, p.228; Kimmerer et al. 2019), resulting in a positive correlation between July–September Delta outflow and *P. forbesi* density in the low salinity zone (Kimmerer et al. 2018). July to September Delta outflow generally would be similar for Refined Alternative 2b and Existing Conditions scenarios, except for differences attributable to the inclusion of fall X2 criteria (beginning in September) under the Existing Conditions scenario, resulting in ~2,000-cfs difference between scenarios at ~5% to 30% exceedance (~10,500–11,500 cfs for the Existing Conditions scenario, and ~8,500–9,500 cfs for the Refined Alternative 2b scenario; Figure 5.3-24). Such differences, amounting to 50 cumecs—the unit used by Kimmerer et al. (2018)—would be predicted to result in *P. forbesi* density that is lower under Refined Alternative 2b than under the Existing Conditions scenario, although statistical uncertainty in the relationship is indicated by the 95% confidence interval on the regression (as shown in Panel B in Figure 4.4-25 in the analysis of the Proposed Project, in Chapter 4.4, Section 4.4.7.4).

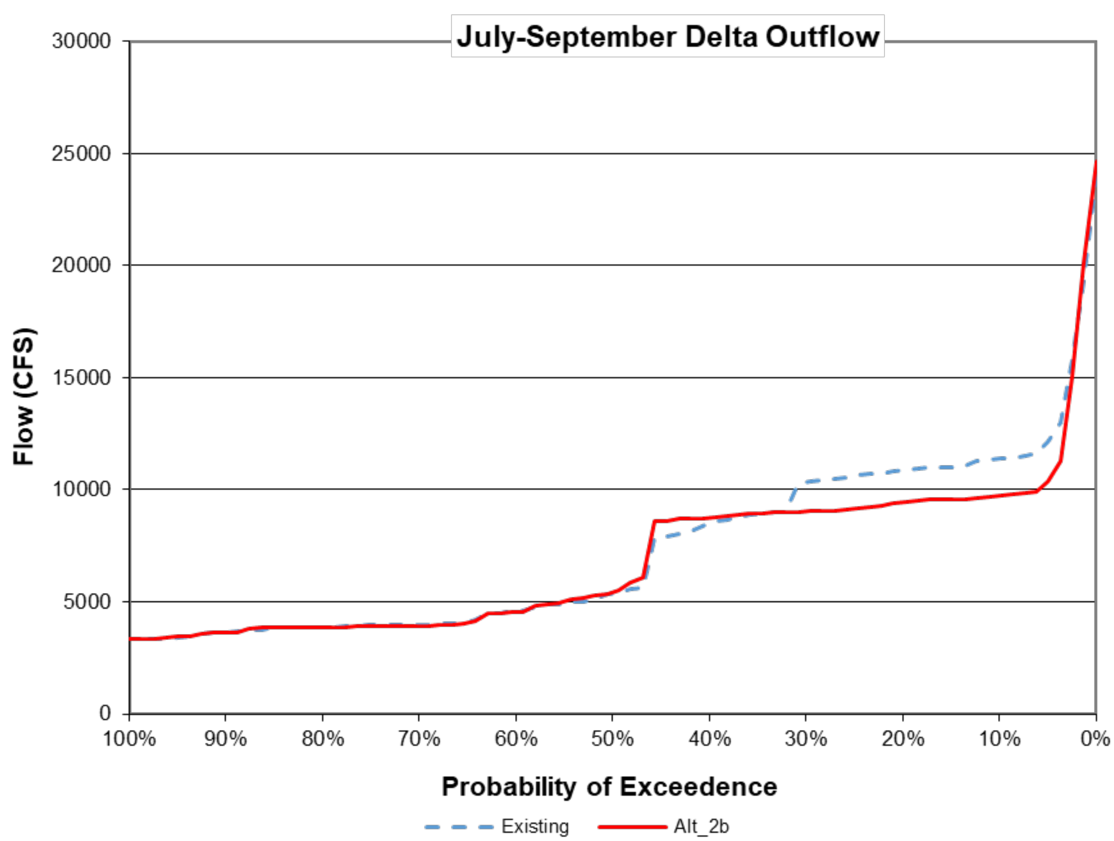


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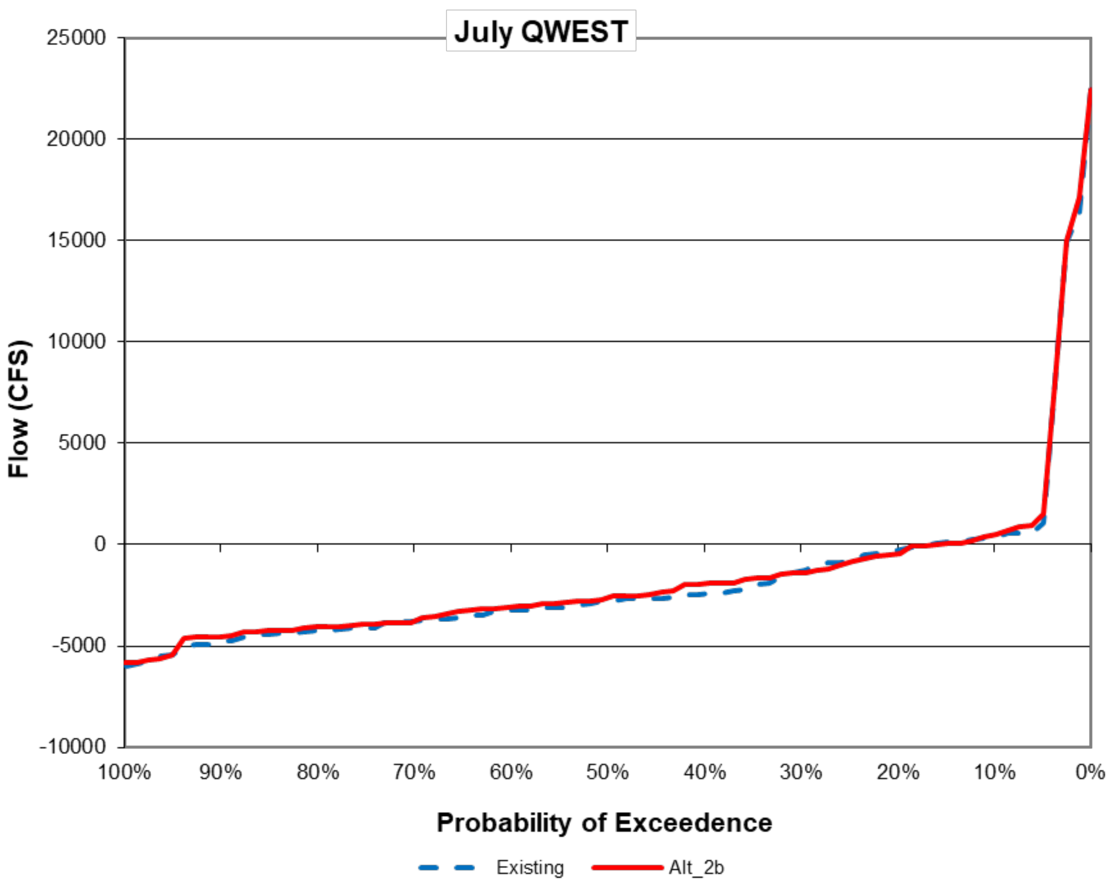
Figure 5.3-24. Mean Modeled Delta Outflow, July–September

As previously noted in the analysis for the Proposed Project, given the suggested importance of the San Joaquin River side of the Delta for spatial subsidy of *P. forbesi* to the low-salinity zone and modeled losses of *P. forbesi* to entrainment by the south Delta export facilities (Kimmerer et al. 2019), modeled flows in the lower San Joaquin River (QWEST) were evaluated as an indicator of downstream *P. forbesi* subsidy potential from the lower San Joaquin River to the low-salinity zone. Based on the assumption that net positive QWEST provides an indicator of downstream *P. forbesi* subsidy potential from the lower San Joaquin River to the low salinity zone, results of the QWEST evaluation suggest that the potential for subsidy of *P. forbesi* to the low-salinity zone may be similar under Refined Alternative 2b and Existing Conditions scenarios in July and August, which have a similar percentage of negative QWEST under both scenarios (Figure 5.3-25 and Figure 5.3-26). In September the percentage of years with positive QWEST was somewhat greater (nearly 20%) under Refined Alternative 2b compared to the Existing Conditions scenario (~10%) (Figure 5.3-27). Uncertainty exists regarding the extent to which changes in the food subsidy to the low-salinity zone would be of consequence should these even occur as a result of lower San Joaquin River flow differences, given the high rate of grazing in the low-salinity zone (Kayfetz and Kimmerer 2017; Kimmerer et al. 2019) and the distribution of an appreciable portion of Delta Smelt upstream of the low-salinity zone, i.e., an average of 23% (range 2% to 47%) during the 2005–2014 period (Bush 2017). Further, Schultz et al. (2019) reported that in 2017, a high outflow year, that the abundance of Delta Smelt prey in the low-salinity zone was not statistically different from other regions and that the mechanism underlying high amphipod abundance in Suisun Bay during the fall is unknown, which further highlights the uncertainty in regarding the extent to which changes in the food subsidy to the low-salinity zone would occur as a result of San Joaquin River flow differences. Nonetheless, QWEST typically would be negative under both the Refined Alternative 2b and Existing Conditions scenarios, indicating potential downstream subsidy of *P. forbesi* would be very limited regardless of scenario.



Source: <ITP_Proposed Project_0819.dss> and <ITP_Alt2B_0102_lastCycle.dss>

Figure 5.3-2~~7~~5. Mean Modeled QWEST Flow, July

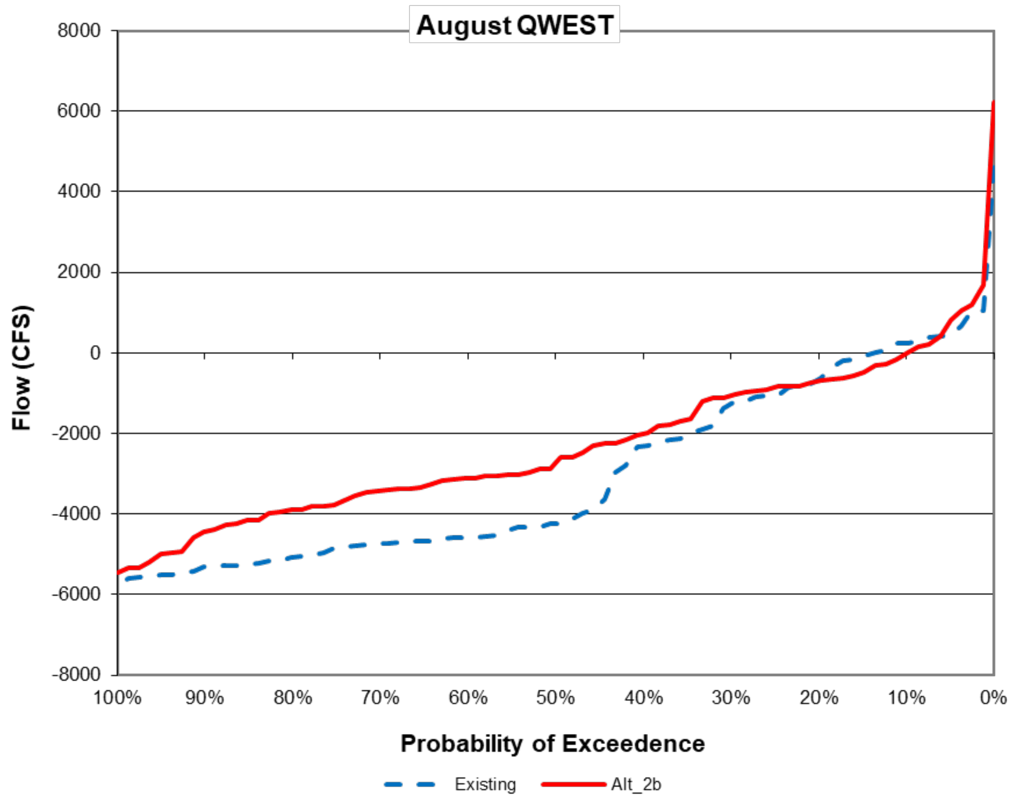


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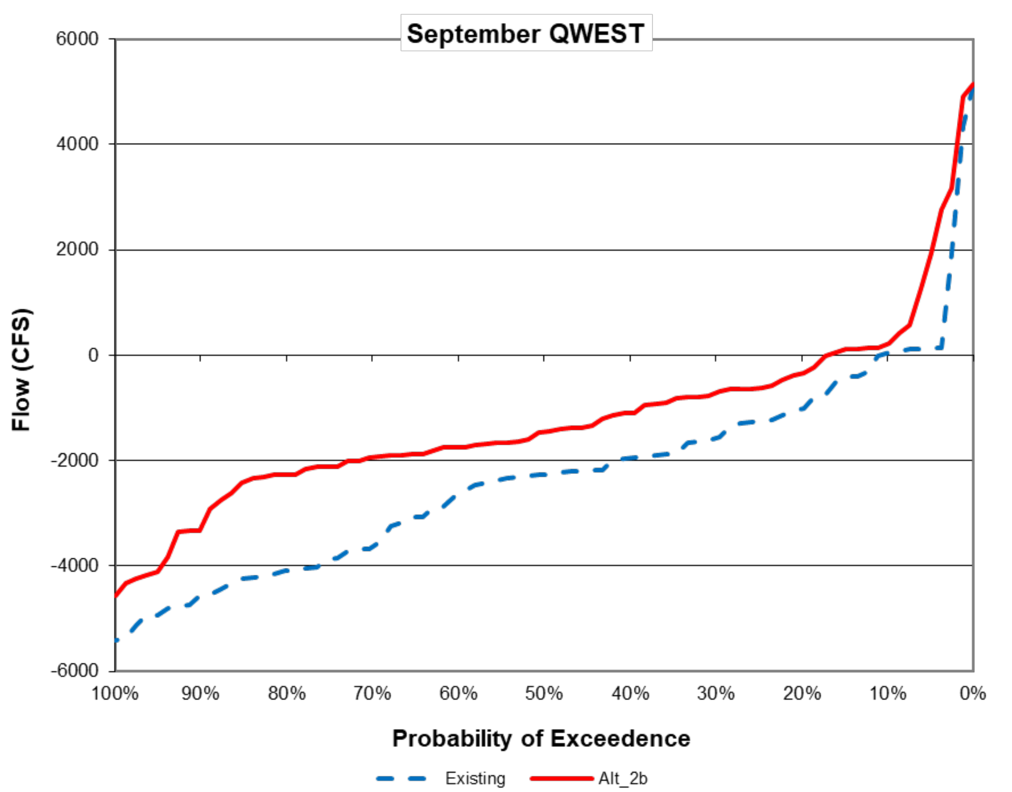
Figure 5.3-286. Mean Modeled QWEST Flow, August



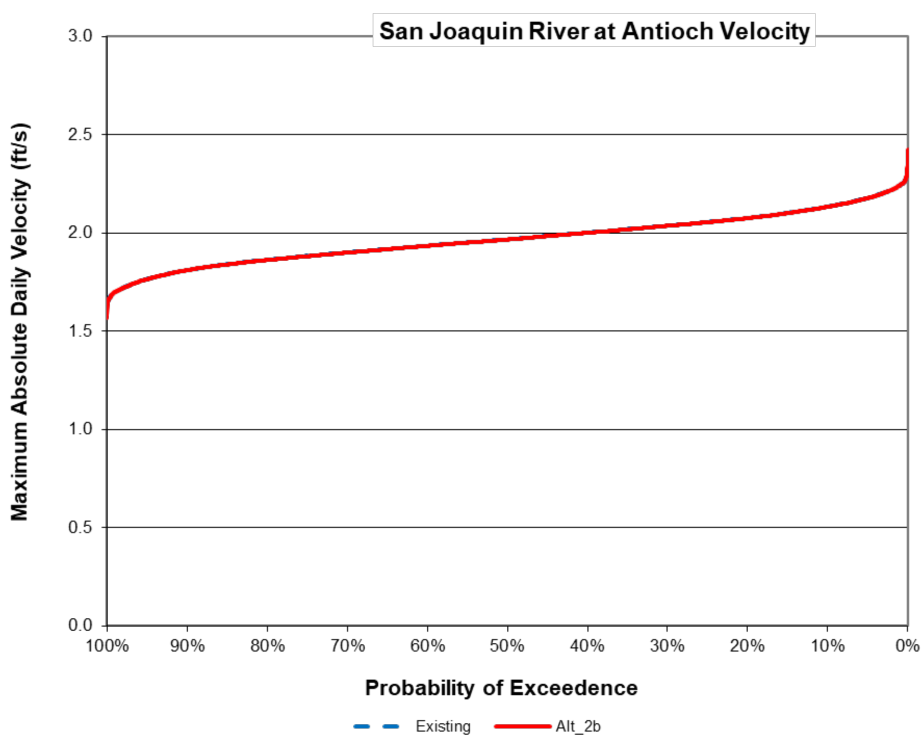
Source: <ITP_Proposed Project_0819.dss> and <ITP_Alt2B_0102_lastCycle.dss>

Figure 5.3-297. Mean Modeled QWEST Flow, September

The potential impacts on the *P. forbesi* food subsidy, as indicated by Delta outflow and QWEST analyses, reflect combined SWP and CVP operations. During September, the main month of potential impacts on *P. forbesi* subsidy to the low salinity zone, the SWP would be responsible for an average of approximately 23% to 28% of Delta water operations in the wet and above-normal years for which fall X2 requirements would not be included in Refined Alternative 2b (see Appendix H).

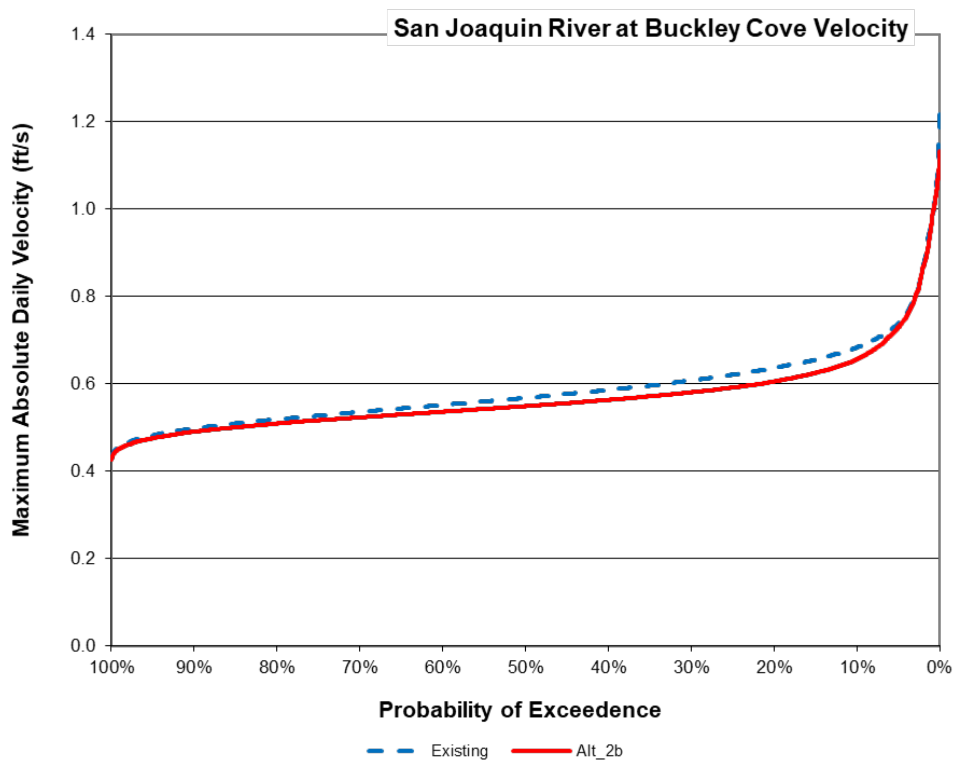
Harmful Algal Blooms

As previously noted in the analysis for the Proposed Project, the IEP MAST (2015) conceptual model posits a linkage between various factors (nutrients, summer hydrology, and air temperature) and toxicity from harmful algal blooms to Delta Smelt and their prey. Based on this conceptual model (see also additional discussion in IEP MAST 2015, p.85-86), differences in flows could influence harmful algal blooms (Lehman et al. 2018); operations would not be expected to affect nutrients or temperature. A previous analysis by RBI (2017) focused on an analysis of maximum daily absolute velocity to assess exceedance of a 1 foot per second (ft/s) threshold, above which turbulent mixing may disrupt *Microcystis* blooms. The same analysis was applied using results from DSM2-HYDRO modeling. The DSM2-HYDRO results suggested that there would be little difference between Refined Alternative 2b and Existing Conditions scenarios in velocity conditions in the central and south Delta during summer and fall (June through November), as shown in Figures 5.3-28 through 5.3-35. In addition, the DSM2-HYDRO results suggest little difference, if any, in the probability of exceeding the 1-ft/s velocity threshold. These results also suggest little difference between Refined Alternative 2b and Existing Conditions scenarios in the potential for velocity conditions affecting harmful algal blooms.



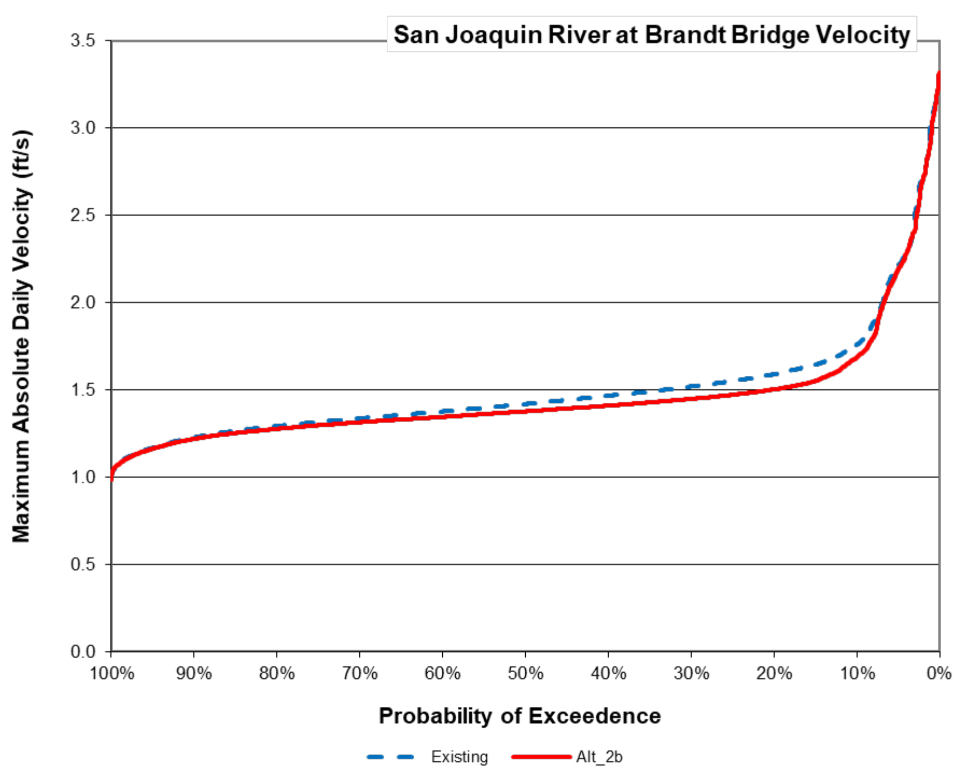
Source: <marin_absDmax.dss, marin_absDmax20200107.dss>

Figure 5.3-28. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Antioch, June–November



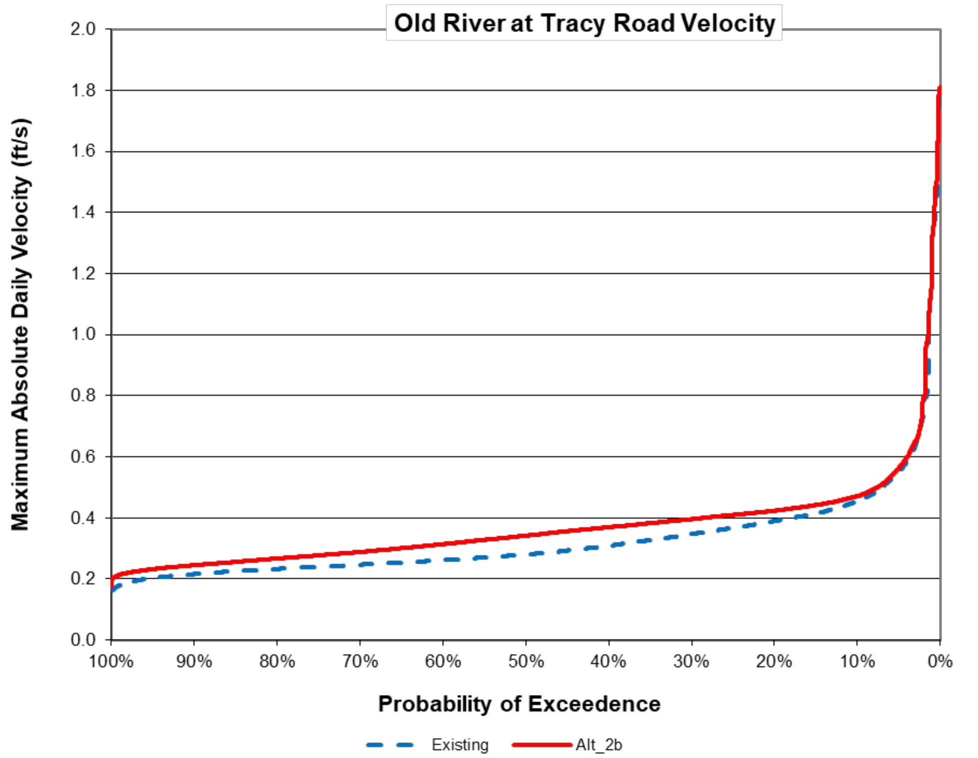
Source: <marin_absDmax.dss, marin_absDmax20200107.dss>

Figure 5.3-29. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Buckley Cove, June–November



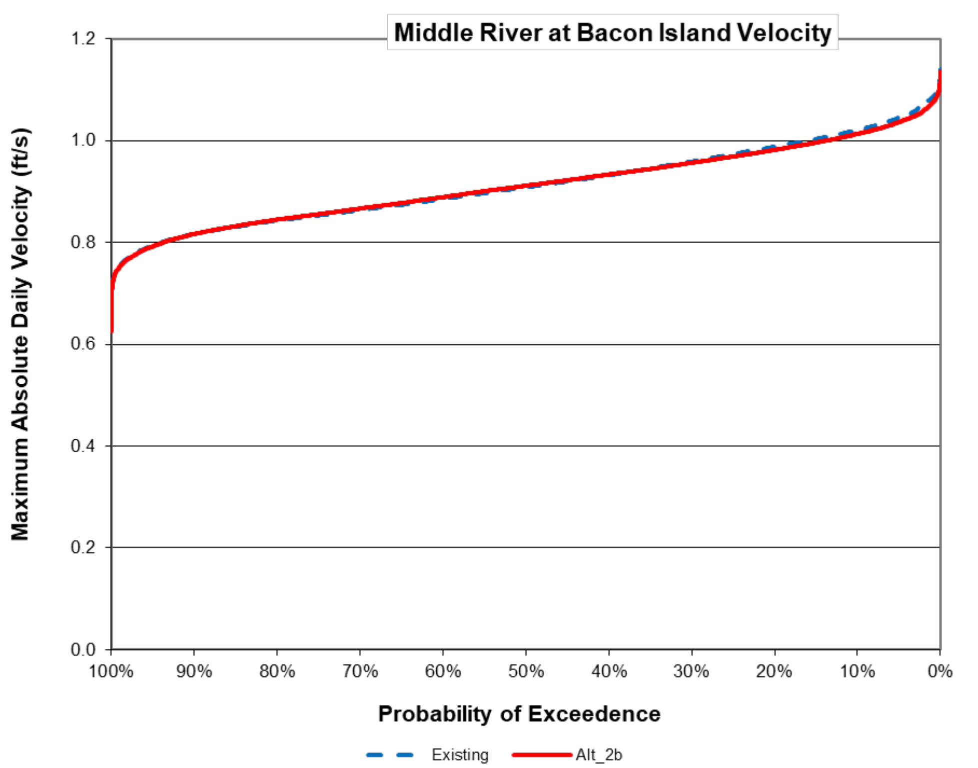
Source: <marin_absDmax.dss, marin_absDmax20200107.dss>

Figure 5.3-30. Modeled Maximum Absolute Daily Velocity in the San Joaquin River at Brandt Bridge, June–November



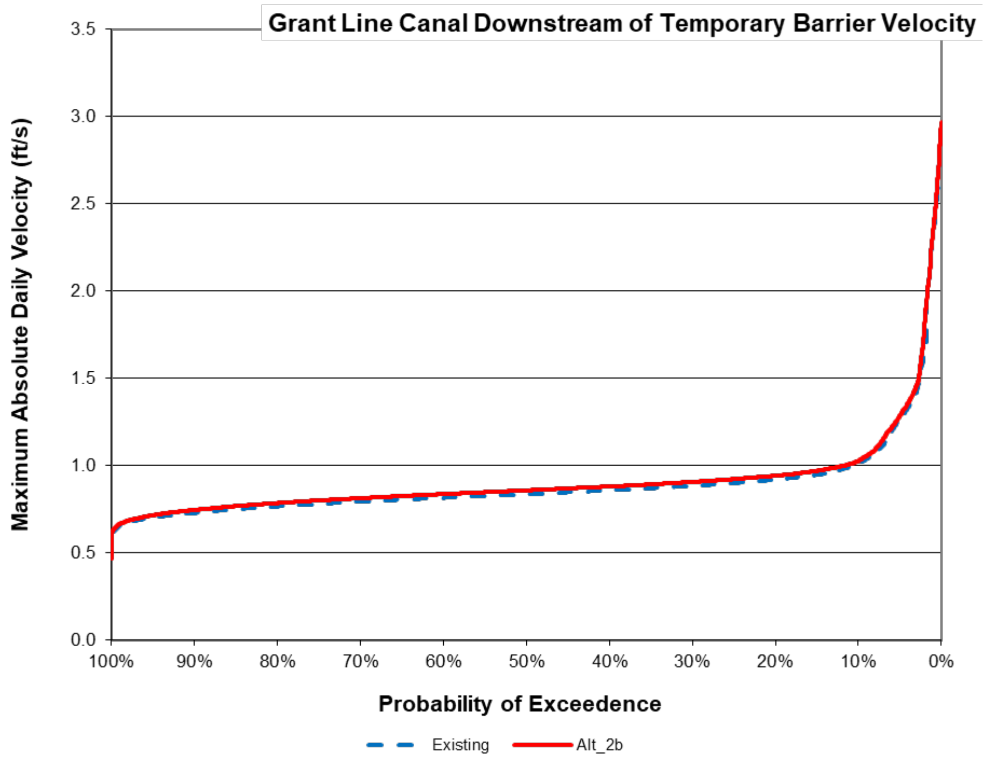
Source: <marin_absDmax.dss, marin_absDmax20200107.dss>

Figure 5.3-31. Modeled Maximum Absolute Daily Velocity in Old River at Tracy Road, June–November



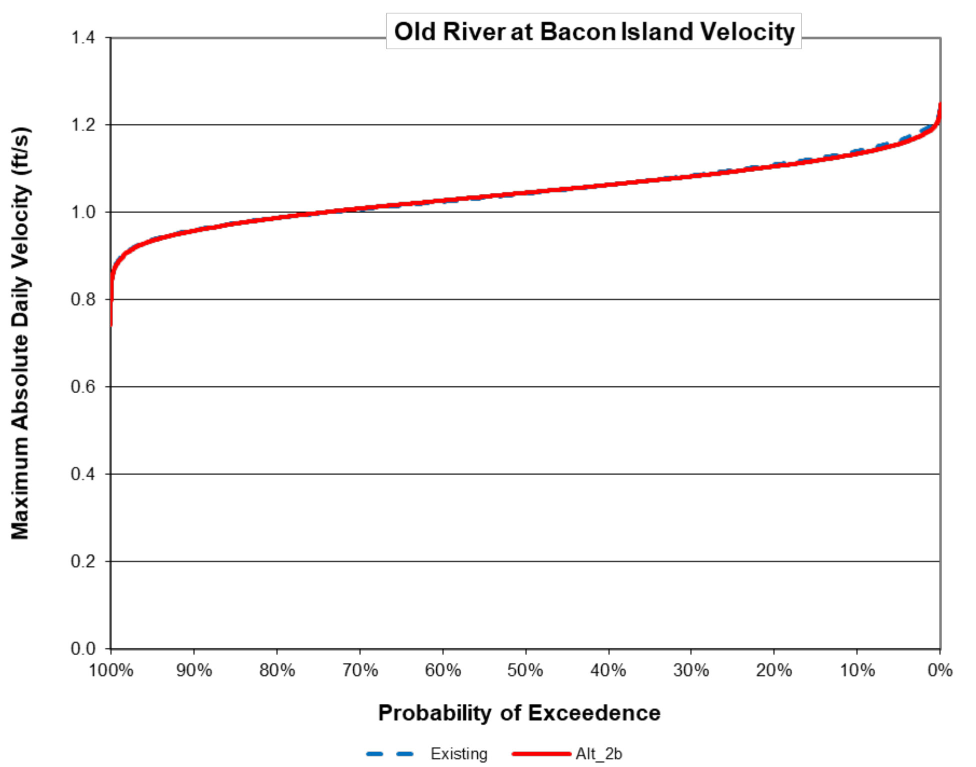
Source: <marin_absDmax.dss, marin_absDmax20200107.dss>

Figure 5.3-32. Modeled Maximum Absolute Daily Velocity in Middle River at Bacon Island, June–November



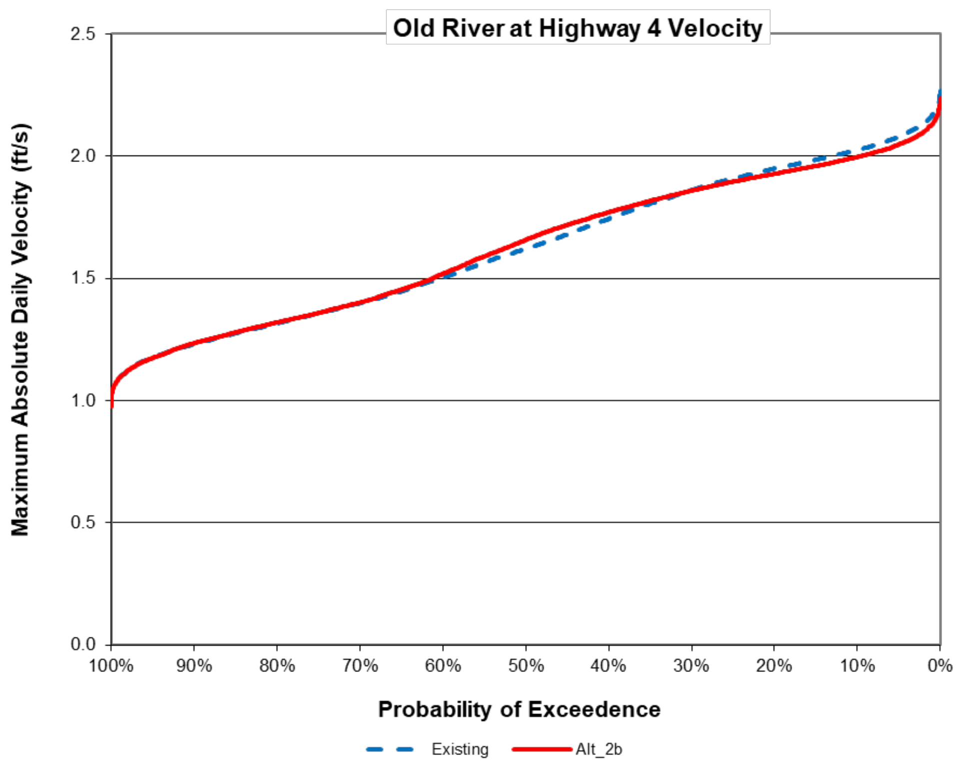
Source: <marin_absDmax.dss, marin_absDmax20200107.dss>

Figure 5.3-33. Modeled Maximum Absolute Daily Velocity in Grant Line Canal Downstream of Temporary Barrier, June–November



Source: <marin_absDmax.dss, marin_absDmax20200107.dss>

Figure 5.3-34. Modeled Maximum Absolute Daily Velocity in Old River at Bacon Island, June–November



Source: <marin_absDmax.dss, marin_absDmax20200107.dss>

Figure 5.3-35. Modeled Maximum Absolute Daily Velocity in Old River at Highway 4, June–November

The potential impacts on harmful algal blooms as a function of velocity at various Delta locations reflect combined SWP and CVP operations. During June-November, the SWP would be responsible for approximately 20–60% of Delta water operations under Refined Alternative 2b, depending on water year type and month (see Appendix H).

Predation

As previously noted in the analysis for the Proposed Project, the IEP MAST (2015) conceptual model posits that predation risk for juvenile Delta Smelt is a function of predators, turbidity, and water temperature. As previously discussed for larval Delta Smelt, water temperature in the Delta under Refined Alternative 2b would be similar to the Existing Conditions scenario because operations have little influence on Delta water temperatures. Bever et al. (2018b) reported that wind was a strong driver of turbidity, which is not affected by Refined Alternative 2b and would be identical under both Refined Alternative 2b and Existing Conditions scenarios.

As discussed above for adult Delta Smelt, differences in winter and spring Rio Vista flow and sediment delivery, together with only small amounts of sediment lost to entrainment, suggest that similar turbidity would occur under Refined Alternative 2b and Existing Conditions scenarios during the winter-spring period. Although sediment input would be similar, the relationship between sediment input during winter and spring and the summer predation potential of juvenile Delta Smelt is unknown. However, wind and water temperature, which are drivers of predation, would be similar. Therefore, predation risk also would be similar.

Summer/ Fall Habitat

Qualitative Analysis

As previously noted in the analysis for the Proposed Project, the IEP MAST (2015) conceptual model posits that Delta Smelt abundance, survival, and growth are affected by the size and location of the low salinity zone during fall, with IEP MAST (2015, p.142) concluding: “The limited amount of available data provides some evidence in support of this hypothesis, but additional years of data and investigations are needed.” Others have found that low salinity zone habitat may not be a predictor of Delta Smelt survival (ICF 2017). Refined Alternative 2b includes structured decision-making to implement Summer-Fall Delta Smelt habitat actions which are intended to improve Delta Smelt food supply and habitat, thereby contributing to the recruitment, growth, and survival of the species. Whereas current management as represented by the Existing Conditions scenario focuses on USFWS (2008) SWP/CVP Biological Opinions fall criteria (i.e., X2 in September–October ≤ 74 km following wet years and ≤ 81 km following above-normal years, with provisions to extend these requirements into November or December if specific conditions are met), Refined Alternative 2b includes the potential for X2 ≤ 80 km in September–October of wet and above-normal years. Based solely on consideration of X2 and the typical distribution of the low salinity zone, this would tend to give a smaller area of low salinity habitat under Refined Alternative 2b in wet years and somewhat larger area of low salinity habitat under Refined Alternative 2b in above-normal years, relative to the Existing Conditions scenario. However, Refined Alternative 2b also includes potential additional operation of the SMSCG, relative to the Existing Conditions scenario for up to 60 days in June–October of above-normal, below-normal, and wet years. Evidence from a pilot 2018 application of the SMSCG action suggests that the Summer-Fall habitat action would provide habitat benefits for Delta Smelt. The SMSCG were operated during August 2018 and it was found that a small number of Delta Smelt were observed in Suisun Marsh and, therefore, had access to additional relatively productive habitat; better water quality conditions (lower salinity and higher turbidity) occurred, relative to the period before the gates were operated; and the benefits extended well beyond the period of gate operations (Sommer et al. 2018). Thus, the proposed SMSCG action potentially increases Delta Smelt habitat suitability in an area with relatively high food availability and growth potential, as reflected by Delta Smelt individual-level responses such as stomach fullness generally being higher in Suisun Marsh than other areas of the Delta Smelt range (Hammock et al. 2015). The 2018 pilot implementation of the SMSCG action illustrated that the action could provide salinity conditions in Suisun Marsh for Delta Smelt during below-normal years that were similar or better than in those observed in wet years (Sommer et al. 2018). The SMSCG action would have the potential to affect a sizable proportion of the Delta Smelt population (e.g., an average of 77% of Delta Smelt in the low salinity zone as observed in recent years [Bush 2017], with approximately 20% of juvenile Delta Smelt in Suisun Marsh as indicated by EDSM surveys during the 2018 pilot action, albeit with considerable uncertainty because of overall low numbers caught in surveys).

In addition to X2 management and SMSCG operations, the Summer-Fall habitat actions included in Refined Alternative 2b potentially include food enhancement actions such as those included in the Delta Smelt Resiliency Strategy (North Delta Food Subsidies and Colusa Basin Drain project, and Suisun Marsh Food Subsidies [Roaring River distribution system reoperation]). As described for the Proposed Project, augmentation of flow from the Colusa Basin drain during summer/early fall as part of the Delta

Smelt Summer-Fall Habitat Action could increase transfer of food web materials to the North Delta, thereby potentially increasing food availability for juvenile Delta Smelt. An average of 23% of Delta Smelt surviving to adulthood are resident in the Cache Slough Complex/Sacramento Deepwater Ship Channel region throughout their lives, whereas the remainder either migrate to the low salinity zone or are resident there (Bush 2017). The proportion of the population resident in the North Delta would be most likely to benefit from the North Delta food subsidies action. A pilot implementation of this action in 2016 found that primary production in the North Delta increased as a result of the action (Frantzich et al. 2018), with enhanced zooplankton growth and egg production (California Natural Resources Agency 2017). Reclamation (2018:2) suggested that a chlorophyll concentration of 10 µg/l of chlorophyll, as achieved in 2016 for a number of days during the action, could support relatively high zooplankton production (Müller-Solger et al. 2002) without adversely affecting water quality (e.g., dissolved oxygen concentration). Analyses are underway to determine the potential effectiveness of a 2018 pilot implementation of the action, but preliminary information suggests that chlorophyll concentration above 10 µg/l was limited in duration in the Yolo Bypass and there was no increase at Rio Vista. Nonetheless, the 2018 action still showed downstream transport of chlorophyll in the Cache Slough Complex, a primary habitat area for Delta Smelt (DWR unpublished data).

SCHISM Analysis

As described for the Proposed Project, to illustrate the potential impacts of SMSCG operations and September/October X2 operations proposed for consideration as part of the Delta Smelt Summer-Fall habitat actions, a hindcasting analysis based on historical conditions in 2012 (a representative below-normal water year) and 2017 (a representative wet water year) was undertaken using the SCHISM model as described in more detail in Appendix D. In each year, a base scenario simulated historical conditions.

Two potential Summer-Fall habitat action scenarios were simulated for 2012. One scenario included 60-day SMSCG operations commencing on June 14 and the other scenario included 60-day SMSCG operations commencing on August 15. The mean area of low salinity (≤ 6 psu) was calculated for each day. In consideration of the importance of the north Delta arc of habitat for Delta Smelt (Hobbs et al. 2017; see Figure 4.4-39 in Section 4.4.7.4), results were calculated for several generalized geographic regions: the north Delta arc; a corridor of channels from Cache Slough to Montezuma Slough; Suisun Marsh; and Suisun Bay (see Figure 4.4-40 in Section 4.4.7.4). In addition to a summary of results considering salinity alone, a second analysis overlaid salinity with interpolated data for water temperature from various monitoring stations and turbidity (Secchi depth) from summer townet and fall midwater trawl surveys (ftp://ftp.wildlife.ca.gov/TownetFallMidwaterTrawl/). For each day, the average area of habitat meeting three criteria (salinity ≤ 6; temperature < 25C; Secchi depth >0.5 m; Bever et al. 2016) was summarized. Appendix D contains additional detail regarding the methods and results of the SCHISM modeling and analyses.

As noted in the analysis of the Proposed Project, the 2012 SCHISM results illustrated that operation of the SMSCG would have yielded a greater extent of low-salinity habitat if undertaken for 60 days commencing on August 15 rather than June 14 (Figure 4.4-41 in Section 4.4.7.4). In general, D-1641 agricultural water quality standards are sufficient to protect low-salinity habitat in Suisun Marsh until August 15, when the standards no longer apply. At the scale of the overall north Delta arc or the Cache to Montezuma corridor, differences in low-salinity area between scenarios as a result of SMSCG operations would be expected to be modest (Figure 4.4-41 in Section 4.4.7.4). The greatest differences would occur within Suisun Marsh, for which SMSCG operations commencing on August 15 would be expected to result in appreciably greater extent of low-salinity habitat from August 15 through October 15, extending somewhat to the November–December time frame. Operation of the SMSCG in this manner would be expected to result in a reduction in the extent of low-salinity habitat in Suisun Bay (including Grizzly Bay) relative to the scenario without SMSCG operation (Figure 4.4-41 in Section 4.4.7.4). The extent to which this reduction in Suisun Bay habitat could affect Delta Smelt would depend on the distribution of the species. However, sampling during the 2018 SMSCG action suggested greater presence of Delta Smelt in Suisun Marsh than Suisun Bay (see Figure 4.4-45 in Section 4.4.7.4), which may indicate greater potential for a positive rather than a negative impact of habitat changes resulting from the SMSCG operation, particularly considering that Suisun Marsh provides habitat in which Delta Smelt generally have appreciably better conditions than in Suisun Bay (Hammock et al. 2015).

As described for the Proposed Project, considering temperature and turbidity (water clarity) in addition to salinity generally suggested a similar overall pattern to salinity alone, with respect to modest differences between scenarios at the scale of the north Delta arc or the Cache to Montezuma link corridor, and with greater differences in Suisun Marsh; however, there was not less habitat meeting all three criteria in Suisun Bay. Notably different from the analysis considering salinity alone was that the area meeting the salinity, temperature, and Secchi depth criteria dropped to zero on a number of occasions, which reflected Secchi depth increasing slightly above the 0.5-meter threshold selected for analysis; as noted in Appendix D, the results are sensitive to a threshold-based approach of defining habitat criteria, particularly in Suisun Bay and Suisun Marsh.

The SCHISM analysis for 2017 considered both SMSCG operations (commencing September 1) as well as operations to maintain X2 at 80 km in September and October. The relatively wet conditions in 2017 led to low salinity habitat throughout much of the simulated area occurring in all scenarios until November, after which time there was a residual impact of the combination of SMSCG operations and maintaining X2 of 80 km (Figure 4.4-43 in Section 4.4.7.4). This suggests the potential for Refined Alternative 2b to increase the area of low salinity relative to the Existing Conditions scenario, with the increase being greatest in Suisun Marsh and modest at the larger scale of the north Delta arc, a pattern also evident when considering the results from the combination of salinity, temperature, and water clarity (see Figure 4.4-44 in Section 4.4.7.4). Additional considerations are provided in Appendix D, but overall, the modeling does not suggest that the extent of low salinity habitat for Delta Smelt would be lower under Refined Alternative 2b than under the Existing Condition.

Operations-related impacts on the size and location of the low salinity reflect combined SWP and CVP operations. Operation of the SMSCG is the responsibility of SWP. During the June to October period of the Delta Smelt Summer-Fall habitat actions, the SWP's responsibility for water operations would be ~30% to 40% in June, ~20% to 50% in July and August, ~20% to 50% in September, and ~40% to 50% in October (see Appendix H).

Subadults to Adults (September December)

Food availability

As previously noted in the analysis for the Proposed Project and as discussed for juvenile Delta Smelt, seasonal south Delta export operations have the potential to affect Delta Smelt food availability through changes in *P. forbesi* subsidy to the low salinity zone rearing habitat occupied by most Delta Smelt reaching adulthood, as illustrated for September (Figure 5.3-27). Although the FLaSH investigations predicted that Delta Smelt food availability (as represented by calanoid copepods) in the fall low salinity zone would be greater with lower X2 (i.e., higher outflow) (Brown et al. 2014, p.25), this was not found to be the case either for the post-*Potamocorbula amurensis* invasion period (1988–2015/2016; Figures 5.16-26, 5.16-27, 5.16-28, 5.16-29, 5.16-30, and 5.16-31 in Reclamation 2019) or for the period following onset of the Pelagic Organism Decline (2003–2015/2016; ICF 2017, p.78–82). Therefore, as described for juvenile Delta Smelt, there is a potential positive impact on *P. forbesi* transport to the low salinity zone under Refined Alternative 2b in September, relative to the Existing Conditions scenario, but not for overall calanoid copepod density in the low salinity zone based on previous analyses related to X2 (ICF 2017, p. 78-82).

The potential impacts of Refined Alternative 2b on *P. forbesi* food subsidy as indicated by Delta outflow and QWEST analyses reflect combined SWP and CVP operations. During September, the main month of potential impact on *P. forbesi* subsidy to the low salinity zone, the SWP would be responsible for an average of approximately 23–28% of Delta water operations in the wet and above-normal years for which fall X2 requirements would not be included in Refined Alternative 2b (see Appendix H).

Harmful Algal Blooms

As discussed for juvenile Delta Smelt, application of the threshold velocity approach from RBI (2017) with DSM2-HYDRO modeling results suggests that there would be little difference in velocity conditions between Refined Alternative 2b and Existing Conditions scenarios in the central and south Delta during Summer-Fall (June–November; Figure 5.3-28 through Figure 5.3-35), which also suggests little difference between scenarios in the potential for velocity conditions affecting harmful algal blooms.

The potential impacts on harmful algal blooms as a function of velocity at various Delta locations reflect combined SWP and CVP operations. During June-November, the SWP would be responsible for around 20–60% of Delta water operations under Refined Alternative 2b, depending on water year type and month (see Appendix H).

Predation

Similar to other Delta Smelt life stages, sediment supply during the winter and spring would be similar under Refined Alternative 2b and Existing Conditions scenarios, so the potential impact on sediment resuspension during the fall subadult period would be expected to be similar for both scenarios. In addition, as previously described for other life stages of Delta Smelt, water temperature and wind-related resuspension of sediment would not be expected to be affected by operations under Refined Alternative 2b. Therefore, predation risk under Refined Alternative 2b would be expected to be similar to the Existing Conditions scenario.

Entrainment

Consideration of OMR

As previously noted in the analysis for the Proposed Project, Old and Middle River (OMR) flows are an important indicator of Delta Smelt entrainment risk (Grimaldo et al. 2009, 2017b). During the main period of adult entrainment risk (December–March; USFWS 2008), Refined Alternative 2b is expected to have generally similar OMR flows to the Existing Conditions scenario (Figure 5.3-35 through Figure 5.3-39), suggesting that adult entrainment risk considering only OMR flows would be similar between the Refined Alternative 2b and Existing Conditions scenarios. As described in the project description, the first flush protection action would be triggered more often under Refined Alternative 2b, than under existing operating criteria (see Figure 4.4-49 in Section 4.4.7.4), thereby potentially providing additional entrainment risk protection under Refined Alternative 2b (the first flush protection is not represented in the CalSim modeling). Other factors such as turbidity are also important influences on entrainment risk but also are not directly modeled in CalSim. Although assumptions about the "turbidity bridge" avoidance actions are included in the CalSim modeling, the modeling cannot simulate real-time decision-making that would limit entrainment risk. OMR management included in Refined Alternative 2b to protect adult Delta Smelt would be expected to result in low levels of entrainment loss similar to those achieved during the implementation of the USFWS (2008) Biological Opinion.

As previously noted in the analysis for the Proposed Project, during the March–June period of concern for larval/juvenile Delta Smelt entrainment risk, OMR flows would tend to be more negative under Refined Alternative 2b compared to the Existing Conditions scenario in April and May, but similar in March and June (Figure 5.3-39 through Figure 5.3-42). Flows in both scenarios would be more positive than the -5,000 cfs inflection point at which entrainment tends to sharply increase (Grimaldo et al. 2017b). SWP exports overall would be similar to Existing Conditions during March–June (see Table 4-1 in Attachment 3-3 of Appendix C); in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than Existing Conditions. The potential for increases in entrainment relative to Existing Conditions at the south Delta export facilities when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period, as a result of effects on OMR flows (see also the particle tracking modeling analyses). As part of real-time operational decision-making OMR management, DWR will use results produced by CDFW and USFWS approved life cycle models along with real-time monitoring of the spatial distribution of Delta Smelt to manage the annual entrainment levels of larval/juvenile Delta Smelt. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment such as OMR flows. On or after

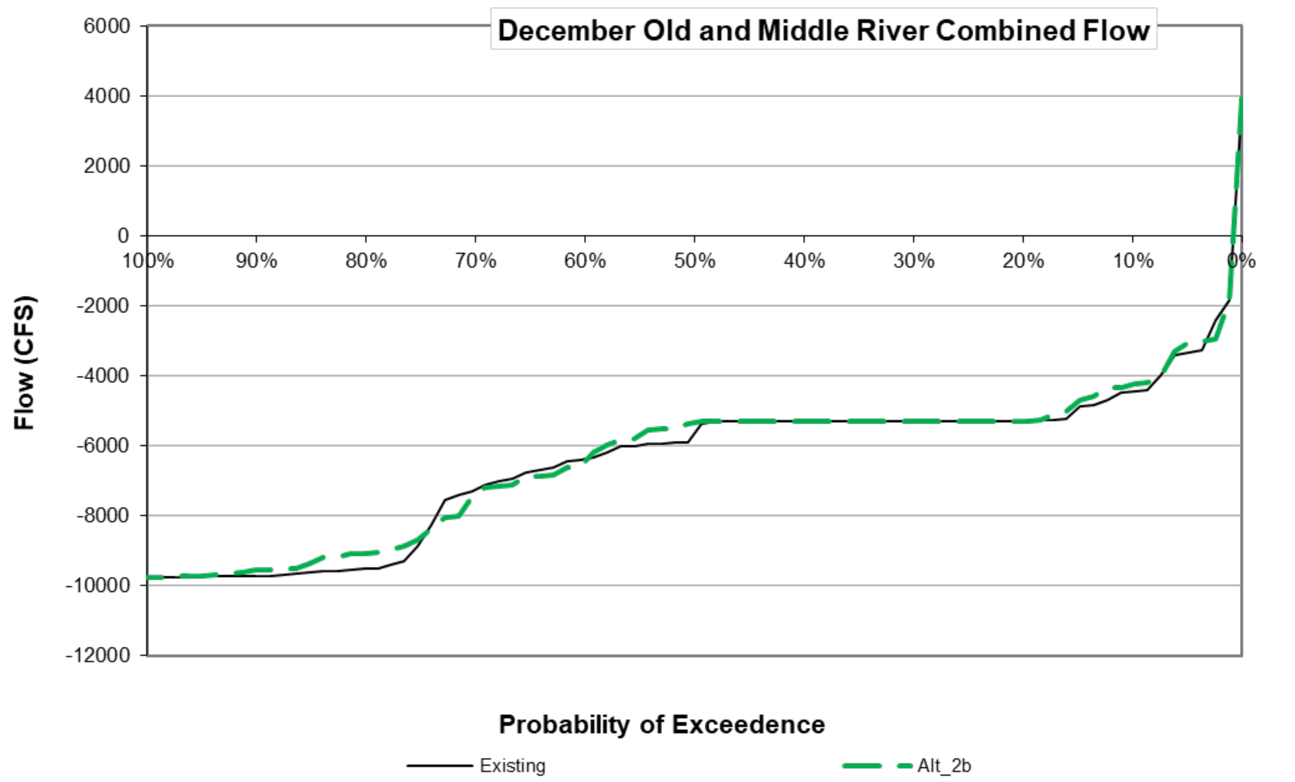


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Figure 5.3-36. Mean Modeled Old and Middle River Flow, December

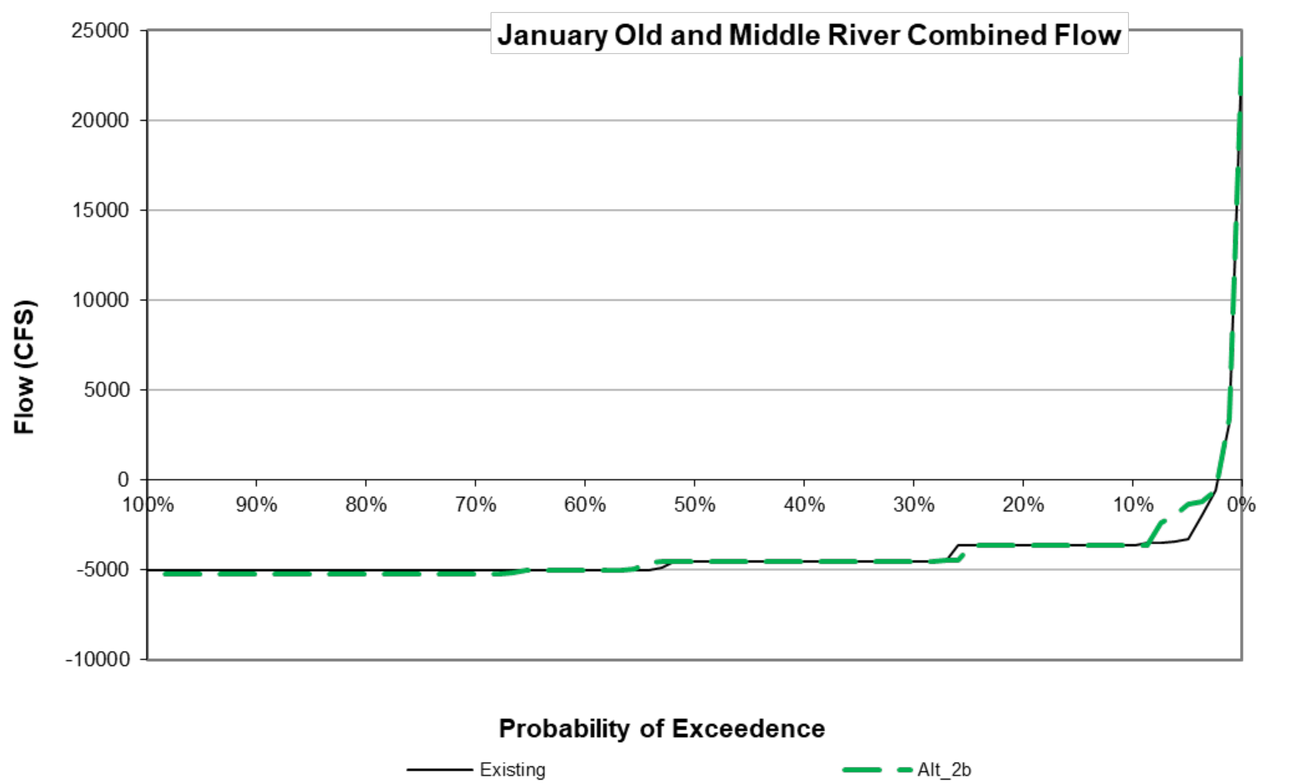

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Figure 5.3-37. Mean Modeled Old and Middle River Flow, January

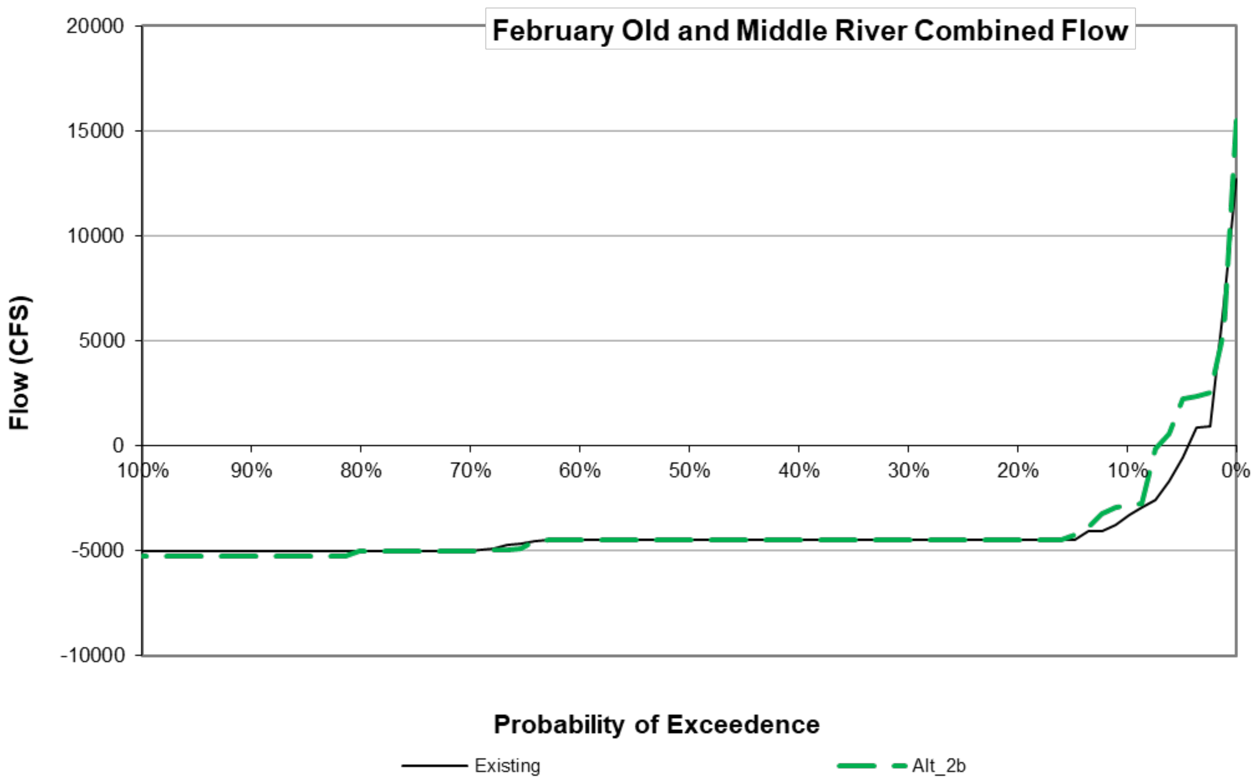

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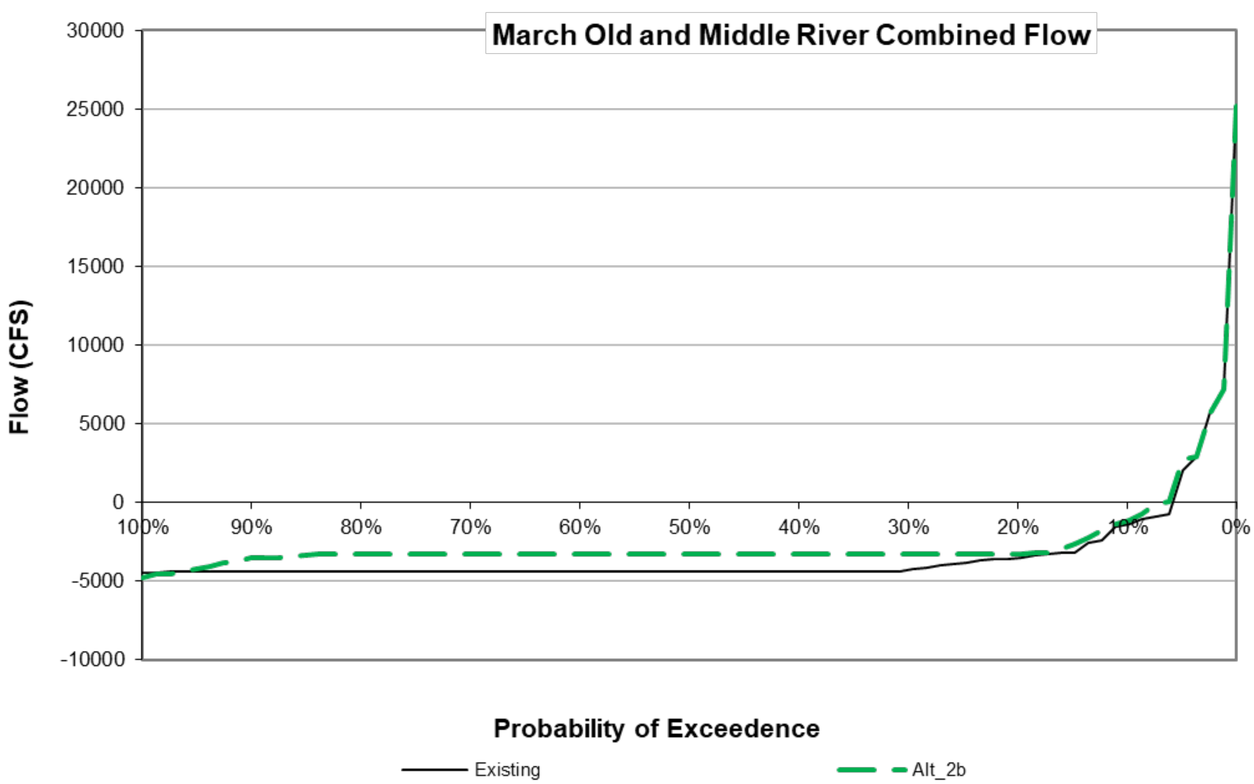
Figure 5.3-38. Mean Modeled Old and Middle River Flow, February



Source: <DRAFT_TrendReport_ITP_BL_PP0819_PPALt2B0102.xlsm>

Figure 5.3-39. Mean Modeled Old and Middle River Flow, March

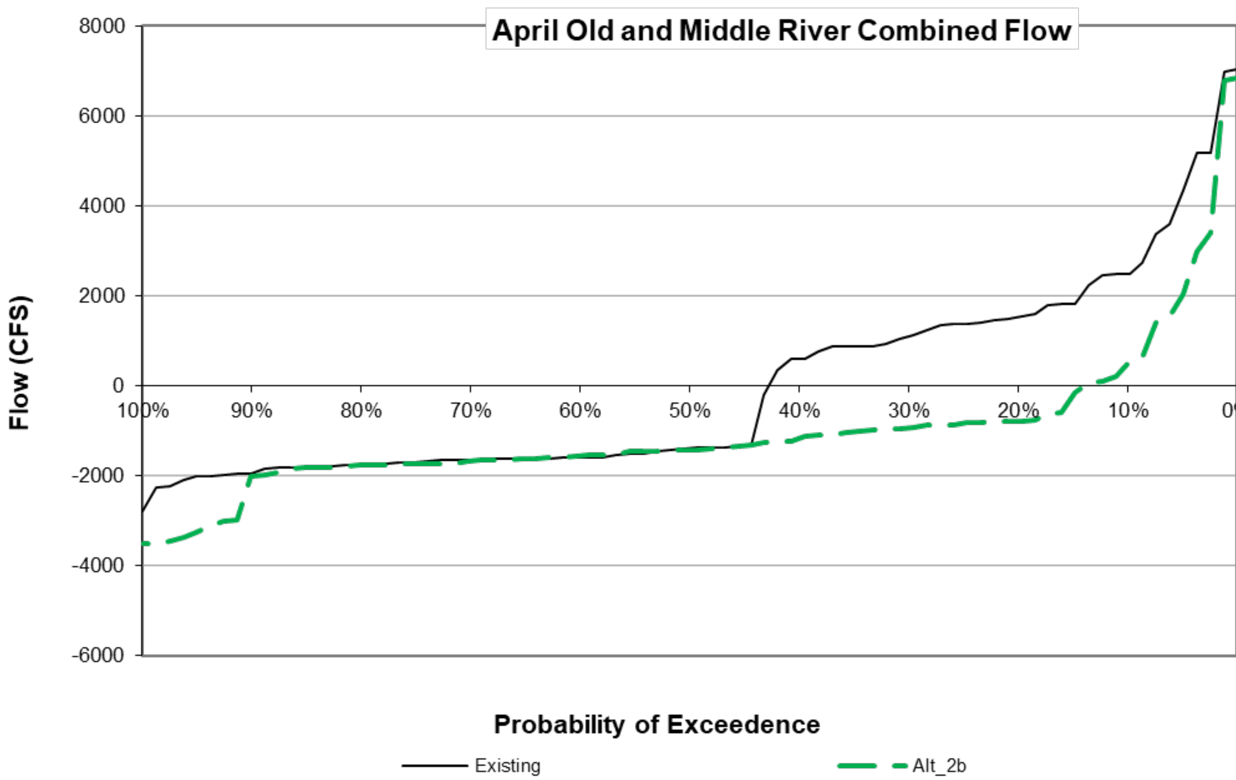


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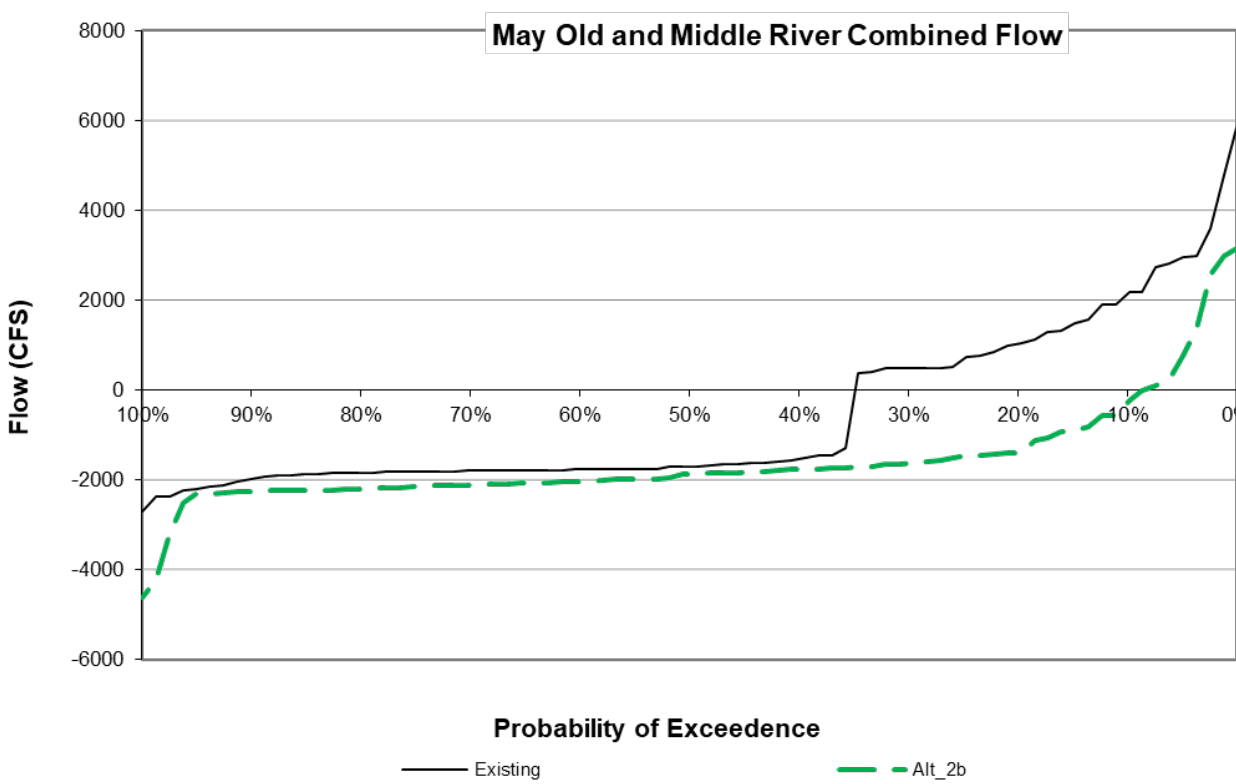
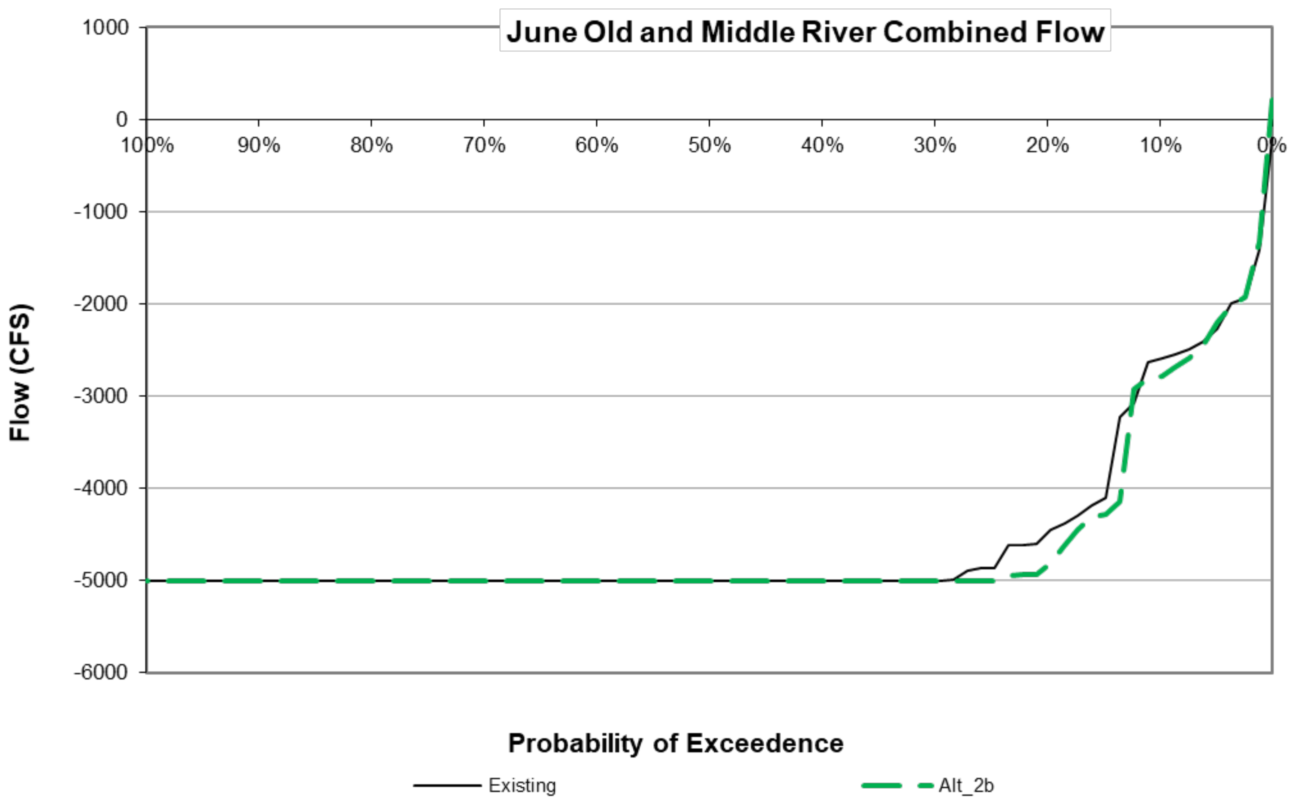
Figure 5.3-40. Mean Modeled Old and Middle River Flow, April



Source: <DRAFT_TrendReport_ITP_BL_PP0819_PPALt2B0102.xlsm>

Figure 5.3-41. Mean Modeled Old and Middle River Flow, May



Source: <DRAFT_TrendReport_ITP_BL_PP0819_PPALt2B0102.xlsm>

Figure 5.3-42. Mean Modeled Old and Middle River Flow, June

March 15 of each year, if QWEST is negative, and larval or juvenile Delta Smelt are detected within the Old and Middle River corridor based on real-time sampling of spawning adults or YOY life stages, DWR (in coordination with Reclamation) will run hydrodynamic models and forecasts of entrainment to estimate the percentage of larval and juvenile Delta Smelt that could be entrained and will manage exports, as necessary, to limit entrainment to be protective based on the modeled recruitment levels. Such OMR management is not reflected in the CalSim modeling. The real-time management would be intended to limit entrainment risk to low levels similar to the levels achieved following implementation of the USFWS (2008) Biological Opinion, during which time loss of juvenile Delta Smelt was within authorized incidental take limits.

The impacts on Old and Middle River flows depend on combined SWP and CVP operations. However, during March–June, the period of larval/early juvenile Delta Smelt entrainment concern, the SWP generally is responsible for approximately 20–60% of Delta water operations, depending on water year type and month; the responsibility is around 20–40% in April and May (see Appendix H).

Particle Tracking Modeling analysis

As previously noted in the analysis for the Proposed Project, DSM2-PTM was used in the impacts analysis to illustrate potential differences in the percentage of entrainment of Delta Smelt larvae by SWP facilities (Clifton Court Forebay and the NBA Barker Slough Pumping Plant) under the Refined Alternative 2b and Existing Conditions scenarios. Detailed information regarding the method is provided in Appendix E. This approach assumed that the susceptibility of Delta Smelt larvae can be represented by entrainment of passive particles, based on existing literature (Kimmerer 2008, 2011). Results of the PTM simulations do not represent the actual entrainment of larval Delta Smelt that could occur under the Refined Alternative 2b and Existing Conditions scenarios, but rather should be viewed as a comparative indicator of the relative risk of larval entrainment under the scenarios, without consideration of the real-time risk management measures included in Refined Alternative 2b.

The DSM2-PTM analysis suggested the potential for increases in larval/early juvenile Delta Smelt entrainment at Clifton Court Forebay during April and May under Refined Alternative 2b compared to the Existing Conditions scenario (Table 5.3-7), which is a result of differences in OMR during this time period (see the "Consideration of OMR" section above). The differences in OMR in large part reflect differences in CVP exports, as also discussed in "Consideration of OMR" above, because SWP exports in April/May generally would be similar under Refined Alternative 2b and Existing Conditions, except in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded. SWP responsibility for operations is approximately 20–40% in April/May (see Appendix H). DSM2-PTM does not include real-time operational decision-making, modeling, and OMR management, which would be used by DWR to minimize entrainment under Refined Alternative 2b. As part of real-time operational decision-making OMR management, DWR will use results produced by CDFW and USFWS approved life cycle models along with real-time monitoring of the spatial distribution of Delta Smelt to manage the annual entrainment levels of larval/juvenile Delta Smelt. The life cycle models statistically link environmental conditions to recruitment, including factors related to loss as a result of entrainment such as OMR flows. On or after March 15 of each year, if QWEST is negative, and larval or juvenile Delta Smelt are detected within the Old and Middle River corridor based on real-time sampling of spawning adults or YOY life stages, DWR (in coordination with Reclamation) will run hydrodynamic models and forecasts of entrainment to estimate the percentage of larval and juvenile Delta Smelt that could be entrained and will manage exports, as necessary, to limit entrainment to be protective based on the modeled recruitment levels. Actual management of larval/juvenile Delta Smelt entrainment during implementation of the USFWS (2008), which the Existing Conditions modeling scenario represents, limited entrainment well below authorized protective take limits. Although Refined Alternative 2b modeling suggests an increase in entrainment relative to the Existing Conditions scenario, entrainment would be expected to be maintained at protective levels.

The DSM2-PTM results suggested that there would be little difference in the potential for entrainment of Delta Smelt at the Barker Slough Pumping Plant under the Refined Alternative 2b and Existing Conditions scenarios (Table 5.3-7). No differences in operational criteria of the Barker Slough Pumping Plant are included in Refined Alternative 2b, relative to the Existing Conditions scenario and the potential for entrainment also would be limited by the incidental take limit from USFWS ROC on LTO Biological Opinion.

Table 5.3-7. Percentage of Particles Entrained Over 30 Days into Clifton Court Forebay and Barker Slough Pumping Plant – Table 5.3-7 a and b

Table 5.3-7 c. Percentage of Particles Entrained Over 30 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
March	Wet	3.28	2.87	-0.41 (-12%)
March	Above Normal	3.66	3.11	-0.55 (-15%)
March	Below Normal	9.63	7.81	-1.82 (-19%)
March	Dry	10.53	9.11	-1.42 (-14%)
March	Critical	7.74	7.44	-0.30 (-4%)
April	Wet	0.75	1.02	0.27 (36%)
April	Above Normal	1.69	2.02	0.33 (19%)
April	Below Normal	3.36	3.87	0.51 (15%)
April	Dry	3.48	3.32	-0.16 (-5%)
April	Critical	3.32	2.79	-0.53 (-16%)
May	Wet	1.31	1.93	0.62 (47%)
May	Above Normal	2.61	3.76	1.16 (44%)
May	Below Normal	2.47	3.61	1.15 (46%)
May	Dry	3.46	3.76	0.30 (9%)
May	Critical	3.25	3.42	0.17 (5%)
June	Wet	9.20	9.17	-0.03 (0%)
June	Above Normal	8.48	8.19	-0.29 (-3%)
June	Below Normal	9.49	9.32	-0.17 (-2%)
June	Dry	10.26	9.86	-0.39 (-4%)
June	Critical	6.09	5.15	-0.94 (-15%)

Water Transfers

As previously noted in the analysis for the Proposed Project, expansion of the water transfer window to include July to November would be unlikely to affect Delta Smelt, given that the species is mostly downstream of the Delta, although upstream migrating adults could overlap the window if first flushes of precipitation of flow occur prior to December. This is unlikely given that the main period of potential entrainment is the December–March period (USFWS 2008).

Georgiana Slough Behavioral Modification Barrier

Operation of a behavioral modification barrier at Georgiana Slough would be expected to have limited effects on Delta Smelt because the species is generally found well downstream of the Georgiana Slough junction. Delta Smelt encountering the barrier would be expected to be early life stages (e.g., larvae) moving downstream to rear in areas such as the low salinity zone and would not be expected to be deterred from entering Georgiana Slough because of weak swimming ability.

Table 5.3-7 d. Percentage of Particles Entrained Over 30 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
March	Wet	0.08	0.09	0.00 (6%)
March	Above Normal	0.06	0.06	0.00 (1%)
March	Below Normal	0.11	0.10	-0.01 (-6%)
March	Dry	0.05	0.04	0.00 (-5%)
March	Critical	0.02	0.03	0.01 (37%)
April	Wet	0.08	0.08	0.00 (-1%)
April	Above Normal	0.17	0.16	0.00 (-2%)
April	Below Normal	0.07	0.07	0.00 (1%)
April	Dry	0.18	0.18	0.00 (-1%)
April	Critical	0.07	0.07	-0.01 (-8%)
May	Wet	0.09	0.09	0.00 (4%)
May	Above Normal	0.15	0.16	0.01 (5%)
May	Below Normal	0.21	0.20	-0.02 (-8%)
May	Dry	0.24	0.12	-0.03 (-21%)
May	Critical	0.04	0.03	-0.01 (-25%)
June	Wet	0.13	0.13	0.00 (1%)
June	Above Normal	0.32	0.31	-0.01 (-3%)
June	Below Normal	0.26	0.26	0.00 (-1%)
June	Dry	0.20	0.19	-0.01 (-7%)
June	Critical	0.02	0.02	0.00 (-3%)

Source: ptm_fate_results_30day_Mar-Jun_qa_ITP_EX_20190901.dat; ptm_fate_results_30day_Mar-Jun_qa_ITP_ALT2B_20200114.dat

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect Delta Smelt include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. These activities likely would have limited impacts on Delta Smelt when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State

Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.

Project Environmental Protective Measure-Related impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures (see Table 3-3) that could potentially affect Delta Smelt include:

- Clifton Court Forebay actions to reduce predation including
    - Continued evaluation of predator relocation studies
    - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
    - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
    - Continued refinement and improvement of the fish sampling and hauling procedures
    - Infrastructure to improve the accuracy and reliability of data and fish survival
- Delta Smelt Reintroduction Studies
- Continue studies to establish a Delta fish Conservation Hatchery

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction best management practices as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish. Delta fish hatchery studies and Delta Smelt reintroduction studies could improve understanding of Delta Smelt culture practices, population genetic structure, and genetic management needs for future reintroduction.

Overall, these Environmental Protective Measures could reduce operations-related impacts on Delta Smelt, potentially improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Delta Smelt

As previously noted in the analysis for the Proposed Project, Delta Smelt inhabit areas of the Delta that could be affected by Refined Alternative 2b throughout their life cycle including transitions from: (1) adults to eggs and larvae from December to March; (2) eggs and larvae from March to June; (3) juveniles to subadults from June to September; and (4) subadults to adults from September to December. Potential operations-related changes to food availability, predation, harmful algal blooms, and summer-fall habitat that could affect Delta Smelt were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures.

The analyses conducted for each life stage of Delta Smelt are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of Delta Smelt are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on Delta Smelt, relative to the Existing Conditions scenario, and are considered **Less than Significant.**

5.3.9.1 LONGFIN SMELT

Operations-Related impacts

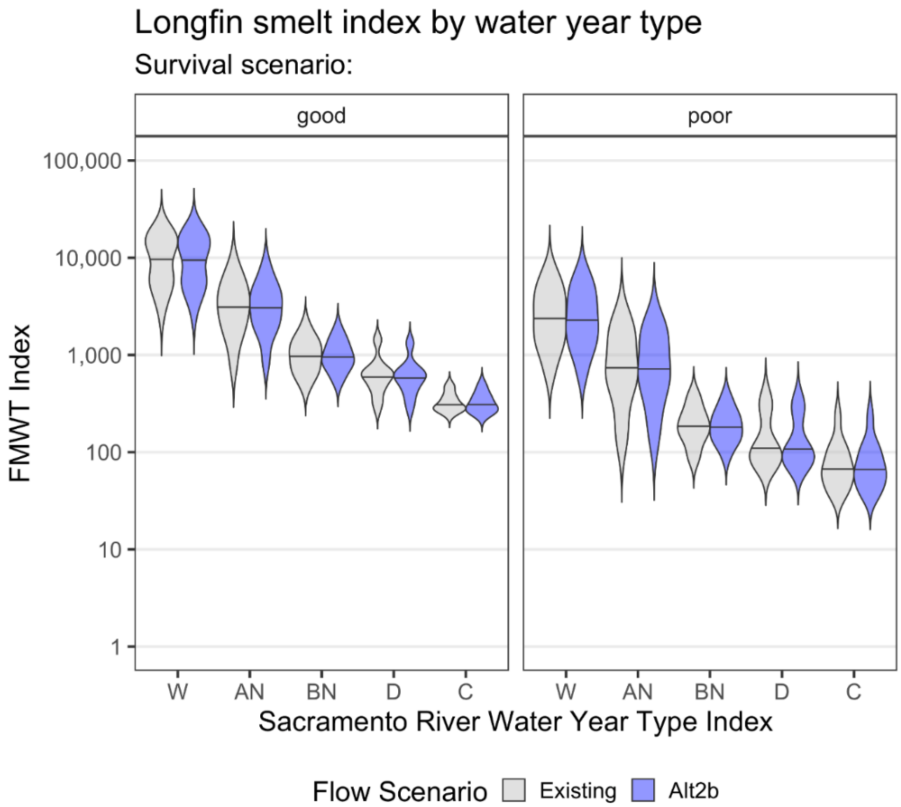
Delta Outflow-Abundance

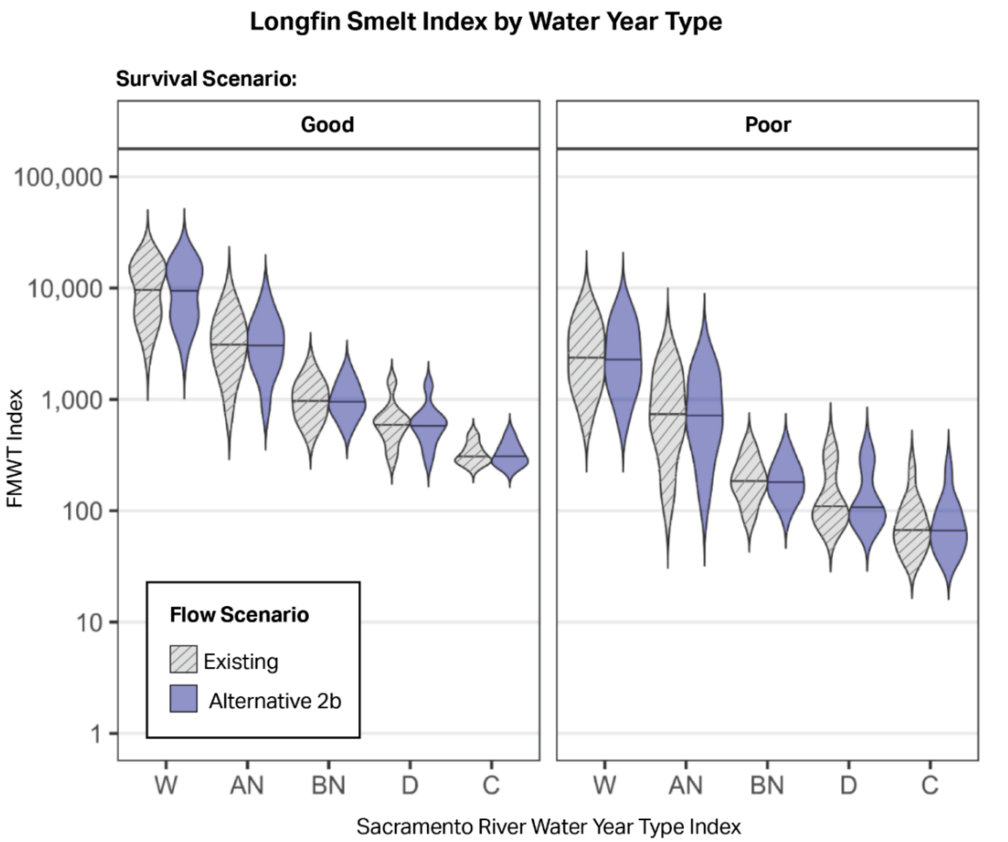
As previously noted in the analysis for the Proposed Project for Longfin Smelt, focus on estuarine flow has centered on the positive relationship found between winter and spring outflow and juvenile abundance during the fall (Rosenfield and Baxter 2007; Kimmerer et al. 2009). Specifically, as X2 (the position of the 2-ppt near-bottom salinity isohaline from the Golden Gate Bridge; see Jassby et al. [1995]) shifts downstream during the winter and spring, the abundance index of Longfin Smelt in the following FMWT survey increases (Kimmerer 2002; Kimmerer et al. 2009). The mechanisms underlying this relationship are poorly understood; however, the significant X2-abundance relationship suggests that higher outflow (lower X2) or conditions associated with wetter hydrological conditions produce conditions that enhance recruitment to juvenile life stages. Hypotheses about underlying mechanisms to this X2-abundance relationship include transport of larval Longfin Smelt out of the Delta to downstream rearing habitats (Moyle 2002; Rosenfield and Baxter 2007); increased extent of rearing habitat as X2 moves seaward (Kimmerer et al. 2009); retention of larvae in suitable rearing habitats (Kimmerer et al. 2009); increased food abundance under higher flows (DFG 2009a); and reduced clam grazing impacts on primary and secondary production (DFG 2009a). With respect to habitat size for early life stages, new information indicates that the distribution of spawning and early life stages may be broader than previously thought, including areas with salinity 2–12 (Grimaldo et al. 2017a). It has also been recognized that abundance of adults (spawners) is an important factor driving Longfin Smelt population dynamics (Baxter et al. 2010), with recent studies examining this link in detail (Maunder et al. 2015; Nobriga and Rosenfield 2016). A state-space modeling study by Maunder et al. (2015) found that multiple factors (flow, ammonium concentration, and water temperature) and density dependence influenced the survival of Longfin Smelt (represented by Bay Study abundance indices during 1980–2009). However, the flow terms included in their best models are not affected by Refined Alternative 2b: Sacramento River October–July unimpaired runoff and Napa River runoff.

As previously noted in the analysis for the Proposed Project, aside from the Maunder et al. (2015) model, which is not useful for the present impacts analysis because it does not include flow terms that could be influenced by Refined Alternative 2b, a recently published Longfin Smelt population dynamics modeling study is that of Nobriga and Rosenfield (2016), which examined various formulations of a Ricker (1954) stock-recruitment model to simulate fall midwater trawl indices through time. They found that December-May Delta outflow had a positive association with recruits per spawner and that juvenile recruitment from age 0 to age 2 was density-dependent (lower survival with greater numbers of juveniles) but cautioned that the density-dependence in the model may be too strong. It should also be noted that analyses relying on surveys such as the fall midwater trawl index do not fully encompass the range of Longfin Smelt and do not reflect potential changes in catchability over time because of factors such as increased water clarity and gear avoidance (Latour 2016) that are the subject of ongoing investigations. Nonetheless, the model may represent the best available option for assessing potential impacts of Refined Alternative 2b. The model described by Nobriga and Rosenfield (2016) was used to compare Refined Alternative 2b to the Existing Conditions scenario, using Delta outflow outputs from CalSim; additional detail of the method is provided in Appendix E.

The results of the Nobriga and Rosenfield (2016) model application suggested that differences in predicted fall midwater trawl abundance index between Refined Alternative 2b and Existing Conditions scenarios would be very small, relative to the variability in the predicted values, which spans several orders of magnitude (Figure 5.3-43; Tables 5.3-8 and 5.3-9). Thus, whereas the percentage difference in median index for the poor (post-1991) juvenile survival scenario, for example, ranges from 0% to 4% less under Refined Alternative 2b, there is a 0% difference when accounting for the high signal to noise ratio (i.e., when divided by the Existing 95% confidence interval) (Table 5.3-9). Specifically, the simulation results showed that the variability in FMWT index predictions within each scenario was considerably greater than the differences between the scenarios. This variability reflects the uncertainty in parameter estimates, which results in uncertainty in the extent to which operations-related differences in Delta outflow could affect Longfin Smelt. Specifically, variability in Delta outflow associated with overall hydrologic conditions (i.e., different water year types) is substantially larger than the minor differences in Delta outflow associated with changes in SWP operations. As described previously, Maunder et al. (2015) found that general hydrological conditions in the Sacramento River watershed and Napa River were a better explanation of population dynamics than Delta outflow. However, investigations funded under the Longfin Smelt Science Program will continue to provide additional information regarding potential mechanisms behind the correlation between flow and Longfin Smelt abundance indices and allow for a better understanding of Longfin Smelt distribution and abundance, which would be used to improve management actions.

The analysis based on the Nobriga and Rosenfield (2016) model application includes consideration of December–May Delta outflow, which depends on combined SWP and CVP operations. During this time period, the SWP is responsible for ~20–60% of Delta water operations, depending on month and water year type (see Appendix H). The main differences in Delta outflow (see Table 9-1 in Attachment 3-3 of Appendix C) reflect greater CVP exports under Refined Alternative 2b in April/May (see Table 7-1 in Attachment 3-3 of Appendix C).





Note: Median is indicated by the horizontal line.

Figure 5.3-43. Violin Plots of Predicted Longfin Smelt Fall Midwater Trawl Index by Water Year Type

Table 5.3-8. Predicted Median Longfin Smelt Fall Midwater Trawl Index Averaged by Water Year Type, Based on Nobriga and Rosenfield (2016) Assuming Good (Pre-1991) Juvenile Survival

Water Year Type	Existing (95% confidence interval)	Refined Alternative 2b (95% confidence interval)	Refined Alternative 2b vs. Existing[1]	Refined Alternative 2b vs. Existing [2]
Wet	10,617 (273–47,140)	10,514 (267–46,495)	-103 (-1%)	-103 (0%)
Above Normal	3,587 (94–11,888)	3,486 (93–11,437)	-101 (-3%)	-101 (0%)
Below Normal	1,047 (25–4,289)	1,032 (25–4,219)	-15 (-1%)	-15 (0%)
Dry	653 (18–2,557)	631 (17–2,487)	-22 (-3%)	-22 (-1%)
Critical	331 (9–1,664)	329 (9–1,640)	-2 (-1%)	-2 (0%)

Notes: [1]Difference is absolute difference between median estimates, with values in parentheses representing % difference in median.
[2] Difference is absolute difference between median estimates, with values in parentheses representing mean % difference based on difference between Refined Alternative 2b and Existing in each year, divided by the Existing 95% confidence interval, which is an indicator of signal to noise. Specifically, the value represents the percentage of the median change in relation to the 95% confidence intervals of the abundance estimates.

Table 5.3-9. Predicted Median Longfin Smelt Fall Midwater Trawl Index Averaged by Water Year Type, Based on Nobriga and Rosenfield (2016) Assuming Poor (Post-1991) Juvenile Survival

Water Year Type	Existing (95% confidence interval)	Refined Alternative 2b (95% confidence interval)	Refined Alternative 2b vs. Existing[1]	Refined Alternative 2b vs. Existing [2]
Wet	2,954 (89–55750)	2,864 (87–53,934)	-90 (-3%)	-90 (0%)
Above Normal	954 (38–12399)	920 (37–12,044)	-34 (-4%)	-34 (0%)
Below Normal	203 (9–4305)	198 (9–4219)	-5 (-3%)	-5 (0%)
Dry	154 (6–2494)	149 (6–2,426)	-5 (-3%)	-5 (0%)
Critical	83 (3–1494)	83 (3–1,480)	0 (0%)	0 (0%)

Notes: [1]Difference is absolute difference between median estimates, with values in parentheses representing % difference in median.
[2] Difference is absolute difference between median estimates, with values in parentheses representing mean % difference based on difference between Refined Alternative 2b and Existing in each year, divided by the Existing 95% confidence interval, which is an indicator of signal to noise. Specifically, the value represents the percentage of the median change in relation to the 95% confidence intervals of the abundance estimates.

Adult Entrainment

As previously noted in the analysis for the Proposed Project, there is the potential for adult Longfin Smelt entrainment to occur under Refined Alternative 2b, although take of adults is very limited relative to other life stages. Grimaldo et al. (2009) found that adult Longfin Smelt salvage at the south Delta export facilities was significantly negatively related to mean December–February Old and Middle River flows, but not to X2 (or other variables that were examined). As previously noted for Delta Smelt, modeling indicates there would be expected to be little difference between Refined Alternative 2b and Existing Conditions scenarios in Old and Middle River flows during this period (Figures 5.3-36, 5.3-37, and 5.3-38). However, Refined Alternative 2b includes OMR management from December 1 through February 28, when additional real-time consideration of adult Longfin Smelt entrainment risk will be undertaken by DWR in association with CDFW and WOMT, to provide protection for adult Longfin Smelt. During December–February, SWP responsibility for Delta water operations is ~40–60% depending on water year type (see Appendix H).

Particle Tracking Modeling (Larval Entrainment)

As previously noted in the analysis for the Proposed Project, larval Longfin Smelt entrainment by water diversions in the Delta, including into the Clifton Court Forebay and the Barker Slough Pumping Plant, could occur under Refined Alternative 2b and winter (January–March) is of particular concern. A DSM2-PTM analysis was undertaken following the methods described in Appendix E. Staff observations from preliminary Longfin Smelt culture efforts at the UC Davis Fish Conservation and Culture Laboratory have suggested that larvae may not be buoyant in freshwater but field studies found that they are buoyant in brackish water (Bennett et al. 2002; S. Acuña, pers. comm.), which may add some uncertainty to the results from PTM analysis. Analysis of surface- and neutrally buoyant particles provides information on two plausible behaviors, recognizing that the estimates are only order-of-magnitude comparisons that are best used in a relative fashion to compare different operational scenarios.

The DSM2-PTM results suggested that there would be relatively minor differences in the potential for entrainment of Longfin Smelt larvae between Refined Alternative 2b and Existing Conditions scenarios (Tables 5.3-11 and 5.3-12). Differences suggested by the PTM results would be expected to lower when Refined Alternative 2b is implemented because real-time operational measures are included in Refined Alternative 2b that would manage OMR flows for the protection of Longfin Smelt. Although the estimates of entrainment are intended to primarily be used comparatively, the weightings applied in the modeling are intended to represent a realistic distribution of larvae in the Delta and downstream and as such may provide some perspective on the magnitude of larval population loss, i.e., generally in the low single digit percentage (Table 5.3-10). Note that these estimates may overestimate entrainment loss because the Smelt Larval Survey providing the weighting for particle starting distributions does not sample the full extent of downstream areas where the species is occurring (see Appendix E).

No differences in operational criteria for the Barker Slough Pumping Plant are included in Refined Alternative 2b, and the DSM2-PTM results suggested little potential for difference in entrainment potential between the two scenarios for neutrally buoyant particles (Table 5.3-10) and surface-oriented particles (Table 5.3-11). However, the modeling does not reflect real-time operational adjustments that would be made if Longfin Smelt larvae were observed at SLS Station 716, i.e., 7-day average diversions of no more than 60 cfs at the Barker Slough Pumping Plant in dry and critical years. Further, as described in the California WaterFix ITP Application (ICF International 2016b), estimated annual entrainment of larval and early juvenile Longfin Smelt < 25 mm at the NBA for 1995-2004 was 0 to 0.4%, indicating low levels of entrainment would occur under Refined Alternative 2b and would be generally similar in magnitude to the levels under the Existing Conditions scenario.

Additional discussion of methods, and uncertainty associated with these analyses is provided in Appendix E.

Table 5.3-10. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into Clifton Court Forebay and Barker Slough Pumping Plant, and passing Chipps Island.

Table 5.3-10 d. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.78	0.77	-0.01 (-1%)
January	Above Normal	1.21	1.22	0.02 (1%)
January	Below Normal	1.96	2.00	0.05 (2%)
January	Dry	2.59	2.93	0.34 (13%)
January	Critical	2.56	2.58	0.01 (1%)
February	Wet	0.53	0.51	-0.02 (-3%)
February	Above Normal	0.91	0.87	-0.04 (-5%)
February	Below Normal	1.28	1.26	-0.02 (-2%)
February	Dry	1.81	1.89	0.08 (5%)
February	Critical	2.19	2.13	-0.06 (-3%)
March	Wet	0.57	0.41	-0.16 (-28%)
March	Above Normal	0.71	0.49	-0.22 (-31%)
March	Below Normal	1.18	0.79	-0.38 (-33%)
March	Dry	1.32	0.97	-0.36 (-27%)
March	Critical	1.17	1.14	-0.02 (-2%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20190901.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table 5.3-10 e. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.20	0.20	-0.01 (-3%)
January	Above Normal	0.21	0.21	0.00 (-2%)
January	Below Normal	0.23	0.22	-0.01 (-5%)
January	Dry	0.25	0.25	-0.01 (-2%)
January	Critical	0.21	0.21	0.00 (0%)
February	Wet	0.20	0.19	0.00 (-2%)
February	Above Normal	0.21	0.21	0.00 (-2%)
February	Below Normal	0.21	0.22	0.01 (2%)
February	Dry	0.17	0.16	-0.01 (-4%)
February	Critical	0.14	0.13	-0.01 (-9%)
March	Wet	0.18	0.18	0.00 (0%)
March	Above Normal	0.18	0.18	-0.01 (-4%)
March	Below Normal	0.23	0.23	-0.01 (-3%)
March	Dry	0.17	0.16	-0.01 (-7%)
March	Critical	0.09	0.09	0.01 (9%)

Table 5.3-10 f. Percentage of Neutrally Buoyant Particles Entrained Over 45 Days Passing Chipps Island

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	46.31	46.44	0.12 (0%)
January	Above Normal	42.91	43.09	0.18 (0%)
January	Below Normal	38.53	38.80	0.27 (1%)
January	Dry	33.50	32.73	-0.77 (-2%)
January	Critical	30.95	30.52	-0.43 (-1%)
February	Wet	46.41	46.49	0.07 (0%)
February	Above Normal	45.04	45.22	0.18 (0%)
February	Below Normal	41.77	41.86	0.10 (0%)
February	Dry	37.96	37.73	-0.24 (-1%)
February	Critical	33.06	33.05	-0.01 (0%)
March	Wet	46.52	46.73	0.21 (0%)
March	Above Normal	45.67	46.02	0.34 (1%)
March	Below Normal	43.76	45.35	0.69 (2%)
March	Dry	41.59	42.38	0.79 (2%)
March	Critical	38.80	38.32	-0.48 (-1%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_20190901.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_20200115.dat

Table 5.3-11. Percentage of Surface-Oriented Particles Entrained Over 45 Days into Clifton Court Forebay and Barker Slough Pumping Plant, and Passing Chipps Island

Table 5.3-11 d. Percentage of Surface-Oriented Particles Entrained Over 45 Days into Clifton Court Forebay

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	3.73	3.70	-0.03 (-1%)
January	Above Normal	6.30	6.18	-0.12 (-2%)
January	Below Normal	9.84	10.05	0.20 (2%)
January	Dry	10.76	11.39	0.63 (6%)
January	Critical	10.01	10.33	0.32 (3%)
February	Wet	2.55	2.35	-0.20 (-8%)
February	Above Normal	4.91	5.35	-0.46 (-9%)
February	Below Normal	7.27	6.39	-0.89 (-12%)
February	Dry	9.02	8.73	-0.30 (-3%)
February	Critical	8.89	8.57	-0.32 (-4%)
March	Wet	2.52	2.30	-0.23 (-9%)
March	Above Normal	3.26	2.35	-0.91 (-28%)
March	Below Normal	6.18	4.99	-1.20 (-19%)
March	Dry	6.76	5.69	-1.07 (-16%)
March	Critical	5.87	5.47	-0.40 (-7%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table 5.3-11 e. Percentage of Surface-Oriented Particles Entrained Over 45 Days into Barker Slough Pumping Plant

Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	0.24	0.23	-0.01 (-3%)
January	Above Normal	0.33	0.31	-0.01 (-4%)
January	Below Normal	0.39	0.39	-0.01 (-2%)
January	Dry	0.34	0.35	0.00 (1%)
January	Critical	0.21	0.22	0.01 (5%)
February	Wet	0.22	0.22	0.00 (-2%)
February	Above Normal	0.30	0.29	0.00 (-1%)
February	Below Normal	0.33	0.34	0.00 (1%)
February	Dry	0.08	0.08	0.00 (0%)
February	Critical	0.04	0.05	0.01 (29%)
March	Wet	0.29	0.28	-0.01 (-2%)
March	Above Normal	0.34	0.33	-0.02 (-5%)
March	Below Normal	0.54	0.53	-0.01 (-2%)
March	Dry	0.14	0.12	-0.02 (-12%)
March	Critical	0.03	0.02	-0.01 (-27%)

Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Table 5.3-11 f. Percentage of Surface-Oriented Particles Entrained Over 45 Days Passing Chipps Island

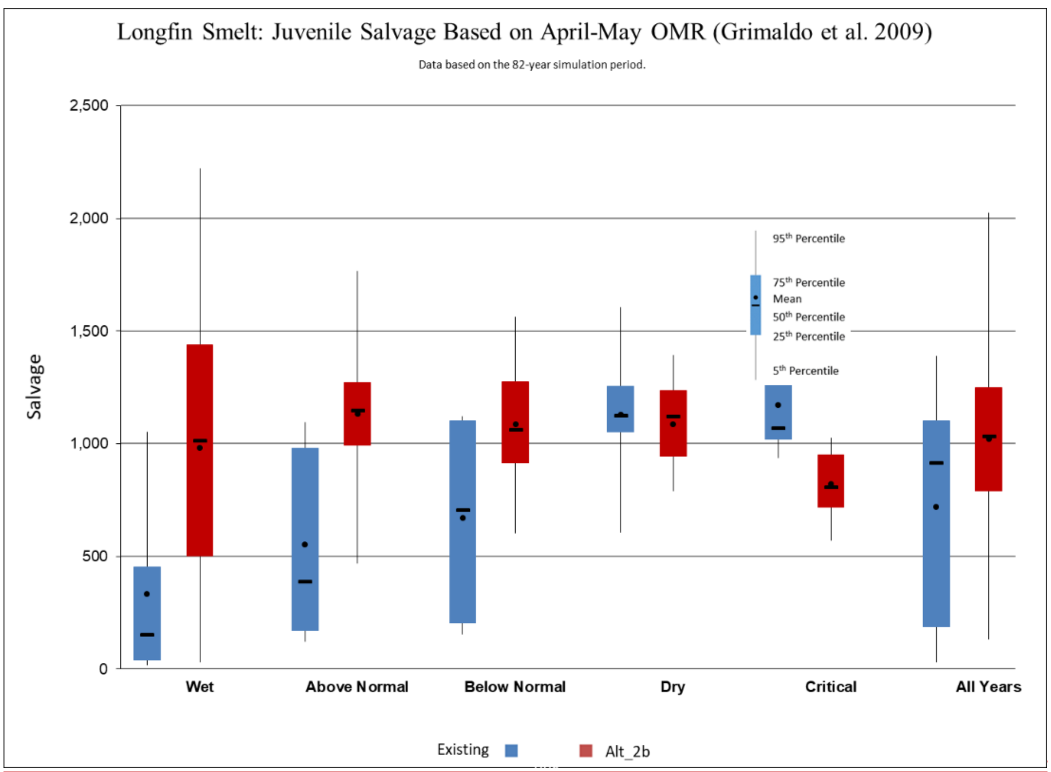
Month	Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
January	Wet	35.13	35.45	0.32 (1%)
January	Above Normal	22.86	23.39	0.53 (2%)
January	Below Normal	7.16	8.21	1.06 (15%)
January	Dry	2.31	2.20	-0.11 (-5%)
January	Critical	0.29	0.30	0.01 (3%)
February	Wet	38.29	38.68	0.39 (1%)
February	Above Normal	28.59	29.08	0.49 (2%)
February	Below Normal	16.96	17.98	1.03 (6%)
February	Dry	6.13	6.14	0.01 (0%)
February	Critical	1.08	1.10	0.02 (1%)
March	Wet	34.93	35.56	0.63 (2%)
March	Above Normal	29.32	31.12	1.80 (6%)
March	Below Normal	9.72	10.96	1.23 (13%)
March	Dry	4.65	5.37	0.72 (15%)
March	Critical	1.60	1.54	-0.07 (-4%)

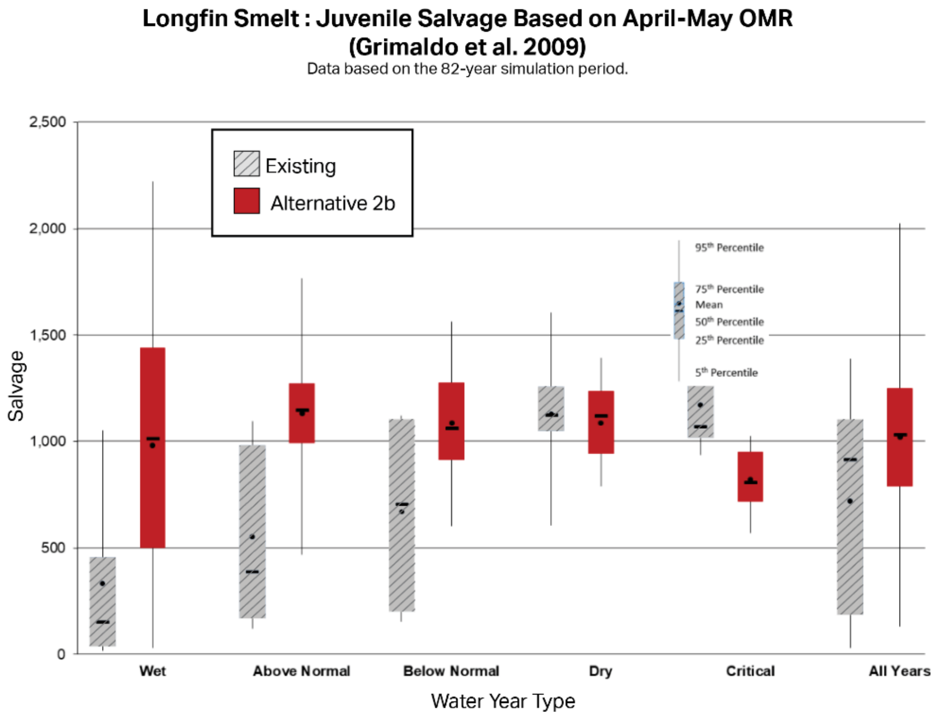
Source: ptm_fate_results_45day_Dec-Mar_qa_ITP_EX_BHV.dat; ptm_fate_results_45day_Dec-Mar_qa_ITP_ALT2B_BHV_20200117.dat

Salvage Old and Middle River Regression

As previously noted in the analysis for the Proposed Project, Grimaldo et al. (2009) found that juvenile Longfin Smelt salvage principally occurred in April–May and was significantly negatively related to mean April–May Old and Middle River flow (and was not related to other factors such as X2). The impacts analysis included an evaluation of potential differences in entrainment between Refined Alternative 2b and Existing Conditions scenarios by recreating and applying the Grimaldo et al. (2009) relationship between salvage and Old and Middle River flows (see Appendix E).

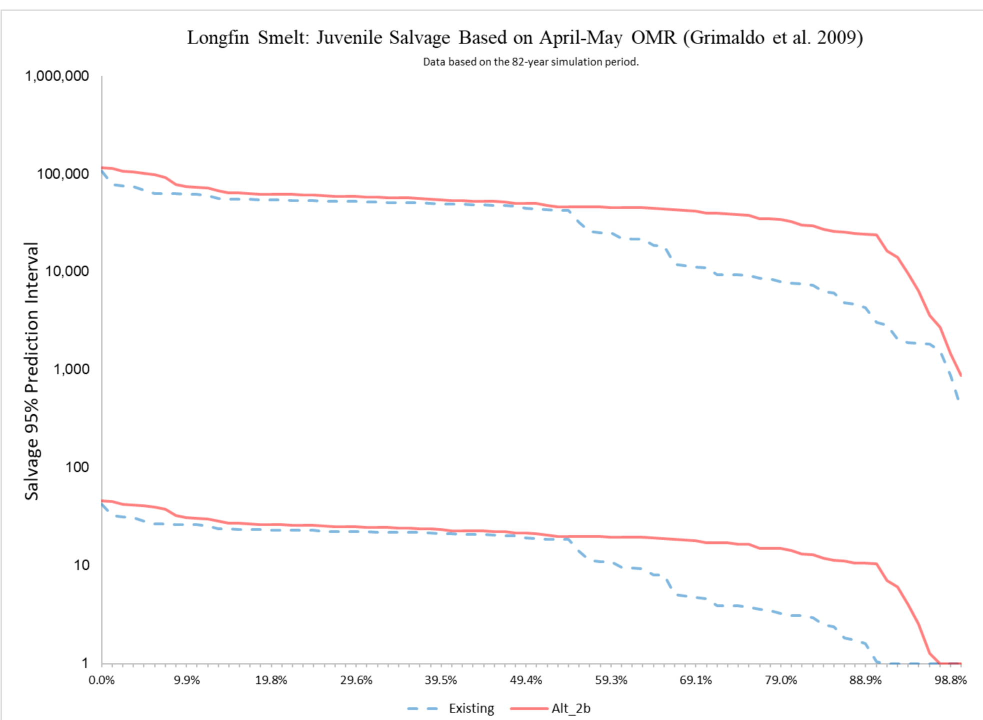
The analysis based on the Grimaldo et al. (2009) salvage-Old and Middle River flow regression suggested the potential for increases in entrainment under Refined Alternative 2b compared to the Existing Conditions scenario with considerable uncertainty around the predictive estimates (Figure 5.3-44 and Figure 5.3-45; Table 5.3-12). As described further below, these modeling results in part reflect differences in CVP operations between scenarios. The modeling results do not reflect real-time operational adjustments that would be undertaken for Longfin Smelt or other species, which would be expected to reduce the difference in entrainment between the Existing Conditions scenario and Refined Alternative 2b. Further, entrainment of juvenile Longfin Smelt is likely to represent a low percentage of the overall juvenile Longfin Smelt population because management of entrainment is estimated to have resulted in a very small percentage of the juvenile population being entrained in recent years (2009 onwards) under the operations regime that is represented by the Existing Conditions modeling scenario (see Table 4.4-15 in Section 4.4.7.4). Specifically, Longfin Smelt entrainment loss under Refined Alternative 2b likely represents a low percentage of the overall juvenile Longfin Smelt population because the species is widely distributed in the San Francisco Bay and its tributaries including the Napa and Petaluma rivers, and South Bay tributaries.





Note: Plot only includes mean responses and does not consider model uncertainty.

Figure 5.3-44. Box Plot of Longfin Smelt April–May Salvage, from the Regression Including Mean Old and Middle River Flows (Grimaldo et al. 2009), Grouped by Water Year Type



Note: Data are sorted by mean estimate, with only 95% prediction intervals shown. Zero estimates are converted to 1 in this plot to allow plotting on a log scale.

Figure 5.3-45. Exceedance Plot of Longfin Smelt April–May Salvage, from the Regression Including Mean Old and Middle River Flows

Table 5.3-12. Mean Annual Longfin Smelt April–May Salvage, from the Regression including Mean Old and Middle River Flows (Grimaldo et al. 2009), Grouped by Water Year Type

Water Year Type	Existing	Refined Alternative 2b	Refined Alternative 2b vs. Existing
Wet	333	983	650 (195%)
Above Normal	551	1,131	580 (105%)
Below Normal	670	1,085	415 (62%)
Dry	1,130	1,085	-45 (-4%)
Critical	1,171	823	-348 (-30%)

This entrainment loss is considered less than significant because of real-time OMR management actions that are expected to minimize entrainment losses and because entrainment losses would occur to a small percentage of the Longfin Smelt population.

The analysis of potential salvage-related impacts on Longfin Smelt from differences in April–May Old and Middle River flows reflect combined SWP and CVP operations. During April–May, the SWP would be responsible for around 20% to 40% of Delta water operations under Refined Alternative 2b, depending on water year type and month (see Appendix H). SWP exports generally would be similar to Existing Conditions during April–May (see Table 4-1 in Attachment 3-3 of Appendix C); in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than Existing Conditions. The potential for increases in entrainment at the south Delta export facilities when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period.

Water Transfers

As previously noted in the analysis for the Proposed Project, expansion of the water transfer window to include July to November would be expected to have limited effects on Longfin Smelt, given that upstream migrating adults have very little entrainment during these months (Grimaldo et al. 2009).

Georgiana Slough Behavioral Modification Barrier

Operation of a behavioral modification barrier at Georgiana Slough would be expected to have limited effects on Longfin Smelt because the species is generally found well downstream of the Georgiana Slough junction. Longfin Smelt encountering the barrier would be expected to be early life stages (e.g., larvae) moving downstream to rear as juveniles in higher salinity areas such as San Francisco Bay, and would not be expected to be deterred from entering Georgiana Slough because of weak swimming ability.

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect Longfin Smelt include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
    - Sediment Removal

- Aquatic Weed Removal

- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. These activities likely would have limited impacts on Longfin Smelt when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.

Project Environmental Protective Measure-Related Impacts

Environmental Protective Measures that could potentially affect Longfin Smelt include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival
- Continue studies to establish a Delta fish Conservation Hatchery
- Longfin Smelt Science Program including
  - Studies to better understand the Longfin Smelt population distribution and abundance in the San Francisco Bay and Delta

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish. The Longfin Smelt Science program is specifically intended improve the scientific understanding of Longfin Smelt to allow for better management of the species and its habitat.

Overall, these Environmental Protective Measures could minimize operations-related impacts on Longfin Smelt, improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Longfin Smelt

Longfin Smelt are relatively widely distributed in the San Francisco Bay, San Pablo Bay, Suisun Bay, and tributaries, but also inhabit areas of the Delta that could be affected by Refined Alternative 2b throughout their life cycle. Potential operations-related changes to Longfin Smelt abundance, larval entrainment, and juvenile and adult salvage were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures

The analyses conducted for each life stage of Longfin Smelt are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of Longfin Smelt are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on Longfin Smelt, relative to the Existing Conditions scenario, and are considered **Less than Significant.**

5.3.9.2 Winter-run Chinook Salmon

Operations-Related Impacts

Immigrating Adults

As previously noted in the analysis for the Proposed Project, and as described in the SAIL Adult Migration from Bay-Delta to Upper River conceptual model, adult Winter-run Chinook Salmon use the lower Sacramento River between the Delta and the confluence with the Feather River as a migration corridor. These immigrating adults can be present from November through July. During this period, changes in simulated average monthly flows at Freeport under Refined Alternative 2b, relative to the Existing Conditions scenario are generally relatively small (see Figure 5.3-46, Figures 5.3-47 through 5.3-51, and Table 5.3-13). In fact, because of the water balance nature of the CalSim, the monthly timestep, and generalized operations assumptions in the model, simulated differences in flow of about 1% to 2% may not represent actual flow changes that could potentially occur as SWP facilities are operated (see Section 4.1.4.1 for discussion of model limitations). Therefore, flows at Freeport are considered similar under Refined Alternative 2b and Existing Conditions scenarios during most months of the year.

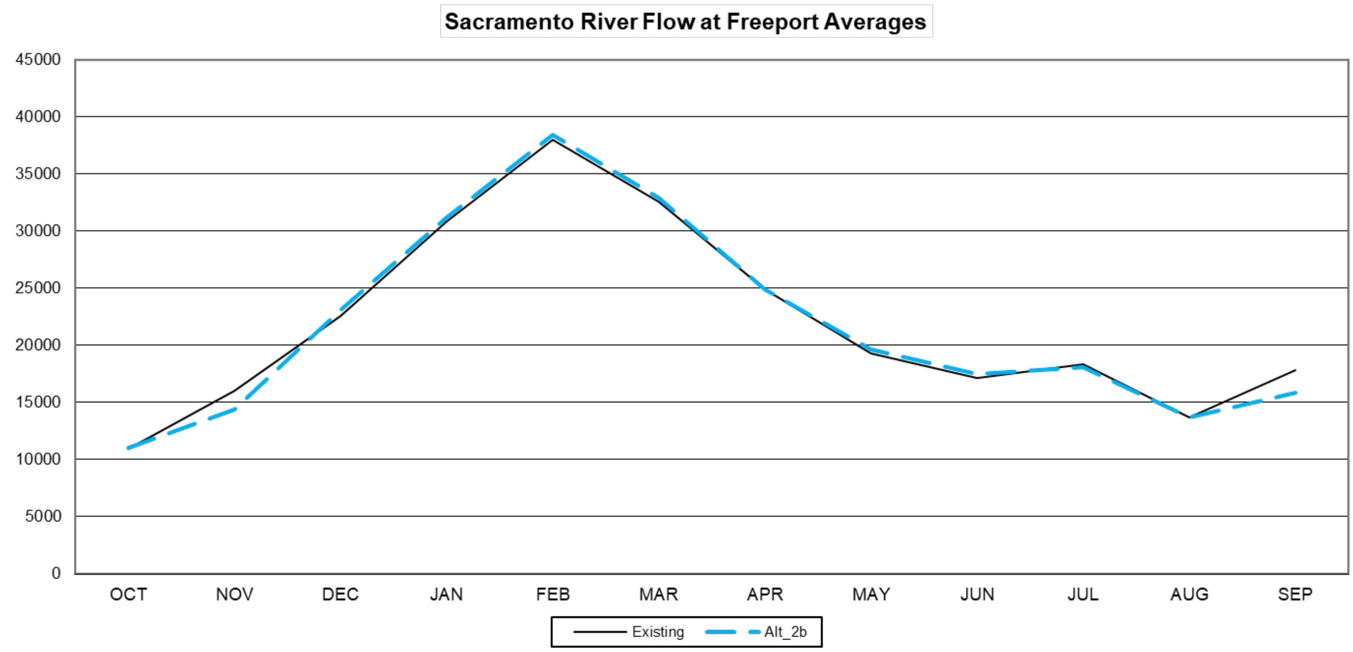


Figure 5.3-46. Simulated Average Monthly Flows in the Sacramento River at Freeport under Refined Alternative 2b and Existing Conditions Modeling Scenarios

Table 5.3-13. Simulated Average Monthly Flows (cfs) at Freeport under Refined Alternative 2b and Existing Conditions Modeling Scenarios, and the Difference and Percentage Difference (Refined Alternative 2b Minus Existing Conditions)

Month	Existing	Refined Alternative 2b	Difference	Percent Difference
January	30,820	31,196	376	1.2%
February	37,978	38,389	411	1.1%
March	32,595	32,894	300	0.9%
April	24,891	24,912	21	0.1%
May	19,312	19,653	341	1.8%
June	17,132	17,529	397	2.3%
July	18,361	18,126	-235	-1.3%
August	13,660	13,704	43	0.3%
September	17,819	15,845	-1,974	-11.1%
October	10,902	11,062	160	1.5%
November	16,017	14,367	-1,650	-10.3%
December	22,564	23,049	484	2.1%

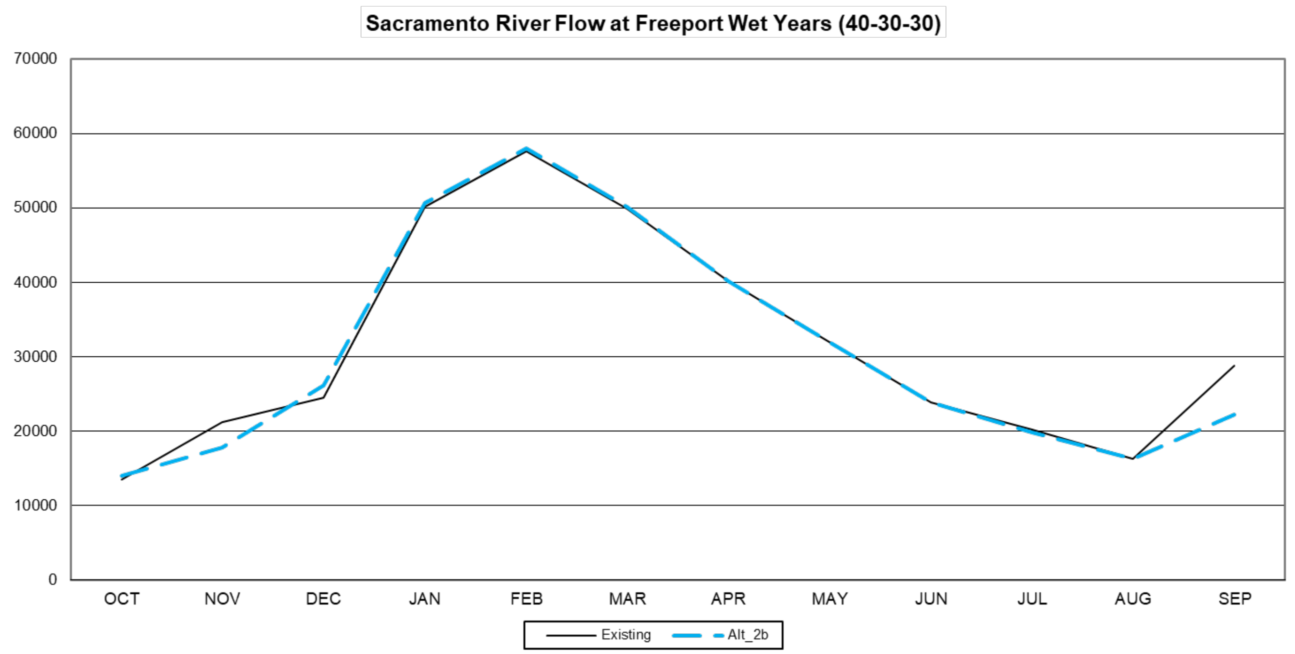


Figure 5.3-47. CalSim-Modeled Mean Sacramento River Flow at Freeport by Month, Wet Years

As previously noted in the analysis for the Proposed Project, because flows are generally similar under Refined Alternative 2b and Existing Conditions scenarios, it is expected that habitat attributes such as water temperature, dissolved oxygen concentrations, and other attributes would also be similar. Further, because flows are similar, and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.2 feet (Table 1-2-1, Appendix C), which would not likely reduce migration opportunities for adult Winter-run Chinook Salmon. In addition, larger differences in flow between Refined Alternative 2b and Existing Conditions scenarios that occur during November suggest little potential for differences in rates of straying of adult Winter-run Chinook Salmon between Refined Alternative 2b and Existing Conditions scenarios. Specifically, because other salmonids in the same genus (i.e., closely related to Chinook Salmon) such as adult Sockeye Salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989). Under the assumption that Sockeye Salmon responses to changes in olfactory cues are similar to those of Winter-Run Chinook Salmon, potential impacts of Refined Alternative 2b on immigrating adult Winter-run Chinook Salmon in the Sacramento River are expected to be similar to those under the Existing Conditions scenario. Evidence from the Bay-Delta suggests that straying rates of Sacramento River basin hatchery-origin Chinook Salmon were very low (<1%) during the period from 1979 through 2007 (Marston et al. 2012), indicating that even across a wide range of differences in flow, straying is very low.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on immigrating adult Winter-run Chinook Salmon; the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the November–July Winter-run Chinook Salmon adult immigration period is approximately 20-60% depending on month and water year type (see Appendix H).

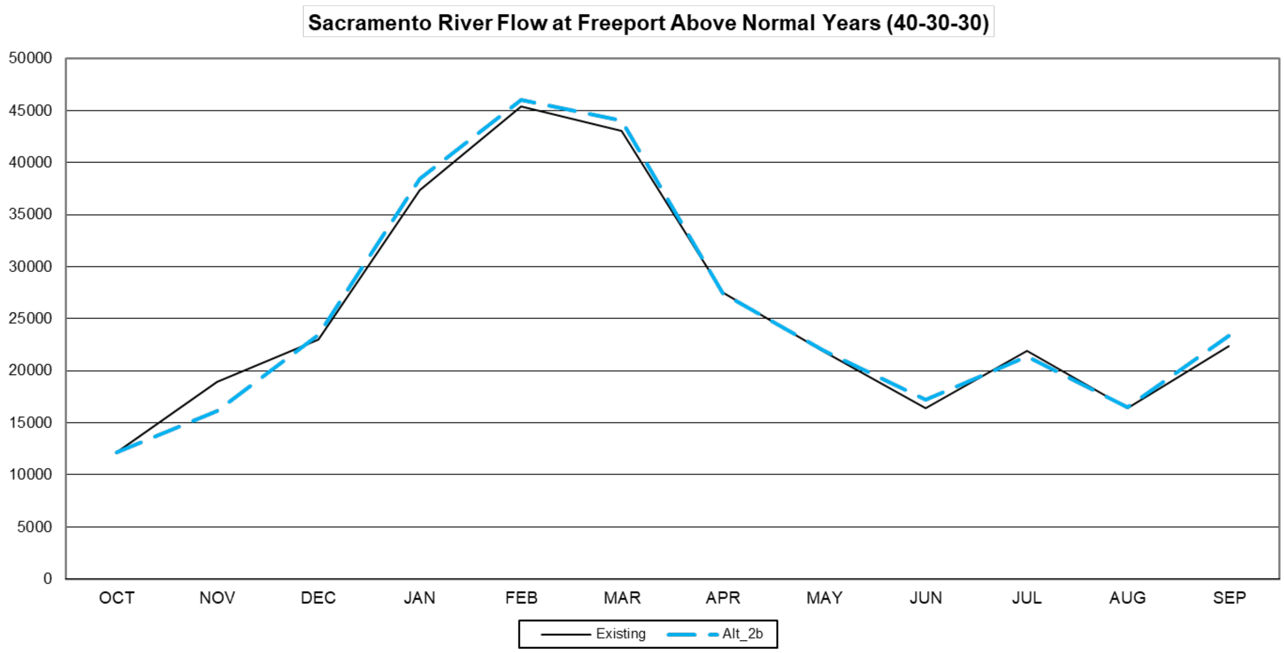


Figure 5.3-48. CalSim-Modeled Mean Sacramento River Flow at Freeport by Month, Above Normal Years

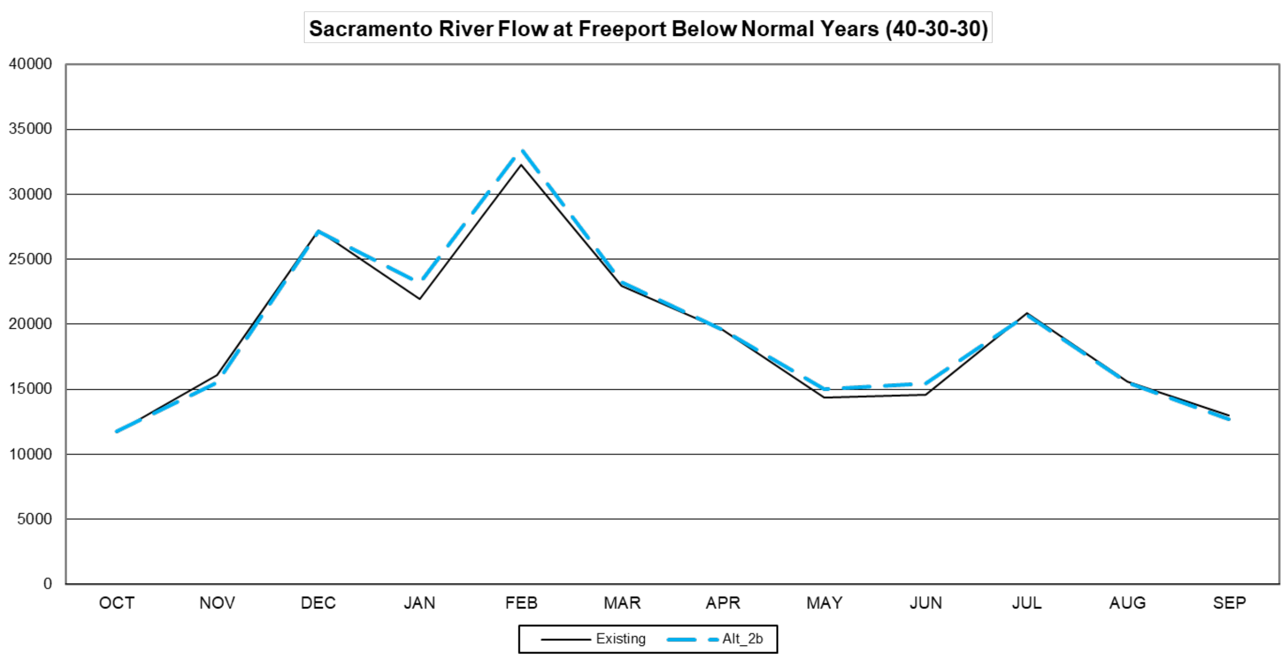


Figure 5.3-49. CalSim-Modeled Mean Sacramento River Flow at Freeport by Month, Below Normal Years

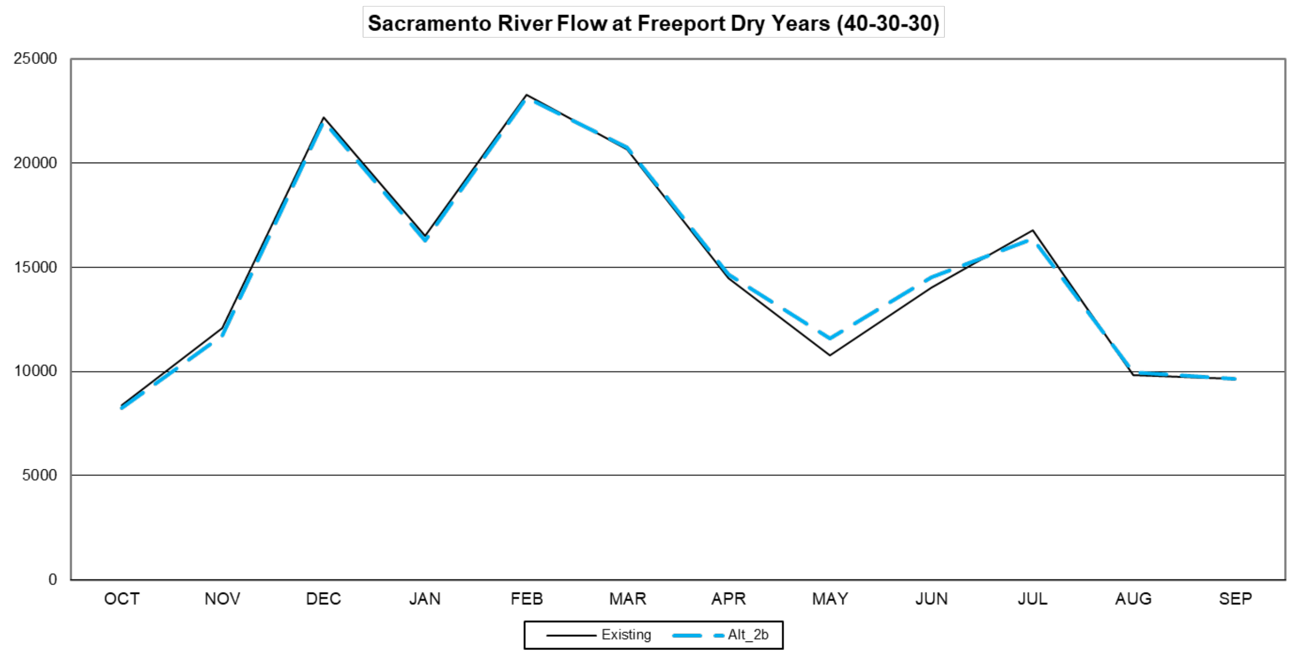


Figure 5.3-50. CalSim-Modeled Mean Sacramento River Flow at Freeport by Month, Dry Years

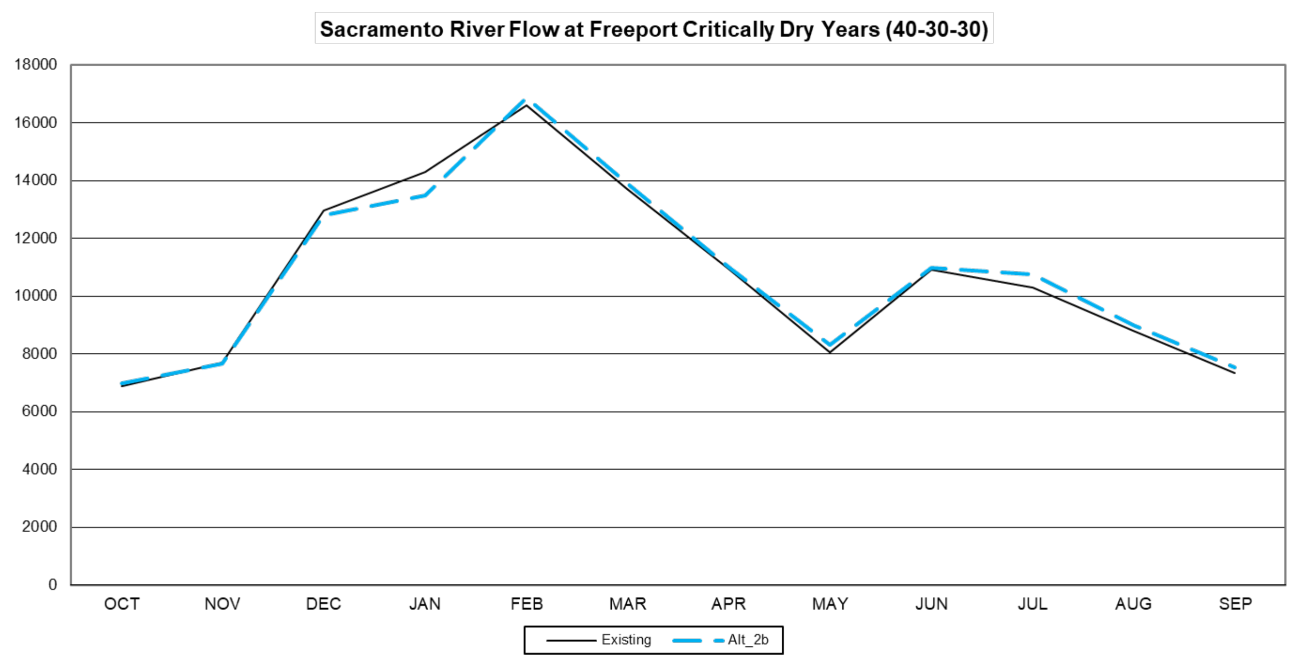


Figure 5.3-51. CalSim-Modeled Mean Sacramento River Flow at Freeport by Month, Critical Years

Adult salmonid straying was reviewed in detail by Lasko et al. (2014). They provided the following overview, which considers both a general background as well as information specific to the Central Valley:

(a) "Nearly all species of salmon and trout (family Salmonidae) spawn in fresh water, and many have at least facultative anadromous life histories (Quinn 1997, Quinn 2005, Railsback et al. 2014). Homing, the behavior of adult salmonids returning to spawn in their natal stream, is a major part of the anadromous life history (Quinn et al. 2000, Beacham et al. 2002, Keefer et al. 2008). Homing serves to genetically isolate populations of the same species spawning in different waterways, thus allowing for eventual adaptation to local conditions (Quinn et al. 2000, Beacham et al. 2002, Keefer et al. 2008). This could include evolved compatibility to natal habitat conditions via adaptations for temperature tolerance or resistance to pathogens in the stream, as locally adapted salmonids are generally far more successful at spawning than occasional strays (Quinn 2005). Overall estimates for natal area fidelity via homing in Pacific salmon (Oncorhynchus spp.) are 80%–100%, based primarily on hatchery data (Quinn 1997). Imprinting, or olfactory learning, of anadromous salmonids to their natal stream appears to occur before and during the parr-smolt transformation, as well as during emigration, although to a lesser extent during earlier life stages in some Pacific salmon of hatchery origin (Dittman et al. 1994, Dittman and Quinn 1996, Quinn 1997, Dittman et al.1996, Lema and Nevitt 2004, Yamamoto et al. 2010)."

(b) "The term "straying," as used in this paper, refers to anadromous salmonids that either intentionally or unintentionally return to and spawn in a non-natal stream. Anadromous salmonids that spawn in a river or stream other than the one of their origin exhibit the "truest" sense of straying (Quinn et al. 1991), which Keefer et al. (2008) referred to as permanent straying. It is not known why some anadromous salmonids stray and the explanation is likely complex. The tendency to home or stray may be genetically inherited, and the pattern and stability of anadromous salmonid distributions may be a reflection of ecological constraints on the fish (Quinn 2005). Straying may occur in response to environmental conditions, or in response to disturbance events that prevent the fish from reaching or spawning in their natal stream (Quinn 2005, Waples et al. 2009). Anadromous salmonids may also wander, explore new habitats for suitability, follow schools of conspecifics from other rivers, or opportunistically spawn in another stream with favorable conditions (Jonsson et al. 2003, Keefer et al. 2008). Furthermore, anadromous salmonids may be distracted by odors or flows from a river they are migrating past, or simply get lost or confused by some combination of cues that they encounter during their upriver migration. Straying can be adaptive through rapid colonization of newly available habitat after events such as landslides, forest fires, or low flows and high temperatures resulting from drought or ice melt and glacial recession (Quinn 1997, Moyle 2002, Quinn 2005, Waples et al. 2009). Straying likely results in gene flow between different populations in the system (Quinn 2005). Strays might be the only successful spawners following a major climatic or catastrophic event, such as the eruption Fall 2014 of Mount St. Helens which rendered natal streams inaccessible or unsuitable for spawning (Quinn 2005). In effect, straying can provide a kind of insurance in space from these types of events (Thorpe 1994)."

(c) "There is great variability in salmon straying rates from year to year and between populations, by size and age (Quinn and Fresh 1984), and across species (Quinn 1997). Salmonids of hatchery origin appear to stray at a higher rate than salmonids that are of natural origin, and straying also appears to increase with increased

> hatchery selection (Jonsson et al. 2003). It may be that this bias towards greater straying by salmonids of hatchery origin is due to fewer studies of straying behavior in wild populations (Quinn 1997). Straying may increase when salmonids of hatchery origin are released away from their natal hatchery, and may also increase with greater release distance from the hatchery (Newman 2008). Different rivers seem to vary in their attractiveness to Pacific salmon strays, possibly because of flow or temperature variations from year to year (Quinn et al. 1991, Carmichael 1997, Crateau 1997, Phillips et al. 2000), and strays might choose a river resembling their natal stream (Quinn et al. 1991). There also appears to be considerable variation in the amount of straying based on location, and straying can occur both upstream and downstream from an individual's natal stream. Johnson et al. (1990) found only a rough correlation between straying rate and release distance from the natal stream."

Lasko et al. (2014) found that straying of hatchery-reared Late fall-run Chinook Salmon from the Coleman National Fish Hatchery into the American River increased relative to proximity of release location to the mouth of the American River and with respect to downstream releases in general; no salmon released in the vicinity of the Coleman National Fish Hatchery were recovered in the lower American River. The straying issue was also examined in detail by Sturrock et al. (2019), who found that transport distance was strongly associated with straying rate (averaging 0–9% vs. 7–89% for salmon released on site vs. in the bay upstream of Golden Gate Bridge, respectively), increasing the effects of hatchery releases on natural spawners. Hence, it appears that hatchery management has a relatively strong effect on straying throughout Central Valley.

Refined Alternative 2b does not change hatchery release strategy, which based on the above information appears to be the main driver of straying risk in the Central Valley.

Delta Hydrodynamic Analysis

Velocity Assessment

As previously noted in the analysis for the Proposed Project, hydrodynamic changes associated with river inflows and South Delta exports have been suggested to adversely affect juvenile Chinook Salmon in two distinct ways: 1) "near-field" mortality associated with entrainment to the export facilities, and 2) "far-field" mortality resulting from altered hydrodynamics. Entrainment effects of seasonal operations are discussed in the Entrainment Loss Density analyses, and in the Winter-run Chinook Salmon Salvage analysis.

As previously noted in the analysis for the Proposed Project, a foundation for assessing far-field hydrodynamic effects has been provided by work of the CAMT SST. The SST concluded altered "Channel Velocity" and altered "Flow Direction" were the only two hydrodynamic mechanisms by which exports and river inflows could affect juvenile salmonids in the Delta (see Figure 4.4-64 in Section 4.4.7.4).

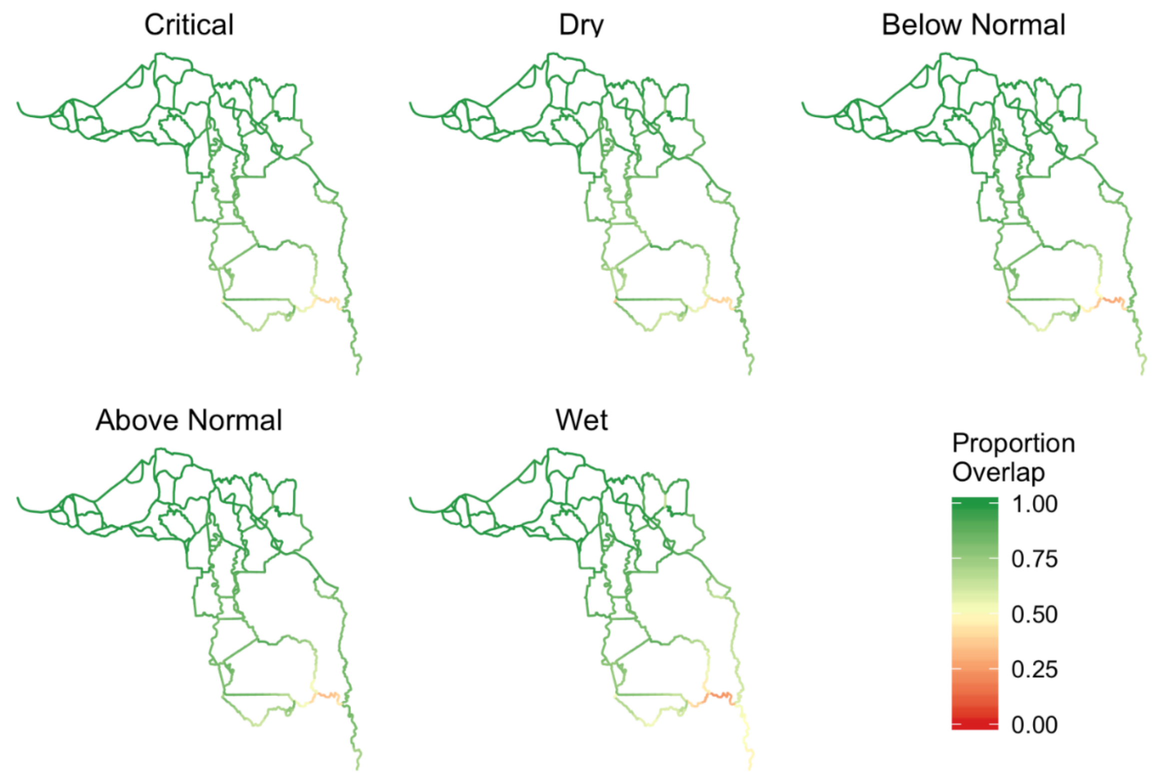
To assess potential hydrodynamic impacts, hourly DSM2 HYDRO outputs were used to identify Delta channels exhibiting velocity changes under Refined Alternative 2b and Existing Conditions scenarios.

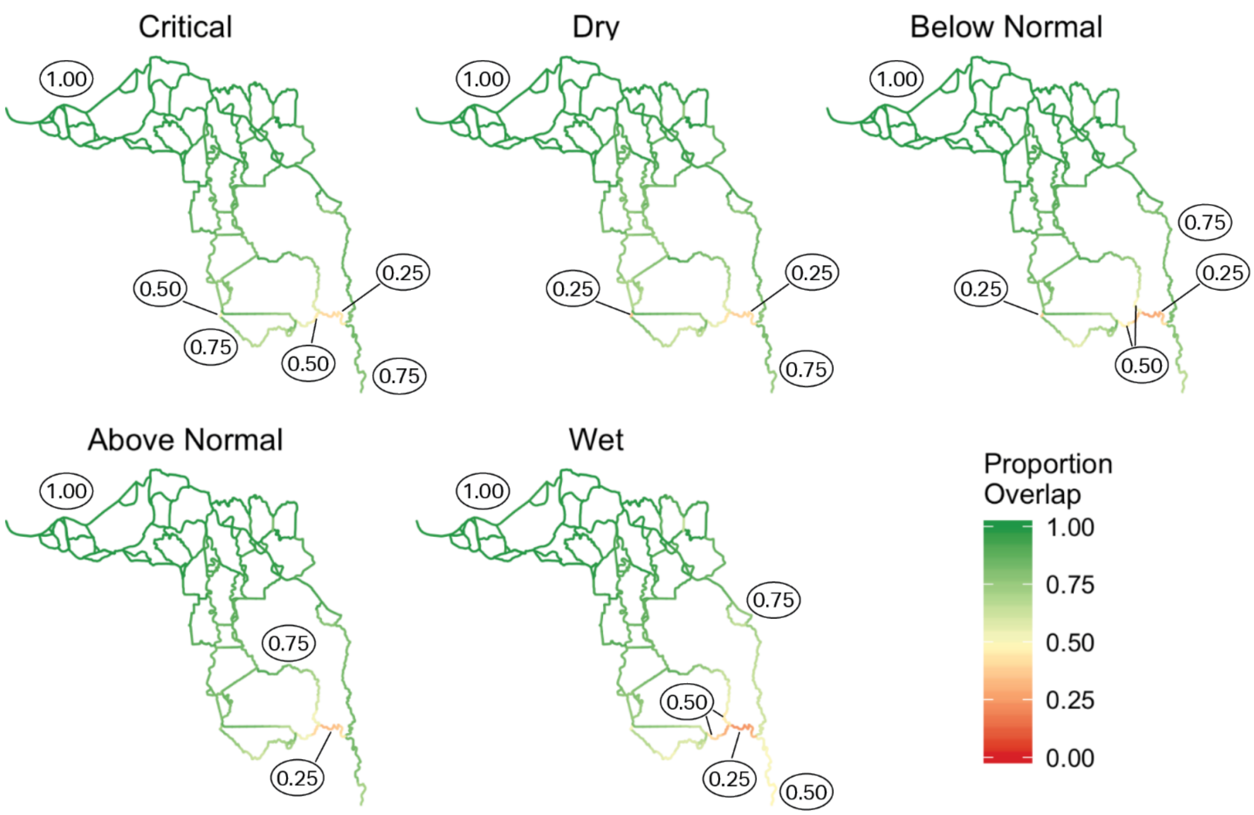
The analysis is stratified by water year type and by the three seasons when juvenile salmonids are present in the Delta (fall, winter, and spring). CalSim modeling indicates that inflows to the Delta from the Sacramento and San Joaquin Rivers generally would not be appreciably different under Refined Alternative 2b and Existing Conditions scenarios. In the Delta, the largest hydrodynamic differences between Refined Alternative 2b and Existing Conditions scenarios that may influence juvenile salmonids occur in the South Delta and result from changes to spring export rates and the HORB.

Between September and November, velocities in the Central Delta (between Highway 4 and north to the San Joaquin River mainstem) are generally similar between Refined Alternative 2b and Existing Conditions scenarios (Figure 5.3-52). The largest velocity changes are apparent near the HOR. Under Refined Alternative 2b, no barrier is in place at this location and, therefore more water is flowing into eastern Old and Middle rivers, increasing velocities in these channels. Velocities in the mainstem San Joaquin River both upstream and downstream of the HOR exhibit few differences in critical, dry, below-normal, and above-normal water years. In wet water years, the absence of the HORB causes moderately increased velocities upstream and slightly decreased velocities downstream of the HOR under Refined Alternative 2b. Exports proposed for fall months (particularly November) lead to slight velocity changes in the South Delta near the export facilities. Flows in the South Delta are tidal (i.e., bidirectional), and velocity changes in this region reflect both slightly stronger negative velocities and slightly weaker positive velocities.

Between December and February, exports between Refined Alternative 2b and Existing Conditions scenarios are similar and the HORB is not installed. Velocities throughout the South and Central Delta are largely unchanged in winter months between the Refined Alternative 2b and the Existing Conditions scenarios.

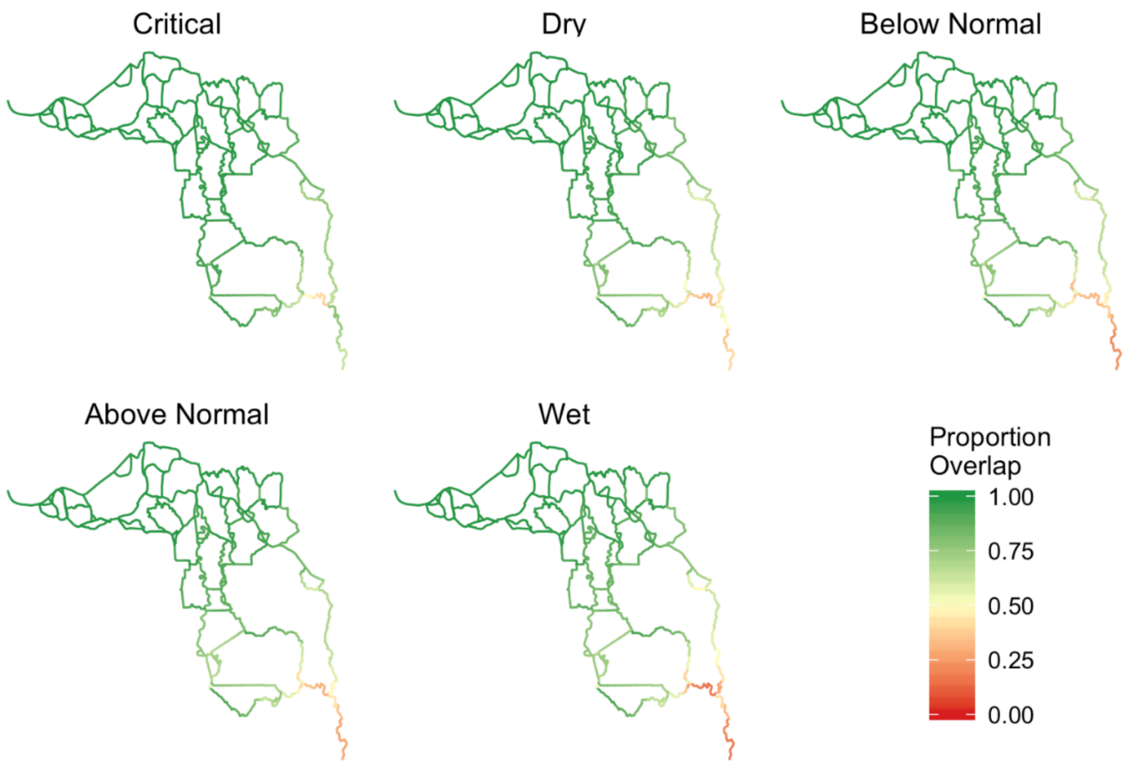
Between March and May, velocities in the Central Delta (between Hwy 4 and north to the San Joaquin River mainstem) are generally similar between Refined Alternative 2b and Existing Conditions scenarios (Figure 5.3-53). The largest velocity changes are apparent near the HOR. Under Refined Alternative 2b, no barrier is in place at this location and, therefore, more water would flow into eastern Old and Middle rivers, increasing velocities in these channels. Velocities in the mainstem San Joaquin River both upstream and downstream of the HOR exhibit increasing differences with wetter water year types. These differences are due to the absence of the HORB under Refined Alternative 2b. The lack of HORB causes moderate to large increases in velocities upstream of the HOR, and slight to moderately decreased velocities downstream of HOR. These impacts occur because the presence of the HORB creates hydraulic head that slows upstream of velocities and this impact is stronger with higher San Joaquin River flows. Exports proposed for spring months (particularly April and May) lead to some velocity changes in the South Delta near the export intake facilities. Minimal impacts are apparent in critically dry years, but slight to moderate velocity differences occurred in the Old and Middle rivers immediately north of the export facilities during wetter water year types. Velocity changes associated with spring exports under Refined Alternative 2b do not appear to extend into the Central Delta. Flows in the South and Central Delta are tidal (i.e., bidirectional), and export-related velocity changes observed in these regions reflect both slightly stronger negative velocities and slightly weaker positive velocities.

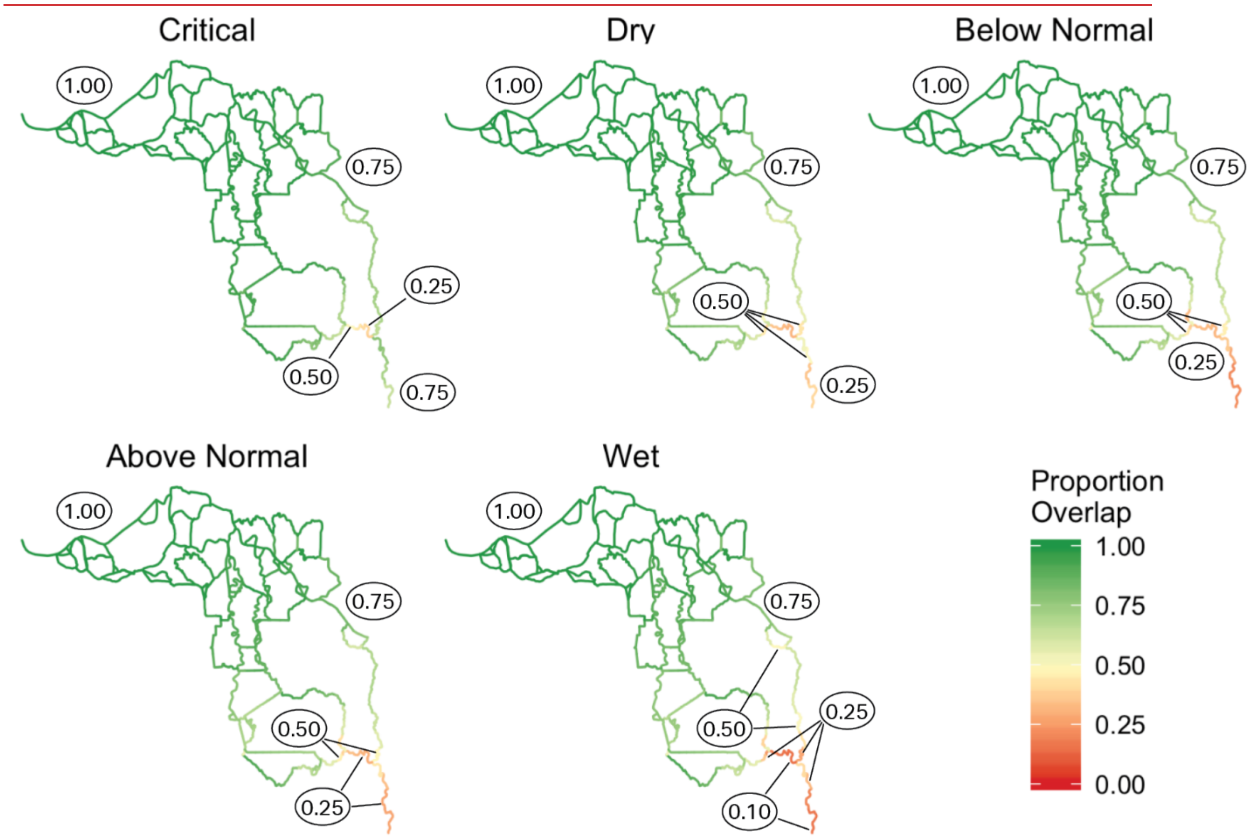




Map colors depict the proportion of overlap in velocity-frequency distribution with these contrasting export rates. Green indicates velocities are very similar (high overlap), while orange indicates large velocity differences (low overlap). More information on the source of these data and an interactive Shiny application is available at https://fishsciences.shinyapps.io/delta-hydrodynamics/ The Shiny application allows the user to select and view hydrodynamic conditions resulting from a variety of operating conditions and for a variety of hydrodynamic metrics.

Figure 5.3-52. Changes in Delta Water Velocities, September-November, with Refined Alternative 2b vs. Existing Condition





Map colors depict the proportion of overlap in velocity-frequency distribution with these contrasting export rates. Green indicates velocities are very similar (high overlap), while orange indicates large velocity differences (low overlap). More information on the source of these data and an interactive Shiny application is available at https://fishsciences.shinyapps.io/delta-hydrodynamics/ The Shiny application allows the user to select and view hydrodynamic conditions resulting from a variety of operating conditions and for a variety of hydrodynamic metrics.

Figure 5.3-53. Changes in Delta Water Velocities March-May with Refined Alternative 2b vs. Existing Condition

Delta hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the September through May period evaluated above is approximately 20-60% depending on the month and water year type (see Appendix H).

Hydrodynamic Impacts on Winter-run Chinook Salmon

As previously noted in the analysis for the Proposed Project, coded wire tagging and acoustic tagging studies suggest relatively few juvenile Chinook salmon entering the Delta from the North will be exposed to velocity changes observed in the South Delta with Refined Alternative 2b (e.g., less than 1% of coded-wire-tagged fish were found in salvage; Zeug and Cavallo 2014). Fish passing through the Delta Cross Channel or Georgiana Slough and continuing to migrate westward in the mainstem San Joaquin River will experience no velocity changes likely to influence their survival or behavior. Fish that move southward enough in the Old and Middle River corridor to reach areas of altered velocities may be more likely to continue moving toward the export facilities and become vulnerable to entrainment.

However, velocity changes that could occur in the Spring and Fall are not likely to affect Winter-run Chinook Salmon because most Winter-run Chinook Salmon are expected to have exited the Delta by April and May and are not generally present in the region in September and November. As discussed further below, the operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Winter-run Chinook Salmon entry into the interior Delta at Georgiana Slough, and reduce south Delta entrainment risk.

Entrainment

Entrainment Loss Density

As previously noted in the analysis for the Proposed Project, to provide perspective on potential differences in entrainment loss of Winter-run Chinook Salmon juveniles between Refined Alternative 2b and Existing Conditions scenarios, the salvage-density method was used (Appendix E). Note that this method is based on length-at-date classification of Chinook Salmon race, and therefore the determination of race in historical salvage is uncertainty. Therefore, all months are evaluated in this analysis but only those Chinook Salmon that were reported as Winter-run Chinook Salmon based on their length at the time of salvage were included in the weighting and subsequent reporting of Winter-run Chinook Salmon loss density.

As previously noted in the analysis for the Proposed Project, the estimates of entrainment loss obtained from the salvage-density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim-modeled differences in south Delta exports between the evaluated scenarios. Therefore, the results are basically a description of differences in export flows weighted by monthly loss density. Historical loss density numbers provide some perspective on the absolute numbers of fish being entrained but are a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected[22]. Although the emphasis is consideration of the relative difference between scenarios, it is important to appreciate that the modeling is limited in its representation of real-time adjustments to operations in order to minimize impacts on listed fishes, so that differences between scenarios are likely to be less than suggested by the method.

The salvage-density method suggested that entrainment loss of juvenile Winter-run Chinook Salmon at the SWP south Delta export facility would be similar between Refined Alternative 2b and Existing Conditions scenarios (Table 5.3-14). These results occur because most Winter-run Chinook Salmon entrainment largely occurs prior to the April–May period when the largest difference in simulated south Delta exports occurs between the scenarios. It should be noted that the analysis herein is based on size-at-date criteria and does not reflect potential errors in Chinook Salmon race identification based on these criteria (Harvey et al. 2014). It is expected that the latest information (e.g., genetic assignment) would be used as it becomes available, to limit potential entrainment loss of Winter-run Chinook Salmon. In addition, the risk assessment-based approach for OMR flow management included in Refined Alternative 2b would be expected to limit entrainment loss for Winter-run Chinook Salmon juveniles to no more than the protective levels required by the NMFS ROC on LTO Biological Opinion. These protective low levels would continue the low levels of entrainment (i.e., less than ~1% of genetically identified Winter-run Chinook Salmon juveniles entering the Delta), that occurred as a result of the NMFS (2009) Biological Opinion criteria implementation (see, for example, Islam et al. 2018).

Winter-run Chinook Salmon Salvage (Based on Zeug and Cavallo 2014)

As previously noted in the analysis for the Proposed Project, a predictive model of Winter-run Chinook Salmon salvage was developed based on a study of 178 release groups of Winter-run Chinook Salmon from the Livingston Stone hatchery by Zeug and Cavallo (2014). The predictive salvage model was run for the Existing Conditions and Refined Alternative 2b scenarios using export and flow data from the DSM2 model. Additional discussion of the method is provided in Appendix E. Results were compared among the two scenarios and summarized on an annual basis, and for each month winter run occur in the Delta by water year type.

Across the 82-year DSM2 simulation period, salvage of juvenile Winter-run Chinook Salmon was predicted to be less than 0.15% of the total juvenile population for both scenarios. Median salvage was slightly lower under Refined Alternative 2b relative to the Existing Conditions scenario over the entire modeling period (0.1032% and 0.1071%, respectively). Despite the trend of lower median salvage under Refined Alternative 2b across all years, there was variation in which scenario produced lower salvage in individual years (Figure 5.3-54).

[22] The loss density estimates reflect the regulatory accepted multipliers for estimating loss as a function of observed salvage; it is acknowledged herein that loss is likely to vary from the regulatory multipliers, for example, as illustrated by historical and recent studies of prescreen loss in Clifton Court Forebay (Gingras 1997; Miranda 2019), but it is assumed that loss density provides a reasonable depiction of seasonal patterns in entrainment from which to weight modeled exports for comparison of the Existing and Alternative 2b scenarios.

Table 5.3-14. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-14 a – f

Table 5.3-14 g. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2,397	624	1,846	126	11	0	0	0	0	0	0	377
Refined Alternative 2b	2,452	633	1,589	235	16	0	0	0	0	0	0	376

Table 5.3-14 h. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	4,613	1,710	1,076	25	0	0	0	0	0	0	0	760
Refined Alternative 2b	4,651	1,599	825	32	0	0	0	0	0	0	0	707

Table 5.3-14 i. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,272	1,209	1,447	0	0	0	0	0	0	0	0	68
Refined Alternative 2b	1,372	1,248	1,086	26	12	0	0	0	0	0	0	69

Table 5.3-14 j. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	531	990	2,039	44	0	0	0	0	0	0	0	354
Refined Alternative 2b	576	1,017	1,652	41	0	0	0	0	0	0	0	381

Table 5.3-14 k. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	386	697	436	39	7	0	0	0	0	0	0	243
Refined Alternative 2b	417	683	418	31	7	0	0	0	0	0	0	235

Table 5.3-14 l. Estimates of Winter-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	5,381	8,184	4,031	3,958	1,809
Refined Alternative 2b	5,301	7,815	3,814	3,667	1,790
Refined Alternative 2b vs. Existing	-80 (-1%)	-369 (-5%)	-217 (-5%)	-291 (-7%)	-18 (-1%)

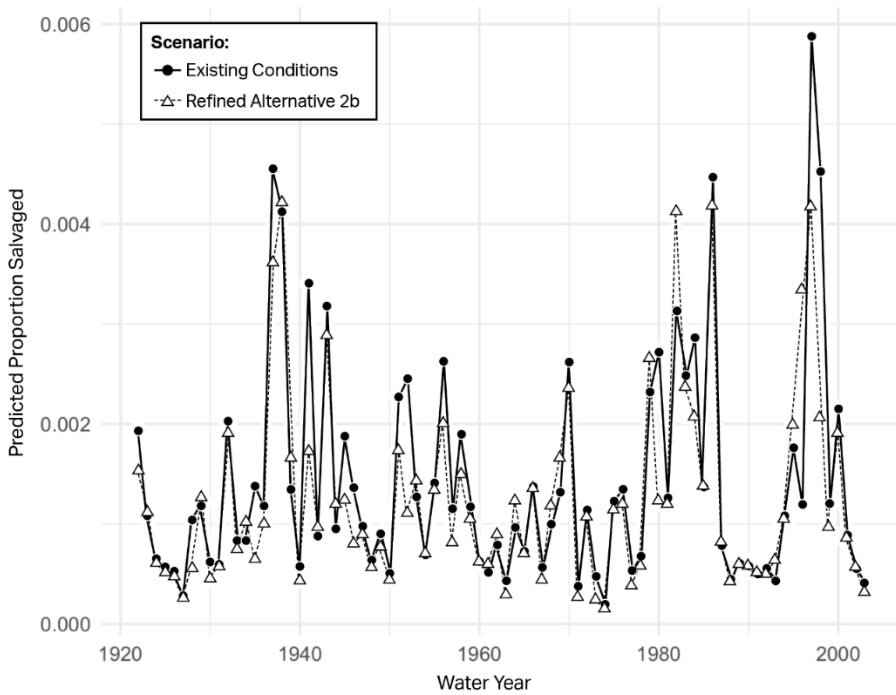
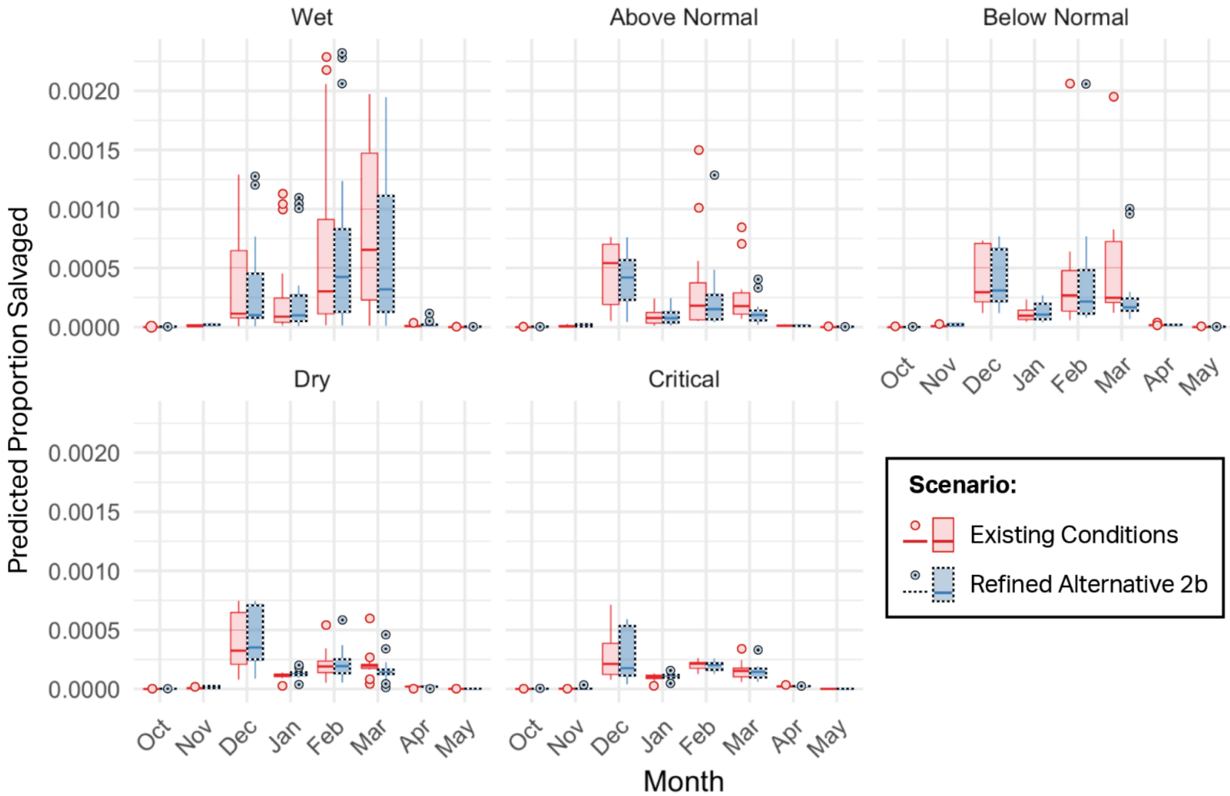


Figure 5.3-54. Predicted Proportion of Juvenile Winter-run Chinook Salmon Salvage at the SWP under the Existing Conditions and Refined Alternative 2b Scenarios across the 82-Year DSM2 Simulation Period

Median predicted salvage was higher under Refined Alternative 2b in some months of some water year types and was higher under the Existing Conditions scenario in some months of some water year types (Figure 5.3-55). In most months of all water year types, considerable overlap in the interquartile ranges occurred. The highest median salvage for both scenarios occurred in wet water years, but salvage did not exceed 0.25% in any month (Figure 5.3-55). The lowest salvage for all scenarios occurred in critical water years. Overall, in most months, salvage of Winter-run Chinook Salmon is similar for Refined Alternative 2b and Existing Conditions scenarios. However, notable differences in predicted salvage occur in some months of some water years. For example, in March of wet water years salvage is expected to be higher under the Existing Conditions scenarios and in December of dry water and above normal years salvage is expected to be higher under Refined Alternative 2b (Figure 5.3-55). In February of wet water years Refined Alternative 2b is predicted to have the highest salvage values (Figure 5.3-55). Further, the underlying DSM2 modeling does not reflect real-time operational decision-making, modeling, and OMR management that would occur under Refined Alternative 2b. These real-time operations, including cumulative and single year loss thresholds would be expected to limit entrainment (and thus, salvage) to protective levels.

The analysis of potential salvage-related impacts on Winter-run Chinook Salmon from differences in October–May Old and Middle River flows reflect combined SWP and CVP operations. The SWP responsibility for Delta water operations during the October-May period evaluated above is approximately 20% to 60% depending on the month and water year type (see Appendix H).



Note: The horizontal line is the median value, the box defines the interquartile range, and vertical lines define the minimum and maximum values. Single points are outliers.

Figure 5.3-55. Box and Whisker Plots of Predicted Proportion of Juvenile Winter-run Chinook Salmon Salvaged at the Skinner Delta Fish Protective Facility of the State Water Project as a Function of SWP Exports and Sacramento River Flow for Existing Conditions and Refined Alternative 2b Scenarios

Outmigrant Survival

Delta Passage Model

As previously noted in the analysis for the Proposed Project, the DPM integrates operational impacts of the Existing Conditions and Refined Alternative 2b scenarios that could influence through-Delta survival of migrating juvenile Chinook Salmon smolts, including Sacramento River Winter-run. Functions included in the DPM include reach-specific flow-survival and flow travel-time relationships, flow-routing relationships, and export-survival relationships. Uncertainty in the quantitative relationships included in the DPM were integrated into the analysis, using Monte Carlo techniques. One hundred iterations of the model were run for each scenario in which distributions for each parameter were resampled for each iteration. Model output reported here is annual through-Delta survival in the 82-year CalSim period and through-Delta survival aggregated by water year-type. Further details of the method are provided in Appendix E.

Across the 82-year simulation period, mean through-Delta survival was 0.2% greater for Refined Alternative 2b (28.5%, 95% CI 15.7 – 44.2) relative to the Existing Conditions scenario (28.3%, 95% CI15.9 – 44.5). Survival was greater under the Existing Conditions scenario for 24 of the 82 years and greater under Refined Alternative 2b in 37 years (Figure 5.3-56). Differences in individual years were generally small (< 1%) with the largest difference occurring in 1975 when survival was 1.9% higher than

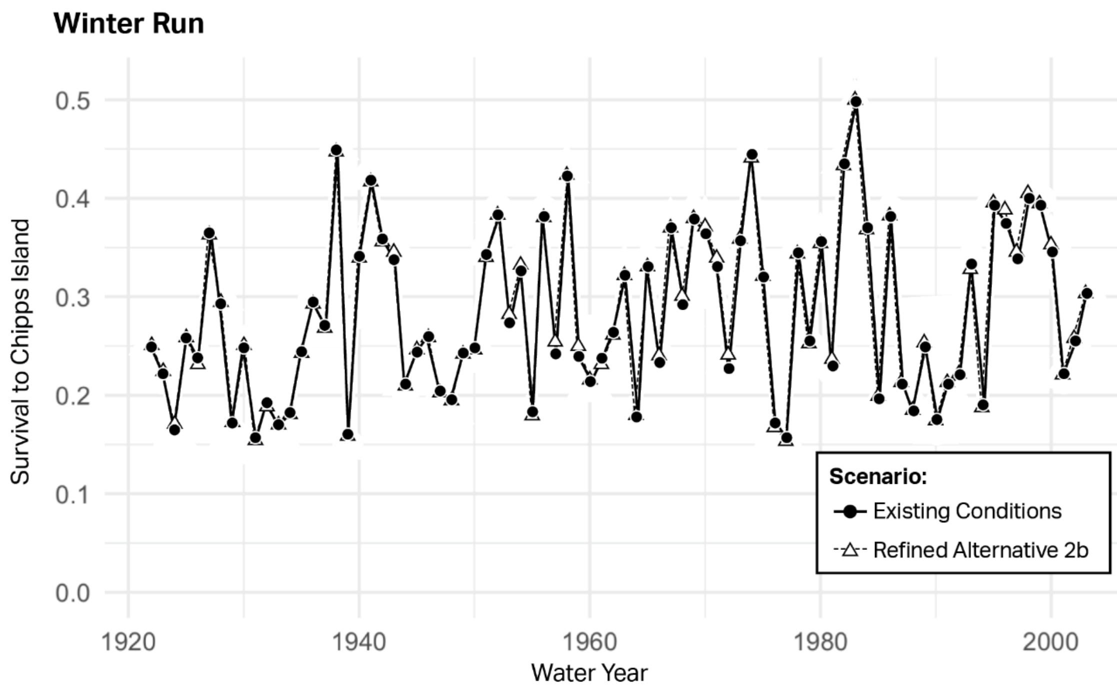


Figure 5.3-56. Mean Estimates of Winter-run Chinook Salmon Through-Delta survival with 95% Confidence Intervals for Refined Alternative 2b and the Existing Condition in Each Simulation Year

under the Existing Conditions scenario. Confidence intervals for through-Delta survival overlapped between scenarios in all years.

For all scenarios, mean survival rates tracked water year type with the highest value in wet years and the lowest value in critical years (Figure 5.3-57). In each water year-type, mean survival was slightly higher under Refined Alternative 2b, relative to the Existing Condition. However, 95% confidence intervals overlapped substantially between survival estimates. The largest difference between scenarios occurred in below-normal years when mean survival under Refined Alternative 2b was 0.32% higher than the Existing Conditions scenario.

Through-Delta survival impacts as represented by the Delta Passage Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the main winter-spring (~December–April) period of Winter-run Chinook Salmon entry into the Delta is approximately 20% to 60% (see Appendix H).

STARS

As previously noted in the analysis for the Proposed Project, the Survival, Travel Time, And Routing Simulation Model (STARS; Perry et al. 2018) was used to provide perspective on potential differences in the routing to the interior Delta of juvenile Chinook Salmon between Refined Alternative 2b and Existing Conditions scenarios. The model simulated migration routing using CalSim modeled flows (82-year time series) and DCC gate operations to assess differences between the two scenarios in

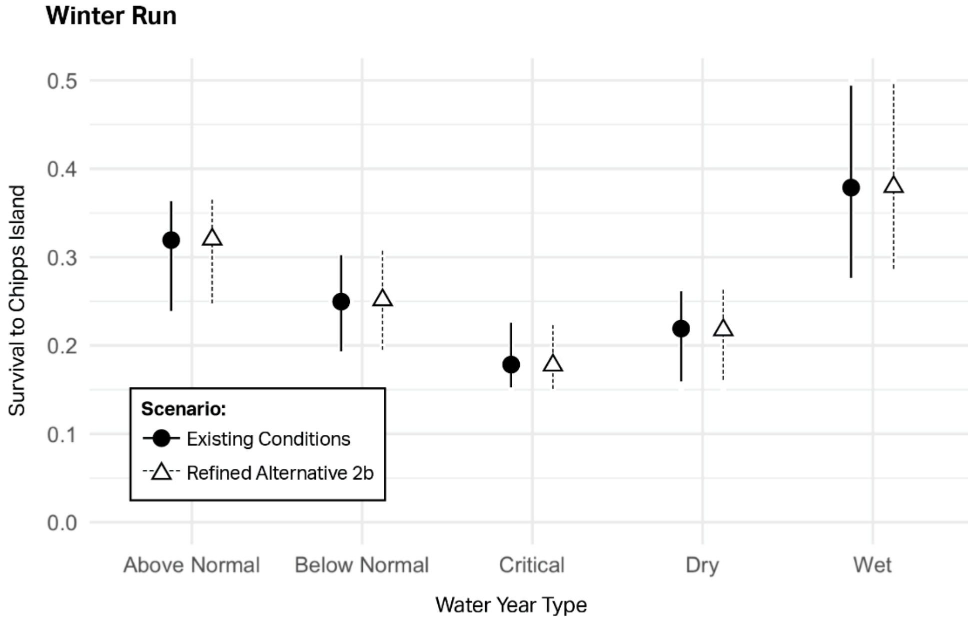


Figure 5.3-57. Mean Through-Delta Survival with 95% Confidence Intervals for Juvenile Winter-run Chinook Salmon under Refined Alternative 2b and the Existing Condition. Values were summarized by water year-type over the 82-year CalSim period

entrainment to the interior Delta of juvenile Chinook Salmon from October-June. However, the analyses of the STARS model results for Winter-run Chinook Salmon considered the months of October through May based on the time period when they could potentially rear and emigrate from Delta (NMFS 2009, p.80; NMFS 2017, p.67).

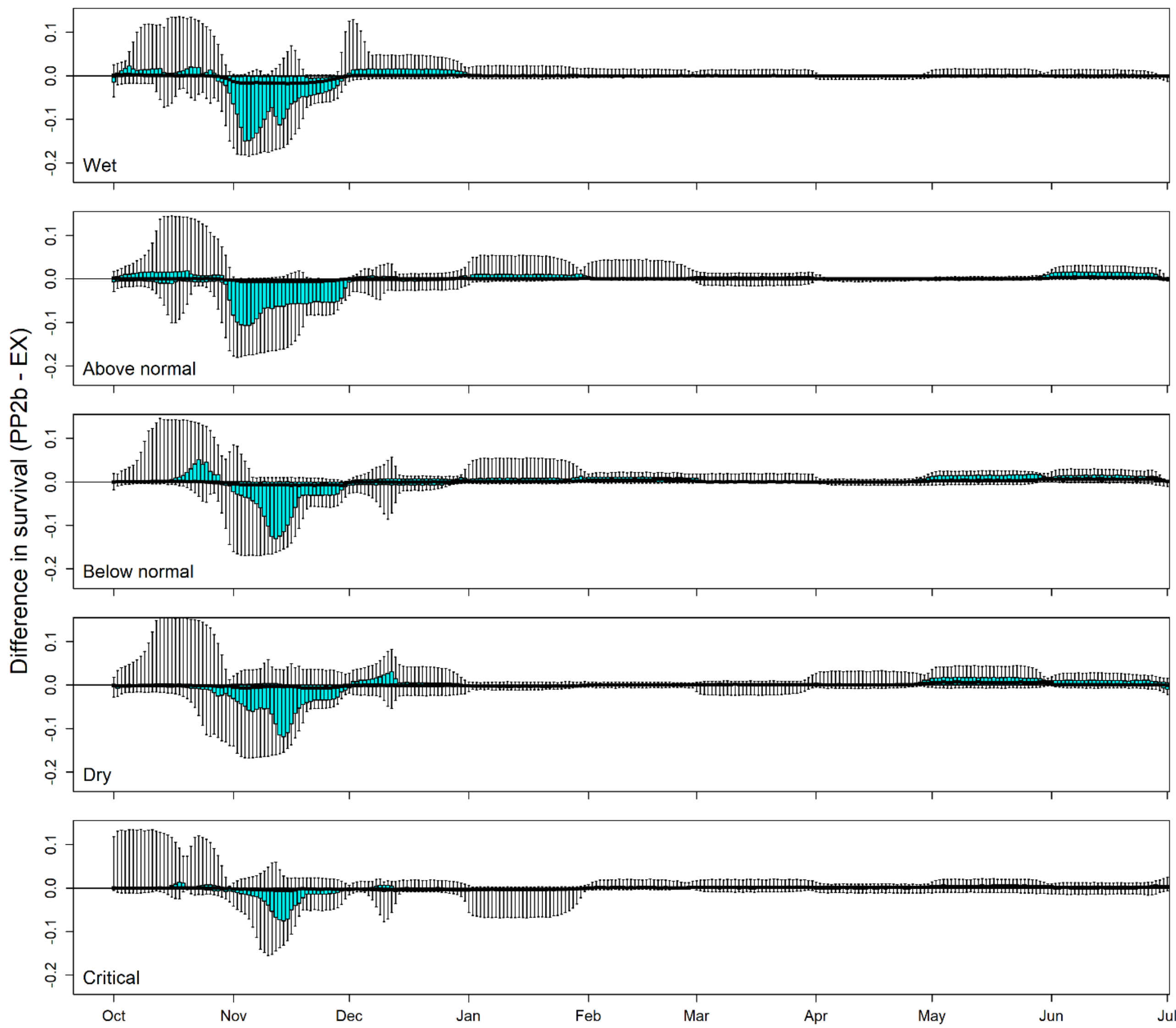
The parameters on which the model is based were derived from a Bayesian mark-recapture model that jointly estimated reach-specific travel time, migration routing, and survival of juvenile Chinook salmon. The model is designed to predict survival of a cohort of fish that experience variable daily river flows as they migrate through the Delta from the Sacramento River. The STARS model provides causal inference (flow affects routing and travel time which ultimately affects survival) based on studies conducted on Late Fall-run Chinook Salmon and the results contain some degree of uncertainty that comes with making predictions on out-of-sample conditions (i.e., predictions for Winter-run Chinook Salmon entering the Delta at different sizes and during different time periods). A complete description of the STARS model, limitations and assumptions, and the results of this analysis are located in Appendix E (see Attachment 1, “Using the STARS Model to Evaluate the Effects of the Two Proposed Projects on Juvenile Salmon Survival, Travel Time, and Migration Routing for the Long-Term Operation of the State Water Project Incidental Take Permit Application and CEQA Compliance”).

As previously noted in the analysis for the Proposed Project, although the STARS model addresses potential impacts associated with routing and travel time, the discussion focuses on differences in survival because the survival calculations integrate flow-survival relationships, travel time, and routing of fish into different parts of the Delta with varying survival estimates. Past studies have shown a negative correlation between routing to the interior Delta and survival of juvenile Chinook Salmon (Perry et al. 2013; Perry et al. 2014; Perry et al. 2015).

Perry et al. (2018) determined that median travel time was related to the inflow in all reaches of the Delta. In contrast, survival was strongly related to inflow in only three of eight reaches. In the three reaches that exhibited strong inflow-survival relationships, river flows transitioned from tidally influenced, bidirectional flow at low net inflow to unidirectional downstream flow as net inflows increased and tidal forcing was dampened. Thus, these three reaches caused route-specific survival through the Delta to increase with flow, yet fish that entered the interior Delta through Georgiana Slough or the DCC experienced lower route-specific survival than other migration routes. In addition, Perry et al. (2018) identified that the proportion of fish entering the interior Delta increased as 1) inflows decreased below about 25,000 cfs and 2) when the Delta Cross Channel gate was opened. These mechanisms increase the proportion of fish experiencing low-survival migration routes, thereby further reducing overall survival through the Delta. Because the STARS model incorporates the effect of river flow and DCC gate operation on juvenile Chinook Salmon survival, travel time, and migration routing, the analysis can be used to identify mechanisms by which SWP operations affect overall survival through the Delta. One limitation, however, is that the statistical model of Perry et al. (2018) did not include south Delta exports. Thus, the modeling results presented herein are insensitive to any difference in exports between the scenarios being considered.

The STARS analyses presented in Appendix E were conducted for October–June and revealed that overall, there generally was little difference in predicted survival between Refined Alternative 2b and Existing Conditions scenarios (Figure 5.3-58). The exception generally was in November, for which survival under Refined Alternative 2b was typically lower than the Existing Conditions scenario. This likely reflected differences in inflow to the Delta as a result of Refined Alternative 2b not including the fall X2 action that was included in the Existing Conditions scenario, resulting in lower Freeport flow and therefore greater frequency of opening of the DCC (assumed to be open at flow <25,000 cfs). Although the fall X2 action applies in wet and above-normal water year types, the difference between the Refined Alternative 2b and Existing Conditions scenarios in November survival was apparent in all water year types because November is part of the subsequent water year, for which the water year type would vary irrespective of the prior water year type.

The STARS model results suggest little difference in predicted through-Delta survival of Winter-run Chinook Salmon between Refined Alternative 2b and Existing Conditions scenarios, except for juveniles migrating before December. Given that most individuals appear to migrate into the Delta with early winter flow pulses (del Rosario et al. 2013) that may coincide with closure of the DCC, this may limit the potential for some of the early outmigrating juvenile Winter-run Chinook Salmon to find their way to the south Delta and potentially be entrained at the SWP export facility. Historically, a relatively low proportion of juvenile Winter-run Chinook Salmon are salvaged (Zeug and Cavallo 2014). Therefore, the differences between the Existing Conditions and Refined Alternative 2b scenarios in outmigrant survival, as influenced by routing (entrainment into the interior Delta) and travel time, are not considered a substantial impact on the outmigrating Winter-run Chinook Salmon population.



Note: Each boxplot represents the distribution of median survival differences among the 82 years for a given date. The point in each box represents the median, the box hinges represent the 25th and 75th percentile, and the whiskers display the minimum and maximum.

Figure 5.3-58. Daily Boxplots of Median Differences in Median Through-Delta Survival between Refined Alternative 2b (PP2b) and Existing Conditions (EX) Scenarios by Water Year Type

The analysis of through Delta survival, routing, and timing as represented by the STARS model reflect combined SWP and CVP operations. The SWP responsibility for Delta water operations during November when differences in survival were most pronounced is approximately 50-60% depending on the water year type (see Appendix H).

Additional discussion of methods, results, and uncertainty associated with the STARS analyses is provided in Appendix E.

Rearing Effects

Background for Juvenile Salmonid Rearing Delta

As described in the analysis of the PP, the ITP Application for the Proposed Project (p.2-21) noted that "Although the Delta was historically used for rearing, it appears that Winter-run Chinook Salmon now use the Delta primarily as a migration corridor to Suisun Bay and Marsh (Hassrick, pers. comm)." This statement was based primarily on relatively short residence times within the Delta for acoustically tagged juvenile Winter-run Chinook Salmon of 80-127 mm (Hassrick et al. 2014, Hassrick et al. 2016). However, there is some uncertainty with respect to rearing in the Delta: for example, Phillis et al. (2018) estimated from isotopic evidence that around 6–20% of returning Winter-run Chinook Salmon adults had reared in the Delta. Moreover, del Rosario et al. (2013) looked at apparent migration rates of winter-run sized fish at different points in the system and concluded that there was evidence of substantial Delta rearing, perhaps 1-3 months.

As described in the analysis of the PP, based on this evidence, a recent conceptual model for the rearing to migrating life stage of Winter-run Chinook Salmon in the Bay-Delta hypothesizes that changes in flow could interact with shallow water habitat availability in the Bay-Delta to affect the availability of refuge habitat and survival (Windell et al. 2017). As noted by the authors of this conceptual model, information regarding Winter-run Chinook Salmon use of Delta habitats is limited because of routine sampling limitations (Windell et al. 2017, p.19).

Previous Analyses of Rearing Habitat

As described in the analysis of the Proposed Project, the California WaterFix (CWF) project included analyses that can be used to inform the effects analysis of Refined Alternative 2b. These analyses included an assessment of reduction in juvenile salmonid rearing habitat at restored wetland and riparian benches in the north Delta as a result of diversions by the proposed north Delta intakes (see methods in ICF International 2016, Appendix 5.D, beginning p.5-268). The analysis found that the estimated reduction in water level (stage) in the Sacramento River from the proposed diversions could give somewhat reduced access to riparian bench habitats, which are at relatively higher elevations, but would be expected to give little difference in access to wetland benches, which are at relatively lower elevations (ICF International 2016, p.5-179 to p.5-184).

The National Marine Fisheries Service Winter-Run Chinook Salmon Life Cycle Model (WRLCM) was also used to assess potential CWF effects (NMFS 2017). This model addresses Delta rearing habitat capacity through consideration of channel type (high quality: blind channels; low quality: mainstem river, distributaries, open water), cover (high quality: vegetated; low quality: not vegetated), and water depth (high quality: >0.2 meters, ≤ 1.5 meters; low quality: ≤ 0.2 meters, >1.5 meters) (Hendrix et al. 2014). The model did not suggest that changes in Delta rearing capacity would have appreciable effects on the species: for example, a sensitivity analysis of an additional 11,000 acres of restored tidal habitat in the Delta, with resulting increase in habitat capacity, gave little difference in cohort replacement rate (NMFS 2017, p.807–810). As noted by NMFS (2017, p.810), "…the proposed Delta habitat restoration did not improve the cohort replacement rate under this scenario because the current low abundance of the winter-run population is not limited by Delta rearing habitat. As the population abundance increases because of recovery action implementation (such as newly reintroduced populations in Battle Creek and upper Sacramento River – above Shasta Reservoir) the availability of additional tidal Delta rearing habitats will become more important for the species."

As described in the analysis of the Proposed Project, results of the WRLCM for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and the State Water Project found limited effects of the Proposed Action (PA) compared to the Current Operations Scenario (COS; NMFS 2019). Although there have been refinements to the model since the CWF analysis, the method of assessing habitat capacity in the Delta remains the same (see NMFS 2019, Appendix A). Overall this suggested limited potential for effects of changes in rearing habitat within the Delta as a result of differences in operations between the PA and COS scenarios.

Implications for Refined Alternative 2b Operational Effects

The analyses of rearing habitat (bench inundation and WRLCM rearing habitat capacity) described above are largely driven by Sacramento River flow into the Delta. This suggests that a qualitative assessment of differences in Freeport flow for Refined Alternative 2b relative to Existing Conditions provides an indication of potential changes to juvenile salmonid rearing habitat as a result of differences in operations. CalSim modeling results for Freeport flow generally suggest little difference between Refined Alternative 2b and Existing during the winter-spring juvenile salmonid rearing period (see Figures 5.3-46 through 5.3-51 in the discussion related to "Immigrating Adults", above). Some reductions in rearing habitat could occur under the Proposed Project during late fall (November) as a result of lower Freeport flow, which is caused by the Proposed Project not including the USFWS (2008) fall X2 action flows. However, based on results of the WRLCM model for the Reinitiation of Consultation on the Long-Term Operation of the Central Valley Project and the State Water Project, such differences would be expected to have limited population-level effects on juvenile Winter-run Chinook Salmon (NMFS 2019).

Rearing habitat availability for juvenile salmonids in the Delta is also affected by Yolo Bypass inundation (e.g., Takata et al. 2017). Based on modeled operations, there would be minimal differences in Yolo Bypass flows between Refined Alternative 2b and Existing scenarios (see Figures 5.3-14 through 5.3-19 in the analysis of Delta Smelt). In addition, construction of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project is anticipated to be completed by December 2022, which will contribute to minimizing and mitigating potential Refined Alternative 2b effects.

Water Transfers

As previously noted in the analysis for the Proposed Project, expansion of the water transfer window to include July to November would be expected to have limited overlap with Winter-run Chinook Salmon occurrence in the Delta, given that most individuals appear to migrate into the Delta with early winter flow pulses (del Rosario et al. 2013). The potential for greater South Delta entrainment would exist for juvenile Winter-run Chinook Salmon occurring during the water transfer window, but this would be expected to be limited and any entrainment loss would count toward cumulative thresholds, which would protect the species throughout the entire winter/early spring entrainment risk period.

Georgiana Slough Behavioral Modification Barrier

Operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Winter-Run Chinook Salmon entry into the interior Delta at Georgiana Slough. Modeling of through-Delta survival (e.g., with the Delta Passage Model) suggested little difference between Existing Conditions and Refined Alternative 2b, so reducing entry into Georgiana Slough would have the potential to result in greater through-Delta survival than Existing Conditions based on available scientific studies (Perry et al. 2013; Perry et al. 2014). Upstream-migrating Winter-Run Chinook Salmon adults would have the potential to encounter the barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Annual O&M Activities-Related impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect Winter-run Chinook Salmon include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
    - Sediment Removal
    - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
    - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. These activities likely would have limited impacts on Winter-run Chinook Salmon when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect Winter-run Chinook Salmon include:

- Clifton Court Forebay actions to reduce predation including
    - Continued evaluation of predator relocation studies
    - Aquatic weed control

- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are expected to minimize operations-related impacts on Winter-run Chinook Salmon, improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Winter-run Chinook Salmon

Winter-run Chinook Salmon inhabit areas of the Delta that could be affected by Refined Alternative 2b during the adult migration and juvenile rearing to outmigrating portions of their life cycle as identified in the SAIL conceptual model. Potential operations-related changes to migration and rearing habitat attributes, outmigrant survival, entrainment into the Delta from the Sacramento River, and entrainment at SWP facilities were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures.

The analyses conducted for each life stage of Winter-run Chinook Salmon are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of Winter-run Chinook Salmon are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on Winter-run Chinook Salmon, relative to the Existing Conditions scenario, and are considered **Less than Significant.**

5.3.9.3 Spring-run Chinook Salmon

Operations-Related impacts

Immigrating Adults

As previously noted in the analysis for the Proposed Project, adult Spring-run Chinook Salmon use the lower Sacramento River between the Delta and the confluence with the Feather River as a migration corridor. These immigrating adults can be present from January through June. During this period, changes in simulated average monthly flows at Freeport under Refined Alternative 2b, relative to the Existing Conditions scenario, are generally relatively small (see Figure 5.3-46, Figures 5.3-47 through 5.3-51, and Table 5.3-13) and flows at Freeport are considered similar under the Refined Alternative 2b and Existing Conditions scenarios during most months of the year. In addition, the SWP is responsible for between approximately 20% to 60% of Delta water operations, depending on month and water year type.

Because flows are generally similar under the Refined Alternative 2b and Existing Conditions scenarios, it is expected that habitat attributes such as water temperature, dissolved oxygen concentrations, and other attributes would also be similar. Further, because flows are similar, and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is less than one foot (Table 1-2-1, Appendix C), which would not likely reduce migration opportunities. In addition, little potential for differences in rates of straying exist for adult Spring-run Chinook Salmon between the Refined Alternative 2b and Existing Conditions scenarios. Specifically, because other salmonids in the same genus (i.e., closely related to Chinook Salmon) such as adult Sockeye Salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989). Under the assumption that Sockeye Salmon responses to changes in olfactory cues are similar to those of Spring-Run Chinook Salmon, potential impacts of Refined Alternative 2b on immigrating adult Spring-run Chinook Salmon in the Sacramento River are expected to be similar to those under the Existing Conditions scenario. Evidence from the Bay-Delta suggests that straying rates of Sacramento River basin hatchery-origin Chinook Salmon were very low (<1%) during 1979-2007 (Marston et al. 2012), indicating that even across a wide range of differences in flow, straying is very low. As noted for Winter-run Chinook Salmon, Refined Alternative 2b does not change hatchery release strategy, which appears to be the main driver of straying risk in the Central Valley.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on immigrating adult Spring-run Chinook Salmon the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the January-June Spring-run Chinook Salmon adult immigration period is approximately 20%-60% depending on month and water year type (see Appendix H).

Delta Hydrodynamic Assessment and Salmonid Junction Entry

As previously noted in the analysis for the Proposed Project, in considering changes in flow proportion impacts, it is important to consider when juvenile salmon of various races may be present in the Delta. Juvenile Spring-run Chinook Salmon are present in the Delta between November and early June with a peak in April. Coded wire tagging and acoustic tagging studies suggest few juvenile Chinook salmon entering the Delta from the Sacramento River would be exposed to velocity changes observed in the south Delta under Refined Alternative 2b (e.g., Zeug and Cavallo 2014). Juvenile Spring-run entering the Delta from the Sacramento River and passing through the Delta Cross Channel or Georgiana Slough and continuing to migrate westward in the mainstem San Joaquin River would be expected to experience no velocity changes likely to influence their survival or behavior. Fish that move southward enough in the Old and Middle River corridor to reach areas of altered velocities may be more likely to continue moving toward the export facilities and become vulnerable to entrainment. Though the geographic footprint of velocity changes is relatively small, greater exports under Refined Alternative 2b during April and May could affect a greater number of Spring-run Chinook Salmon juveniles than under the Existing Conditions scenario, with this season generally coinciding with the peak of juvenile Spring-run Chinook Salmon migration. SWP exports generally would be similar to Existing Conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than Existing Conditions. The potential for increases in entrainment at the south Delta export facilities when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period. As discussed further below, the operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Spring-run Chinook Salmon entry into the interior Delta at Georgiana Slough, and reduce south Delta entrainment risk.

For Spring-run Chinook Salmon from the San Joaquin River basin, the absence of the HORB under the Proposed Project and Refined Alternative 2b causes relatively large differences to velocities in the mainstem San Joaquin River between approximately Mossdale and Stockton. Velocities upstream of the HOR are higher under Refined Alternative 2b (without HORB) and have the potential to be beneficial to juvenile Chinook Salmon and steelhead by increasing their migration rate. This increase in velocity occurs when HORB is not installed because the presence of the HORB creates hydraulic head that slows upstream velocities and the impact is stronger with higher San Joaquin River flows. However, velocities downstream of the HOR under Refined Alternative 2b are reduced and may offset the potential benefit of increased velocities upstream of HOR. The absence of HORB under Refined Alternative 2b will allow more San Joaquin River origin juvenile salmonids to pass through Old River and the Grant Line Canal and approach the export facilities. While this routing increases entrainment risk for these fish, available coded wire tagging and acoustic tagging studies indicate survival in this region is very poor generally and not adversely influenced by export rates (SST 2017). Entrainment at the CVP has been observed to yield higher through-Delta survival (via trucking) than volitional migration through the Delta by other routes, even with positive OMR conditions (Buchanan et al. 2018; SJRGA 2011, 2013). Though entrainment has the potential to increase during April and May due to increased exports under Refined Alternative 2b in these months, through-Delta survival of juvenile Spring-run Chinook salmon originating from the San Joaquin River basin may not be impaired by these operations, relative to the Existing Conditions scenario (see also the analysis below based on the San Joaquin River-Origin Spring-run Chinook Salmon Structured Decision Model).

As previously noted in the analysis for the Proposed Project, the junction routing analysis for the HOR junction (see method description in Appendix E) indicates the proportion of flow moving into the Old River route and toward the CVP and SWP export facilities and is relevant for juvenile Spring-run Chinook Salmon emigrating from the San Joaquin River basin. Thus, lower flow proportion values indicate decreased flow toward the export facilities. Flow proportion into the Old River varied by month and water year type. Differences between Refined Alternative 2b and Existing Conditions scenarios were apparent in November, April, and May (Figure 5.3-59). For these months, flow proportion into the Old River route is higher under Refined Alternative 2b in all water year types, but the differences were clearest and most substantial in below-normal and drier years. In April and May of dry years, flow proportion into the Old River route was 40% greater under Refined Alternative 2b than under the Existing Conditions scenario. Results for April and May in wet, above-normal, and below-normal water years were highly variable for the Existing Conditions scenario because placement

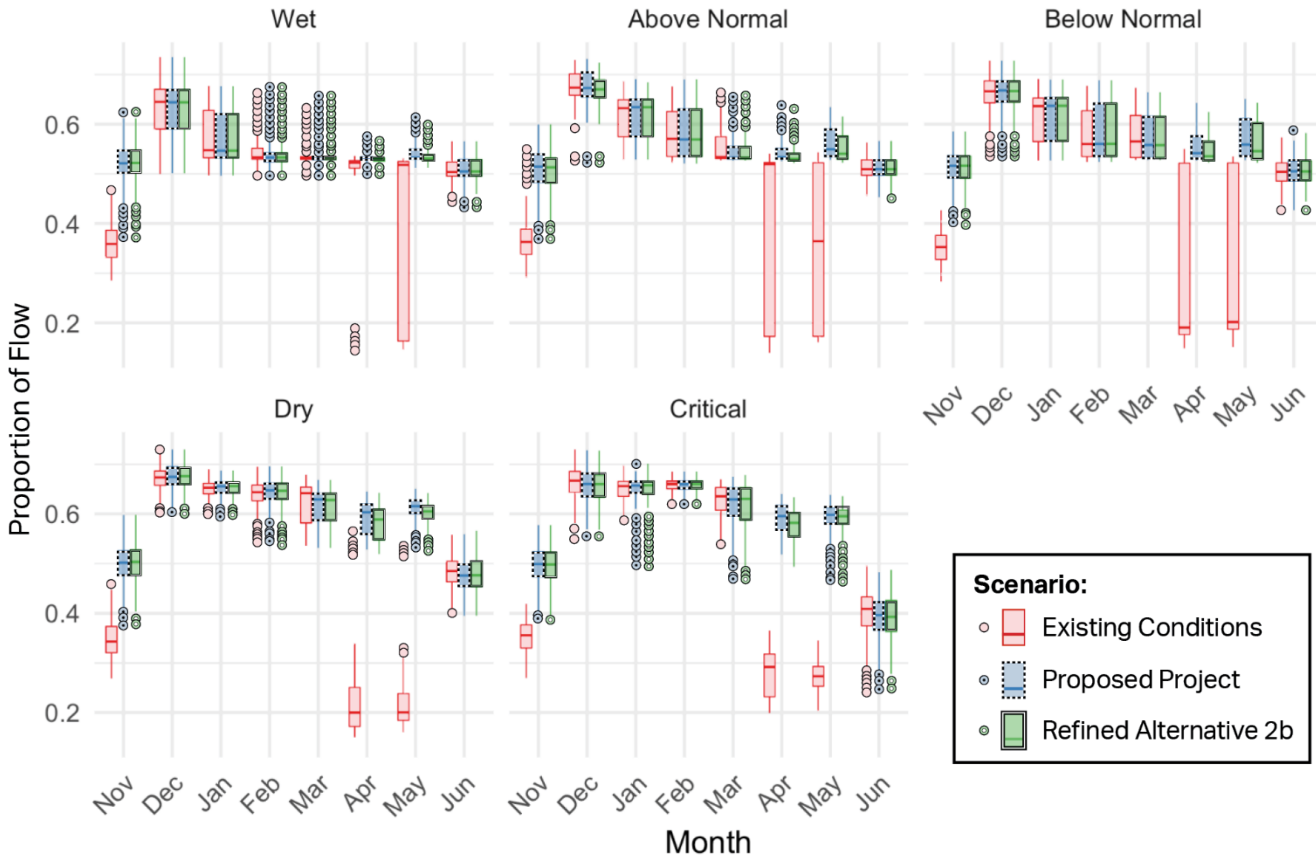


Figure 5.3-59. Boxplots of Proportion of Flow Entering the Head of Old River by Month and Water Year Type

of the HORB was variable under wetter conditions (the barrier was assumed not to be installed at Vernalis flow >5,000 cfs). This change in flow proportion indicates juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are much more likely to enter the Old River route under Refined Alternative 2b than under the Existing Conditions scenario. Juvenile Spring-run Chinook Salmon originating from the Sacramento River basin would not encounter the HOR junction and would therefore not be affected by these differences. No juvenile Spring-run Chinook Salmon are expected to be emigrating from the San Joaquin River basin in November, so differences in this month do not have biological significance. All juvenile salmon emigrating from the San Joaquin River basin must pass through the HOR junction. Thus, Refined Alternative 2b is expected to result in an increased proportion of juvenile salmon passing through the Old River route. However, recent acoustic tagging studies indicate no difference in survival for fish migrating through the Old River route relative to fish continuing through the San Joaquin River route (Buchanan et al. 2018). It is also important to note that although Refined Alternative 2b does not include installation of the HORB, Spring-run Chinook Salmon juveniles may receive some ancillary protection during April and May from the risk assessment-based approach for OMR flow management included in Refined Alternative 2b that would be undertaken for other species.

Delta hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the November through June period evaluated above is approximately 20%-60% depending on the month and water year type (see Appendix H).

Entrainment

Entrainment Loss Density

As previously noted in the analysis for the Proposed Project, to provide perspective on potential differences in entrainment loss of Spring-run Chinook Salmon juveniles between Existing and Refined Alternative 2b scenarios, the salvage-density method was used, as described for Winter-run Chinook Salmon (see Appendix E). The same caveats including those regarding length-at-date classification and the appropriate use of these results that are described for Winter-run Chinook Salmon also apply to Spring-run Chinook Salmon. In addition, as described for Winter-run Chinook Salmon, all months are evaluated in this analysis but only those Chinook Salmon that were reported as Spring-run Chinook Salmon based on their length at the time of salvage were included in the weighting and subsequent reporting of Spring-run Chinook Salmon loss density.

The salvage-density method suggested that entrainment loss of juvenile Spring-run Chinook Salmon at the SWP south Delta export facility could be greater under Refined Alternative 2b compared to the Existing Conditions scenario (Table 5.3-15). This is because most juvenile Spring-run Chinook Salmon entrainment occurs during the April–May period when the largest difference in south Delta exports is projected to occur between Refined Alternative 2b and Existing Conditions scenarios[23]. As described for Winter-run Chinook Salmon, it should be noted that this analysis is based on size-at-date criteria, and does not reflect potential errors in Chinook Salmon race identification based on these criteria. Classification errors resulting from the use of size-at-date criteria are particularly pronounced for Spring-run Chinook Salmon, for which genetic studies have shown that the great majority of spring-run-sized fish may actually be Fall-run Chinook Salmon (Harvey et al. 2014). It is expected that the latest information (e.g., genetic assignment) would be used as it becomes available, to assess and limit potential entrainment loss of Spring-run Chinook Salmon. In addition, a very small proportion (<1%) of Spring-run Chinook Salmon are likely to approach the South Delta (Zeug and Cavallo 2014). During April-May, Spring-run Chinook Salmon juveniles may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in Refined Alternative 2b that would be undertaken for other species. In addition, entrainment (i.e., incidental take) would be required to be within protective limits required by the NMFS ROC on LTO Biological Opinion. As discussed further below, the operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Spring-Run Chinook Salmon entry into the interior Delta at Georgiana Slough, and reduce south Delta entrainment risk.

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[23] Fish entrained during April-May would be expected to primarily be young-of-the-year; yearlings would tend to occur somewhat earlier in the winter, during a period when Existing and Alternative 2b scenarios would not be expected to differ greatly in exports based on CalSim modeling.

Table 5.3-15. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-15 a - f

Table 5.3-15 g. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	55	2,911	12,166	9,447	2,214	0	0	0	3	0	0
Refined Alternative 2b	2	56	2,506	22,698	14,286	2,195	0	0	0	3	0	0

Table 5.3-15 h. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	8	50	4,114	12,066	2,838	136	0	0	10	0	0	0
Refined Alternative 2b	8	47	3,156	15,611	3,899	134	0	0	10	0	0	0

Table 5.3-15 i. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 -- Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	6	1,178	1,598	879	16	0	0	0	0	0	0
Refined Alternative 2b	2	6	884	1,934	888	16	0	0	0	0	0	0

Table 5.3-15 j. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	789	4,007	1,654	0	0	0	0	0	0	0
Refined Alternative 2b	0	0	639	3,697	1,573	0	0	0	0	0	0	0

Table 5.3-15 k. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	2	69	1,495	942	14	0	0	0	0	0	0
Refined Alternative 2b	0	1	66	1,175	920	12	0	0	0	0	0	0

Table 5.3-15 l. Estimates of Spring-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	26,798	19,221	3,679	6,449	2,521
Refined Alternative 2b	41,747	22,865	3,730	5,909	2,174
Refined Alternative 2b vs. Existing	14,949 (56%)	3,644 (19%)	51 (1%)	-540 (-8%)	-347 (-14%)

Outmigrant Survival

Delta Passage Model

As previously noted in the analysis for the Proposed Project, the DPM integrates operational impacts of the Existing and Refined Alternative 2b scenarios that could influence through-Delta survival of migrating juvenile Chinook Salmon smolts including Central Valley Spring-run. Functions included in the DPM include reach-specific flow-survival and flow travel-time relationships, flow-routing relationships and export-survival relationship. Uncertainty in the quantitative relationships included in the DPM were integrated into the analysis using Monte Carlo techniques. One hundred iterations of the model were run for each scenario where distributions for each parameter were resampled for each iteration. Model output reported here is annual through-Delta survival in the 82-year CalSim period and through-Delta survival aggregated by water year-type. Further details of the method are provided in Appendix E.

Across the 82-year simulation period, mean through-Delta survival was 0.4% greater under the Existing Conditions scenario (26.4%, 95% CI 14.5-45.5) relative to Refined Alternative 2b (26.0%, 95% CI 14.7-44.7). Survival was greater under the Existing Conditions scenario for 58 of the 82 years and greater under Refined Alternative 2b in 16 years (Figure 5.3-60). Differences in individual years were generally small (< 1.5%) with the largest difference occurring in the 1975 model year when survival under the Existing Conditions scenario was 1.9 % higher than under Refined Alternative 2b. Confidence intervals for through-Delta survival overlapped between scenarios in all years.

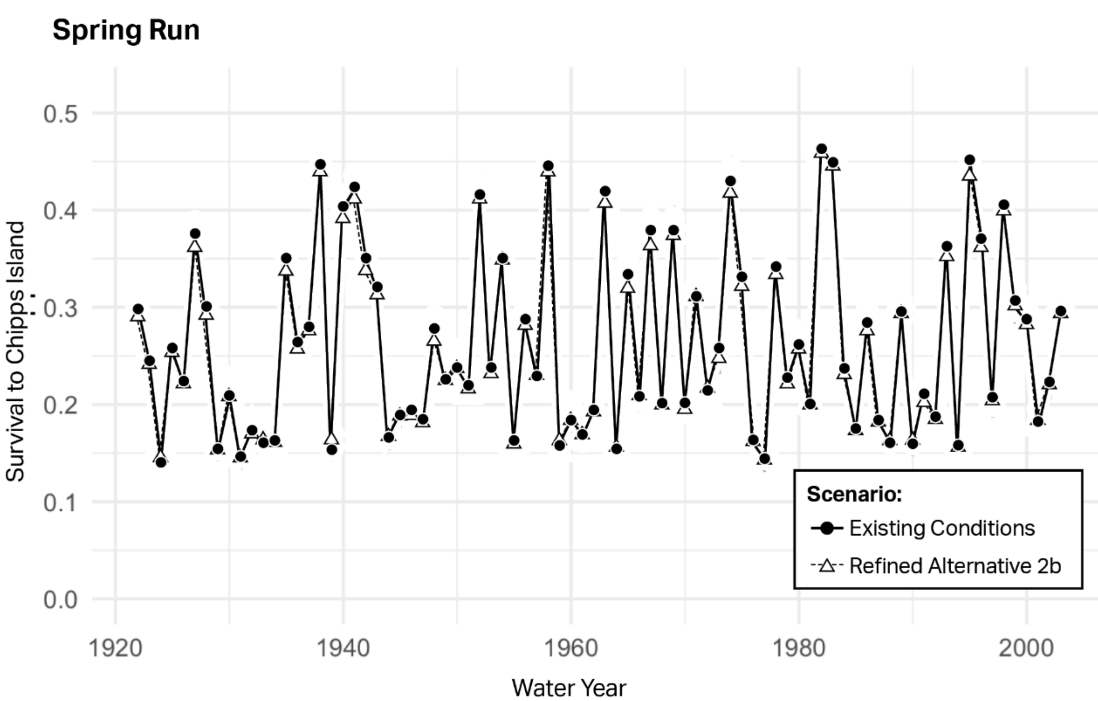

Figure 5.3-60. Mean Estimates of Spring-run Chinook Salmon Through-Delta Survival with 95% confidence Intervals for Refined Alternative 2b and the Existing Condition in Each Simulation Year

For both scenarios, mean survival rates tracked water year type with the highest value in wet years and the lowest value in critical years (Figure 5.3-61). Mean through-Delta survival was greater for the Existing Conditions scenario relative to Refined Alternative 2b in all but critical water year types (Figure 5.3-61). The 95% confidence intervals for survival estimates overlapped between scenarios in each water year type.

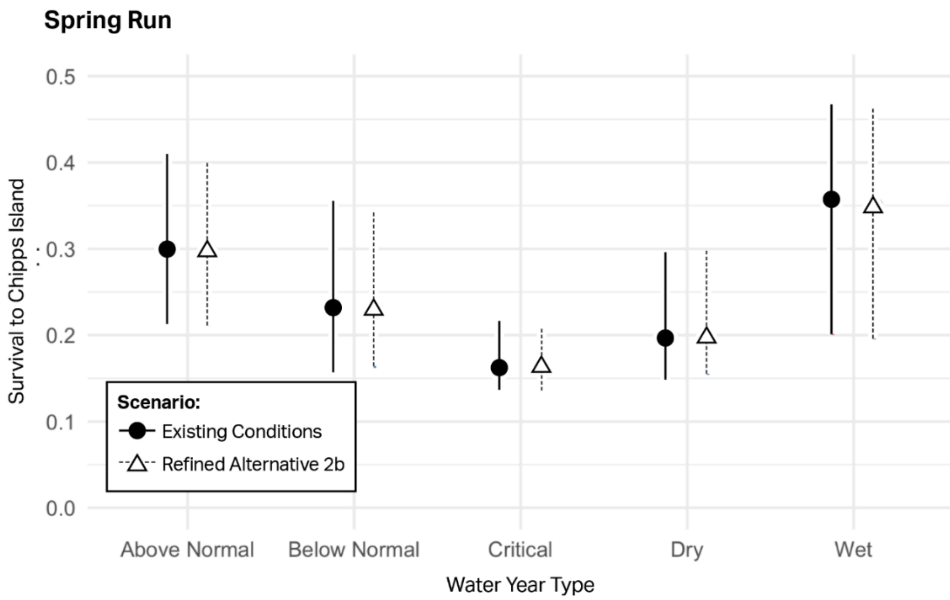

Figure 5.3-61. Mean Through-Delta Survival with 95% Confidence Intervals for Juvenile Spring-run Chinook Salmon under Refined Alternative 2b and the Existing Condition. Values were summarized by water year-type over the 82-year CalSim period

Through-Delta survival impacts as represented by the Delta Passage Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 20%–60% (see Appendix H). SWP exports generally would be similar to Existing Conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than Existing Conditions. The potential changes in through-Delta survival when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period.

San Joaquin River-Origin Spring-run Chinook Salmon Structured Decision Model

As previously noted in the analysis for the Proposed Project, the Delta Structured Decision Model was developed by the Central Valley Project Improvement Act Science Integration Team to evaluate the impact of different management decisions on the survival and routing of juvenile Fall-run Chinook Salmon. The model relies on survival-environment relationships and routing-environment relationships from acoustic studies conducted in the Sacramento and San Joaquin Rivers and at the State and Federal export facilities. Only results from the San Joaquin River sub model are reported. The model and documentation has not been finalized and the code for the most recent version of the model that was used was accessed at https://github.com/FlowWest/chinookRoutingApp. Additional details of the model are presented in Appendix E.

As previously noted in the analysis for the Proposed Project, survival results from the SDM model were estimated for San Joaquin-origin Spring-run Chinook Salmon by weighting the daily proportion of Spring-run Chinook Salmon captured in the Sacramento trawl and reported as annual estimates and as aggregations by water year type. Sacramento River Spring-run Chinook Salmon timing was used because the reintroduced Spring-run Chinook Salmon population in the San Joaquin River has not existed long enough to generate a San Joaquin River-specific entry distribution.

Across the 82-year CalSim period, through-Delta survival was low (< 4%) for Refined Alternative 2b and Existing Conditions modeling scenarios (Figure 5.3-6~~3~~2). Survival was higher under Refined Alternative 2b relative to the Existing Condition for all years except one. Although survival was higher under Refined Alternative 2b in most years the magnitude of the difference between scenarios was variable. In all water year types survival was higher under Refined Alternative 2b relative to the Existing Condition.

Through Delta survival of Spring-run Chinook Salmon under Refined Alternative 2b tracked water year-type with the highest values in wet and above-normal years and the lowest values in dry and critical years (Figure 5.3-63). Interquartile ranges of survival under the Existing Conditions and Refined Alternative 2b overlapped only in critical years. However, in all water year types, interquartile ranges of survival were greater under Refined Alternative 2b.

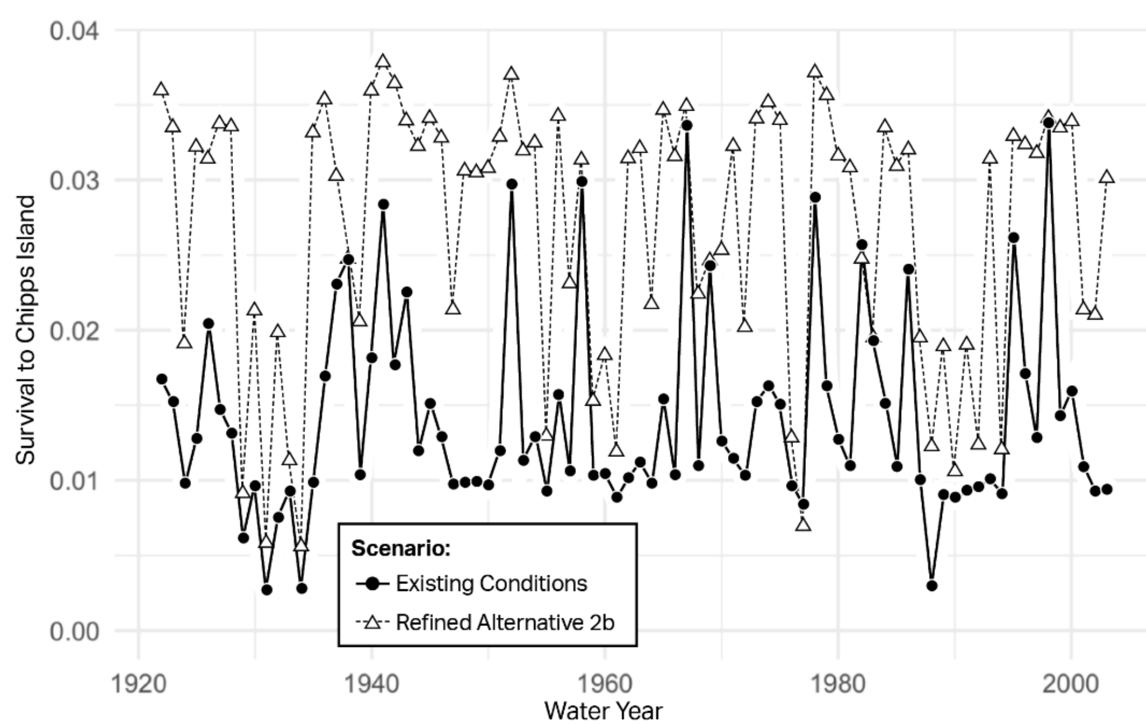

Figure 5.3-62. Mean Estimates of San Joaquin River Spring-run Chinook Salmon Through-Delta Survival for Refined Alternative 2b and the Existing Condition in Each Simulation Year

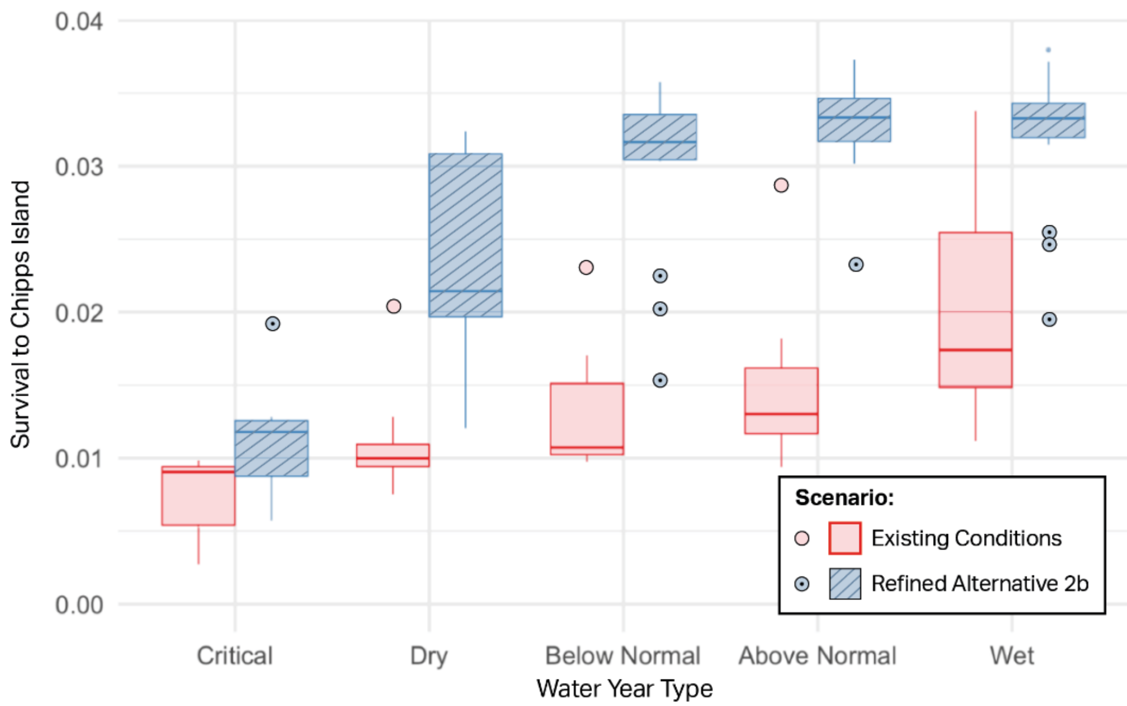

Figure 5.3-63. Median Through-Delta Survival (Horizontal Line) with Interquartile Ranges (Boxes), Minimum and Maximum Values (Vertical Lines) for Juvenile San Joaquin River-origin Spring-run Chinook Salmon under Refined Alternative 2b and the Existing Condition. Values were summarized by water year-type over the 82-year CalSim period

Through-Delta survival impacts as represented by the San Joaquin River Structured Decision Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 20% to 60% (see Appendix H). SWP exports generally would be similar to Existing Conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than Existing Conditions. The potential changes in through-Delta survival when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period.

STARS

As previously noted in the analysis for the Proposed Project, the STARS model provides an assessment of potential differences between Refined Alternative 2b and Existing Conditions scenarios in travel time, migration routing, and survival of juvenile Chinook Salmon emigrating from the Sacramento River through the Delta. The STARS model provides causal inference (flow affects routing and travel time which ultimately affects survival) based on studies conducted on Late Fall-run Chinook Salmon and the results contain some degree of uncertainty that comes with making predictions on out-of-sample conditions (i.e., predictions for Spring-run Chinook Salmon entering the Delta at different sizes and during different time periods). A complete description of the STARS model, limitations and assumptions, and the results of this analysis are located in Appendix E (see Attachment 1, "Using the STARS Model to Evaluate the Effects of the Two Proposed Projects on Juvenile Salmon Survival, Travel

Time, and Migration Routing for the Long-Term Operation of the State Water Project Incidental Take Permit Application and CEQA Compliance").

As previously noted in the analysis for the Proposed Project, peak movement of juvenile Spring-run Chinook Salmon in the Sacramento River at Knights Landing generally occurs in December and again in March. However, juveniles also have been observed migrating between November and the end of May (Snider and Titus 1998, 2000a, 2000b, 2000c; Vincik et al. 2006; Roberts 2007). YOY Spring-run Chinook Salmon presence in the Delta peaks during April and May, as suggested by the recoveries of Chinook Salmon in the CVP and SWP salvage operations and the Chipps Island trawls of a size consistent with the predicted size of Spring-run fish at that time of year.

Run-specific analyses are not conducted using the STARS model. Rather, a daily analysis of juvenile Chinook Salmon entry into the Delta was conducted from October–June, which encompasses the Spring-run Chinook Salmon migration period. However, the discussion of the STARS model results for Spring-run Chinook Salmon considered the months of November through May based on the time period when they could potentially rear and emigrate from Delta.

The analysis revealed that overall, there generally was little difference in predicted survival between Refined Alternative 2b and Existing Conditions scenarios (Figure 5.3-58). Specifically, the STARS model results suggest little difference in predicted through-Delta survival of Spring-run Chinook Salmon between Refined Alternative 2b and Existing Conditions scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December. Although the STARS analysis showed decreases in Chinook Salmon survival under Refined Alternative 2b associated with entrainment into the Delta during November in all water year types (Figure 5.3-58), the difference was attributed mainly to Delta Cross Channel operations. Further, these differences in survival during November may not necessarily be applicable to emigrating Spring-run Chinook Salmon because it is likely that Spring-run Chinook Salmon emigrating out of the Sacramento River during November are yearling fish that may exhibit differences in susceptibility to routing into the Delta from the Late Fall-run Chinook Salmon used to develop the model. Therefore, the differences between Refined Alternative 2b and Existing Conditions scenarios in outmigrant survival, as influenced by routing (entrainment into the interior Delta) and travel time, are not considered a substantial impact on the outmigrating Spring-run Chinook Salmon population.

Through-Delta survival impacts as represented by the STARS Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 20%–60% depending on the month and water year type (see Appendix H).

Rearing Effects

The analysis of potential rearing effects provided for Winter-run Chinook Salmon is also applicable to Spring-run Chinook Salmon and indicates little potential for negative effects of Refined Alternative 2b relative to Existing.

Water Transfers

As previously noted in the analysis for the Proposed Project, expansion of the water transfer window to include July to November would be expected to have limited overlap with Spring-run Chinook Salmon occurrence in the Delta. Yearlings generally may migrate in winter (as indicated by monitoring of Late Fall-run surrogate fish for entrainment management) and young-of-the-year Spring-run Chinook Salmon migrate through the Delta in spring, so potential for take would be limited.

Georgiana Slough Behavioral Modification Barrier

Operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Spring-run Chinook Salmon juvenile entry into the interior Delta at Georgiana Slough, thereby reducing the potential limited negative effects of greater south Delta exports under Refined Alternative 2b compared to Existing Conditions that were suggested by the Delta Passage Model. Upstream-migrating Spring-Run Chinook Salmon adults would have the potential to encounter the barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Annual O&M Activities-Related impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect Spring-run Chinook Salmon include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
    - Sediment Removal
    - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
    - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. These activities likely would have limited impacts on Spring-run Chinook Salmon when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect Spring-run Chinook Salmon include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are expected to minimize operations-related impacts on Spring-run Chinook Salmon, improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Spring-run Chinook Salmon

Spring-run Chinook Salmon inhabit areas of the Delta that could be affected by Refined Alternative 2b during the adult migration and juvenile rearing to outmigrating portions of their life cycle. Potential operations-related changes to migration and rearing habitat attributes, outmigrant survival, entrainment into the Delta from the Sacramento River, and entrainment at SWP facilities were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures.

The analyses conducted for each life stage of Spring-run Chinook Salmon are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of Spring-run Chinook Salmon are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on Spring-run Chinook Salmon, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

5.3.9.4 Fall-run and Late Fall-run Chinook Salmon

Operations-Related Impacts

Immigrating Adults

As previously noted in the analysis for the Proposed Project, adult Fall-run Chinook Salmon of Sacramento River basin origin use the lower Sacramento River between the Delta and the confluence with the Feather River as a migration corridor. These immigrating adults can be present from July through December. Late Fall-run Chinook Salmon adults immigrate from October through April. During all months of the immigration period, average monthly simulated flows under Refined Alternative 2b are slightly higher than under the Existing Conditions scenario except during November. During these periods, changes in simulated average monthly flows at Freeport under Refined Alternative 2b, relative to the Existing Conditions scenario are generally relatively small (see Figure 5.3-46 Figures 5.3-47 through 5.3-51, and Table 5.3-13) and flows at Freeport are considered similar under Refined Alternative 2b and Existing Conditions scenarios during most months of the year.

Because flows are generally similar under Refined Alternative 2b and Existing Conditions scenarios, it is expected that habitat attributes such as water temperature, dissolved oxygen concentrations, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.2 feet (Table 1-2-1, Appendix C), which would not likely reduce migration opportunities. In addition, little potential for differences in rates of straying exist for adult Fall-run Chinook Salmon between Refined Alternative 2b and Existing Conditions scenarios. Specifically, because other salmonids in the same genus (i.e., closely related to Chinook Salmon) such as adult Sockeye Salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989). Under the assumption that Sockeye Salmon responses to changes in olfactory cues are similar to those of Winter-Run Chinook Salmon, potential impacts of Refined Alternative 2b on immigrating adult Spring-run Chinook Salmon in the Sacramento River are expected to be similar to those under the Existing Conditions scenario. Evidence from the Bay-Delta suggests that straying rates of Sacramento River basin hatchery-origin Chinook Salmon were very low (<1%) during 1979-2007 (Marston et al. 2012), indicating that even across a wide range of differences in flow, straying is very low.

As previously noted in the analysis for the Proposed Project, in the north Delta, migrating fish have multiple potential pathways as they move upstream into the Sacramento or Mokelumne river systems. Marston et al. (2012) studied stray rates for immigrating San Joaquin River basin adult salmon that stray into the Sacramento River basin. Results indicated that it was unclear whether reduced San Joaquin River pulse flows or elevated exports caused increased stray rates. The DCC, when open, can divert fish as they out-migrate along this route. The opening of the DCC when Salmon are returning to spawn to the Mokelumne and Cosumnes Rivers is believed to lead to increased straying of these fish into the American and Sacramento Rivers because of confusion over olfactory cues. Experimental DCC closures have been scheduled during the Fall-run Chinook Salmon migration season for selected days, coupled with pulsed flow releases from reservoirs on the Mokelumne River, in an attempt to reduce straying rates of returning adults. These closures have corresponded with reduced recoveries of Mokelumne River hatchery fish in the American River system and increased returns to the Mokelumne River hatchery (EBMUD 2012). However, the DCC is not an SWP facility and SWP facilities would not alter DCC operations. Therefore, Refined Alternative 2b would not be expected to alter straying rates of Mokelumne River Fall-run Chinook Salmon.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on immigrating adult Fall-run and Late Fall-run Chinook Salmon. The simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 60% of Delta water operations during the July through December Fall-run Chinook Salmon immigration period and between approximately 20% to 60% of Delta water operations during the October through April Late Fall-run Chinook Salmon immigration period, depending on month and water year type (see Appendix H).

As noted for Winter-run Chinook Salmon, Refined Alternative 2b does not change hatchery release strategy, which appears to be the main driver of straying risk in the Central Valley.

Delta Hydrodynamic Assessment and Salmonid Junction Entry

As previously noted in the analysis for the Proposed Project, in considering changes in flow proportion impacts, it is important to consider when juvenile salmon of various races may be present in the Delta. Juvenile Fall-run Chinook Salmon abundance in the Delta is greatest between February and May, whereas Late Fall-run Chinook Salmon are present in the Delta between November and July with peaks in January-February and April-May. Coded wire tagging and acoustic tagging studies suggest few juvenile Chinook salmon entering the Delta from the Sacramento River would be exposed to velocity changes observed in the south Delta under Refined Alternative 2b (e.g., Zeug and Cavallo 2014). Specifically, less than 1% of Fall-run Chinook Salmon and less than 2% of Late Fall-run Chinook Salmon are likely to approach the South Delta (Zeug and Cavallo 2014). Fish passing through the Delta Cross Channel or Georgiana Slough and continuing to migrate westward in the mainstem San Joaquin River would be expected to experience no velocity changes likely to influence their survival or behavior. Fish that move southward enough in the Old and Middle River corridor to reach areas of altered velocities may be more likely to continue moving toward the export facilities and become vulnerable to entrainment. Though the geographic footprint of velocity changes is relatively small, greater exports under Refined Alternative 2b during April and May could affect a greater number of Fall-run and Late Fall-run Chinook Salmon juveniles than under the Existing Conditions scenario. SWP exports generally would be similar to Existing Conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than Existing Conditions. The potential for increases in entrainment at the south Delta export facilities when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period. As discussed further below, the operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Fall- and Late Fall-run Chinook Salmon entry into the interior Delta at Georgiana Slough, and reduce south Delta entrainment risk.

For Fall-run Chinook Salmon from the San Joaquin River basin, the absence of the HORB under Refined Alternative 2b causes relatively large differences to velocities in the mainstem San Joaquin River between approximately Mossdale and Stockton. Velocities upstream of the HOR are higher under Refined Alternative 2b (without HORB) and have the potential to be beneficial to juvenile Chinook Salmon and steelhead by increasing their migration rate. This increase in velocity occurs when HORB is not installed because the presence of the HORB creates hydraulic head that slows upstream velocities and the impact is stronger with higher San Joaquin River flows. However, velocities downstream of the HOR under Refined Alternative 2b are reduced and may offset the potential benefit of increased velocities upstream of HOR. The absence of HORB under Refined Alternative 2b would allow more San Joaquin River origin juvenile salmonids to pass through Old River and the Grant Line Canal and approach the export facilities. While this routing increases entrainment risk for these fish, available coded wire tagging and acoustic tagging studies indicate survival in this region is very poor generally and not adversely influenced by export rates (SST 2017). Entrainment at the CVP has been observed to yield higher through-Delta survival (via trucking) than volitional migration through the Delta by other routes, even with positive OMR conditions (Buchanan et al. 2018; SJRGA 2011, 2013). Though entrainment has the potential to increase during April and May due to increased exports under Refined Alternative 2b in these months, through-Delta survival of juvenile Fall-run Chinook salmon originating from the San Joaquin River basin may not be impaired by these operations, relative to the Existing Condition.

The junction routing analysis for the HOR junction, the flow proportion indicates the proportion of flow moving into the Old River route and toward the CVP and SWP export facilities and is relevant for juvenile Fall-run Chinook Salmon emigrating from the San Joaquin River basin. Thus, lower flow proportion values indicate decreased flow toward the export facilities. Flow proportion into the Old River varied by month and water year type. Differences between Refined Alternative 2b and Existing Conditions scenarios were apparent in November, April, and May (Figure 5.3-~~60~~59). For these months, flow proportion into the Old River route is higher under Refined Alternative 2b in all water year types, but the differences were clearest and most substantial in below-normal and drier years. In April and May of dry years, flow proportion into the Old River route was 40% greater under Refined Alternative 2b than under the Existing Conditions scenario. Results for April and May in wet, above-normal, and below-normal water years were highly variable for the Existing Conditions scenario because placement of the HORB was variable under wetter conditions (the barrier was assumed not to be installed at Vernalis flow >5,000 cfs). This change in flow proportion indicates juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are much more likely to enter the Old River route under Refined Alternative 2b than under the Existing Conditions scenario. Juvenile Fall-run Chinook Salmon originating from the Sacramento River basin would not encounter the HOR junction and would therefore not be affected by these differences. No juvenile salmon are expected to be emigrating from the San Joaquin River basin in November, so differences in this month do not have biological significance. All juvenile salmon emigrating from the San Joaquin River basin must pass through the HOR junction. Thus, Refined Alternative 2b is expected to result in an increased proportion of juvenile salmon passing through the Old River route. However, recent acoustic tagging studies indicate no difference in survival for fish migrating through the Old River route relative to fish continuing through the San Joaquin River route (Buchanan et al. 2018). It is also important to note that although Refined Alternative 2b does not include installation of the HORB, Fall-run Chinook Salmon juveniles may receive some ancillary protection during April and May from the risk assessment-based approach for OMR flow management included in Refined Alternative 2b that would be undertaken for other species.

These hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the period evaluated for San Joaquin River basin Fall-run Chinook Salmon (November–April) is approximately 20% to 60%, depending on the month and water year type (see Appendix H).

Mokelumne River Fall-run Chinook Salmon Junction Analysis

As previously noted in the analysis for the Proposed Project, juvenile Fall Run Chinook Salmon originating from the Mokelumne River must migrate through the mainstem San Joaquin River on their way to Chipps Island. Once these fish enter the San Joaquin River, they can potentially enter channels leading to the export facilities (Old-Middle River corridor) where hydrodynamic impacts of pumping are more likely to occur, and potentially cause entrainment at higher rates than Sacramento River Fall-run Chinook Salmon. The primary junctions where fish would be routed south are the junction of Old River and the San Joaquin river (hereafter ORV) and the junction of Middle River and the San Joaquin River (hereafter MRV). To estimate changes in the potential for Mokelumne River-origin Fall Run Chinook Salmon to be routed into the South Delta as a result of Refined Alternative 2b, the proportion of water entering the ORV and MRV junctions was compared between Refined Alternative 2b and Existing Conditions modeling scenarios (see the method description in Appendix E). Results were summarized from November through June for each water year type.

Middle River (MRV)

As previously noted in the analysis for the Proposed Project, the Middle River junction (MRV) is located on the San Joaquin River mainstem upstream of the junction of the Mokelumne River and the San Joaquin River. Fall Run Chinook Salmon originating from the Mokelumne River could encounter this junction if they use distributary routes on the South Fork of the Mokelumne or if they migrate east at the junction of the Mokelumne and San Joaquin Rivers. For the Middle River junction, flow proportion indicates the proportion of flow away from the San Joaquin River. Thus, higher flow proportion values indicate increased flow south toward the export facilities. Differences between Refined Alternative 2b and Existing Conditions scenarios were minimal in all months of each water year type (<1%; Figure 5.3-64). The largest differences were observed in April and May of Wet and Above Normal Year types. However, mean differences in April and May were always less than 1%. This small change in flow proportion indicates juvenile salmon reaching the Middle River junction are likely to continue moving southward at a similar rate under Refined Alternative 2b as they do under the Existing Conditions scenario. Little information is currently available regarding the fraction of Mokelumne River-origin Chinook Salmon juvenile salmon passing through the Delta that are likely to arrive at Middle River.

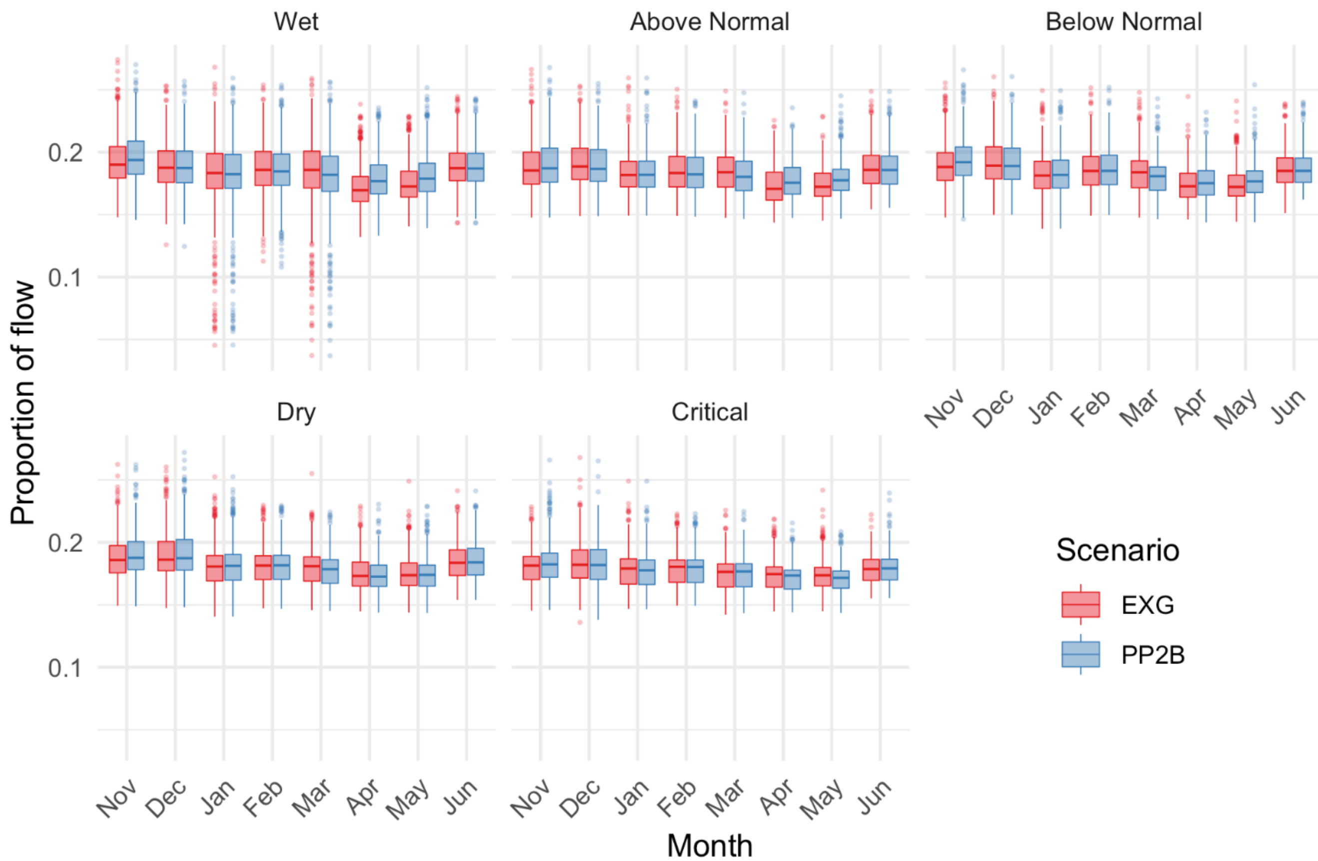

Figure 5.3-64. Box and Whisker Plots of the Proportion of Flow Entering the Middle River Junction with the San Joaquin River. Proportions were summarized for Refined Alternative 2b (PP2B) and Existing Conditions (EXG) scenarios between November and June for each water year-type

Old River (ORV)

As previously noted in the analysis for the Proposed Project, the Old River junction (ORV) is located on the San Joaquin River mainstem just upstream of the junction of the Mokelumne River and the San Joaquin River and downstream of the junction with Middle River. Fall Run Chinook Salmon originating from the Mokelumne River could encounter this junction if they use distributary routes on the South Fork of the Mokelumne and then move west on the San Joaquin River or if they migrate east at the junction of the Mokelumne and San Joaquin Rivers. For the Old River junction, flow proportion indicates the proportion of flow away from the San Joaquin River. Thus, higher flow proportion values indicate increased flow south toward the export facilities. Differences between Refined Alternative 2b and Existing Conditions modeling scenarios were minimal in all months of each water year type (<1%; Figure 5.3-65). The largest differences were observed in April and May of Wet and Above Normal Year types. However, mean differences in April and May were always less than 0.7%. This small change in flow proportion indicates juvenile salmon reaching the Old River junction are likely to continue moving southward at a similar rate under Refined Alternative 2b as they do under the Existing Conditions scenario. Little information is currently available about the fraction of Mokelumne River-origin Chinook Salmon juvenile salmon passing through the Delta that are likely to arrive at Old River.

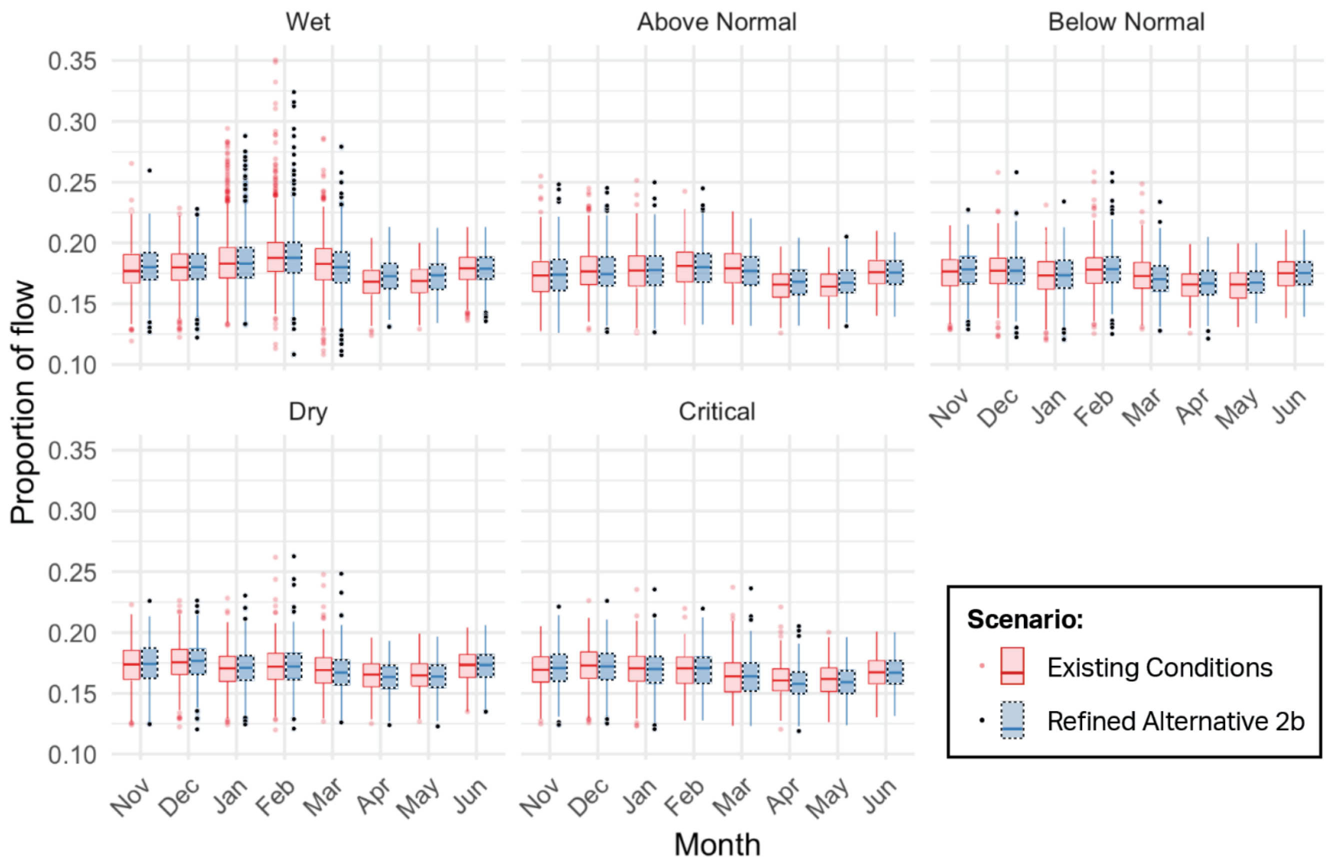

Figure 5.3-65. Box and Whisker Plots of the Proportion of Flow Entering the Old River Junction with the San Joaquin River. Proportions were summarized for Refined Alternative 2b and Existing Conditions scenarios between November and June for each water year-type

These hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the period evaluated for Mokelumne River Fall-run Chinook Salmon (November–April) is approximately 20% to 60% depending on the month and water year type (see Appendix H).

Mokelumne River Fall-run Chinook Salmon Qualitative Discussion

As previously noted in the analysis for the Proposed Project, greater April-May south Delta export pumping under Refined Alternative 2b would have the potential to result in greater entrainment loss of juvenile Mokelumne River Fall-run Chinook Salmon emigrating from the Mokelumne River than under the Existing Conditions scenario. However, available data on coded-wire tag releases suggests that historical entrainment losses have represented a small percentage of the population. During 1992-2006, the total number of fish released in the Mokelumne River was around 25-26 million[24]; of these, an average of 9% were coded-wire-tagged (Workman 2018a, p.181), suggesting that around 2.25

[24] As previously noted in the analysis for the Proposed Project, Workman (2018a, p.181) in response to cross-examination regarding the number of coded-wire-tagged fish released in river during 1992-2006 stated that “an average of 9% of the Mokelumne River production was tagged in those years, and that is approximately 26 million fish”; this appears in rough agreement with the data collated by Sturrock et al. (2019) if limiting the data to Mokelumne River releases in April and May (for all months together, the total increases to just over 38 million fish).

million coded-wire-tagged juvenile Fall-run Chinook Salmon were released. The number of coded-wire-tagged fish released in the Mokelumne River that were recovered at the south Delta export salvage facilities during 1992-2006 was 292 (Workman 2018b, her Figure 3). The loss represented by the number of fish counted in salvage requires expansion to account for the fraction of time that salvage was being sampled and for losses due to factors such as predation. The fraction of time that salvage was sampled during these years was around 11% to 19%[25], so a conservative multiplier of 10 is used for illustrative purposes. A multiplier of 4.33 was used to account for losses such as predation, which represents the SWP multiplier typically used (it is unknown from Workman 2018b at which facility the fish recovered, but the SWP multiplier is conservatively used as it is higher than the CVP multiplier). Thus, with these assumptions, the estimated entrainment loss of Mokelumne River Fall-run Chinook Salmon would have been around 292 * (100/10) * 4.33 = around 12,600 fish. This loss would have represented around 0.6% of the total release.

As previously noted in the analysis for the Proposed Project, for 2007-2014, Workman (2018b, Figure 3) described that 194 coded-wire-tagged fish were recovered at the salvage facilities. In these, more recent years, the fraction of time that salvage was sampled increased, ranging from around 18% to near 30%. Assuming the lower end of this range and applying the 4.33 multiplier to account for predation, etc., the estimated entrainment loss of coded-wire-tagged fish during 2007-2014 could have been on the order of 194 * (100/18) * 4.33 = 4,700 fish. Considerably fewer coded-wire-tagged fish were released in the Mokelumne River during 2007-2014 (most releases occurred in the west Delta; Workman 2018b, her Figure 3). It is unclear how many of these fish specifically were released in the river based on Workman (2018a, p.181), but the data compilation by Sturrock et al. (2019) suggests that around 4.2 million were released[26]. Given a coded-wire-tag fraction of 31% (Workman 2018a, p.181), this would suggest that around 1.3 million coded-wire-tagged fish were released in the Mokelumne River during 2007-2014. Thus, the loss estimate of around 4,700 juvenile Fall-run Chinook Salmon in 2007-2014 could have represented around 0.4% of the total number released. As illustrated in the DSM2-HYDRO velocity analysis, there would be expected to be little difference between the Refined Alternative 2b and Existing Conditions operational scenarios in the hydrodynamics of the lower San Joaquin River where Mokelumne River Fall-run Chinook Salmon would enter the Delta (larger differences between scenarios are limited to southern half of the south Delta as illustrated in Figure 5.3-53).

Based on observed historical coded wire tagging studies showing small proportions of Mokelumne River Fall-run Chinook Salmon entrained, and based on high pumping rates that occurred during the 1992-2006 period when those studies were conducted, greater April-May south Delta export pumping under Refined Alternative 2b would not be expected to substantially impact Mokelumne River Fall-run Chinook Salmon. The Mokelumne River Chinook Salmon junction analysis described above shows similar conclusions.

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[25] Salvage data are available at ftp://ftp.wildlife.ca.gov/salvage/

[26] As in the calculation for 1992-2006, data from Sturrock et al. (2019) were limited to releases in the Mokelumne River in the months of April and May. For all months of the year, the total released was around 4.7 million; had this number been used in the calculation, the percentage entrainment loss would have been lower.

These hydrodynamic impacts include the combined impacts of the SWP and CVP. As previously noted, the SWP responsibility for Delta water operations during the period evaluated for Mokelumne River basin Fall-run Chinook Salmon (November–April) is approximately 20% to 60% depending on the month and water year type (see Appendix H).

Entrainment

Entrainment Loss Density

As previously noted in the analysis for the Proposed Project, analysis of potential differences in entrainment loss of Fall-run and Late Fall-run Chinook Salmon juveniles between Refined Alternative 2b and Existing Conditions scenarios was undertaken with the salvage-density method, as described for the other races of Chinook Salmon. The same caveats including those regarding length-at-date classification and the appropriate use of these results that are described for the other races also apply to Fall-run and Late Fall-run Chinook Salmon. In addition, as described for Winter-run Chinook Salmon, all months are evaluated in this analysis but only those Chinook Salmon that were reported as Fall-run and Late Fall-run Chinook Salmon based on their length at the time of salvage were included in the weighting and subsequent reporting of loss density.

The salvage-density method suggested that entrainment loss of juvenile Fall-run Chinook Salmon at the SWP south Delta export facility could be greater under Refined Alternative 2b compared to the Existing Conditions scenario (Table 5.3-16). This is because considerable juvenile Fall-run Chinook Salmon entrainment occurs during the April–May period when the largest difference in south Delta exports is projected to occur between Existing Conditions and Refined Alternative 2b. As described for the other races of Chinook Salmon, it should be noted that the analysis herein is based on size-at-date criteria, and does not reflect potential errors in Chinook Salmon race identification based on these criteria (Harvey et al. 2014). Fall-run Chinook Salmon juveniles may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in Refined Alternative 2b, which would be implemented in real time to protect CESA- or ESA-listed salmonids and smelts. Available data from studies of marked juvenile fall-run Chinook Salmon suggest that losses at the salvage facilities comprise a small percentage of Delta migration mortality (e.g., ~0.1% of fish from the Sacramento River and ~2% of fish from the San Joaquin River) (Zeug and Cavallo 2014). In addition, less than 1% of Sacramento River Fall-run Chinook Salmon enter the Delta as indicated by coded wire tag studies (Zeug and Cavallo 2014); this suggests that increases in salvage would result in impacts on a very small proportion of the Fall-run Chinook Salmon population. Therefore, potential increases under Refined Alternative 2b would be expected to also be a small percentage of overall Delta mortality.

The salvage-density method suggested that there would be little difference in potential entrainment loss of Late Fall-run Chinook Salmon between Existing Conditions and Refined Alternative 2b (Table 5.3-17), reflecting relatively little difference in potential South Delta exports during the main salvage period for Late Fall-run Chinook Salmon.

Table 5.3-16. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-16 a - f

Table 5.3-16 g. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,313	3,603	1,866	2,398	12,381	13,764	401	29	34	4	72	88
Refined Alternative 2b	1,343	3,655	1,606	4,473	18,722	13,648	389	22	31	4	93	88

Table 5.3-16 h. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	31	4,455	1,635	3,124	7,775	4,217	76	24	796	0	6	7
Refined Alternative 2b	31	4,165	1,255	4,042	10,683	4,184	75	18	796	0	8	7

Table 5.3-16 i. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	18	1,074	856	1,877	302	4	0	0	0	0	6
Refined Alternative 2b	0	19	806	1,036	1,897	296	4	0	0	0	0	6

Table 5.3-16 j. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	5	17	554	5,830	7,034	119	0	2	0	89	8	266
Refined Alternative 2b	6	18	449	5,379	6,692	119	0	2	0	99	10	285

Table 5.3-16 k. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	10	9	213	1,483	220	0	0	0	8	13	0
Refined Alternative 2b	1	9	9	168	1,448	186	0	0	0	8	18	98

Table 5.3-16 l. Estimates of Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	35,953	22,147	4,138	13,925	2,059
Refined Alternative 2b	44,076	25,263	4,063	13,060	1,946
Refined Alternative 2b vs. Existing	8,122 (23%)	3,116 (14%)	-75 (-2%)	-865 (-6%)	-113 (-6%)

Outmigrant Survival

Delta Passage Model

Central Valley Fall-run Chinook Salmon

As previously noted in the analysis for the Proposed Project, the DPM integrates operational impacts of the Existing Condition and Refined Alternative 2b scenarios that could influence through-Delta survival of migrating juvenile Chinook Salmon smolts including Central Valley Fall-run. Functions included in the DPM include reach-specific flow-survival and flow travel-time relationships, flow-routing relationships and export-survival relationship. Uncertainty in the quantitative relationships included in the DPM were integrated into the analysis using Monte Carlo techniques. One hundred iterations of the model were run for each scenario where distributions for each parameter were resampled for each iteration. Model output reported here is annual through-Delta survival in the 82-year CalSim period and through-Delta survival aggregated by water year-type. Further details of the method are provided in Appendix E.

Across the 82-year simulation period, mean through-Delta survival was not greatly different between Refined Alternative 2b and Existing Conditions scenarios, 0.3% greater for the Existing Conditions scenario (22.8%, 95% CI 13.4-39.8) relative to Refined Alternative 2b (22.5%, 95% CI 13.5-38.9). Survival was greater under the Existing Conditions scenario for 53 of the 82 years and was greater under Refined Alternative 2b in 14 years (Figure 5.3-66). Confidence intervals for mean through-Delta survival overlapped between scenarios in all years.

For both scenarios, mean survival rates tracked water year type with the highest values in wet years and the lowest values in critical years (Figure 5.3-67). Mean through-Delta survival was greater for the Existing Conditions scenario relative to Refined Alternative 2b in wet, above-normal and below-normal years and higher under Refined Alternative 2b in dry and critical water year types (Figure 5.3-67). The 95% confidence intervals for survival estimates overlapped between scenarios in each water year type.

Late Fall-run Chinook Salmon

Across the 82-year simulation period, mean through-Delta survival was 0.3% greater under the Existing Conditions scenario (22.0%, 95% CI 13.9-38.1), relative to Refined Alternative 2b (21.7%, 95% CI 13.7-37.7). Survival was greater under the Existing Conditions scenario for 55 of the 82 years and greater under Refined Alternative 2b in 16 years (Figure 5.3-68). Differences in individual years were generally small (< 1.0%) with the largest difference occurring in the 1975 model year when survival under the Existing Condition was 1.9 % higher than under Refined Alternative 2b. Confidence intervals for mean through-Delta survival overlapped between scenarios in all years.

Table 5.3-17. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-17 a - f

Table 5.3-17 g. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	765	5	0	0	0	0	0	4	1	8	8	680
Refined Alternative 2b	782	5	0	0	0	0	0	3	1	9	10	677

Table 5.3-17 h. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	534	44	0	0	0	0	0	0	8	5	33	330
Refined Alternative 2b	538	41	0	0	0	0	0	0	8	6	42	307

Table 5.3-17 i. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	234	113	21	0	0	0	0	0	0	0	0	120
Refined Alternative 2b	253	117	16	0	0	0	0	0	0	0	0	122

Table 5.3-17 j. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	39	0	3	2	0	0	0	0	0	2	19	670
Refined Alternative 2b	42	0	2	1	0	0	0	0	0	2	24	720

Table 5.3-17 k. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	94	6	0	0	0	0	0	0	0	3	0	355
Refined Alternative 2b	102	6	0	0	0	0	0	0	0	3	0	344

Table 5.3-17 l. Estimates of Late Fall-run Chinook Salmon Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	1,471	954	488	734	458
Refined Alternative 2b	1,489	942	507	791	455
Refined Alternative 2b vs. Existing	17 (1%)	-12 (-1%)	19 (4%)	57 (8%)	-3 (-1%)

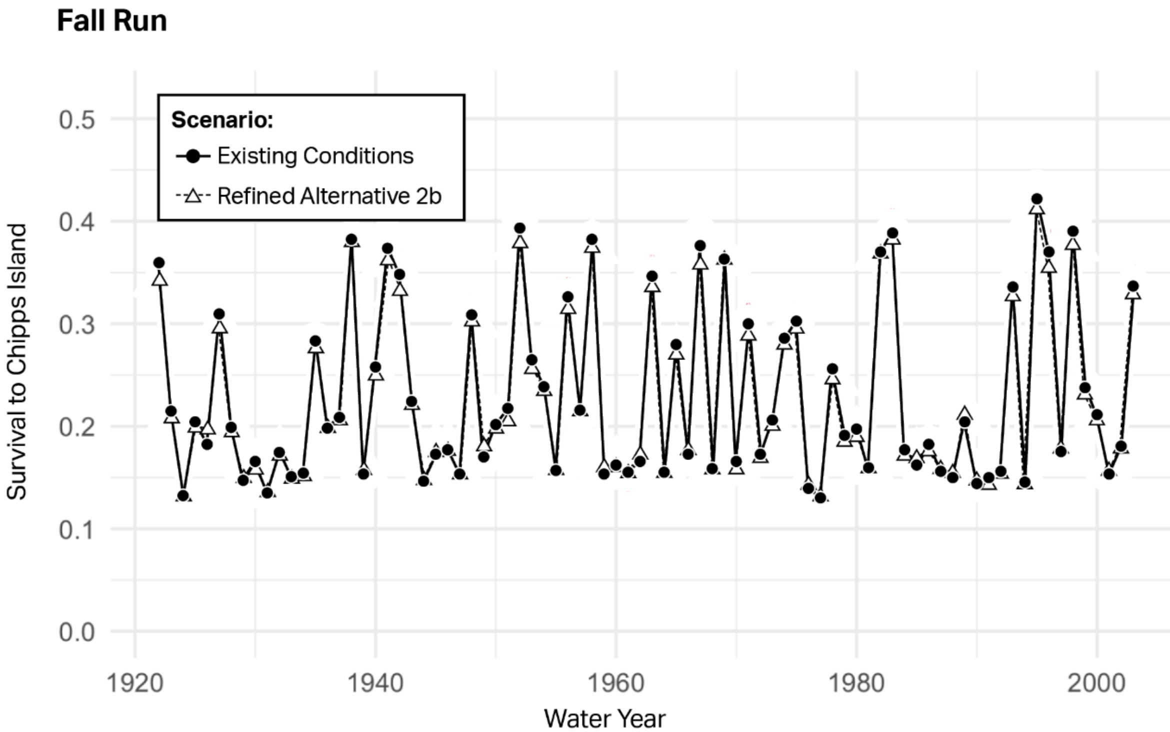


Figure 5.3-66. Mean Estimates of Fall-run Chinook Salmon Through-Delta Survival with 95% Confidence Intervals for Refined Alternative 2b and the Existing Condition in Each Simulation Year

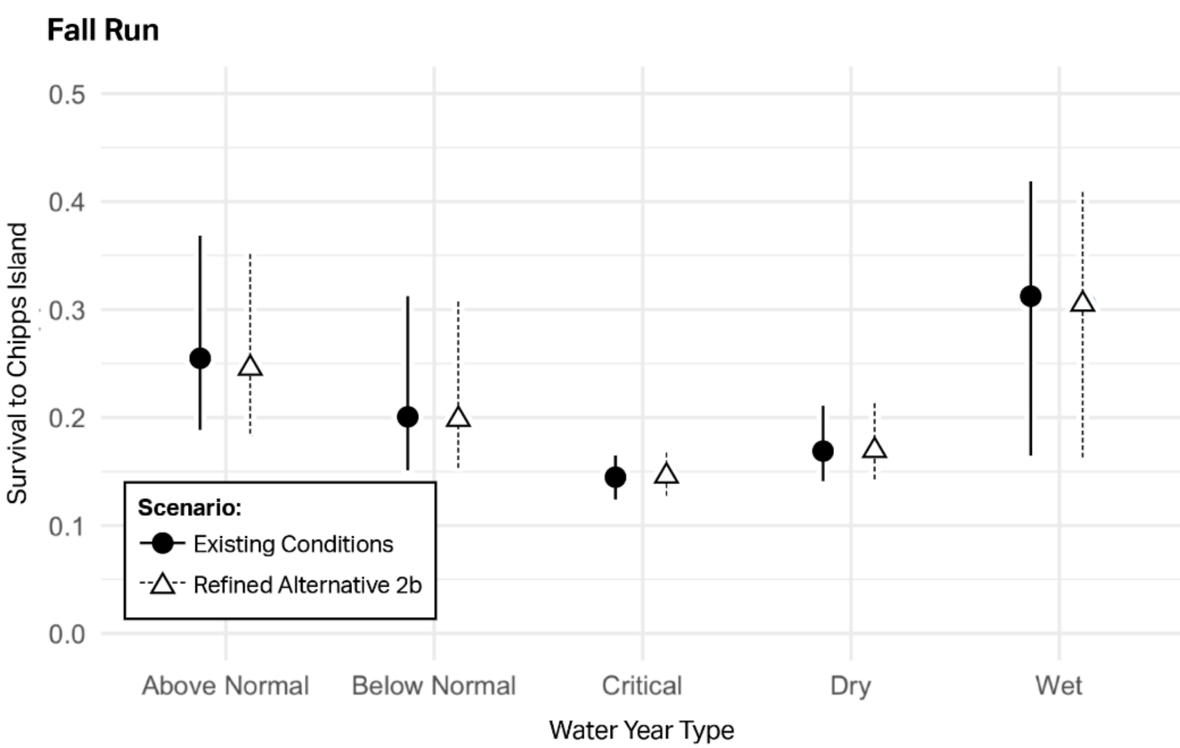


Figure 5.3-67. Mean Through-Delta Survival with 95% Confidence Intervals for Juvenile Fall-run Chinook Salmon under Refined Alternative 2b and the Existing Condition. Values were summarized by water year-type over the 82-year CalSim period

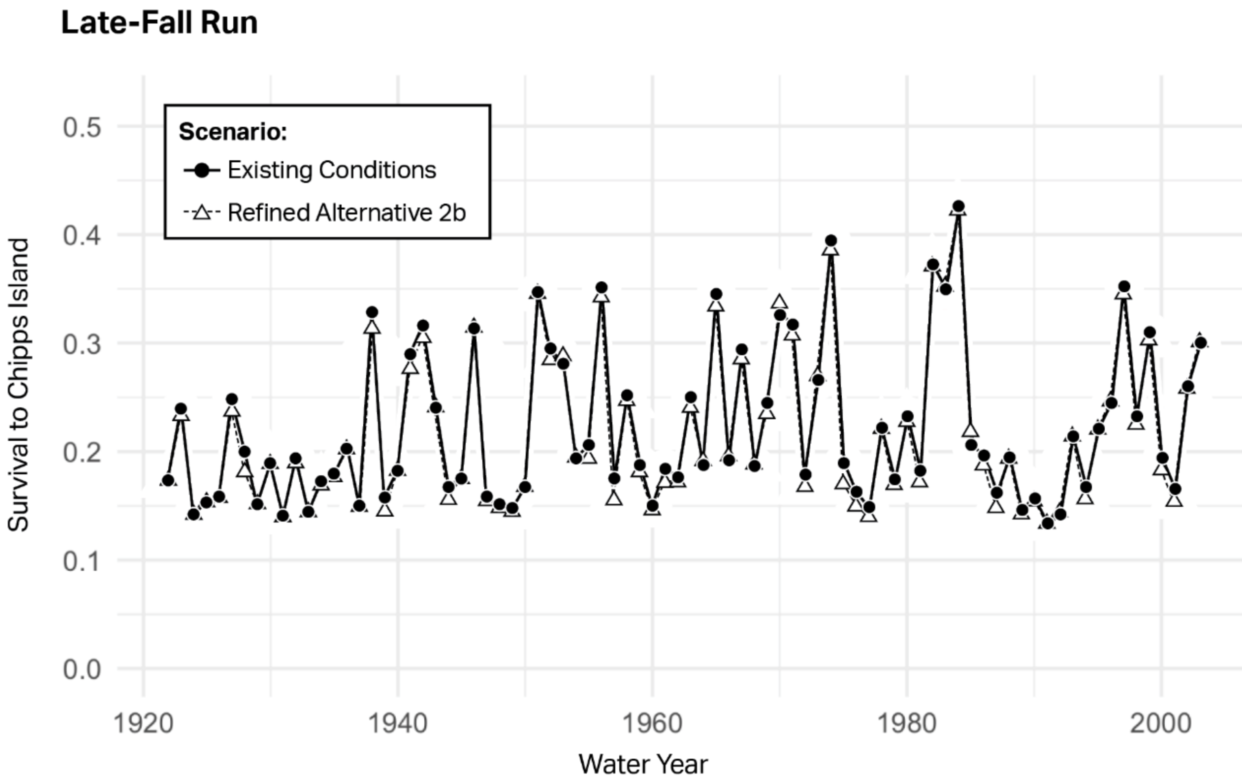


Figure 5.3-68. Mean Estimates of Juvenile Late Fall-run Chinook Salmon Through-Delta survival with 95% Confidence Intervals for Refined Alternative 2b and the Existing Condition in Each Simulation Year

For both scenarios, mean survival rates tracked water year type with the highest values in wet years and the lowest values in critical years (Figure 5.3-69). Mean through-Delta survival was greater under the Existing Conditions scenario relative to Refined Alternative 2b in all water year types. However, differences were < 0.6% across all year types (Figure 5.3-69). Although 95% confidence intervals for survival estimates overlapped between scenarios in each water year type, the largest difference occurred in wet years when mean survival for the Existing Conditions scenario was 0.56% higher than Refined Alternative 2b. The smallest difference occurred in below-normal years when survival was 0.11% higher under the Existing Conditions scenario relative to Refined Alternative 2b (Figure 5.3-69).

Through-Delta survival impacts as represented by the Delta Passage Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 20-60% depending on the month and water year type (see Appendix H).

San Joaquin River-Origin Fall-run Chinook Salmon Structured Decision Model

As previously noted in the analysis for the Proposed Project, the Delta Structured Decision Model was developed by the Central Valley Project Improvement Act Science Integration Team to evaluate the impact of different management decisions on the survival and routing of juvenile fall run Chinook Salmon. The model relies on survival-environment relationships and routing-environment relationships from acoustic studies conducted in the Sacramento and San Joaquin Rivers and at the State and

Federal export facilities. Only results from the San Joaquin River sub model are reported. The model and documentation has not been finalized and the code for the most recent version of the model that was used was accessed at https://github.com/FlowWest/chinookRoutingApp.

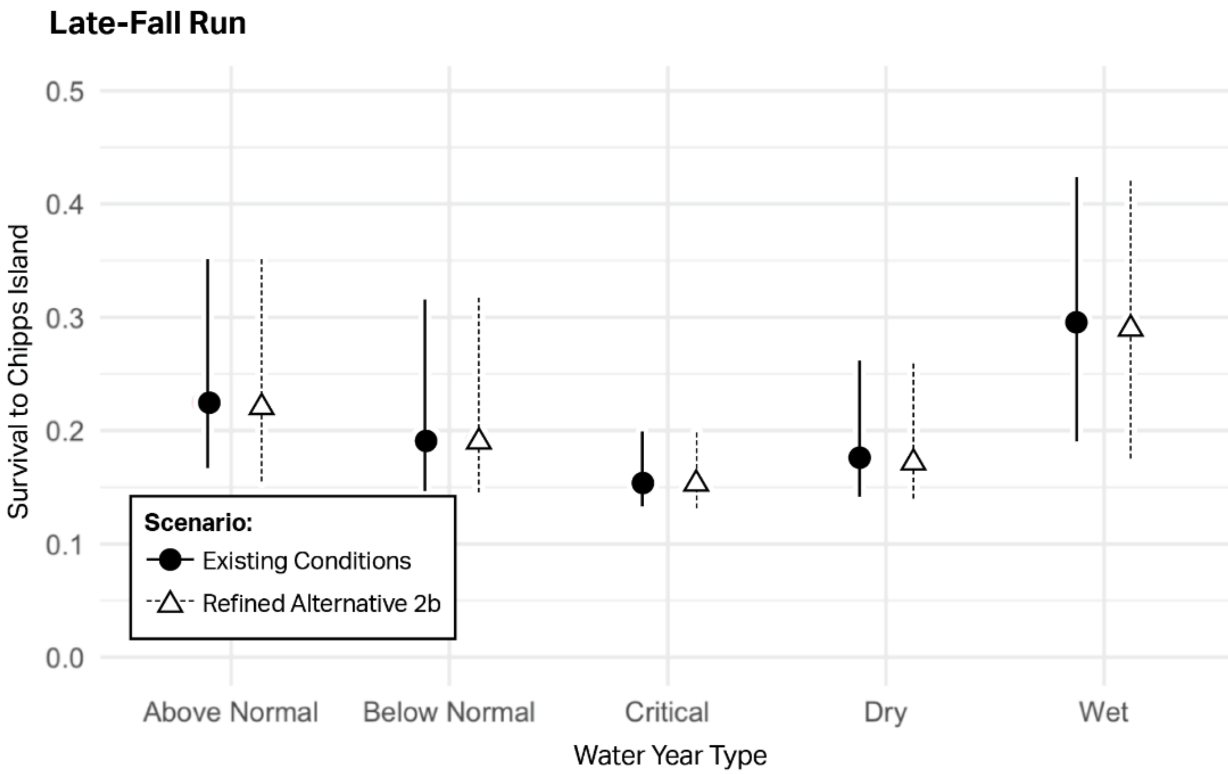


Figure 5.3-69. Mean Through-Delta Survival with 95% Confidence Intervals for Juvenile Late Fall-run Chinook Salmon under Refined Alternative 2b and the Existing Condition. Values were summarized by water year-type over the 82-year CalSim period

Survival results from the SDM model were estimated specifically for San Joaquin River-origin Fall-run Chinook Salmon by weighting daily survival values by the daily proportion of Fall-run Chinook Salmon captured in the Mossdale Kodiak trawl and reported as annual estimates and as aggregations by water year type.

Across the 82-year CalSim period through-Delta survival was low (< 4%) for both the Existing Conditions and Refined Alternative 2b (Figure 5.3-70). Survival under Refined Alternative 2b was higher than the Existing Condition scenario for all years, although the magnitude of the difference was variable.

Through Delta survival under all scenarios tracked water year-type with the highest values in wet years and the lowest values in critical years. However, the differences in survival between these water years is very small (Figure 5.3-71). Interquartile ranges of survival were greater under Refined Alternative 2b in all water year types although the range of survival values was small for all scenarios (Figure 5.3-71).

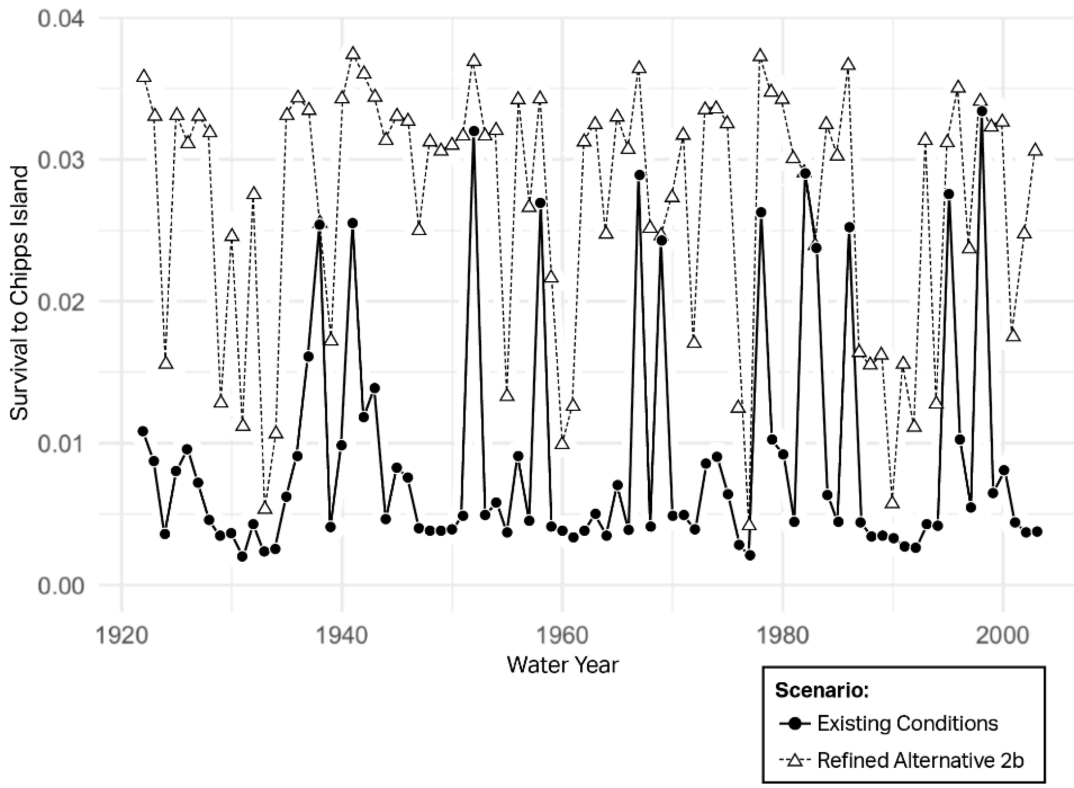


Figure 5.3-70. Mean Estimates of San Joaquin River Fall-run Chinook Salmon Through-Delta Survival from for Refined Alternative 2b and the Existing Condition in Each Simulation Year

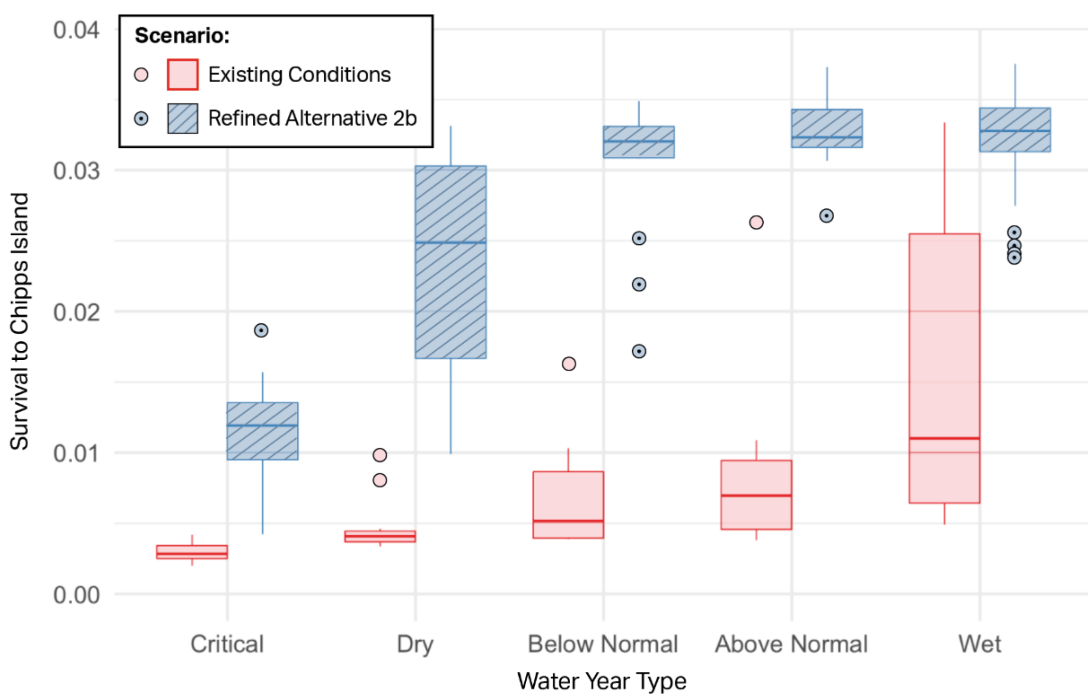


Figure 5.3-71. Median Through-Delta Survival (horizontal line) with Interquartile Ranges (Boxes), Minimum and Maximum Values (Vertical Lines) for Juvenile San Joaquin River-origin Fall-run Chinook Salmon under Refined Alternative 2b (PP2B) and the Existing Condition (EXG). Values were summarized by water year-type over the 82-year CalSim period

Through-Delta survival impacts as represented by the Structured Decision Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 20% to 60% depending on the month and water year type (see Appendix H). SWP exports generally would be similar to Existing Conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than Existing Conditions. The potential changes in through-Delta survival when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period.

STARS

As previously noted in the analysis for the Proposed Project, the STARS model provides an assessment of potential differences between Refined Alternative 2b and Existing Conditions scenarios in travel time, migration routing, and survival of juvenile Chinook Salmon emigrating from the Sacramento River through the Delta. The STARS model results suggest little difference in predicted through-Delta survival of Fall and Late Fall-run Chinook Salmon between scenarios, except for juveniles migrating before December. Fall-run Chinook Salmon outmigration occurs primarily from January through June and would not be affected by differences in routing that were modeled to occur during November. Late Fall-run Chinook Salmon fry rear in fresh water from April through the following April and outmigrate as smolts from October through February (Snider and Titus 2000a). Therefore, the differences between Refined Alternative 2b and Existing Conditions scenarios in outmigrant survival, as influenced by routing (entrainment into the interior Delta) and travel time, are not considered a substantial impact on the outmigrating Fall-run and Late Fall-run Chinook Salmon population.

Through-Delta survival impacts as represented by the STARS Model include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 20% to 60% depending on the month and water year type (See Appendix H).

Rearing Effects

The analysis of potential rearing effects provided for Winter-run Chinook Salmon is also applicable to Fall- and Late fall-run Chinook Salmon and indicates little potential for negative effects of Refined Alternative 2b relative to Existing.

Water Transfers

As previously noted in the analysis for the Proposed Project, expansion of the water transfer window to include July to November would be expected to have limited overlap with Fall-run and Late Fall-run Chinook Salmon in the Delta, which occur primarily in the Delta primarily in winter and spring.

Georgiana Slough Behavioral Modification Barrier

Operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Fall-run and Late Fall-run Chinook Salmon juvenile entry into the interior Delta at Georgiana Slough, thereby further reducing the less-than-significant effects of greater south Delta exports under Refined Alternative 2b compared to Existing Conditions that were suggested by the Delta Passage Model. Upstream-migrating Late Fall-run Chinook Salmon adults would have the potential to encounter the barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect Fall- and Late Fall-run Chinook Salmon include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. These activities likely would have limited impacts on Chinook Salmon when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect Fall-run and Late Fall-run Chinook Salmon include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including

- Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
- Continued refinement and improvement of the fish sampling and hauling procedures
- Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impact of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are expected to minimize operations-related impacts on Fall-run and Late Fall-run Chinook Salmon, improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Fall-run and Late Fall-run Chinook Salmon

Fall-run and Late Fall-run Chinook Salmon inhabit areas of the Delta that could be affected by Refined Alternative 2b during the adult migration and juvenile rearing to outmigrating portions of their life cycle. Potential operations-related changes to migration and rearing habitat attributes, outmigrant survival, entrainment into the Delta from the Sacramento River, and entrainment at SWP facilities were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures.

The analyses conducted for each life stage of Fall-run and Late Fall-run Chinook Salmon are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of Fall-run and Late Fall-run Chinook Salmon are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on Fall-run and Late Fall-run Chinook Salmon, relative to the Existing Conditions scenario, and are considered **Less than Significant.**

5.3.9.5 Central Valley Steelhead

Operations-Related Impacts

Immigrating Adults

As previously noted in the analysis for the Proposed Project, adult Central Valley Steelhead use the lower Sacramento River between the Delta and the confluence with the Feather River from July through March for the purposes of immigration. During this period, changes in simulated average monthly flows at Freeport under Refined Alternative 2b, relative to the Existing Conditions scenario are generally relatively small (see Figure 5.3-46, Figures 5.3-47 through 5.3-51, and Table 5.3-13) and flows at Freeport are considered similar under Refined Alternative 2b and Existing Conditions scenarios during most months of the year. Additionally, the SWP is responsible for between approximately 20% to 60% of Delta water operations, depending on month and water year type.

As previously noted in the analysis for the Proposed Project, because flows are generally similar under Refined Alternative 2b and Existing Conditions scenarios, it is expected that habitat attributes such as water temperature, dissolved oxygen concentrations, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.2 feet (Table 1-2-1, Appendix C), which would not likely reduce migration opportunities. Additionally, little potential for differences in rates of straying exist for adult steelhead between Refined Alternative 2b and Existing Conditions scenarios because. Specifically, because other salmonids in the same genus (i.e., closely related to steelhead) as adult Sockeye Salmon detected and behaviorally responded to a change in olfactory cues (e.g., dilution of olfactory cues from their natal stream) of greater than approximately 20% (Fretwell 1989). Therefore, potential impacts of Refined Alternative 2b on immigrating adult steelhead in the Sacramento River are expected to be similar to those under the Existing Conditions scenario.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on immigrating adult Central Valley steelhead the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20-60% of Delta water operations during the July through March Central Valley steelhead immigration period depending on month and water year type (see Appendix H).

Delta Hydrodynamic Analysis

Based on the results of the Delta Hydrodynamic Analysis presented in the discussion of Winter-run Chinook Salmon, above, changes in south Delta hydrodynamics could occur in the Spring and Fall under Refined Alternative 2b, relative to the Existing Condition. Fish passing through the Delta Cross Channel or Georgiana Slough and continuing to migrate westward in the mainstem San Joaquin River will experience no velocity changes likely to influence their survival or behavior. Fish that move southward enough in the Old and Middle River corridor to reach areas of altered velocities may be more likely to continue moving toward the export facilities and become vulnerable to entrainment. However, velocity changes that could occur in the Spring and Fall are not likely to affect Central Valley steelhead because most Central Valley steelhead are expected to have exited the Delta by April and May and generally occur in low numbers in the region between September and November. In addition, implementing OMR management, including single year and cumulative loss thresholds for steelhead, would limit entrainment. SWP exports generally would be similar to Existing Conditions during April–May; in April/May of wetter years when the 44,500-cfs Delta outflow threshold would be exceeded, there would be greater SWP exports under Refined Alternative 2b than Existing Conditions. The potential changes in Delta hydrodynamics when Delta outflow is below 44,500 cfs would be attributable to CVP operations during the April through May period.

Delta hydrodynamic impacts include the combined impacts of the SWP and CVP. The SWP responsibility for Delta water operations during the April and May period when changes to Delta hydrodynamics are greatest under Refined Alternative 2b is approximately 20% to 40% depending on the month and water year type (see Appendix H).

Entrainment

Entrainment Loss Density

The entrainment loss-density method was used to assess potential differences in entrainment loss of steelhead juveniles between Refined Alternative 2b and Existing Conditions scenarios. The same caveats described for other species apply to steelhead. Specifically, the estimates of entrainment loss obtained from the entrainment loss density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim-modeled differences in south Delta exports between the evaluated scenarios. Therefore, the results are basically a description of differences in export flows weighted by monthly loss density. Historical loss density numbers provide some perspective on the absolute numbers of fish being entrained, but are a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected. Although the emphasis is consideration of the relative difference between scenarios, it is important to appreciate that the modeling is limited in its representation of real-time adjustments to operations in order to minimize impacts on listed fishes, so that differences between scenarios are likely to be less than suggested by the method.

The salvage-density method suggested that entrainment loss of juvenile steelhead at the SWP south Delta export facility would generally be similar between Refined Alternative 2b and Existing Conditions (Table 5.3-18). However, because the loss density method relies on CalSim results, this analysis does not account for real-time operational adjustments that would be undertaken to limit entrainment loss, including risk assessment for OMR management that includes consideration of factors such as salvage thresholds. Real-time OMR management, combined with the need to keep entrainment below the authorized take limit from the NMFS ROC on LTO Biological Opinion, would be expected to limit entrainment and salvage loss of steelhead juveniles.

Water Transfers

As previously noted in the analysis for the Proposed Project, expansion of the water transfer window to include July to November would be expected to have limited overlap with Steelhead in the Delta, which occur primarily in the Delta primarily in winter and spring.

Table 5.3-18. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-18 a - f

Table 5.3-18 g. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1,277	1,362	2,010	443	318	347	20	2	3	8	10	28
Refined Alternative 2b	1,306	1,382	1,730	826	481	344	20	2	3	10	12	28

Table 5.3-18 h. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	3,720	5,436	2,058	248	197	82	12	0	0	0	30	325
Refined Alternative 2b	3,751	5,082	1,579	320	270	81	12	0	0	0	38	303

Table 5.3-18 i. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	309	2,756	2,184	254	106	48	5	0	0	0	0	14
Refined Alternative 2b	333	2,845	1,639	307	107	47	5	0	0	0	0	14

Table 5.3-18 j. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	476	2,056	2,995	471	151	42	18	0	0	1	33	82
Refined Alternative 2b	517	2,113	2,427	435	144	43	16	0	0	1	41	88

Table 5.3-18 k. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	84	1,481	540	155	77	27	5	0	0	0	4	0
Refined Alternative 2b	91	1,450	517	122	75	22	6	0	0	0	6	0

Table 5.3-18 l. Estimates of Steelhead Juvenile Loss (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	5,829	12,107	5,677	6,326	2,373
Refined Alternative 2b	**6,143**	**11,435**	**5,299**	**5,825**	**2,289**
Refined Alternative 2b vs. Existing	**315 (5%)**	**-672 (-6%)**	**-379 (-7%)**	**-502 (-8%)**	**-84 (-4%)**

Georgiana Slough Behavioral Modification Barrier

Operation of a behavioral modification barrier at Georgiana Slough would have the potential to reduce Central Valley Steelhead juvenile entry into the interior Delta at Georgiana Slough, as observed during the 2012 pilot study (DWR 2014), thereby reducing the less-than-significant effects of greater south Delta exports under Refined Alternative 2b compared to Existing Conditions that were suggested by the salvage-density method. Upstream-migrating Central Valley Steelhead adults would have the potential to encounter the barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect Central Valley Steelhead include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. These activities likely would have limited impacts on steelhead when they are implemented because existing permit conditions such as work windows and BMPs to protect water quality would also be continued. Specifically, work windows and BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs and work windows included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect Central Valley Steelhead include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including

- Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
- Continued refinement and improvement of the fish sampling and hauling procedures
- Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are expected to minimize operations-related impacts on Central Valley Steelhead, improve habitat conditions, or directly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Central Valley Steelhead

Central Valley steelhead inhabit areas of the Delta that could be affected by Refined Alternative 2b during the adult migration and juvenile rearing to outmigrating portions of their life cycle. Potential operations-related changes to migration and rearing habitat attributes, outmigrant survival, entrainment into the Delta from the Sacramento River, and entrainment at SWP facilities were evaluated along with annual operations and maintenance activities and project Environmental Protective Measures.

The analyses conducted for each life stage of Central Valley Steelhead are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of steelhead are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on Central Valley Steelhead, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

5.3.9.6 Central California Coast Steelhead

As previously noted in the analysis for the Proposed Project, the Central California Coast Steelhead DPS includes all naturally spawned populations of steelhead in streams from the Russian River to Aptos Creek, in Santa Cruz County (inclusive). It also includes the drainages of San Francisco and San Pablo bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin rivers. Critical habitat for CCC Steelhead includes stream reaches in the Russian River, Bodega, Marin Coastal, San Mateo, Bay Bridge, Santa Clara, San Pablo, and Big Basin Hydrologic Units. Because CCC Steelhead do not occur in the Delta, changes in Delta outflow are the only mechanism by which SWP operations could affect CCC Steelhead or their Designated Critical Habitat. Operation of the SWP would not substantially alter Delta outflow on an annual basis (Figure 5.3-72), or on a monthly basis (Figure 5.3-743). Because no spawning occurs in San Pablo or San Francisco bays, these areas are potentially used for rearing and migration. Slightly reduced outflows are not expected to substantially alter CCC steelhead rearing and migration habitat attributes in the San Francisco or San Pablo bays, including salinity distribution, food availability, migration cues, dilution of toxins, or other habitat attributes. Therefore, slightly reduced outflow would not substantially affect CCC Steelhead in San Francisco or San Pablo bays. In addition, these minor reductions in Delta Outflow would not substantially affect designated critical habitat for this DPS. Therefore, impacts of Refined Alternative 2b on CCC Steelhead are considered **Less Than Significant**.

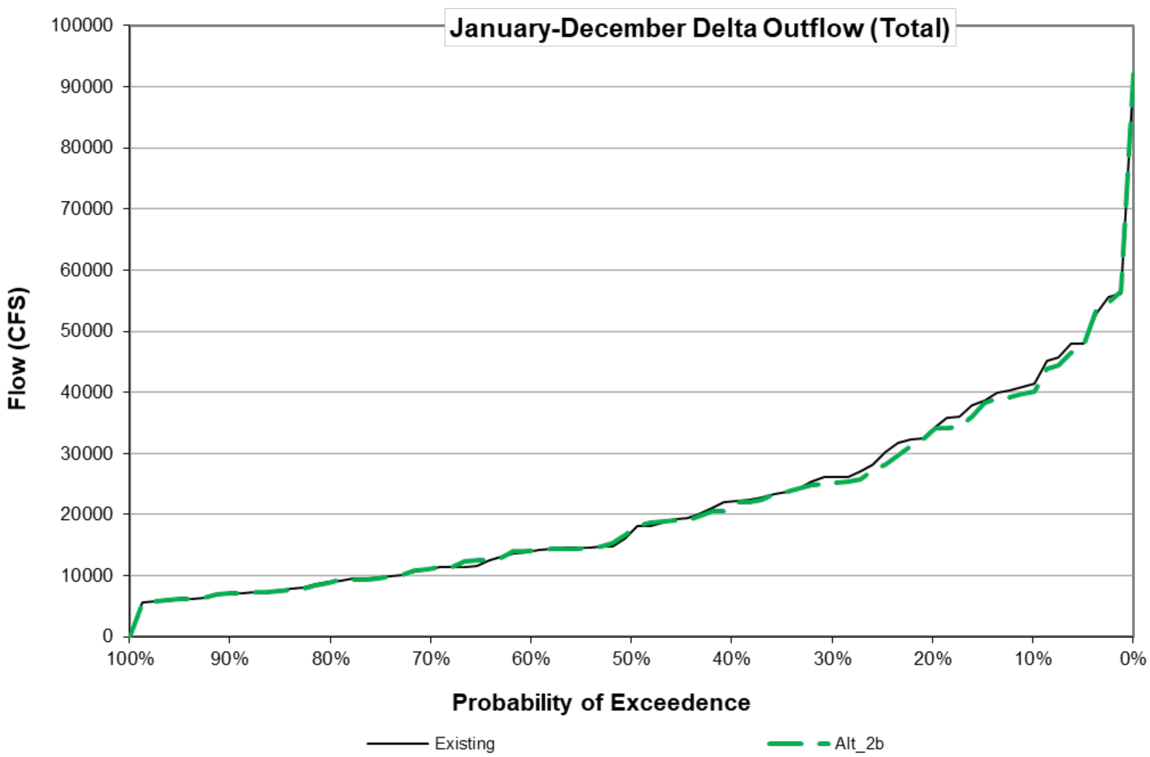


Figure 5.3-72. Cumulative Probability Distribution of Simulated Annual Total Delta Outflow under Refined Alternative 2b and Existing Conditions CalSim II Modeling Scenarios

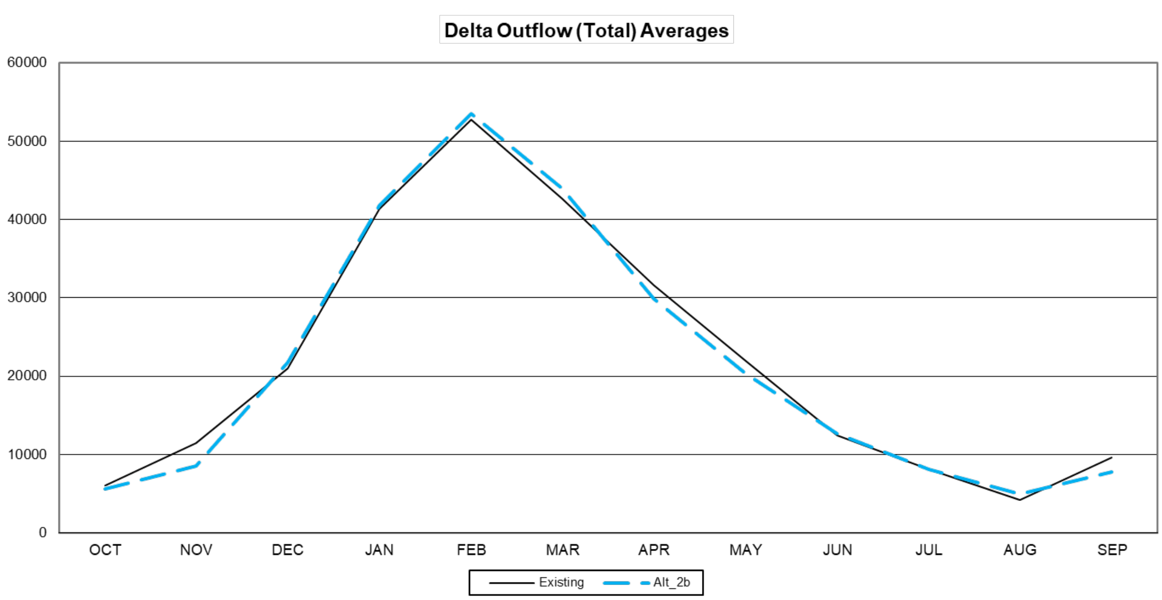


Figure 5.3-73. Monthly Average Simulated Total Delta Outflow under Refined Alternative 2b and Existing Conditions CalSim II Modeling Scenarios

5.3.9.7 North American Green Sturgeon

Operations-Related Impacts

Immigrating Adults and Emigrating Juveniles

As previously noted in the analysis for the Proposed Project, Green Sturgeon use the lower Sacramento River, between the Delta and the confluence with the Feather River, at different times of the year based on the timing of individual life stage activities. Adult Green Sturgeon could occupy the river throughout the entire year for the purposes of immigration and holding (pre- and post-spawn). During the year, changes in simulated average monthly flows at Freeport under Refined Alternative 2b, relative to the Existing Conditions scenario are generally relatively small (see Figure 5.3-46, Figures 5.3-47 through 5.3-51, and Table 5.3-13).

Because reach-specific relationships between Green Sturgeon habitat attributes and flow are not readily available, a detailed discussion of flow-related impacts on habitat is inappropriate. Nonetheless, because flows are generally similar under Refined Alternative 2b and Existing Conditions scenarios, it is expected that habitat attributes such as food availability, water temperature, migration and foraging habitat, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.2 feet (Table 1-2-1, Appendix C), which would not likely reduce migration opportunities. In addition, larger differences in flow between Refined Alternative 2b and Existing Conditions scenarios that occur during September and November would not occur with sufficient duration or frequency to result in long-term changes in habitat attributes for Green Sturgeon. Specifically, these reductions occur in two non-consecutive months of the year-round period of potential presence. In addition, reductions during September occur primarily during wet years. During November reductions occur with varying magnitude depending on the water year type (ranging from about 6% to 13% reduction). Therefore, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of Refined Alternative 2b associated with flow on immigrating adult Green Sturgeon in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Spawning and egg incubation occur in the Sacramento River upstream of the confluence of the Feather River and in the Feather River, and are not evaluated further. Green Sturgeon juveniles emigrate and rear in Sacramento River from the confluence with the Feather River through the Delta year-round. Similar to the adult habitat attributes, because flows are similar under both scenarios during most months, habitat attributes including food availability, rearing habitat, water temperature, predation risk, and other habitat attributes are anticipated to be similar.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on Green Sturgeon in the Sacramento River; the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20-60% of Delta water operations during the year depending on the month and water year type (see Appendix H).

Entrainment

Daily Salvage Density

The salvage-density method was used to assess potential differences in salvage of juvenile Green Sturgeon between Refined Alternative 2b and Existing Conditions scenarios. The same caveats described for other species apply to Green Sturgeon. Specifically, the estimates of entrainment loss obtained from the salvage-density method should not be construed as accurate predictions of future entrainment loss, but relatively coarse assessments of potential relative differences considering only CalSim-modeled differences in south Delta exports between the evaluated scenarios. Therefore, the results are basically a description of differences in export flows weighted by monthly salvage density. Historical salvage density numbers provide some perspective on the absolute numbers of fish being entrained, but are a reflection of overall population abundance and prevailing entrainment management regimes in place at the time the data were collected. Although the emphasis is consideration of the relative difference between scenarios, it is important to appreciate that the modeling is limited in its representation of real-time adjustments to operations in order to minimize impacts on listed fishes, so that differences between scenarios are likely to be less than suggested by the method. In addition, in contrast to the salmonid loss density analyses, this analysis is based on salvage rather than fish loss (which is a calculation of loss associated with Clifton Court Forebay and regional mortality that is expanded from salvage).

Historically, Green Sturgeon salvage has been relatively low, but has been greatest in wet years (see https://apps.wildlife.ca.gov/Salvage). In recent years the low numbers of Green Sturgeon salvaged has been reported to be a very small percentage of the most recently available population estimate (i.e., ~4,400 juveniles; Mora et al. 2018).

Under Refined Alternative 2b, the salvage-density method suggested that salvage of Green Sturgeon would remain low and be similar to the Existing Conditions scenario, particularly in wet years when most salvage occurred historically (Table 5.3-19). Green Sturgeon salvage under Refined Alternative 2b would also continue to be limited and real-time operations would be adjusted to remain below the protective level required by the NMFS ROC on LTO Biological Opinion.

Water Transfers

As noted for the Proposed Project, expansion of the water transfer window to include July to November would overlap Green Sturgeon occurrence in the Delta and potential for salvage could increase based on historical patterns in salvage density (Table 5.3-19). However, relatively few Green Sturgeon are entrained and salvage would be required to remain below the protective level required by the NMFS ROC on LTO Biological Opinion.

Table 5.3-19. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-19 a-f

Table 5.3-19 g. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	5	3	0	0	2	7	32	10	2	1	0
Refined Alternative 2b	2	6	2	0	0	2	6	24	9	3	1	0

Table 5.3-19 h. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	5	0	0	0	0	4	0	0	0	0	0
Refined Alternative 2b	2	4	0	0	0	0	4	0	0	0	0	0

Table 5.3-19 i. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	0	0	0	0	0	0	0	0	0	0	0
Refined Alternative 2b	1	0	0	0	0	0	0	0	0	0	0	0

Table 5.3-19 j. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	2	0	0	0	0	0	0	0	0	13
Refined Alternative 2b	0	0	2	0	0	0	0	0	0	0	1	14

Table 5.3-19 k. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	1	0	0	0	0	0	0	0	4	0
Refined Alternative 2b	0	0	1	0	0	0	0	0	0	0	6	0

Table 5.3-19 l. Estimates of Green Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Conditions and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	63	11	1	15	5
Refined Alternative 2b	55	10	1	16	7
Refined Alternative 2b vs. Existing	-8 (-13%)	0 (-3%)	0 (8%)	1 (4%)	2 (32%)

Georgiana Slough Behavioral Modification Barrier

Operation of a behavioral modification barrier at Georgiana Slough would be expected to have little effect on Green Sturgeon because sturgeons generally have poor hearing ability (Lovell et al. 2005) and therefore would be unlikely to be deterred by the acoustic stimulus of the barrier. The near-bottom water column position of the sturgeons (Moyle 2002) also would tend to limit their potential to encounter the behavioral modification barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect Green Sturgeon include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. Although Green Sturgeon could potentially be present at the locations where O&M activities would occur year-round, it is not likely that large numbers of individuals would be present during O&M activities. These activities likely would have limited impacts on Green Sturgeon when they are implemented because existing permit conditions, including BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b. Therefore, annual O&M activities likely would have limited impacts on Green Sturgeon.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect Green Sturgeon include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including

- Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
- Continued refinement and improvement of the fish sampling and hauling procedures
- Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures would not substantially affect Green Sturgeon, but could minimize operations-related impacts on Green Sturgeon or indirectly benefit the species by reducing pre-screen mortality and increasing survival or salvaged fish.

Significance of Impacts on Green Sturgeon

Green Sturgeon inhabit areas of the Delta that could be affected by Refined Alternative 2b throughout year as adults and juveniles.

The analyses conducted for each life stage of Green Sturgeon are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of Green Sturgeon are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on Green Sturgeon, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

5.3.9.8 White Sturgeon

Operations-Related Impacts

Immigrating Adults and Emigrating Juveniles

As previously noted in the analysis for the Proposed Project, White Sturgeon adults and juveniles use the reach of the Sacramento River from the confluence with the Feather River through the Delta year round. Changes in flows during the year are described above for Green Sturgeon. Similarly, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of Refined Alternative 2b associated with flow on immigrating adult and emigrating juvenile White Sturgeon habitat attributes described in the SAIL conceptual models in the Sacramento River generally are expected to be similar to those under the Existing Conditions scenario, and differences are not expected to be substantial. Statistically significant positive correlations between White Sturgeon year-class strength and Delta outflow have been found for November–February and March–July outflow averaging periods (Fish 2010). Other similar analyses were found that also examined the April-May outflow (ICF International 2016a, p.5-197 to p.5-205). The mechanisms for these correlations are uncertain and could reflect upstream or in-Delta impacts. Appreciable amounts of variation are left unexplained by the relationships (i.e., r^2 of ~70%), with differences possibly reflecting hydrological conditions as opposed to operational differences in outflow, and which would be expected to give limited differences in year-class strength between the Existing Conditions and Refined Alternative 2b scenarios.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on White Sturgeon in the Sacramento River. The simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 60% of Delta water operations during the year, depending on the month and water year type, and specifically about 20% to 40% of Delta water operations during April and May (see Appendix H).

Entrainment

Daily Salvage Loss Density

As previously noted in the analysis for the Proposed Project, the salvage-density method was used to assess potential differences in salvage of juvenile White Sturgeon between Refined Alternative 2b and Existing Conditions scenarios. The same caveats described for other species apply to White Sturgeon. In addition, in contrast to the salmonid loss density analyses, this analysis is based on salvage rather than fish loss (which is a calculation of loss associated with Clifton Court Forebay and regional mortality that is expanded from salvage).

Under Refined Alternative 2b, the salvage-density method suggested that salvage of White Sturgeon would remain low and be similar to the Existing Conditions scenario (Table 5.3-20). Salvage is expected to be a very small proportion of the White Sturgeon population. White Sturgeon salvage under Refined Alternative 2b also could be limited incidentally by real-time OMR management actions that would be implemented for listed species.

Water Transfers

As noted for the Proposed Project, expansion of the water transfer window to include July to November would overlap White Sturgeon occurrence in the Delta and potential for salvage could increase based on historical patterns in salvage density (Table 5.3-20). However, relatively few White Sturgeon are entrained and so any effects of water transfers would be expected to be limited.

Georgiana Slough Behavioral Modification Barrier

Operation of a behavioral modification barrier at Georgiana Slough would be expected to have little effect on White Sturgeon because sturgeons generally have poor hearing ability (Lovell et al. 2005) and therefore would be unlikely to be deterred by the acoustic stimulus of the barrier. The near-bottom water column position of the sturgeons (Moyle 2002) also would tend to limit their potential to encounter the behavioral modification barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Table 5.3-20 Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet – Table 5.3-20 a-f

Table 5.3-20 g. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	22	10	7	2	0	4	24	30	14	10	28	14
Refined Alternative 2b	22	10	6	4	0	4	23	23	13	12	36	13

Table 5.3-20 h. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	1	4	0	0	0	0	0	0	1	0	6
Refined Alternative 2b	0	1	3	0	0	0	0	0	0	1	0	6

Table 5.3-20 i. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	1	0	0	4	0	0	0	0	2	3
Refined Alternative 2b	0	0	1	0	0	3	0	0	0	0	2	3

Table 5.3-20 j. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	1	0	0	2	0	0	1	0	1	1	4
Refined Alternative 2b	1	1	0	0	2	0	0	1	0	1	2	4

Table 5.3-20 k. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	2	0	1	0	0	0	0	2	2	5	1
Refined Alternative 2b	1	2	0	1	0	0	0	0	2	2	7	1

Table 5.3-20 l. Estimates of White Sturgeon Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	165	12	9	11	14
Refined Alternative 2b	167	11	10	12	16
Refined Alternative 2b vs. Existing	2 (1%)	-1 (-10%)	0 (1%)	1 (6%)	2 (14%)

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect White Sturgeon include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. Although White Sturgeon could potentially be present at the locations where O&M activities would occur year-round, it is not likely that large numbers of individuals would be present during O&M activities. Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. These activities likely would have limited impacts on White Sturgeon when they are implemented because existing permit conditions including BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b. Therefore, annual O&M activities likely would have limited impacts on White Sturgeon.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect White Sturgeon include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and

various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures would not substantially affect White Sturgeon, but could minimize operations-related impacts on White Sturgeon or indirectly benefit the species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on White Sturgeon

White Sturgeon inhabit areas of the Delta that could be affected by Refined Alternative 2b throughout year as adults and juveniles.

The analyses conducted for each life stage of White Sturgeon are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of White Sturgeon are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on White Sturgeon, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

5.3.9.9 Pacific Lamprey and River Lamprey

Operations-Related Impacts

Immigrating Adults, Ammocoetes, and Migrating Juveniles

As previously noted in the analysis for the Proposed Project, adult Pacific Lamprey use the river from March through June for the purposes of immigration. Larval lampreys (ammocoetes) could potentially occur in the evaluated reach of the Sacramento River year round while juveniles typically emigrate during winter and spring. During all months, changes in simulated average monthly flows at Freeport under Refined Alternative 2b, relative to the Existing Conditions scenario are generally relatively small (see Figure 5.3-46 Figures 5.3-47 through 5.3-51, and Table 5.3-13). Because reach-specific relationships between lamprey habitat attributes and flow are not readily available, a detailed discussion of flow-related impacts on habitat is inappropriate. Nonetheless, because flows are generally similar under Refined Alternative 2b and Existing Conditions scenarios, it is expected that habitat attributes such as food availability, water temperature, migration habitat, depth, burrowing substrate for ammocoetes, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is 1.2 feet (Table 1-2-1, Appendix C), which would not likely reduce migration opportunities. In addition, larger differences in flow between Refined Alternative 2b and Existing Conditions scenarios that occur during September and November would not occur with sufficient duration or frequency to result in long-term changes in habitat attributes for juvenile Pacific Lamprey. Specifically, these reductions occur in two non-consecutive months and reductions in September occur mostly during wet years (see Appendix C). Therefore, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of Refined Alternative 2b associated with flow on immigrating adult Pacific Lamprey, and emigrating and rearing juveniles in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on lampreys in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20-60% of Delta water operations during the year depending on the month and water year type (see Appendix H).

As previously noted in the analysis for the Proposed Project, like Pacific Lamprey, River Lamprey use the lower Sacramento River, between the Delta and the confluence with the Feather River as rearing and migratory habitat. Adult River Lamprey likely use the river from September through May for the purposes of immigration. Larval lamprey could use the reach year-round and juveniles migrate from May through July. As described for Pacific Lamprey, changes in flows that occur would not be anticipated to be of sufficient frequency or duration to substantially alter habitat attributes for these life stages. Therefore, these flow reductions are not expected to result in substantial impacts on River Lamprey.

Entrainment

Daily Salvage Loss Density

As previously noted in the analysis for the Proposed Project, the salvage-density method was used to assess potential differences in salvage of lampreys between Refined Alternative 2b and Existing Conditions scenarios. The same caveats described for other species apply to lampreys. In addition, because the species identity of most salvaged lampreys is unknown, the analysis was based on the salvage density of combined Pacific Lamprey and River Lamprey[27].

The salvage-density method suggested that salvage of lampreys could be similar between Refined Alternative 2b and Existing Conditions scenarios (Table 5.3-21). It is important to note that salvage of lampreys at the south Delta export facilities is inefficient relative to species such as Chinook Salmon and Striped Bass (Goodman et al. 2017). Therefore, entrainment loss of lampreys is likely to be greater per fish observed in salvage than loss for these other species. Information on the population-level importance of south Delta entrainment loss to lampreys is lacking, although Goodman et al. (2017) suggested that there is the potential for metapopulation-level impacts depending on how much of the total river flow is exported. Given the seasonality of lamprey occurrence in salvage — greatest numbers occur in winter and spring (Table 5.3-21) — it would be expected that lampreys could receive some ancillary protection from real-time OMR management that would occur under Refined Alternative 2b for listed fishes. In particular, the first flush action to protect adult Delta Smelt may

[27] As previously noted in the analysis for the Proposed Project, the salvage database at https://apps.wildlife.ca.gov/Salvage does not include any recorded species-specific data for Pacific Lamprey or River Lamprey at the SWP facility, so the analysis in this DEIR was based solely on the "Lamprey Unknown" category in the database.

Table 5.3-21. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-21 a – f

Table 5.3-21 g. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	775	100	14	21	18	34	29	6	0	0	0	93
Refined Alternative 2b	792	102	12	39	27	34	28	5	0	0	0	92

Table 5.3-21 h. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	93	178	80	2	2	7	2	0	0	0	4	28
Refined Alternative 2b	94	167	62	3	3	7	2	0	0	0	5	26

Table 5.3-21 i. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	42	14	61	5	11	43	14	0	0	0	0	0
Refined Alternative 2b	46	14	46	6	11	42	14	0	0	0	0	0

Table 5.3-21 j. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	188	34	58	18	26	6	16	0	0	3	1	17
Refined Alternative 2b	204	35	47	17	24	6	14	0	0	3	1	18

Table 5.3-21 k. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	36	17	22	8	20	5	3	0	0	0	0	4
Refined Alternative 2b	39	16	21	6	20	4	3	0	0	0	0	4

Table 5.3-21 l. Estimates of Lamprey Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	1,091	398	190	366	114
Refined Alternative 2b	1,133	369	179	370	113
Refined Alternative 2b vs. Existing	41 (4%)	-29 (-7%)	-12 (-6%)	3 (1%)	-1 (-1%)

coincide with considerable movement of lamprey into the Delta. Sacramento River lamprey have been observed to move within two days of peak streamflow or rain events (Goodman et al. 2015), leading Goodman et al. (2017) to predict that curtailment of exports during these periods would substantially reduce entrainment. As described in the project description and summarized above for Delta Smelt in the discussion *Consideration of OMR*, the first flush action would be expected to be triggered more often under Refined Alternative 2b than under the Existing Conditions scenario (see Figure 4.4-49 in Section 4.4.7.4), which could limit impacts on lamprey from entrainment under Refined Alternative 2b, relative to the Existing Conditions scenario. Goodman et al. (2017) suggested that predator removal in the vicinity of diversion facilities also would be likely to improve lamprey survival. This potential positive impact of Refined Alternative 2b would have the potential to limit entrainment under Refined Alternative 2b.

Water Transfers

As noted for the Proposed Project, expansion of the water transfer window to include July to November would have limited potential to increase lamprey salvage based on historical patterns in salvage density (Table 5.3-21).

Georgiana Slough Behavioral Modification Barrier

Operation of a behavioral modification barrier at Georgiana Slough would be expected to have little effect on Pacific Lamprey and River Lamprey because lampreys generally have poor hearing ability (Turnpenny pers. comm.) and therefore would be unlikely to deterred by the acoustic stimulus of the barrier.

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect Pacific Lamprey and River Lamprey are the following:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities, including
    - Sediment Removal
    - Aquatic Weed Removal
- Clifton Court Forebay maintenance, including
    - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. Although lampreys could potentially be present at the locations where O&M activities would occur, it is not likely that large numbers of individuals would be present during O&M activities. These activities likely would have limited impacts on lampreys when they are implemented because existing permit conditions, including BMPs, would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b. Therefore, annual O&M activities likely would have limited impacts on Pacific Lamprey and River Lamprey.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect Pacific Lamprey and River Lamprey include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures would not substantially affect Pacific Lamprey and River Lamprey, but could minimize operations-related impacts or indirectly benefit these species by potentially reducing pre-screen mortality and potentially increasing survival of salvaged fish.

Significance of Impacts on River Lamprey and Pacific Lamprey

Pacific Lamprey inhabit areas of the Delta that could be affected by Refined Alternative 2b from March through June for migration, and throughout year as larvae. River Lamprey inhabit areas of the Delta that could be affected by Refined Alternative 2b from September through May for adult migration, May through July for juvenile migration, and throughout year as larvae.

The analyses conducted for each life stage of Pacific Lamprey and River Lamprey are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of Pacific Lamprey and River Lamprey are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on lampreys, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

5.3.9.10 NATIVE MINNOWS

Operations-Related Impacts

Spawning and Resident Adults and Juveniles

Native Minnow Residence

As previously noted in the analysis for the Proposed Project, native adult and juvenile minnows reside in the Sacramento River from the confluence with the Feather River through the Delta throughout the entire year. As described above for Green Sturgeon, reach-specific habitat attribute-flow relationships are not readily available for native minnows. Further, because flows are generally similar under the Refined Alternative 2b and Existing Conditions scenarios (Figure 5.3-4~~7~~6 through Figure 5.3-5~~2~~1), it is expected that habitat attributes such as food availability, water temperature, depth, and other attributes would also be similar. In addition, larger differences in flow between Refined Alternative 2b and Existing Conditions scenarios that occur during September and November would not occur with sufficient duration or frequency to result in long-term changes in habitat attributes for resident native minnows. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.2 feet (Table 1-2-1, Appendix C), which would not likely alter foraging opportunities. Specifically, these reductions occur in two non-consecutive months of the year-round period of potential presence. In addition, reductions during September occur primarily during wet years. Therefore, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of Refined Alternative 2b associated with flow on resident native minnows in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Although flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on native minnows residing in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 60% of Delta water operations during the year, depending on the month and water year type (see Appendix H).

Splittail Spawning

As previously noted in the analysis for the Proposed Project, Splittail use the lower Sacramento River, between the Delta and the confluence with the Feather River, solely for spawning purposes from February through May. During all of these months, simulated average monthly flows at Freeport under Refined Alternative 2b, relative to the Existing Conditions scenario are similar (see Figure 5.3-46 through Figure 5.3-51, and Table 5.3-13). Likewise, flow into the Yolo Bypass—which as previously discussed in the “Environmental Setting” section is one of the most important habitats for Splittail—generally would be similar between Refined Alternative 2b and Existing Conditions scenarios during the Splittail spawning period (Figures 5.3-15 through 5.3-19). Therefore, potential flow-related impacts of

Refined Alternative 2b on Splittail spawning in the Sacramento River and Yolo Bypass are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on Splittail spawning in the Sacramento River; the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 60% of Delta water operations during the February through May spawning period, depending on month and water year type (see Appendix H).

Hardhead Spawning

As previously noted in the analysis for the Proposed Project, Hardhead use the lower Sacramento River, between the Delta and the confluence with the Feather River, at different times of the year based on the timing of individual life stage activities. Spawning Hardhead use the river in the months of April, May, and June when flows under Refined Alternative 2b are similar to flows under the Existing Conditions scenario. Therefore, potential flow-related impacts of Refined Alternative 2b on Hardhead spawning in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on Hardhead spawning in the Sacramento River, the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 40% of Delta water operations during the April through June spawning period, depending on month and water year type (see Appendix H).

Central California Roach Spawning

Central California Roach use the lower Sacramento River between the Delta and the confluence with the Feather River for spawning during the months of March through June when flows under the Refined Alternative 2b are similar to flows under the Existing Conditions scenario. Therefore, potential flow-related impacts of Refined Alternative 2b on Central California Roach spawning in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on Central California Roach spawning in the Sacramento River; the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 60% of Delta water operations during the March through June spawning period, depending on month and water year type (see Appendix H).

Entrainment

Daily Salvage Loss Density

The salvage-density method was used to assess potential differences in salvage of native minnows between Existing Conditions and Refined Alternative 2b scenarios and the same caveats described for other species apply to native minnows regarding the method. The analysis focused on Sacramento Splittail and Hardhead.

The salvage-density method suggested the potential for generally similar entrainment of Sacramento Splittail under Refined Alternative 2b and Existing Conditions (Table 5.3-22). Sacramento Splittail may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in Refined Alternative 2b that would be implemented to protect listed salmonids and smelts. Analyses of historical data do not suggest entrainment has negative population-level effects (Sommer et al. 1997). In addition, the main driver of Sacramento Splittail population dynamics appears to be inundation of floodplain habitat such as the Yolo Bypass, which as described above would not change under Refined Alternative 2b (Sommer et al. 1997).

Hardhead are salvaged in very small numbers at the SWP south Delta export facility, a situation which would not be expected to change under Refined Alternative 2b (Table 5.3-23).

Water Transfers

As noted for the Proposed Project, expansion of the water transfer window to include July to November could somewhat increase Sacramento Splittail salvage based on historical patterns in salvage density (Table 5.3-22), but for the reasons discussed in the Daily Salvage Loss Density section, would be expected to have limited effects. Expansion of the water transfer window would not be expected to increase salvage of Hardhead based on historical patterns in salvage density (Table 5.3-23).

Georgiana Slough Behavioral Modification Barrier

Of the native minnows considered under the analysis of alternatives, only Sacramento Splittail would have considerable potential to be affected by the Georgiana Slough behavioral modification barrier. Juvenile Splittail migrating downstream could encounter the Georgiana Slough behavioral modification barrier but would only be expected to be deterred away from Georgiana Slough if sufficiently large to swim away from the acoustic stimulus. As with adult salmonids, upstream-migrant adult Splittail would be able to swim under the barrier as necessary to avoid passage obstruction.

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect native minnows include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
    - Sediment Removal
    - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
    - Aquatic Weed Control Program

Table 5.3-22. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-22 a - f

Table 5.3-22 g. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	510	288	845	762	83,826	371,239	185,923	6,669	442	96	44	131
Refined Alternative 2b	522	292	728	1,422	126,758	368,106	180,703	5,080	407	111	56	131

Table 5.3-22 h. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	361	725	1,629	144	7,404	13,762	3,976	207	63	15	34	77
Refined Alternative 2b	364	678	1,250	187	10,173	13,652	3,932	159	63	16	42	71

Table 5.3-22 i. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	63	277	306	47	304	3,080	829	106	18	119	534	86
Refined Alternative 2b	68	286	229	57	307	3,015	806	103	17	141	687	88

Table 5.3-22 j. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	197	278	514	301	70	106	161	7	17	49	24	93
Refined Alternative 2b	214	285	416	278	67	106	145	7	17	55	30	100

Table 5.3-22 k. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	47	475	257	111	82	68	21	0	1	17	36	99
Refined Alternative 2b	50	465	246	88	80	57	24	1	1	17	50	96

Table 5.3-22 l. Estimates of Sacramento Splittail Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	650,775	28,396	5,768	1,817	1,214
Refined Alternative 2b	684,315	30,588	5,804	1,719	1,175
Refined Alternative 2b vs. Existing	33,540 (5%)	2,192 (8%)	36 (1%)	-98 (-5%)	-39 (-3%)

Table 5.3-23. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-23 a – f

Table 5.3-23 g. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	1	0	0	0	0	0	0	0	0	0	0
Refined Alternative 2b	1	1	0	1	0	0	0	0	0	0	0	0

Table 5.3-23 h. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Refined Alternative 2b	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.3-23 i. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Refined Alternative 2b	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.3-23 j. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	1	0	0	0	0	0	0	0	0	0	0
Refined Alternative 2b	0	1	0	0	0	0	0	0	0	0	0	0

Table 5.3-23 k. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	1
Refined Alternative 2b	0	0	0	0	0	0	0	0	0	0	0	1

Table 5.3-23 l. Estimates of Hardhead Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	2	1	0	1	1
Refined Alternative 2b	3	1	0	1	1
Refined Alternative 2b vs. Existing	0 (19%)	0 (11%)	0 (0%)	0 (3%)	0 (-3%)

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. Native minnows could potentially be present at the locations where O&M activities would occur. These activities likely would have limited impacts on native minnows when they are implemented because existing permit conditions, including BMPs, would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b. Therefore, annual O&M activities likely would have similar impacts on native minnows under Refined Alternative 2b as currently occur under the Existing Condition.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect native minnows include:

- Clifton Court Forebay actions to reduce predation including
    - Continued evaluation of predator relocation studies
    - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
    - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
    - Continued refinement and improvement of the fish sampling and hauling procedures
    - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures would not substantially affect native minnows, but could minimize operations-related impacts or indirectly benefit these species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on Native Minnows

Native minnows inhabit areas of the Delta that could be affected by Refined Alternative 2b throughout the year. In addition, impacts could occur to Sacramento Splittail spawning from February through

May, Hardhead spawning from April through June, and Central California Roach spawning from March through June.

The analyses conducted for native minnows presented in the sections above and summarized in Table 5.3-5 show that impacts on all life stages of these species are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on native minnows, relative to the Existing Conditions scenario, and are considered **Less than Significant.**

5.3.9.11 Striped Bass

Operations-Related Impacts

Immigrating and Spawning Adults and Rearing and Emigrating Juveniles

As previously noted in the analysis for the Proposed Project, Striped Bass use the lower Sacramento River, between the Delta and the confluence with the Feather River for immigration and spawning from April through June. Striped Bass larvae and fry, as well as juvenile rearing and emigration use the river throughout the year. During the year, changes in simulated average monthly flows at Freeport under Refined Alternative 2b, relative to the Existing Conditions scenario are generally relatively small (see Figure 5.3-46 through Figure 5.3-51 through 5.3-64, and Table 5.3-13). Because reach-specific relationships between Striped Bass habitat attributes and flow are not readily available, a detailed discussion of flow-related impacts on habitat is inappropriate. Nonetheless, because flows are generally similar under Refined Alternative 2b and Existing Conditions scenarios, it is expected that habitat attributes such as migration and foraging habitat, and other attributes would also be similar. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is less than one foot (Table 1-2-1, Appendix C), which would not likely reduce migration opportunities. In addition, larger differences in flow between Refined Alternative 2b and Existing Conditions scenarios that occur during the spawning and larval migration period, would not affect Striped Bass migration to spawning areas or larval dispersal. Therefore, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of Refined Alternative 2b associated with flow on Striped Bass in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

There is a negative correlation between fall X2 and Striped Bass fall midwater trawl index (Mac Nally et al. 2010), which suggests that, relative to the Existing Conditions scenario, there could be a potential negative impact of Refined Alternative 2b as a result of greater X2 in fall following wet years and a potential positive impact of Refined Alternative 2b as a result of smaller X2 in fall following above-normal years. However, any such differences generally would be expected to have limited impacts on the Striped Bass population because, as described by Grimaldo et al. (2009), population dynamics in the San Francisco estuary exhibit density dependence between age-1 and age-2 year classes, a bottleneck that dampens variation from impacts early in life (Kimmerer et al. 2000).

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on Striped Bass immigration and spawning, or rearing and emigration in the Sacramento River. These results represent combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20% to 40% of Delta water operations during the April through June spawning period, approximately 20% to 60% during the year-round rearing and emigration period, depending on month and water year type, and also approximately 20% to 60% during the fall X2 period (September through December; Mac Nally et al. 2010) (see Appendix H).

Entrainment

Entrainment Loss Density

The salvage-density method was used to assess potential differences in salvage of Striped Bass between Refined Alternative 2b and Existing Conditions scenarios and the same caveats described for other species apply to Striped Bass. In addition, salvage of juvenile Striped Bass occurs following a period wherein early life stages, particularly larvae, could be vulnerable to entrainment, so a qualitative discussion of entrainment risk for larvae is also provided.

The salvage-density method suggested similar entrainment of juvenile Striped Bass under Refined Alternative 2b and Existing Conditions scenarios because most salvage occurs following the April-May period when export differences between scenarios are greatest (Table 5.3-24). Most Striped Bass spawning occurs between May 10 and June 12 (Turner 1976), which suggests that larvae occurring in May could be subject to greater entrainment risk under Refined Alternative 2b. However, entrainment during may be limited even with increased exports (as indicated by CalSim modeling) because real-time decision-making and OMR management actions that would be implemented to protect listed salmonids and smelts could incidentally protect Striped Bass larvae. Also, as previously noted, density-dependence during the juvenile stage of the Striped Bass life cycle means that losses of early life stages do not necessarily translate into proportional reductions in abundance of older individuals (Kimmerer et al. 2001), and entrainment has not recently been identified as a significant driver of juvenile abundance (Mac Nally et al. 2010; Thomson et al. 2010).

Water Transfers

As noted for the Proposed Project, expansion of the water transfer window to include July to November could increase Striped Bass salvage based on historical patterns in salvage density (Table 5.3-24), but for the reasons discussed in the Entrainment Loss Density section, would be expected to have limited effects.

Georgiana Slough Behavioral Modification Barrier

Upstream-migrating Striped Bass adults would have the potential to encounter the Georgiana Slough barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only cover the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Table 5.3-24. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003. – Table 5.3-24 a-f

Table 5.3-24 g. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	16,365	14,097	6,417	370	1,384	189,529	420,659	139,742	13,721	13,838	40,699	26,922
Refined Alternative 2b	16,738	14,298	5,524	690	2,093	187,930	408,848	106,439	12,640	15,888	52,270	26,815

Table 5.3-24 h. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	6,937	8,239	3,670	185	13,618	445,984	439,538	61,723	7,125	2,429	82,767	50,490
Refined Alternative 2b	6,995	7,702	2,816	240	18,712	442,415	434,713	47,362	7,125	2,746	104,482	47,009

Table 5.3-24 i. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	3,051	6,376	6,747	247	11,436	108,672	112,219	17,203	2,476	13,631	41,439	14,972
Refined Alternative 2b	3,290	6,582	5,063	299	11,555	106,380	109,150	16,725	2,305	16,213	53,324	15,297

Table 5.3-24 j. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	9,108	4,796	2,378	610	6,695	147,298	189,305	3,963	2,809	37,008	61,346	45,471
Refined Alternative 2b	9,888	4,930	1,927	563	6,369	147,815	169,981	3,897	2,744	41,133	75,862	48,864

Table 5.3-24 k. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	12,671	5,392	931	70	11,433	164,461	35,176	842	1,349	6,590	17,031	5,671
Refined Alternative 2b	13,670	5,279	892	55	11,165	138,453	39,405	1,220	1,430	6,843	23,713	5,502

Table 5.3-24 l. Estimates of Striped Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	883,742	1,122,706	338,470	510,788	261,617
Refined Alternative 2b	850,174	1,122,316	346,182	513,973	247,625
Refined Alternative 2b vs. Existing	-33,568 (-4%)	-390 (0%)	7,712 (2%)	3,185 (1%)	-13,993 (-5%)

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect Striped Bass include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. Although Striped Bass could be present at the locations where O&M activities would occur year-round, conducting these activities likely would have limited impacts on Striped Bass when they are implemented because existing permit conditions, including BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b. However, vegetation maintenance is intended to reduce predator populations locally and could result in reduced Striped Bass abundance in CCF and near the BSPP. However, because these activities are ongoing under Refined Alternative 2b, annual O&M activities likely would have similar impacts on Striped Bass under Refined Alternative 2b as currently occur under the Existing Condition.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect Striped Bass include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation and could potentially reduce freshwater bass abundance in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are not expected to substantially affect Striped Bass.

Significance of Impacts on Striped Bass

Striped Bass inhabit areas of the Delta that could be affected by Refined Alternative 2b throughout year as adults and juveniles. In addition, spawning occurs from April through June.

The analyses conducted for Striped Bass are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of the species are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on Striped Bass, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

5.3.9.12 American Shad

Operations-Related Impacts

Immigrating and Spawning Adults and Rearing and Emigrating Juveniles

As previously noted in the analysis for the Proposed Project, American Shad use the lower Sacramento River, between the Delta and the confluence with the Feather River, in a similar manner during the same time periods as Striped Bass. As described for Striped Bass, the changes in flow that could occur as a result of implementing Refined Alternative 2b would not likely substantially affect American Shad immigration and spawning, or rearing and emigration.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on American Shad immigration and spawning, or rearing and emigration in the Sacramento River; the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20%-60% of Delta water operations during the April through June spawning period, and approximately 20%-60% during the year-round rearing and emigration period, depending on month and water year type (see Appendix H).

Entrainment

Entrainment Loss Density

The salvage-density method was used to assess potential differences in salvage of American Shad between Refined Alternative 2b and Existing Conditions scenarios and the same caveats described for other species apply to American Shad. As discussed for Striped Bass, salvage of juvenile American Shad occurs following a period wherein early life stages, particularly larvae, could be vulnerable to entrainment, so a qualitative discussion of entrainment risk for larvae is also provided.

Juvenile American Shad occur in the Delta mostly in the summer, a period during which relatively little difference in simulated south Delta exports occurs between Refined Alternative 2b and Existing Conditions scenarios. Therefore, salvage generally is expected to be similar under Refined Alternative 2b and Existing Conditions scenarios (Table 5.3-25).

As previously noted in the analysis for the Proposed Project, larval American Shad could be susceptible to entrainment following spawning and movement to the Delta during spring. However, in contrast to Striped Bass, a greater portion of the American Shad population rears in the Sacramento River and its tributaries upstream of the Delta (Stevens et al. 1987). Thus, most American Shad entering the Delta after spring would be expected to be of sufficiently large size to be salvaged. American Shad occurring near the south Delta may also receive some ancillary protection from the risk assessment-based approach for OMR flow management described in the project description that would be undertaken for listed salmonids and smelts.

Water Transfers

As noted for the Proposed Project, expansion of the water transfer window to include July to November could increase American Shad salvage based on historical patterns in salvage density (Table 5.3-25). However, as noted by Stevens et al. (1977), the main summer nursery of American Shad appears to be lower Feather and to extend from Colusa on the Sacramento River to the north Delta, with only modest numbers of fish using the south Delta; this greater use of the northern Delta is also apparent during fall (Stevens 1966). This would tend to limit the potential for impact from the expansion of the water transfer window by limiting the spatial overlap of the species with the hydrodynamic influence of the south Delta export facilities (see Delta Hydrodynamic Analysis for Winter-run Chinook Salmon).

Georgiana Slough Behavioral Modification Barrier

Upstream-migrating Striped Bass adults would have the potential to encounter the Georgiana Slough barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only cover the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect American Shad include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Table 5.3-25. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-25 a - f

Table 5.3-25 g. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	27,099	2,932	710	135	504	17,477	304,848	238,808	51,953	26,181	67,845	37,299
Refined Alternative 2b	27,718	2,973	611	253	762	17,330	296,289	181,896	47,858	30,061	87,135	37,151

Table 5.3-25 h. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	14,784	4,619	722	61	301	57,079	739,128	316,898	88,076	5,282	54,065	73,059
Refined Alternative 2b	14,907	4,318	554	78	414	56,622	731,013	243,165	88,076	5,972	68,249	68,022

Table 5.3-25 i. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	9,796	4,334	1,272	50	1,103	4,323	83,949	59,788	10,313	25,516	39,988	36,789
Refined Alternative 2b	10,561	4,474	955	60	1,114	4,232	81,653	58,126	9,600	30,349	51,456	37,588

Table 5.3-25 j. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	10,806	1,839	426	208	78	3,672	157,662	17,665	15,815	29,512	61,095	56,298
Refined Alternative 2b	11,732	1,891	345	192	74	3,685	141,568	17,373	15,446	32,802	75,551	60,500

Table 5.3-25 k. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	7,617	2,319	114	25	200	22	2,243	1,830	9,801	7,782	14,112	11,577
Refined Alternative 2b	8,218	2,271	109	20	195	19	2,513	2,650	10,395	8,080	19,648	11,232

Table 5.3-25 l. Estimates of American Shad Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	775,791	1,354,073	277,220	355,078	57,643
Refined Alternative 2b	730,036	1,281,389	290,166	361,159	65,351
Refined Alternative 2b vs. Existing	-45,755 (-6%)	-72,683 (-5%)	12,946 (5%)	6,081 (2%)	7,708 (13%)

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. Although American Shad could potentially be present at the locations where O&M activities would occur year-round, it is not likely that large numbers of individuals would be present during O&M activities. These activities likely would have limited impacts on American Shad when they are implemented because existing permit conditions, including BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways and impact special-status species. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b. Therefore, annual O&M activities likely would have limited impacts on American Shad.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect American Shad include:

- Clifton Court Forebay actions to reduce predation including
    - Continued evaluation of predator relocation studies
    - Aquatic weed control
- Skinner Fish Facility Studies and Performance Improvements including
    - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
    - Continued refinement and improvement of the fish sampling and hauling procedures
    - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to in-water work windows and various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures would not substantially affect American Shad, but could minimize operations-related impacts or indirectly benefit these species by reducing pre-screen mortality and increasing survival of salvaged fish.

Significance of Impacts on American Shad

American Shad inhabit areas of the Delta that could be affected by Refined Alternative 2b throughout year as adults and juveniles. In addition, spawning occurs from April through June.

The analyses conducted for American Shad are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of the species are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on American Shad, relative to the Existing Conditions scenario, and is considered **Less than Significant.**

5.3.9.13 Non-Native Freshwater Bass

Operations-Related Impacts

Resident Adults and Juveniles

As previously noted in the analysis for the Proposed Project, non-native freshwater bass use the lower Sacramento River between the Delta and the confluence with the Feather River year round. Spawning generally occurs during the spring months based on water temperature. During the year, changes in simulated average monthly flows at Freeport under Refined Alternative 2b, relative to the Existing Conditions scenario are generally relatively small (see Figure 5.3-46 through Figure 5.3-51, and Table 5.3-13).

Because reach-specific relationships between non-native freshwater bass habitat attributes and flow are not readily available, a detailed discussion of flow-related impacts on habitat is inappropriate. Nonetheless, because flows are generally similar under Refined Alternative 2b and Existing Conditions scenarios, it is expected that habitat attributes such as food availability, water temperature, and foraging habitat, and other attributes would also be similar. In addition, larger differences in flow between Refined Alternative 2b and Existing Conditions scenarios that occur during September and November would not occur with sufficient duration or frequency to result in long-term changes in habitat attributes for these species, and do not occur during the spawning periods. Further, because flows are similar and the Sacramento River is deep and wide in this reach depth and velocity is anticipated to also be similar. Although velocity was not modeled, the maximum depth reduction at Freeport is approximately 1.2 feet (Table 1-2-1, Appendix C), which would not likely alter foraging opportunities. Specifically, these reductions occur in two non-consecutive months of the year-round period of potential presence. Therefore, because flows in the reach of the Sacramento River from the Feather River confluence to and through the Delta (as indicated by flows at Freeport) are similar most of the time, potential impacts of Refined Alternative 2b associated with flow on resident non-native freshwater bass in the Sacramento River are expected to be similar to those under the Existing Conditions scenario and are not expected to be substantial.

Flows are similar most of the time under Refined Alternative 2b and Existing Conditions scenarios and are not anticipated to result in substantial impacts on non-native bass in the Sacramento River; the simulated Freeport flows include the combined impacts of the SWP and CVP. The SWP is responsible for between approximately 20-60% during the year, depending on month and water year type (see Appendix H).

Entrainment

Entrainment Loss Density

The salvage-density method was used to assess potential differences in salvage of non-native freshwater bass between Refined Alternative 2b and Existing Conditions scenarios and the same caveats described for other species apply to the method.

The salvage-density method suggested the potential for entrainment of Largemouth Bass to be similar under Refined Alternative 2b and the Existing Conditions scenario (Table 5.3-26). This reflects the general similarity of SWP exports during the historically observed entrainment periods. Largemouth Bass occurring near the south Delta may also receive some ancillary protection from the risk assessment-based approach for OMR flow management included in Refined Alternative 2b that would be implemented to protect listed salmonids and smelts. It should be noted, however, that analyses by Grimaldo et al. (2009) did not find a significant relationship between Largemouth Bass salvage and OMR flows. Grimaldo et al. (2009) suggested that the littoral (nearshore) habitat occupied by the species probably provides a buffer from entrainment, which is in contrast to pelagic species such as Delta Smelt. Overall, differences in south Delta exports would be expected to have limited impact on changes in Largemouth Bass entrainment under Refined Alternative 2b.

Smallmouth Bass and Spotted Bass are salvaged in very small numbers at the SWP south Delta export facility, a situation which would not be expected to change under Refined Alternative 2b (Table 5.3-27 and Table 5.3-28).

Water Transfers

As noted for the Proposed Project, expansion of the water transfer window to include July to November could increase non-native bass salvage based on historical patterns in salvage density (primarily for Largemouth Bass; see Table 5.3-26), but given that the main salvage period is in summer, such effects would be limited.

Georgiana Slough Behavioral Modification Barrier

Non-native freshwater bass are largely resident in limited areas (DWR 2016) and therefore would not be expected to encounter the barrier as part of migratory movements, but as with other species such as Striped Bass and American Shad, would be able to pass beneath the barrier if necessary.

Table 5.3-26. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-26 a - f

Table 5.3-26 g. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	57	20	18	3	1,546	8,764	21,393	1,583	333	220	142	59
Refined Alternative 2b	59	20	16	6	2,338	8,690	20,793	1,206	307	253	183	59

Table 5.3-26 h. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	15	23	21	1	1,352	5,892	3,685	1,209	146	142	121	132
Refined Alternative 2b	15	21	16	2	1,858	5,845	3,645	928	146	160	153	123

Table 5.3-26 i. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	33	20	26	25	2,023	3,061	7,707	888	230	309	126	81
Refined Alternative 2b	35	21	20	30	2,044	2,996	7,496	863	214	367	163	83

Table 5.3-26 j. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	33	5	9	9	2,860	7,271	4,764	85	199	401	137	60
Refined Alternative 2b	36	6	8	8	2,720	7,297	4,278	83	194	446	170	65

Table 5.3-26 k. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	84	74	10	14	925	7,579	3,192	85	238	278	190	77
Refined Alternative 2b	91	72	10	11	903	6,380	3,575	124	253	289	265	74

Table 5.3-26 l. Estimates of Largemouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	34,140	12,741	14,528	15,833	12,747
Refined Alternative 2b	33,928	12,913	14,332	15,309	12,048
Refined Alternative 2b vs. Existing	-211 (-1%)	172 (1%)	-196 (-1%)	-524 (-3%)	-699 (-5%)

Table 5.3-27. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Table 5.3-27 a - f

Table 5.3-27 g. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	2	1	0	0	0	0	0	1	11	5	0	0
Refined Alternative 2b	2	1	0	0	0	0	0	1	10	6	0	0

Table 5.3-27 h. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	1	0	2	0	0	2	5	0	0	0	0	0
Refined Alternative 2b	1	0	1	0	0	2	5	0	0	0	0	0

Table 5.3-27 i. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	6	0	0
Refined Alternative 2b	0	0	0	0	0	0	0	0	0	7	0	0

Table 5.3-27 j. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	1	0	1	0	78	1	2	6	1	0
Refined Alternative 2b	0	0	1	0	1	0	70	1	2	7	1	0

Table 5.3-27 k. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	1	0	0	0	0	1	0	0
Refined Alternative 2b	0	0	0	0	1	0	0	0	0	1	0	0

Table 5.3-27 l. Estimates of Smallmouth Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	20	10	6	89	2
Refined Alternative 2b	20	9	7	82	2
Refined Alternative 2b vs. Existing	0 (-2%)	0 (-4%)	1 (16%)	-7 (-8%)	0 (-1%)

Table 5.3-28. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Table 5.3-28 a - f

Table 5.3-28 g. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Wet

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	1	0	0
Refined Alternative 2b	0	0	0	0	0	0	0	0	0	1	0	0

Table 5.3-28 h. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Above Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Refined Alternative 2b	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.3-28 i. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 – Below Normal

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	2	0	0	0	0	0	0	0	0	0
Refined Alternative 2b	0	0	1	0	0	0	0	0	0	0	0	0

Table 5.3-28 j. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Dry

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	0	0	0	0
Refined Alternative 2b	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.3-28 k. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Water Years 1922-2003 - Critical

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Existing	0	0	0	0	0	0	0	0	3	0	0	0
Refined Alternative 2b	0	0	0	0	0	0	0	0	3	0	0	0

Table 5.3-28 l. Estimates of Spotted Bass Salvage (Numbers of Fish Per Year) at the State Water Project South Delta Export Facility for Existing Condition and Refined Alternative 2b Scenarios, Based on the Salvage-Density Method Applied to Wa3999999ter Years 1922-2003 - Totals

Totals per Condition	Wet	Above Normal	Below Normal	Dry	Critical
Existing	1	0	2	0	3
Refined Alternative 2b	1	0	1	0	4
Refined Alternative 2b vs. Existing	0 (15%)	0 (0%)	0 (-23%)	0 (0%)	0 (11%)

Annual O&M Activities-Related Impacts

As previously noted in the analysis for the Proposed Project, annual O&M activities that could potentially affect non-native freshwater bass include:

- North Bay Aqueduct and Barker Slough Pumping Plant maintenance activities including
  - Sediment Removal
  - Aquatic Weed Removal
- Clifton Court Forebay maintenance including
  - Aquatic Weed Control Program

Annual O&M activities listed above are ongoing activities that will continue under Refined Alternative 2b. Although non-native freshwater bass could potentially be present at the locations where O&M activities would occur year-round. These activities likely would have limited impacts on non-native freshwater bass when they are implemented because existing permit conditions, including BMPs would be in place to minimize the likelihood that in water activities or accidental spills and stormwater runoff would enter waterways. BMPs included in the USFWS Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project (USFWS 2019) would also be implemented along with the permit terms and conditions from existing permits that would be continued under Refined Alternative 2b.

Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Refined Alternative 2b. However, vegetation maintenance is intended to reduce predator populations locally and could result in reduced non-native freshwater bass abundance in CCF and near the BSPP. However, because these activities are ongoing under Refined Alternative 2b, annual O&M activities likely would have similar impacts on non-native freshwater bass under Refined Alternative 2b as currently occur under the Existing Condition.

Project Environmental Protective Measure-Related Impacts

As previously noted in the analysis for the Proposed Project, Environmental Protective Measures that could potentially affect Striped Bass include:

- Clifton Court Forebay actions to reduce predation including
  - Continued evaluation of predator relocation studies
  - Aquatic weed control
- Skinner Fish Facility Improvements including
  - Changes to release site scheduling and rotation of release site locations to reduce post-salvage predation
  - Continued refinement and improvement of the fish sampling and hauling procedures
  - Infrastructure to improve the accuracy and reliability of data and fish survival

Water quality-related impacts of any in-water work associated with these Environmental Protective Measures (e.g., aquatic weed control) would be minimized by adhering to various construction BMPs as described above for Annual O&M Activities. Continued evaluation of predator management and continued aquatic weed control in Clifton Court Forebay would potentially reduce predation and could potentially reduce freshwater bass abundance in the forebay. Improvements at the Skinner Fish Facility would improve fish salvage operations and overall survival of salvaged fish.

Overall, these Environmental Protective Measures are not expected to substantially affect non-native freshwater bass species.

Significance of Impacts on Non-Native Freshwater Bass

Non-native freshwater bass inhabit areas of the Delta that could be affected by Refined Alternative 2b throughout year as adults and juveniles. In addition, spawning generally occurs during Spring.

The analyses conducted for non-native freshwater bass are presented in the sections above and summarized in Table 5.3-5, show that impacts on all life stages of these species are less than significant. Therefore, impacts associated with implementing Refined Alternative 2b in its entirety would not cause a substantial adverse impact on non-native freshwater bass, relative to the Existing Conditions scenario, and is considered **Less than Significant**.

5.3.9.14 Killer Whale

As previously noted in the analysis for the Proposed Project, potential impacts of Refined Alternative 2b on Southern Resident Killer Whale could occur as an indirect impact of SWP operations as a result of impacts on Chinook Salmon because they are a medium-priority prey species for this Killer Whale DPS (i.e., comprise 18% to 41% of the killer whale diet when the DPS is off the coast of California and Oregon).

Reductions in Sacramento River flow during the spring juvenile Chinook Salmon outmigration period could increase the duration of juvenile travel time and decrease survival, along with potential increases in entrainment that could occur during the spring could potentially result in reduced ocean abundance of Chinook Salmon, although results of analyses presented above for Chinook Salmon indicate that impacts would generally be similar under Refined Alternative 2b and Existing Conditions scenarios.

As previously noted in the analysis for the Proposed Project, studies have suggested that most Chinook salmon in the coastal ocean off California appear to be of hatchery origin (Barnett-Johnson et al. 2007; Johnson et al. 2016). Impacts of the Refined Alternative 2b on Central Valley Chinook Salmon stocks would not be expected to occur to hatchery-origin juvenile Chinook Salmon released downstream of the Delta. The percentage of hatchery-origin fish released downstream of the Delta has been variable over time. For example, from the mid-1980s to 2012, the proportion of hatchery-origin Fall-run Chinook Salmon juveniles released downstream of the Delta by state and federal hatcheries varied from around 20% to 60% (Huber and Carlson 2015). Similarly, from 2013 to 2017, the percentage of juvenile Fall-run and Spring-run Chinook Salmon released by state Central Valley hatcheries downstream of the Delta varied between 24% (2016) and 60% (2013) (California Department of Fish and Wildlife 2018).

Refined Alternative 2b is not likely to negatively impact individual Central Valley Chinook salmon from operation of the export facilities and is not expected to result in decreased overall ocean abundance or availability of prey for killer whale, when considered with hatchery production.

Central Valley Chinook Salmon stocks generally are a medium priority prey species that comprise 18-41% of the killer whale diet (only when off the coast of California and Oregon). In addition, hatchery-origin Chinook Salmon released downstream of the Delta also are not affected by SWP facilities and operations, but likely contribute to the killer whale prey base. Therefore, reductions in Chinook Salmon ocean abundance as a result of Refined Alternative 2b likely would not result in population-level impacts on killer whale.

Significance of Effects on Killer Whale

Overall, because reductions in Chinook Salmon abundance in the ocean likely would not result in population-level impacts on killer whale, the impacts of Refined Alternative 2b on Southern Resident Killer Whale are considered **Less than Significant**.

5.3.10 Mitigation Measures

No potentially significant impacts were identified in the analysis of impacts of the Refined Alternative 2b on special-status, or recreationally and commercially important fish and aquatic resources. Therefore, no mitigation is required.

~~5.3.4~~5.3.11 Other Resources

As described in Section 1.4 *Summary of Environmental Consequences* and the information and analyses presented in the Initial Study, Appendix A, the Proposed Project would result in no impacts to the following resource topics:

- Aesthetics
- Agriculture and Forestry Resources
- Air Quality
- Biological Resources (Terrestrial)
- Cultural Resources
- Energy
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards and Hazardous Materials
- Land Use and Planning
- Mineral Resources
- Noise
- Population and Housing
- Public Services

- Recreation
- Transportation/Traffic
- Tribal Cultural Resources
- Utilities and Service Systems
- Wildfire

The differences between the Proposed Project and Refined Alternative 2b are the addition of spring maintenance flows in April and May, the development and redeployment of spring maintenance flows following Wet years, the potential dedication of water to instream flow via agreements with water users or via other means (e.g., under Section 1707 of the California Water Code), the allocation of 100 TAF for Delta smelt resiliency plan objectives, OMR management actions to provide greater protections for Winter-run and Spring-run Chinook Salmon, increased authority for CDFW in the adaptive management process, and implementation of the Georgiana Slough Behavioral Modification Barrier. These changes generally would not alter the conclusions related to the resource areas listed above as described in the Initial Study. Exports would be further reduced compared to Alternative 2a and the Proposed Project. These export reductions would almost entirely offset the modeled increase in exports associated with the proposed project. Therefore, the effect on exports would be negligible compared to Existing Conditions, which would further reduce the less than significant impacts identified in the Initial Study for the resources listed above.

Construction and annual installation of the Georgiana Slough Behavioral Barrier could potentially impact terrestrial biological resources, cultural resources, air quality, and noise. However, the specific design and operating criteria of the barrier is subject to future refinements based on coordination with Reclamation and CDFW. A programmatic evaluation of the potential impacts is presented below because the specific impacts are not known at this time. When the design and operating criteria are known, DWR will conduct additional environmental compliance review under CEQA prior to installing and operating the barrier.

The Georgiana Slough Behavioral Barrier consists of the following components:

- Bio-Acoustic Fish Fence
- Navigation Aids
- Fish Tracking and other Data Collection Monitoring Equipment

To avoid and minimize the potential for impacts to listed fishes, pile driving, and installation of anchors and pier blocks is expected to occur in August and September of each year. The BAFF would be installed as early as December through January (conditions permitting) and be operational between January through April of each year. Supporting infrastructure, including piles, would remain in place throughout the year but the BAFF components would be removed annually. Removal of the BAFF components would occur as early as May through September, with August and September being the optimal period for in-water construction, each year. Land and water-based mobilization would occur within 15 days prior to and after installation of each component.

The Georgiana Slough BMB was previously evaluated in an Initial Study/Mitigated Negative Declaration (DWR 2011) and the footprint of this facility is well known. Although the design details and operational criteria of Georgiana Slough Behavioral Barrier proposed as part of Refined Alternative 2b are not known at this time, the following impacts are described and evaluated based on the 2011 Initial Study/Mitigated Negative Declaration:

5.3.11.1 Terrestrial Biological Resources

Potential impacts to terrestrial biological resources include impacts to special status plant species, sensitive natural communities, western pond turtle, or special status nesting bird species. These impacts would be avoided or minimized by: (1) selecting appropriate staging areas; (2) utilizing construction Best Management Practices (BMPs) such as implementing a spill prevention and response plan; (3) utilizing exclusion fencing; and (4) conducting preconstruction surveys for nesting birds.

A potential staging area on the right bank of Georgiana Slough with its confluence with the Sacramento River will be disturbed for materials staging and installation of an electric power supply source. The area also would be utilized for staging during annual installation and removal of the BAFF components. DWR will conduct a pre-activity survey to identify any sensitive natural communities, and special status plants and animals, including nesting birds, before the staging area is utilized. Sensitive natural communities and special status plants have not been previously identified in the footprint of this facility. However, if any sensitive biological resources are detected during the pre-activity surveys, DWR would avoid the occurrences or coordinate with CDFW or USFWS to identify appropriate remedial measures prior to continuing construction activities.

If necessary, a barge anchored in Georgiana Slough could be utilized in lieu of an upland staging area. No impacts to terrestrial resources are anticipated if a barge is used for staging. Nesting bird surveys would be conducted annually prior to installation and removal of the BAFF components.

Appropriate Best Management Practices (BMPs) would be implemented during initial construction of infrastructure (e.g., during pile driving) and during annual installation and removal of BAFF components.

Implementation of the Georgiana Slough BMB as described above would avoid or substantially minimize the potential for any impacts to sensitive biological resources. Therefore, potential impacts to terrestrial biological resources are considered to be **less than significant**.

5.3.11.2 Cultural Resources

The potential staging area on the right bank of Georgiana Slough with its confluence with the Sacramento River will be disturbed during staging for initial construction and installation of an electric power supply source. This area will require cultural resources record search and tribal consultation and may require a field survey prior to any disturbance activities. If cultural resources are determined to be present, DWR would avoid them or stop work and identify appropriate treatment measures. Therefore, potential impacts on cultural resources are considered **less than significant**.

5.3.11.3 Noise

~~**Table 5.3-1. Estimated Impacts on Aquatic Resources Occurring Under Alternative 2b Compared to Existing Conditions and the Proposed Project.**~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Delta Smelt~~	~~Adult to Eggs and Larvae~~	~~Food Availability~~	~~Similar flow through the Yolo Bypass~~	~~Similar food production and input to the Delta under both scenarios.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Similar food production and input to the Delta under both scenarios.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~No difference between the Proposed Project and Alternative 2b. Yolo Bypass is not affected by south Delta exports~~
~~Delta Smelt~~	~~Adult to Eggs and Larvae~~	~~Predation~~	~~Similar Rio Vista Flows from December through May~~	~~Similar suspended sediment input to the Delta and low sediment removal from the Delta therefore similar predation potential under both scenarios~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Similar suspended sediment input to the Delta and low sediment removal from the Delta therefore similar predation potential under both scenarios.~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Rio Vista flow is not affected by south Delta exports~~
~~Delta Smelt~~	~~Eggs and Larvae to Juveniles~~	~~Food Availability~~	~~Delta outflow from March through June is lower under the Proposed Project, and predicted *Eurytemora affinis* density is 2% to 4% lower under the Proposed Project.~~	~~Food availability might be slightly reduced under the Proposed Project, but uncertainty is high~~ ~~SWP responsibility for the impact is between approximately 40% to 60%~~	~~Less than Significant~~	~~Food availability might be slightly reduced under Alternative 2b, but uncertainty is high~~	~~Less than Significant~~	~~Delta outflow in April-May would be greater under Alternative 2b than Proposed Project, but less than Existing Conditions~~
~~Delta Smelt~~	~~Eggs and Larvae to Juveniles~~	~~Predation~~	~~Similar Rio Vista Flows from December through May.~~ ~~South Delta exports are higher from March through May under the Proposed Project.~~ ~~Delta inflow from June through September is slightly lower under the Proposed Project.~~	~~Similar predation potential associated with turbidity~~ ~~Potentially lower silverside cohort strength with high uncertainty, based on greater March–May south Delta exports~~ ~~Potentially higher silverside cohort strength with high uncertainty, based on lower June–September Delta outflow~~ ~~SWP contribution between approximately 40% to 60% during March May~~ ~~SWP responsibility for the June-September impact is between approximately between 20-50%~~	~~Less than Significant~~	~~Similar predation potential associated with turbidity~~ ~~Potentially lower silverside cohort strength with high uncertainty, based on greater March–May south Delta exports~~ ~~Potentially higher silverside cohort strength with high uncertainty, based on lower June–September Delta outflow~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project but greater than Existing Conditions~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Delta Smelt~~	~~Juveniles to Subadults~~	~~Food Availability~~	~~Delta outflow from July through September is similar most of the time (75% of the time) but is lower about 25% of the time, suggesting slightly lower predicted *Pseudodiaptomus forbesi* density.~~ ~~Similar QWEST under both scenarios in July and August. Higher (positive more often) QWEST in September under the Proposed Project.~~	~~Slightly lower *P. forbesi* density under the Proposed Project as a result of lower Delta outflow some of the time. Analysis has high uncertainty~~ ~~Similar *P. forbesi* subsidy to the LSZ from the San Joaquin River most of the time under both scenarios, but potentially slightly higher *P. forbesi* subsidy in September under the Proposed Project. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty.~~ ~~This is a combined SWP and CVP result~~ ~~SWP responsibility for the change in Delta Outflow and QWEST that could affect *P. forbesi* subsidy to the LSZ is between approximately 23-28% in wet and above-normal water year types (when X2 requirements are not in place under the Proposed Project)~~	~~Less than Significant~~	~~Slightly lower *P. forbesi* density could occur under the Alternative 2b as a result of lower Delta outflow some of the time, or slightly higher *P. forbesi* density in August under Alternative 2b as a result of 100 TAF additional Delta outflow in wet and above normal years. Analysis has high uncertainty~~ ~~Similar *P. forbesi* subsidy to the LSZ from the San Joaquin River most of the time under both scenarios, but potentially slightly higher *P. forbesi* subsidy in September under Alternative 2b.~~ ~~Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty.~~	~~Less than Significant~~	~~Generally similar operations of Proposed Project and Alternative 2b in July-September; except in August, when additional 100 TAF would result in mean Delta outflow as follows:~~ • ~~Wet years:~~ • ~~Existing: 316 TAF~~ • ~~Proposed Project: 318 TAF~~ • ~~Alternative 2b: 418 TAF~~ • ~~Above normal years:~~ • ~~Existing: 244 TAF~~ • ~~Proposed Project: 245 TAF~~ • ~~Alternative 2b: 345 TAF~~
~~Delta Smelt~~	~~Juveniles to Subadults~~	~~Predation~~	~~Similar Rio Vista Flows from December through May.~~	~~Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and summer predation potential is unknown. Wind and water temperature, which are drivers of turbidity would be similar therefore similar predation potential under both scenarios~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and summer predation potential is unknown. Wind and water temperature, which are drivers of turbidity would be similar therefore similar predation potential under both scenarios~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Rio Vista flow is not affected by south Delta exports~~
~~Delta Smelt~~	~~Juveniles to Subadults~~	~~Harmful Algal Blooms~~	~~Similar probability of remaining below 1 foot per second (ft/sec) velocity Microcystis threshold at each of the 8 Delta locations.~~	~~Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations~~ ~~Similar potential for velocity conditions to affect harmful algal blooms under both scenarios~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations~~ ~~Similar potential for velocity conditions to affect harmful algal blooms under both scenarios~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Operational differences between Proposed Project and Alternative 2b in June-November would not be expected to greatly change velocity~~
~~Delta Smelt~~	~~Juveniles to Subadults~~	~~Summer/Fall Habitat Qualitative Discussion~~	~~N/A~~	~~Manage overlapping suitable habitat based on the latest conceptual model of suitable habitat for Delta Smelt in summer-fall using multiple tools including outflow augmentation, Suisun Marsh Salinity Control Gates (SMSCG) operation, and food actions.~~ ~~LSZ would tend to be further upstream following wet years, without detailed consideration of SMSCG operation.~~ ~~Evidence from 2018 SMSCG pilot action showed that Delta Smelt had access to suitable low salinity habitat during the action.~~	~~Less than Significant~~	~~Manage overlapping suitable habitat based on the latest conceptual model of suitable habitat for Delta Smelt in summer-fall using multiple tools including outflow augmentation, Suisun Marsh Salinity Control Gates (SMSCG) operation, and food actions.~~ ~~LSZ would tend to be further upstream following wet years in fall, without detailed consideration of SMSCG operation, but downstream in August of wet and above normal years.~~ ~~Evidence from 2018 SMSCG pilot action showed that Delta Smelt had access to suitable low salinity habitat during the action.~~	~~Less than Significant~~	~~Alternative 2b includes 100 TAF additional Delta outflow in summer/fall, which would increase Delta outflow, e.g., in August (see above summary in consideration of juveniles to subadults food availability discussion).~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Delta Smelt~~	~~Juveniles to Subadults~~	~~Summer/Fall Habitat– SCHISM WY 2012 (salinity alone)~~	~~Limited benefits in the north Delta Arc or Cache to Montezuma Slough corridor.~~ ~~Improved conditions in Suisun Marsh extending beyond the SMSCG operation period.~~ ~~Reduced habitat area in Suisun Bay.~~	~~Modeled benefits are greater when gates are operated starting in August rather than June~~ ~~Lower salinity in Suisun Marsh has the potential to increase habitat for Delta Smelt during the summer and fall.~~	~~Less than Significant~~	~~Modeled benefits are greater when gates are operated starting in August rather than June~~ ~~Lower salinity in Suisun Marsh has the potential to increase habitat for Delta Smelt during the summer and fall.~~	~~Less than Significant~~	~~Alternative 2b includes 100 TAF additional Delta outflow in summer/fall, which would increase Delta outflow, e.g., in August (see above summary in consideration of juveniles to subadults food availability discussion).~~
~~Delta Smelt~~	~~Juveniles to Subadults~~	~~Summer/Fall Habitat– SCHISM WY 2012 (salinity, temperature, and turbidity)~~	~~Limited benefits overall in the north Delta Arc or Cache to Montezuma Slough corridor.~~ ~~Improved conditions in Suisun Marsh extending beyond the SMSCG operation.~~	~~Potentially beneficial overall because of improved Suisun Marsh Conditions~~	~~Less than Significant~~	~~Potentially beneficial overall because of improved Suisun Marsh Conditions~~	~~Less than Significant~~	~~Alternative 2b includes 100 TAF additional Delta outflow in summer/fall, which would increase Delta outflow, e.g., in August (see above summary in consideration of juveniles to subadults food availability discussion).~~
~~Delta Smelt~~	~~Juveniles to Subadults~~	~~Summer/Fall Habitat– SCHISM WY 2017 (salinity alone)~~	~~Limited benefits overall in the north Delta Arc or Cache to Montezuma Slough corridor.~~ ~~Improved conditions in Suisun Marsh extending beyond the SMSCG operation.~~	~~Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under the Proposed Project~~	~~Less than Significant~~	~~Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under the Proposed Project from modeling of that scenario~~	~~Less than Significant~~	~~Alternative 2b includes 100 TAF additional Delta outflow in summer/fall, which would increase Delta outflow, e.g., in August (see above summary in consideration of juveniles to subadults food availability discussion).~~
~~Delta Smelt~~	~~Juveniles to Subadults~~	~~Summer/Fall Habitat– SCHISM WY 2017 (salinity, temperature, and turbidity)~~	~~Limited benefits in the north Delta Arc or Cache to Montezuma Slough corridor.~~ ~~Improved conditions in Suisun Marsh extending beyond the SMSCG operation.~~	~~Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under the Proposed Project.~~	~~Less than Significant~~	~~Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under the Proposed Project from modeling of that scenario~~	~~Less than Significant~~	~~Alternative 2b includes 100 TAF additional Delta outflow in summer/fall, which would increase Delta outflow, e.g., in August (see above summary in consideration of juveniles to subadults food availability discussion).~~
~~Delta Smelt~~	~~Subadults to Adults~~	~~Food Availability~~	~~Higher (positive more often) QWEST in September under the Proposed Project, although Delta outflow is lower.~~	~~Potentially slightly higher *P. forbesi* subsidy in September under the Proposed Project based on net flow on the San Joaquin River at Jersey Point (QWEST), but slightly lower based on Delta outflow. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. Overall density of calanoid copepods in the low salinity not shown to be related to Delta outflow (X2) by other analyses.~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Potentially slightly higher *P. forbesi* subsidy in September under Alternative 2b based on net flow on the San Joaquin River at Jersey Point (QWEST), but slightly lower based on Delta outflow. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. Overall density of calanoid copepods in the low salinity not shown to be related to Delta outflow (X2) by other analyses.~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~No operational differences between Proposed Project and Alternative 2b in September~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Delta Smelt~~	~~Subadults to Adults~~	~~Predation~~	~~Similar Rio Vista Flows from December through May.~~	~~Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and fall predation potential is unknown. However, wind and water temperature, which are drivers of predation would be similar therefore similar predation potential under both scenarios~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and fall predation potential is unknown. However, wind and water temperature, which are drivers of predation would be similar therefore similar predation potential under both scenarios~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Rio Vista flow is not affected by south Delta exports~~
~~Delta Smelt~~	~~Subadults to Adults~~	~~Harmful Algal Blooms~~	~~Similar velocity conditions at 8 Delta locations~~ ~~Similar probability of remaining below 1 ft/sec threshold at each of the 8 Delta locations~~	~~Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations~~ ~~Similar potential for velocity conditions to affect harmful algal blooms under both scenarios~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations~~ ~~Similar potential for velocity conditions to affect harmful algal blooms under both scenarios~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Operational differences between Proposed Project and Alternative 2b in September-November would not be expected to greatly change velocity~~
~~Delta Smelt~~	~~Entrainment~~	~~Consideration of OMR~~	~~During the March–June period of concern for larval/juvenile Delta Smelt entrainment risk, OMR flows would generally be lower (more negative) under the Proposed Project in April and May but would be similar under both scenarios in March and June.~~ ~~During this period, flows under both scenarios would be at or less negative than the -5,000 cfs inflection point at which entrainment tends to sharply increase.~~	~~Based on CalSim modeling estimated entrainment could increase for larvae/early juveniles (March – June) under the Proposed Project however there are number of measures that will keep entrainment risk at protective levels:~~ • ~~OMR flows during April and May under the Proposed Project are less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk.~~ • ~~Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts~~ • ~~Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles~~ • ~~SWP responsibility for the impact is between approximately 30-60%~~	~~Less than Significant~~	~~Estimated entrainment could increase for larvae/early juveniles (March – June) under Alternative 2b however there are number of measures that will keep entrainment risk at protective levels:~~ • ~~OMR flows during April and May under Alternative 2b would be less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk.~~ • ~~Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts~~ • ~~Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles~~ • ~~SWP responsibility for the impact is between approximately 30-60%~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project but greater than Existing Conditions~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Delta Smelt~~	~~Entrainment~~	~~Particle Tracking Modeling~~	~~DSM2 PTM showed increases in Delta Smelt entrainment in April and May.~~	~~Based on DSM2 PTM modeling estimated entrainment is appreciably greater under the Proposed Project in April and May. However, there are number of measures that will keep entrainment risk at protective levels:~~ • ~~OMR flows during April and May under the Proposed Project are less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk.~~ • ~~Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts~~ • ~~Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles~~	~~Less than Significant~~	~~Entrainment has the potential to be greater under Alternative 2b in April and May. However, there are number of measures that will keep entrainment risk at protective levels:~~ • ~~OMR flows during April and May under Alternative 2b would be less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk.~~ • ~~Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts~~ • ~~Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project but greater than Existing Conditions~~
~~Delta Smelt~~	~~All Life Stages~~	~~Annual O&M Activities~~	~~N/A~~	~~Annual O&M activities likely would have limited impacts on Delta Smelt because work windows and best management practices (BMPs) would be implemented.~~ ~~Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~Annual O&M activities likely would have limited impacts because work windows and best management practices (BMPs) would be implemented.~~ ~~Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2b.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed project and Alternative 2b.~~
~~Delta Smelt~~	~~All Life Stages~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay (CCF) predator relocation and aquatic weed control;~~ • ~~Skinner Fish Facility performance improvements;~~ • ~~Longfin Smelt Science Program;~~ • ~~Continue Studies to Establish a Delta Fish Hatchery; and~~ • ~~Conduct further Studies to Prepare for Delta Smelt Reintroduction from the FCCL (see Table 3-3)~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Delta Smelt reintroduction and Delta Fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics~~ ~~Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival~~	~~Less than Significant~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Delta Smelt reintroduction and Delta Fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics~~ ~~Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed project and Alternative 2b.~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Longfin Smelt~~	~~Population Abundance~~	~~Delta Outflow-Abundance~~	~~The results of the Nobriga and Rosenfield (2016) model application suggested that differences in the predicted fall midwater trawl abundance index between scenarios would be very small, with mean indices slightly lower under the Proposed Project and with some uncertainty, especially when considered in relation to the confidence intervals, as a result of high uncertainty in the outflow–abundance relationship.~~	~~Recruitment under the Proposed Project is modeled to slightly decrease under good survival (2% max difference) and poor survival (1% max difference) scenarios when confidence intervals are accounted for. The following measures should help reduce any potential small effects in real-time:~~ • ~~Increased measures to reduce entrainment losses for all Longfin Smelt life stages~~ • ~~A commitment to a Longfin Smelt Science program to understand mechanisms underlying flow-abundance relationships, and to identify and test additional options for Longfin Smelt management.~~ • ~~A commitment to support the Fish Culture Facility for Longfin Smelt culture for future study and adaptive management application.~~ • ~~This is a combined SWP and CVP result with the SWP responsibility of approximately 40% to 60%~~	~~Less than Significant~~	~~Recruitment under Alternative 2b has the potential to slightly decrease. The following measures should help reduce any potential small effects in real-time:~~ • ~~Increased measures to reduce entrainment losses for all Longfin Smelt life stages~~ • ~~A commitment to a Longfin Smelt Science program to understand mechanisms underlying flow-abundance relationships, and to identify and test additional options for Longfin Smelt management.~~ • ~~A commitment to support the Fish Culture Facility for Longfin Smelt culture for future study and adaptive management applications.~~ • ~~This is a combined SWP and CVP result with the SWP responsibility of approximately 40% to 60%~~	~~Less than Significant~~	~~Delta outflow in April-May would be greater under Alternative 2b than proposed project, but less than Existing Conditions~~
~~Longfin Smelt~~	~~Adult~~	~~Entrainment~~	~~Similar OMR flow from December-February.~~	~~Modeled entrainment under the Proposed Project is similar to the existing project. Other measures should reduce real-time entrainment risk, including:~~ • ~~OMR management Dec-Feb~~ • ~~OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt~~ • ~~Existing adult Longfin Smelt entrainment is less than 1% of the population (all years except 2008 @ 3%)~~ • ~~SWP responsibility for slight differences in OMR is between approximately 40% to 60%~~	~~Less than Significant~~	~~Entrainment under Alternative 2b would be expected to be similar to Existing Conditions. Other measures should reduce real-time entrainment risk, including:~~ • ~~OMR management Dec-Feb~~ • ~~OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt~~ • ~~Existing adult Longfin Smelt entrainment is less than 1% of the population (all years except 2008 @ 3%)~~ • ~~SWP responsibility for slight differences in OMR is between approximately 40% to 60%~~	~~Less than Significant~~	~~No operational differences between Proposed Project and Alternative 2b in December-February~~
~~Longfin Smelt~~	~~Larvae~~	~~Entrainment~~	~~DSM2-PTM results suggested that entrainment potential of Longfin Smelt larvae is similar between scenarios.~~	~~Modeled entrainment of larval Longfin Smelt does not increase under the Proposed Project. Other measures should reduce real-time entrainment risk, including:~~ • ~~OMR management Jan-Mar~~ • ~~OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt, shifting spawning seaward of interior Delta.~~ • ~~Adult Longfin Smelt presence as detected by the surveys and salvage suggests spawning is limited in interior Delta, which reduces subsequent larval entrainment risk.~~ • ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Entrainment of larval Longfin Smelt would not be expected to increase under Alternative 2b. Other measures should reduce real-time entrainment risk, including:~~ • ~~OMR management Jan-Mar~~ • ~~OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt, shifting spawning seaward of interior Delta.~~ • ~~Adult Longfin Smelt presence as detected by the surveys and salvage suggests spawning is limited in interior Delta, which reduces subsequent larval entrainment risk.~~ • ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~No operational differences between Proposed Project and Alternative 2b in January-March~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Longfin Smelt~~	~~Juvenile~~	~~Salvage~~	~~Based on the Grimaldo et al. (2009) salvage-Old and Middle River flow regression, the potential exists for large relative increases in entrainment under the Proposed Project.~~	~~Modeled juvenile Longfin Smelt salvage is increased under the Proposed Project. However, the following measures/considerations are expected to minimize entrainment:~~ • ~~OMR flows during April and May under the PP are less negative than the -5000 cfs inflection point deemed protective of entrainment risk for Longfin Smelt and other ESA species.~~ • ~~Real-time OMR management, PTM models and CDFW Smelt Larval Survey (SLS) monitoring will be used to assess entrainment risk in real-time.~~ • ~~Increased first flush protection actions should lead to less movement and spawning in the interior Delta, subsequently decreasing entrainment risk of larvae and juveniles~~ • ~~SWP responsibility for differences in OMR flows is between approximately 40-50%~~	~~Less than Significant~~	~~Juvenile Longfin Smelt salvage has the potential to increase Alternative 2b. However, the following measures/considerations are expected to minimize entrainment:~~ • ~~OMR flows during April and May under the PP are less negative than the -5000 cfs inflection point deemed protective of entrainment risk for Longfin Smelt and other ESA species.~~ • ~~Real-time OMR management, PTM models and CDFW Smelt Larval Survey (SLS) monitoring will be used to assess entrainment risk in real-time.~~ • ~~Increased first flush protection actions should lead to less movement and spawning in the interior Delta, subsequently decreasing entrainment risk of larvae and juveniles~~ • ~~SWP responsibility for differences in OMR flows is between approximately 40-50%~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project but greater than Existing Conditions~~
~~Longfin Smelt~~	~~All Life Stages~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~Annual O&M activities likely would have limited impacts because work windows and best management practices (BMPs) would be implemented.~~ ~~Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2b.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed project and Alternative 2b.~~
~~Longfin Smelt~~	~~All Life Stages~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control;~~ • ~~Skinner Fish Facility performance improvements;~~ • ~~Longfin Smelt Science Program; and~~ • ~~Continue Studies to Establish a Delta Fish Hatchery (see Table 3-3)~~	~~N/A~~	~~Longfin Smelt Science Program would improve understanding of Longfin Smelt ecology, population distribution, and abundance to better inform management decisions. Delta fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics.~~ ~~Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Longfin Smelt Science Program would improve understanding of Longfin Smelt ecology, population distribution, and abundance to better inform management decisions. Delta fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics.~~ ~~Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed project and Alternative 2b.~~
~~Winter-run Chinook Salmon~~	~~Immigrating Adults~~	~~Qualitative Discussion of SAIL Conceptual Model Habitat Attributes~~	~~Similar flow conditions at Freeport during most months of the immigration period.~~	~~Similar flow conditions would likely result in similar habitat conditions including SAIL Conceptual Model habitat attributes of water temperature, dissolved oxygen concentrations, and other attributes that influence the timing, condition, and survival of adult Winter-run Chinook Salmon during their upstream migration.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Similar flow conditions would likely result in similar habitat conditions including SAIL Conceptual Model habitat attributes of water temperature, dissolved oxygen concentrations, and other attributes that influence the timing, condition, and survival of adult Winter-run Chinook Salmon during their upstream migration.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Winter-run Chinook Salmon~~	~~Juvenile~~	~~Delta Hydrodynamic Assessment~~	~~Changes in hydrodynamic conditions (velocity distributions) indicate that juvenile winter run entering the interior Delta from Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor may be more likely to become entrained under the Proposed Project, if exports are greater at the time they are present. There is little difference during the main December-February period when Winter-Run are most abundant in the Delta.~~	~~Although Chinook Salmon in the Old-Middle River Corridor could become entrained more often under the Proposed Project, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of winter run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile winter run Chinook salmon encounter the South Delta salvage facilities.~~ ~~Velocity changes that could occur in the Spring and Fall under the proposed project are less t likely to affect Winter-run Chinook Salmon because most Winter-run Chinook Salmon are expected to have exited the Delta by April and May and are generally present in low abundance in September and November.~~ ~~This is a combined SWP and CVP result~~ ~~Implementing OMR management, including factors such as cumulative loss thresholds, would limit entrainment of Winter-run Chinook Salmon that do enter the Old-Middle River corridor.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF could reduce pre-screen losses, which could increase observed salvage.~~ ~~Skinner Fish Facility Improvements also have the potential to improve survival of salvaged winter-run Chinook Salmon.~~	~~Less than Significant~~	~~Although Chinook Salmon in the Old-Middle River Corridor could become entrained more often under Alternative 2b, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers for the Proposed Project modeling indicate that probabilities of moving south from that point are similar. Thus, Alternative 2b would be unlikely to increase the proportion of winter run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile winter run Chinook salmon encounter the South Delta salvage facilities.~~ ~~Velocity changes that could occur in the Spring and Fall under Alternative 2b are less likely to affect Winter-run Chinook Salmon because most Winter-run Chinook Salmon are expected to have exited the Delta by April and May and are generally present in low abundance in September and November.~~ ~~This is a combined SWP and CVP result~~ ~~Implementing OMR management, including factors such as cumulative loss thresholds, would limit entrainment of Winter-run Chinook Salmon that do enter the Old-Middle River corridor.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF could reduce pre-screen losses, which could increase observed salvage.~~ ~~Skinner Fish Facility Improvements also have the potential to improve survival of salvaged winter-run Chinook Salmon.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project; the difference in entrainment loss would be small because there is little temporal overlap of Winter-Run with April-May~~
~~Winter-run Chinook Salmon~~	~~Juvenile~~	~~Entrainment Loss Density~~	~~Entrainment loss of juvenile Winter-run Chinook Salmon at the SWP south Delta export facility would be similar between the scenarios.~~	~~Entrainment loss would be similar under both scenarios, but the analysis is uncertain because it is not scaled by population size and there is uncertainty about the true racial identity of Chinook Salmon in salvage.~~ ~~The model does not include real-time management operations, which would reduce entrainment.~~ ~~The model does not include the genetic identity of salvaged Chinook salmon, and some fish in historical salvage could be misidentified, which would artificially increase the estimated salvage in the analysis.~~	~~Less than Significant~~	~~Entrainment loss would be similar under both scenarios, but the analysis is uncertain, and the models run for the Proposed Project do not include real-time management operations or genetic identity of salvaged Chinook salmon.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project; the difference in entrainment loss would be small because there is little temporal overlap of Winter-Run with April-May~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Winter-run Chinook Salmon~~	~~Juvenile~~	~~Salvage based on Zeug and Cavallo (2014)~~	~~Winter-run Chinook Salmon salvage is similar under both scenarios. Medain salvage of the juvenile population at the SWP was 0.149% under the existing condition and 0.140% under the proposed project (≈ 0.01% lower under the proposed project). Median salvage at both the SWP and CVP combined was 0.353% under the proposed project and 0.380% under the existing condition.~~	~~The maximum annual proportion of juvenile Winter-run Chinook Salmon production predicted to be salvaged is low (<1.2%) for both the proposed project and the existing condition. Differences between scenarios in individual years were small (<0.5%). Additionally, small differences in predicted salvage occurred in certain months and water year types. However, there was high overlap in interquartile ranges and the scenario with greater salvage was not consistent across these comparisons.~~	~~Less than Significant~~	~~The maximum annual proportion of juvenile Winter-run Chinook Salmon production that would be predicted to be salvaged would low (<~1.2%) for both Alternative 2b and the existing condition. Differences between scenarios in individual years would be expected to be small (<0.5%).~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project; the difference in entrainment loss would be small because there is little temporal overlap of Winter-Run with April-May~~
~~Winter-run Chinook Salmon~~	~~Outmigrant Survival~~	~~Delta Passage Model~~	~~Across the 82-year simulation period, mean through-Delta survival was 0.1% greater for the Proposed Project. Survival followed water year type for both scenarios with the highest values in wet years and lowest values in critical years. Differences in individual model years were generally small (≤ 1.6%) as were differences within individual water year types.~~	~~Through Delta survival of Winter-run Chinook Salmon was similar under both scenarios with some uncertainty. These results are similar to those of the STARS analysis described below which does not include an export-survival function which is included in the DPM. Together, these results suggest changes in export operations under the proposed project had little influence on through-Delta survival of winter run Chinook Salmon. Uncertainty in the modeled result will be addressed by implementing cumulative loss thresholds as part of OMR management would limit entrainment~~ ~~SWP responsibility for differences in Delta operations is between approximately 40% to 60%~~	~~Less than Significant~~	~~Through Delta survival of Winter-run Chinook Salmon would be expected to be similar under both scenarios with some uncertainty. Modeling results for the Proposed Project suggest changes in export operations under the proposed project would have little influence on through-Delta survival of winter run Chinook Salmon. Uncertainty in the modeled result will be addressed by implementing cumulative loss thresholds as part of OMR management, which would limit entrainment.~~ ~~SWP responsibility for differences in Delta operations is between approximately 40% to 60%~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project; the difference in entrainment loss would be small because there is little temporal overlap of Winter-Run with April-May~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Winter-run Chinook Salmon~~	~~Outmigrant Survival~~	~~STARS~~	~~Generally similar proportions of Winter-run Chinook Salmon entered the interior Delta via Georgiana Slough and the DCC, resulting in similar through-Delta survival under both scenarios except during November, when survival was predicted to be lower under the Proposed Project as a result of less river flow and greater Delta Cross Channel (DCC) opening as a result of model assumptions. However, abundance of Winter-run Chinook Salmon is generally low in November.~~	~~During most months of the outmigration period (October through June for this analysis) Winter-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the central Delta and reduced survival could occur in November. However, abundance of Winter-run Chinook Salmon is generally low in November.~~ ~~This is a combined result. During November when the largest differences in routing occur, the SWP is responsible for approximately 50-60% of operations-related impacts but note that the DCC is a CVP facility.~~	~~Less than Significant~~	~~During most months of the outmigration period (October through June for this analysis) Winter-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the central Delta and reduced survival could occur in November.~~ ~~However, abundance of Winter-run Chinook Salmon is generally low in November.~~ ~~This is a combined result. During November when the largest differences could occur, the SWP is responsible for approximately 50-60% of operations-related impacts but note that the DCC is a CVP facility.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~
~~Winter-run Chinook Salmon~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~Annual O&M activities likely would have limited impacts because work windows and best management practices (BMPs) would be implemented.~~ ~~Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2b.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~Winter-run Chinook Salmon~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~
~~Spring-run Chinook Salmon~~	~~Immigrating Adults~~	~~Qualitative Discussion of SAIL Conceptual Model Habitat Attributes~~	~~Similar flow conditions at Freeport during the January through June immigration period.~~	~~Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration.~~ ~~SWP responsibility for differences in Delta operations is between approximately 30-60%.~~	~~Less than Significant~~	~~Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Spring-run Chinook Salmon~~	~~Juvenile~~	~~Delta Hydrodynamic Assessment and Junction Entry~~	~~For juvenile spring-run Chinook Salmon migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the Old and Middle River corridors during April and May suggest entrainment of fish entering Old River at HOR would be higher.~~ ~~For juvenile spring-run Chinook Salmon originating from the Sacramento River, changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor in April and May are more likely to become entrained under the Proposed Project.~~	~~Greater frequency of routing San Joaquin-origin spring-run into Old River increases entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under the proposed project (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River.~~ ~~For Sacramento River-origin spring-run, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of spring run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May~~ ~~This is a combined SWP and CVP result.~~ ~~OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~Greater frequency of routing San Joaquin-origin spring-run into Old River would increase entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under the proposed project (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River.~~ ~~For Sacramento River-origin spring-run, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers for modeling of the proposed project indicate that probabilities of moving south from that point are similar. Thus, Alternative 2b would be unlikely to increase the proportion of spring run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May~~ ~~This is a combined SWP and CVP result.~~ ~~OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Spring-run Chinook Salmon~~	~~Juvenile~~	~~Entrainment Loss Density~~	~~Entrainment loss of juvenile Spring-run Chinook Salmon at the SWP south Delta export facility could be appreciably greater under the Proposed Project.~~	~~Entrainment loss of Spring-run Chinook Salmon could be higher under the Proposed Project, but the analysis is uncertain, and the model does not include genetic identity of salvaged Chinook salmon or account for the total number of juveniles that could potentially be salvaged (data are not scaled).~~ ~~Coded wire tag studies indicate that small fractions of Sacramento River Chinook Salmon encounter the South Delta salvage facilities, so entrainment-related impacts on the ESU would be small.~~ ~~OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~Entrainment loss of Spring-run Chinook Salmon could be higher under Alternative 2b.~~ ~~Coded wire tag studies indicate that small fractions of Sacramento River Chinook Salmon encounter the South Delta salvage facilities, so entrainment-related impacts on the ESU would be small.~~ ~~OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~
~~Spring-run Chinook Salmon~~	~~Outmigrant Survival~~	~~Delta Passage Model~~	~~Across the 82-year simulation period, mean through-Delta survival was 0.6% lower under the Proposed Project. Differences in individual years were generally small (< 1.5%), with the largest difference occurring in the 1995 model year when survival under the Proposed Project was 1.6 % lower than the Existing Condition.~~	~~Through-Delta survival of Spring-run Chinook Salmon was similar under both scenarios with some uncertainty. The Delta Passage Model contains an export-survival relationship. Thus, higher exports in April and May did not result in substantial changes in through-delta survival. Only a small fraction of Sacramento River-origin Spring-run enter the interior Delta and most of the juvenile population is not exposed to the hydrodynamic effect of exports.~~ ~~This is a combined SWP and CVP result~~	~~Less than Significant~~	~~Through-Delta survival of Spring-run Chinook Salmon would be expected to be similar under both scenarios with some uncertainty.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~
~~Spring-run Chinook Salmon~~	~~Outmigrant Survival~~	~~San Joaquin River Structured Decision Model~~	~~Across the 82-year simulation period, through-Delta survival was low (< 4%) under both scenarios. Survival was higher under the Proposed Project for all years, but the magnitude of the difference between scenarios was variable in specific years. Survival was more similar between scenarios in drier year types relative to wetter year types.~~	~~Survival of San Joaquin River-origin Spring-run Chinook Salmon has the potential to be higher under the Proposed Project.~~ ~~Although exports will be higher under the proposed project in April and May, the SDM includes the latest acoustic tagging data from the CVP and south Delta. These data and the model suggest that volitional migration survival from the facilities north can be lower than entrainment at CVP and trucking to the West Delta. Thus, more fish being routed into Old River and higher exports lead to a higher survival under the proposed project. However, overall through-delta survival for San Joaquin River-origin Chinook Salmon is low regardless of scenario (<4%).~~	~~Less than Significant~~	~~Survival of San Joaquin River-origin Spring-run Chinook Salmon has the potential to be higher under Alternative 2b. Although exports will be higher under the Alternative 2b in April and May, the SDM includes the latest acoustic tagging data from the CVP and south Delta. These data and the model suggest that volitional migration survival from the facilities north can be lower than entrainment at CVP and trucking to the West Delta. Thus, more fish being routed into Old River and higher exports lead to a higher survival under the proposed project. However, overall through-delta survival for San Joaquin River-origin Chinook Salmon would be low regardless of scenario.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Spring-run Chinook Salmon~~	~~Outmigrant Survival~~	~~STARS~~	~~The STARS model results suggest little difference in predicted through-Delta survival of Spring-run Chinook Salmon between the scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December.~~	~~During most months of the outmigration period (November through May for this analysis) Spring-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the Delta and reduced survival could occur in November.~~ ~~Although the STARS model does not include an export-survival function, results generally followed those of the DPM which does. Only small fractions of Sacramento River Chinook Salmon encounter the South Delta facilities as indicated by coded wire tag studies. This likely explains the minor effect of increased exports during April and May on total through-Delta survival.~~ ~~The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40–60% depending on the month and water year type.~~	~~Less than Significant~~	~~During most months of the outmigration period (November through May for this analysis) Spring-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the Delta and reduced survival could occur in November.~~ ~~Although the STARS model run for the Proposed Project does not include an export-survival function, results generally followed those of the DPM which does. Only small fractions of Sacramento River Chinook Salmon encounter the South Delta facilities as indicated by coded wire tag studies. This likely explains the minor effect of increased exports during April and May on total through-Delta survival.~~ ~~The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40–60% depending on the month and water year type.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~
~~Spring-run Chinook Salmon~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2b.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~Spring-run Chinook Salmon~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~
~~Fall-run and Late Fall-run Chinook Salmon~~	~~Immigrating Adults~~	~~Qualitative Discussion of SAIL Conceptual Model Habitat Attributes~~	~~Similar flow conditions at Freeport during the July through December Fall-run Chinook Salmon and October through April Late Fall-run Chinook Salmon adult immigration periods.~~ ~~No SWP influence on DCC operations.~~	~~Similar flow conditions would likely result in similar habitat conditions in the Sacramento River including SAIL Conceptual Model habitat attributes and olfactory cues for immigration.~~ ~~SWP responsibility for differences in Freeport flows is between approximately 20-60% during the Fall-run Chinook Salmon Immigration Period.~~ ~~SWP responsibility for differences in Freeport flows is between approximately 40% to 60% during the Late Fall-run Chinook Salmon Immigration Period.~~ ~~There is no difference in straying rates of Mokelumne River Fall-run Chinook Salmon because there is no SWP influence on DCC operations.~~	~~Less than Significant~~	~~Similar flow conditions would likely result in similar habitat conditions in the Sacramento River including SAIL Conceptual Model habitat attributes and olfactory cues for immigration.~~ ~~There would be no difference in straying rates of Mokelumne River Fall-run Chinook Salmon because there is no SWP influence on DCC operations.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Fall-run and Late Fall-run Chinook Salmon~~	~~Juvenile~~	~~Delta Hydrodynamic Assessment and Junction Entry~~	~~For juvenile fall-run Chinook Salmon migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the Old and Middle River corridors during April and May suggest entrainment of fish entering Old River at HOR would be higher.~~ ~~For juvenile fall-run and late-fall run Chinook Salmon originating from the Sacramento River, Changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor in April and May (primarily fall run) and November (late-fall run) are more likely to become entrained under the Proposed Project.~~	~~Greater frequency of routing San Joaquin-origin fall-run into Old River increases entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under the proposed project (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River.~~ ~~For Sacramento River-origin fall-run, and late fall-run that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of fall and late-fall run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May (fall run) or November (late fall-run).~~ ~~This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the period evaluated for San Joaquin River basin Fall-run Chinook Salmon is approximately 40% to 60%.~~ ~~OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements would improve survival of salvaged fish.~~	~~Less than Significant~~	~~Greater frequency of routing of San Joaquin-origin fall-run into Old River under Alternative 2b would increase entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model undertaken for the Proposed Project incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under the proposed project (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River.~~ ~~For Sacramento River-origin fall-run, and late fall-run that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers for Proposed Project modeling indicate that probabilities of moving south from that point are similar. Thus, Alternative 2b would be unlikely to increase the proportion of fall and late-fall run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May (fall run) or November (late fall-run).~~ ~~This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the period evaluated for San Joaquin River basin Fall-run Chinook Salmon is approximately 40% to 60%.~~ ~~OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements would improve survival of salvaged fish.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~
~~Fall-run and Late Fall-run Chinook Salmon~~	~~Juvenile~~	~~Mokelumne River Fall-run Chinook Salmon Qualitative Discussion~~	~~N/A~~	~~Coded wire tag analysis suggests that very small percentages of Mokelumne River Fall-run Chinook Salmon would be expected to be entrained, ranging from 0.4-0.6% of outmigrants.~~	~~Less than Significant~~	~~Coded wire tag analysis suggests that very small percentages of Mokelumne River Fall-run Chinook Salmon would be expected to be entrained, ranging from 0.4-0.6% of outmigrants.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Fall-run and Late Fall-run Chinook Salmon~~	~~Juvenile~~	~~Entrainment Loss Density~~	~~Entrainment loss of juvenile Fall-run Chinook Salmon at the SWP south Delta export facility could be appreciably greater under the Proposed Project.~~ ~~Entrainment loss of Late Fall-run Chinook Salmon is similar between scenarios.~~	~~Entrainment loss could be higher under the Proposed Project, but the analysis is uncertain, and the model does not include genetic identity of salvaged Chinook salmon.~~ ~~Small percentages of juvenile Sacramento River Fall-run and Late Fall-run Chinook Salmon are estimated to encounter the south Delta export facilities, so entrainment-related impacts on the ESU would be small.~~ ~~Entrainment losses likely to be higher for San Joaquin River-origin fall run. However, the SDM model indicated higher survival under the proposed project due to poor volitional survival through Old River relative to salvage and trucking~~ ~~OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~Entrainment loss could be higher under Alternative 2b, but the analysis is uncertain, and the modeling done for the Proposed Project does not include genetic identity of salvaged Chinook salmon.~~ ~~Small percentages of juvenile Sacramento River Fall-run and Late Fall-run Chinook Salmon are estimated to encounter the south Delta export facilities, so entrainment-related impacts on the ESU would be small.~~ ~~Entrainment losses likely to be higher for San Joaquin River-origin fall run. However, the SDM model indicated higher survival under the Proposed Project due to poor volitional survival through Old River relative to salvage and trucking~~ ~~OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~
~~Fall-run and Late Fall-run Chinook Salmon~~	~~Outmigrant Survival~~	~~Delta Passage Model CV Fall-run and Late Fall-run Chinook Salmon~~	~~Across the 82-year simulation period, mean Fall-run Chinook Salmon through-Delta survival was 0.5% lower under the Proposed Project. Differences in individual years were generally small (< 1.5%).~~ ~~Across the 82-year simulation period, mean Late Fall-run Chinook Salmon through-Delta survival was 0.3% lower under the Proposed Project. Differences in individual years were generally small (< 1.0%).~~	~~Through-Delta survival of Fall-run and Late Fall-run Chinook Salmon was similar under both scenarios with some uncertainty.~~ ~~These results were similar to those from the STARS model which does not include an export-survival relationship like to DPM. This suggests changes to exports did not have a substantial effect on through-Delta survival.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Through-Delta survival of Fall-run and Late Fall-run Chinook Salmon would be expected to be similar under both scenarios with some uncertainty.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Fall-run and Late Fall-run Chinook Salmon~~	~~Outmigrant Survival~~	~~San Joaquin River Structured Decision Model~~	~~Across the 82-year simulation period through-Delta survival was low (< 4%) under both scenarios.~~ ~~Survival was higher under the Proposed Project for all years, but the magnitude of the difference between scenarios was variable.~~ ~~Survival was higher under the Proposed Project in all water year types.~~	~~Greater proportions of fish would be routed into Old River relative to the San Joaquin River under the proposed project and exports will be higher in April and May when fall-run are migrating. However, survival of San Joaquin River-origin Fall-run Chinook Salmon has the potential to be higher under the Proposed Project.~~ ~~The SDM uses the most recent survival data from acoustic tagging studies in the South Delta and at the CVP. This indicates survival is higher for fish in Old River that are salvaged and trucked rather than volitional migration.~~	~~Less than Significant~~	~~Survival of San Joaquin River-origin Fall-run Chinook Salmon has the potential to be higher under Alternative 2b because data from acoustic tagging studies in the South Delta and at the CVP indicate survival is higher for fish in Old River that are salvaged and trucked rather than volitional migration.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~
~~Fall-run and Late Fall-run Chinook Salmon~~	~~Outmigrant Survival~~	~~STARS~~	~~The STARS model results suggest little difference in predicted through-Delta survival of Chinook Salmon between the scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December.~~	~~During most months of the outmigration period (January through June) Fall-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios.~~ ~~Late Fall-run Chinook Salmon could be exposed to increased routing into the Delta and reduced survival in November, although this is because of DCC operational assumptions related to Freeport flow.~~ ~~Small percentages of Sacramento River Fall-run Chinook Salmon and Late Fall-run Chinook Salmon enter the South Delta, so entrainment-related impacts on the ESU would be small.~~ ~~This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 40% to 60%, depending on the month and water year type.~~	~~Less than Significant~~	~~During most months of the outmigration period (January through June) Fall-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios.~~ ~~Late Fall-run Chinook Salmon could be exposed to increased routing into the Delta and reduced survival in November, although modeling of this for the Proposed Project reflects DCC operational assumptions related to Freeport flow.~~ ~~Small percentages of Sacramento River Fall-run Chinook Salmon and Late Fall-run Chinook Salmon enter the South Delta, so entrainment-related impacts on the ESU would be small.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~
~~Fall-run and Late Fall-run Chinook Salmon~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2b.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~Fall-run and Late Fall-run Chinook Salmon~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Central Valley Steelhead~~	~~Immigrating Adults~~	~~Qualitative Discussion of SAIL Conceptual Model Habitat Attributes~~	~~Similar flow conditions at Freeport during the July through March immigration period.~~	~~Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration.~~ ~~SWP responsibility for differences in OMR flows is between approximately 20-60%.~~	~~Less than Significant~~	~~Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~
~~Central Valley Steelhead~~	~~Juvenile~~	~~Delta Hydrodynamic Assessment and Junction Entry~~	~~For juvenile steelhead migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile fish approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the Old and Middle River corridors during April and May suggest entrainment of fish entering Old River at HOR would be higher.~~ ~~For juvenile steelhead originating from the Sacramento River, Changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor in April and May are more likely to become entrained under the Proposed Project~~	~~Greater frequency of routing San Joaquin-origin steelhead into Old River increases entrainment risk for these fish but it is unknown if this would translate into a population-level effect on survival.~~ ~~For Sacramento River-origin steelhead, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of steelhead entering the Old-Middle River corridor. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May~~ ~~This is a combined SWP and CVP result.~~ ~~Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~Greater frequency of routing San Joaquin-origin steelhead into Old River under Alternative 2b would increase entrainment risk for these fish but it is unknown if this would translate into a population-level effect on survival.~~ ~~For Sacramento River-origin steelhead, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers based on modeling for the Proposed Project indicate that probabilities of moving south from that point are similar. Thus, Alternative 2b would be unlikely to increase the proportion of steelhead entering the Old-Middle River corridor. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May~~ ~~This is a combined SWP and CVP result.~~ ~~Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project; the difference in entrainment loss would be small because there is little temporal overlap of Steelhead with April-May~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Central Valley Steelhead~~	~~Juvenile~~	~~Entrainment Loss Density~~	~~Entrainment loss of juvenile Central Valley steelhead at the SWP south Delta export facility could be greater under the Proposed Project.~~	~~Entrainment loss of steelhead could be higher under the Proposed Project, but the analysis is uncertain.~~ ~~Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~Entrainment loss of steelhead could be higher under Alternative 2b, but the analysis is uncertain.~~ ~~Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment.~~ ~~Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~
~~Central Valley Steelhead~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~Annual O&M activities likely would have limited impacts because work windows and best management practices (BMPs) would be implemented.~~ ~~Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under Alternative 2b.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~Central Valley Steelhead~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to increase pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~
~~Central California Coast Steelhead~~	~~All Life Stages in San Francisco and San Pablo Bays~~	~~Delta Outflow~~	~~Similar under both scenarios.~~	~~Similar Delta outflow during most of the year would result in similar impacts under both scenarios.~~ ~~This is a combined SWP and CVP result. SWP responsibility for differences in Delta operations is between approximately 20-60%.~~	~~Less than Significant~~	~~Similar Delta outflow during most of the year would result in similar impacts under both scenarios. This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Delta outflow in April-May would be greater under Alternative 2b than Proposed Project, but less than Existing Conditions~~
~~Central California Coast Steelhead~~	~~All Life Stages in San Francisco and San Pablo Bays~~	~~Annual O&M Activities~~	~~N/A~~	~~Annual O&M activities would not occur within the habitats occupied by Central California Coast Steelhead.~~	~~Less than Significant~~	~~Annual O&M activities would not occur within the habitats occupied by Central California Coast Steelhead.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~Central California Coast Steelhead~~	~~All Life Stages in San Francisco and San Pablo Bays~~	~~Project Environmental Protective Measures)~~	~~N/A~~	~~No project environmental protective measures occur in San Francisco Bay and San Pablo Bay, and no impacts on Central California Coast Steelhead would occur.~~	~~Less than Significant~~	~~No project environmental protective measures occur in San Francisco Bay and San Pablo Bay, and no impacts on Central California Coast Steelhead would occur.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Green Sturgeon~~	~~Immigrating Adults and Emigrating Juveniles~~	~~Flow Analysis~~	~~Similar flow conditions at Freeport during most months of the year, except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.~~	~~Similar flows during most of the year would result in similar impacts under both scenarios.~~ ~~Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on Green Sturgeon habitat attributes.~~ ~~This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.~~	~~Less than Significant~~	~~Similar flows during most of the year would result in similar impacts under both scenarios.~~ ~~Reductions in flow during September and November would not be expected to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on Green Sturgeon habitat attributes.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~
~~Green Sturgeon~~	~~Juvenile~~	~~Daily Salvage Loss Density~~	~~Green Sturgeon salvage is low and is similar under both scenarios.~~	~~Green Sturgeon salvage would be expected to be similar under both scenarios.~~	~~Less than Significant~~	~~Green Sturgeon salvage would be expected to be similar under both scenarios.~~	~~Less than Significant~~	~~Little expected salvage during April-May period of export differences.~~
~~Green Sturgeon~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.~~	~~Less than Significant~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~Green Sturgeon~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~
~~White Sturgeon~~	~~Immigrating Adults and Emigrating Juveniles~~	~~Flow Analysis~~	~~Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions and during April and May.~~	~~Similar flows during most of the year would result in similar impacts under both scenarios.~~ ~~Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on White Sturgeon habitat attributes.~~ ~~Reductions in Delta outflow in April/May have the potential to reduce year-class strength based on observed correlations, although there is uncertainty in the mechanism and differences would be expected to be small relative to variability in estimates that may reflect hydrological conditions as opposed to operations.~~ ~~This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%, and for Delta outflow in April/May is approximately 40-50%.~~	~~Less than Significant~~	~~Similar flows during most of the year would result in similar impacts under both scenarios.~~ ~~Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on White Sturgeon habitat attributes.~~ ~~Reductions in Delta outflow in April/May have the potential to reduce year-class strength based on observed correlations, although there is uncertainty in the mechanism and differences would be expected to be small relative to variability in estimates that may reflect hydrological conditions as opposed to operations.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports; Delta outflow in April-May would be greater under Alternative 2b than Proposed Project, but less than Existing Conditions~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~White Sturgeon~~	~~Juvenile~~	~~Daily Salvage Loss Density~~	~~White Sturgeon salvage is low and is similar under both scenarios.~~	~~White Sturgeon salvage is low and is similar under both scenarios.~~	~~Less than Significant~~	~~White Sturgeon salvage would be expected to be low and similar under both scenarios.~~	~~Less than Significant~~	~~Little expected salvage during April-May period of export differences.~~
~~White Sturgeon~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~White Sturgeon~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~
~~Pacific Lamprey and River Lamprey~~	~~Immigrating Adults, Ammocoetes, and Migrating Juveniles~~	~~Flow Analysis~~	~~Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.~~	~~Similar flows during most of the year would result in similar impacts under both scenarios.~~ ~~Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on lamprey habitat attributes.~~ ~~This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.~~	~~Less than Significant~~	~~Similar flows during most of the year would result in similar impacts under both scenarios.~~ ~~Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on lamprey habitat attributes.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~
~~Pacific Lamprey and River Lamprey~~	~~Juvenile~~	~~Daily Salvage Loss Density~~	~~Lamprey salvage is similar under both scenarios in wet and above-normal water years but is higher under the Proposed Project in below-normal, dry, and critical water years.~~	~~Lamprey salvage is similar under both scenarios in wet and above-normal water years but is higher under the Proposed Project in below-normal, dry, and critical water years.~~ ~~Real-time OMR management for other listed species, particularly first flush protections for Delta Smelt, may incidentally limit lamprey salvage.~~ ~~Actions to improve survival in the CCF including aquatic weed control and continued evaluation of predator reduction in the CCF, could limit pre-screen loss.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~Lamprey salvage would be expected to be similar under both scenarios in wet and above-normal water years but may be higher under Alternative 2b in below-normal, dry, and critical water years.~~ ~~Real-time OMR management for other listed species, particularly first flush protections for Delta Smelt, may incidentally limit lamprey salvage.~~ ~~Actions to improve survival in the CCF including aquatic weed control and continued evaluation of predator reduction in the CCF, could limit pre-screen loss.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Pacific Lamprey and River Lamprey~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~Pacific Lamprey and River Lamprey~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~
~~Native Minnows~~	~~Native Minnow Residence~~	~~Flow Analysis~~	~~Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.~~	~~Similar flows during most of the year would result in similar impacts under both scenarios.~~ ~~Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident native minnow habitat attributes.~~ ~~This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.~~	~~Less than Significant~~	~~Similar flows during most of the year would result in similar impacts under both scenarios.~~ ~~Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident native minnow habitat attributes. This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~
~~Native Minnows~~	~~Splittail Spawning~~ ~~Hardhead Spawning~~ ~~Central California Roach Spawning~~	~~Flow Analysis~~	~~Similar flow conditions at Freeport during the native minnow spawning periods and into the Yolo Bypass during the Splittail spawning period.~~	~~Similar flows would not result in substantial long-term impacts on native minnow spawning habitat attributes.~~ ~~This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 30-60%.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports.~~	~~Less than Significant~~	~~Freeport flow and Yolo Bypass flow are not affected by south Delta exports~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Native Minnows~~	~~Juvenile~~	~~Splittail Salvage Loss Density~~	~~Appreciable increases in entrainment of Sacramento Splittail could occur under the Proposed Project.~~	~~Although salvage could be higher under the Proposed Project, the main driver of Sacramento Splittail population dynamics appears to be inundation of floodplain habitat, such as the Yolo Bypass, which would not change.~~ ~~Sacramento Splittail may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in the Proposed Project that would be implemented to protect listed salmonids and smelts.~~ ~~Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in CCF, would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~Although salvage could be higher under Alternative 2b, the main driver of Sacramento Splittail population dynamics appears to be inundation of floodplain habitat, such as the Yolo Bypass, which would not change.~~ ~~Sacramento Splittail may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in Alternative 2b that would be implemented to protect listed salmonids and smelts.~~ ~~Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in CCF, would reduce pre-screen losses.~~ ~~Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~
~~Native Minnows~~	~~Juvenile~~	~~Hardhead Salvage Loss Density~~	~~Hardhead salvage is similar under both scenarios and is low.~~	~~Similar and low salvage loss would not be expected to substantially affect Hardhead.~~	~~Less than Significant~~	~~Similar and low salvage loss would not be expected to substantially affect Hardhead.~~	~~Less than Significant~~	~~Very few Hardhead were salvaged historically, so operational differences between scenarios would not be expected to result in differences in entrainment loss.~~
~~Native Minnows~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~Native Minnows~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Striped Bass~~	~~Immigrating and Spawning Adults, Rearing and Emigrating Juveniles~~	~~Flow Analysis~~	~~Similar flow conditions at Freeport during most months of the year, particularly during the immigration, spawning, and larvae dispersal period (April through June).~~ ~~Less Delta outflow (greater fall X2) in fall following wet years; greater fall outflow (lower fall X2) in fall following above-normal years.~~	~~Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on Striped Bass.~~ ~~Differences in young-of-the-year abundance as a result of differences in fall Delta outflow/X2 may result in potentially limited population-level impacts because of density dependence later in the life cycle.~~ ~~This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.~~	~~Less than Significant~~	~~Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on Striped Bass.~~ ~~Differences in young-of-the-year abundance as a result of differences in fall Delta outflow/X2 may result in potentially limited population-level impacts because of density dependence later in the life cycle.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports; fall operations do not differ between Alternative 2b and the Proposed Project.~~
~~Striped Bass~~	~~Juvenile Entrainment~~	~~Entrainment Loss Density~~	~~Similar salvage of juvenile Striped Bass under both scenarios.~~	~~Similar and low salvage loss would not be expected to substantially affect Striped Bass.~~ ~~Potential for greater entrainment loss of early life stages (eggs/larvae) during spring may be limited by ancillary protection for listed salmonids and smelts, with limited population-level impacts because of density dependence later in the life cycle.~~	~~Less than Significant~~	~~Similar and low salvage loss would not be expected to substantially affect Striped Bass.~~ ~~Potential for greater entrainment loss of early life stages (eggs/larvae) during spring may be limited by ancillary protection for listed salmonids and smelts, with limited population-level impacts because of density dependence later in the life cycle.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~
~~Striped Bass~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~Striped Bass~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~
~~American Shad~~	~~Immigrating and Spawning Adults~~	~~Flow Analysis~~	~~Similar flow conditions at Freeport during most months of the year, particularly during the immigration, spawning, and larvae dispersal period (April through June).~~	~~Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on American Shad.~~ ~~This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.~~	~~Less than Significant~~	~~Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on American Shad.~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~American Shad~~	~~Juvenile Entrainment~~	~~Entrainment Loss Density~~	~~Similar salvage of juvenile American Shad under the both scenarios during most years, with higher salvage occurring under the Proposed Project during critical water years.~~	~~Similar salvage loss would not be expected to result in substantial impacts on American Shad under the Proposed Project.~~ ~~Loss of earlier life stages may be limited because most early rearing is upstream of the Delta, and there may be ancillary protection from OMR management for listed fish in spring.~~	~~Less than Significant~~	~~Similar salvage loss would not be expected to result in substantial impacts on American Shad under Alternative 2b.~~ ~~Loss of earlier life stages may be limited because most early rearing is upstream of the Delta, and there may be ancillary protection from OMR management for listed fish in spring.~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~
~~American Shad~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~American Shad~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~
~~Non-Native Freshwater Bass~~	~~Resident Adults and Juveniles~~	~~Flow Analysis~~	~~Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.~~	~~Similar flows during most of the year would result in similar impacts under both scenarios.~~ ~~Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident non-native freshwater bass habitat attributes~~ ~~This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%~~	~~Less than Significant~~	~~Similar flows during most of the year would result in similar impacts under both scenarios.~~ ~~Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident non-native freshwater bass habitat attributes~~ ~~This is a combined SWP and CVP result.~~	~~Less than Significant~~	~~Freeport flow is not affected by south Delta exports~~
~~Non-Native Freshwater Bass~~	~~Juvenile Entrainment~~	~~Entrainment Loss Density~~	~~The salvage-density method suggested the potential for entrainment of Largemouth Bass to moderately increase under the Proposed Project, particularly in intermediate water years.~~ ~~Similar salvage of juvenile Spotted Bass and Smallmouth Bass under the both scenarios.~~	~~Increased salvage loss of Largemouth Bass could occur but may be mediated because Grimaldo et al. (2009) did not find a significant relationship between Largemouth Bass salvage and OMR flows.~~ ~~Similar, very low salvage of juvenile Spotted Bass and Smallmouth Bass would be expected under both scenarios~~	~~Less than Significant~~	~~Increased salvage loss of Largemouth Bass could occur under Alternative 2b but may be mediated because Grimaldo et al. (2009) did not find a significant relationship between Largemouth Bass salvage and OMR flows.~~ ~~Similar, very low salvage of juvenile Spotted Bass and Smallmouth Bass would be expected under both scenarios~~	~~Less than Significant~~	~~South Delta exports in April-May would be less under Alternative 2b than Proposed Project, but greater than Existing Conditions~~

~~Species~~	~~Life Stage~~	~~Analytical Component~~	~~Model Results (Proposed Project vs. Existing Conditions)~~	~~Analytical Discussion (Proposed Project)~~	~~Impact Conclusion (Proposed Project)~~	~~Expected Effects of Alternative 2b Relative to Existing Conditions~~	~~Impact Conclusion (Alternative 2b)~~	~~Rationale~~
~~Non-Native Freshwater Bass~~	~~All Life Stages Present in the Delta~~	~~Annual O&M Activities~~	~~N/A~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.~~	~~Less than Significant~~	~~In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs.~~ ~~Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.~~	~~Less than Significant~~	~~Annual O&M activities would be the same for the Proposed Project and Alternative 2b.~~
~~Non-Native Freshwater Bass~~	~~All Life Stages Present in the Delta~~	~~Project Environmental Protective Measures including:~~ • ~~Clifton Court Forebay predator relocation studies and aquatic weed control; and~~ • ~~Skinner Fish Facility performance improvements (see Table 3-3)~~	~~N/A~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival~~	~~Less than Significant~~	~~Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.~~	~~Less than Significant~~	~~Project Environmental Protective Measures would be the same for the Proposed Project and Alternative 2b.~~
~~Killer Whale~~	~~All Life Stages~~	~~Food Source Discussion~~	~~See model results for Fall-run and Late Fall-run Chinook Salmon.~~	~~Because impacts on Fall-run and Late Fall-run Chinook Salmon are less than significant, impacts on killer whales resulting from prey reductions would be minimal~~	~~Less Than Significant~~	~~Because impacts on Fall-run and Late Fall-run Chinook Salmon are less than significant, impacts on killer whales resulting from prey reductions would be minimal~~	~~Less Than Significant~~	~~See discussion for Fall-run and Late Fall-run Chinook Salmon~~

~~Sources: Nobriga and Rosenfield 2016; Grimaldo et al. 2009 ;Zeug and Cavallo 2014~~

~~Notes:~~

Underwater noise could potentially impact special status fish, including listed salmonids. Pile driving would be conducted using vibratory methods that would minimize the generation of ambient noise and underwater noise. Noise monitoring will be completed during pile installation. The noise criteria established by the National Marine Fisheries Service will be followed during pile driving and pile driving will be discontinued should those criteria by exceeded. No known sensitive receptors occur in the vicinity of Georgiana Slough, so impacts associated with noise generated during pile driving would be **less than significant**.

5.3.11.4 AIR QUALITY

Construction activities would generate short-term emissions of reactive organic gas (ROG), NO_X, CO, PM10, and PM2.5. Generation of these emissions would result from the use of heavy equipment, such as cranes, and watercraft, such as tugboats. An air quality analyses conducted for the Georgiana Slough Non-Physical Barrier Study Initial Study/Mitigated Negative Declaration (DWR 2011) concluded that the construction and installation of the BAFF and associated infrastructure would be less than significant because construction of the BAFF would not exceed the Sacramento Metropolitan Air Quality Management District (SMAQMD) NO_X threshold, would comply with the SMAQMD's fugitive dust screening threshold, and would implement SMAQMD Basic and Enhanced Construction Emission Control Practices to Reduce Fugitive Dust and Exhaust. It is anticipated that similar construction techniques would be utilized and similar impacts would occur. Additionally, DWR would implement appropriate construction BMPs such as ensuring compliance with SMAQMD rules, ensuring that construction equipment is appropriately maintained and in good working order, and ensuring that construction personnel comply with anti-idling regulations. Therefore, it is anticipated that air quality impacts would be **less than significant**. ~~The only difference between the Proposed Project and Alternative 2B is the addition of an additional export reduction in April and May, the dedication of water under Section 1707 of the California Water Code and the allocation of 100 TAF for Delta smelt resiliency plan objectives. These changes would not alter the conclusions related to the resource areas listed above as described in the Initial Study. Exports would be further reduced compared to~~

~~Alternative 2a and the Proposed Project to provide the 100 TAF of water. These export reductions would almost entirely offset the modeled increase in exports associated with the proposed project. Therefore, the effect on exports would be negligible compared to existing conditions, which would further reduce the less than significant impacts identified in the Initial Study for the resources listed above.~~

~~5.3.5~~5.3.12 OTHER CONSIDERATIONS

The 2009 NMFS BiOp imposed a reasonable and prudent alternative (RPA) for an I:E ratio to be met by combined CVP and SWP operations. The 2019 project description for Long-Term Operations (LTO) does not include an I:E ratio requirement. Instead of the I:E ratio requirement, the SWP is proposing to restrict exports to protect steelhead (federally listed species) in April and May and earlier in the year through restrictions on OMR flows. The proposed April-May flows in Refined Alternative 2b~~2(b)~~ are intended to benefit Longfin Smelt, a state-listed species, which is not addressed in the 2019 federal BiOp.

Unlike~~,~~ Alternative 2a, the CVP would not be able to recapture flows that are not diverted by the SWP because the reduction in exports would be dedicated for instream flow and protected from recapture. However, the duration of the process to modify the water rights dedication and reach agreements with downstream water users is unknown and could delay the potential benefits of the proposed outflow provided by Refined Alternative 2b for steelhead and Longfin Smelt.

The potential benefits of Refined Alternative ~~2B~~ 2b for Longfin Smelt abundance compared to the Proposed Project are not completely understood because the modeled differences in Longfin Smelt abundance are very small relative to the variability in the predicted values.

5.4 ALTERNATIVE 3 – INSTALLATION OF PHYSICAL AND NON-PHYSICAL BARRIERS

Alternative 3 would include the proposed project plus the installation of a physical barrier at head of Old River and a non-physical barrier at Georgiana Slough. Each of the barrier components are described below. The purpose of Alternative 3 is to limit salmonid straying into the interior Delta and to further reduce salmonid entrainment.

5.4.1 HEAD OF OLD RIVER BARRIER (HORB)

The Head of Old River Barrier would be installed at the divergence of Old River from the San Joaquin River near the City of Lathrop. Alternative 3 would include installation of the barrier in the spring to provide a fish barrier to decrease the number of salmonid smolts entering Old River.

DWR would install the Head of Old River Barrier as early as March 1 each year, except when San Joaquin River flow at Vernalis exceeds 5,000 cfs. The HORB would be operated beginning on April 1 of each year. South Delta agricultural barriers would be installed at the same time as the HORB. The proposed barrier would consist of a rock weir with operable culverts to control flows at the head of Old River. Culverts are operated to meet flow and water quality needs downstream but are generally open when the barrier is installed.

Construction of the HORB would include the placement of a rock barrier in the spring within the channel of Old River. South Delta agricultural barriers would also be installed concurrently with the spring HORB installation as described below in the discussion of schedule. Minor sediment removal may be required in order to prepare the area for barrier installation. The removal of sediment in the vicinity of the HORB would be limited to the minimum amount necessary to allow for the installation of the crushed rock bed for the culverts and would not extend more than 200 feet in any direction from the barrier footprint. All removed sediment would be deposited and retained in an area where it will not affect wetlands or other aquatic habitats. The culverts and articulated mats for the HORB would be stockpiled offsite at a storage area on Howard Road and the rock would be stockpiled adjacent to the barrier site on the inland side of the levee.

Heavy construction equipment would be utilized to move the stockpiled culverts, articulated mats and rock from the storage locations into the channel to form the barrier. Large front-end loaders, dump trucks, long reach excavators and potentially barges with spuds and a tug boat would be used to move and place the materials. The machinery would work from both banks of the channel and from a barge within the channel to place the rock, as well as any additional materials such as culverts, concrete reinforcing mats, clay or other structures or materials.

The spring barrier would utilize 48-inch diameter steel pipes used as culverts that would be placed in the channel after the gravel pad of the barrier is constructed. As the rock barrier is extended into the channel, machinery would utilize the crown of the barrier to move farther into the channel on top of the barrier to place additional materials.

The spring HORB included in Alternative 3, would be constructed with approximately 12,500 cy of rock to form a 225-foot long and 85-foot wide (at the base) berm covering approximately 0.44 acre. The crest of the barrier would be elevation 12.3 feet (NAVD88). The middle section of the barrier would include a 75-foot weir at an elevation of 8.3 feet that is capped with clay up to the barrier crest elevation (12.3 feet, NAVD88). There is no boat portage facility at this barrier. A ramp and dock may be secured to the shore in order to allow storage and safe access to small boats that may be used for construction, maintenance and research purposes.

The spring HORB included in Alternative 3 would include conservation measures to limit potential effects to aquatic resources, as described in recent biological opinions for the Temporary Barriers Project (e.g., USFWS 2018, p.17-19): conduct a worker environmental awareness program; prepare and implement an erosion control plan; prepare and implement a spill prevention and control program; prepare and implement a hazardous materials management program; conduct biological monitoring; implement turbidity monitoring during construction/removal and adjust construction; and stockpile materials in designated construction staging areas.

5.4.1.1 Schedule for Installation and Removal

Spring installation of the HORB, including in-water work, and associated construction activities such as mobilization and site clean-up, would be completed in approximately 24 working days. However, extreme weather, tide, and river flow conditions may impact the barrier’s construction schedule. The HORB cannot be constructed when flows in the San Joaquin River are above 5,000 cfs, as measured at Vernalis monitoring station.

Construction activities for the spring HORB would begin as early as March 1 and removal would be completed no later than November 30 of each year. Installation of south Delta agricultural barriers, which are included in the proposed project, would be timed to coincide with installation of the spring HORB. Any rock barrier operating on or after September 15 will be notched beginning September 15 to allow for passage of adult salmon.

Removal of the HORB would be completed in approximately 24 working days. The rock barrier would be removed with an excavator and/or a dragline or a crane with clamshells. Equipment works both from shore and/or from a barge with spuds and a tug boat. The excavator and/or crane would remove the majority of the rock down to the underwater pad of the culvert frames. A dragline with a bucket or barge mounted excavator/crane may be necessary to remove the remainder of the underwater rock associated with the barriers. The removed rock would be stockpiled outside of the waterway at the location described above until used again. At the barrier site, the channel bottom would be restored to pre-project conditions after the barrier is removed. Confirmation that the channel bottom has been restored to pre-project conditions is accomplished via bathymetric surveys, which would be conducted each year before construction (pre-construction) and after removal.

5.4.2 Georgiana Slough Non-Physical Barrier

DWR would install and operate a ~~non-physical barrier (NPB)~~NPB at the confluence of Georgiana Slough and the Sacramento River between river mile 26.4 and river mile 26.7 near the community of Walnut Grove as described in Chapter 5.3.4, Georgiana Slough Behavioral Modification Barrier (Figure 5.3~~.-~~6)~~(Figure 5.4-1)~~. ~~The non-physical barrier, also referred to as a bio-acoustic fish fence (BAFF), would be operated from approximately January through May each year.~~

The Georgiana Slough ~~non-physical barrier~~NPB would be a behavioral deterrent to prevent emigrating Sacramento River juvenile salmonids from entering Georgiana Slough during the period when wild juvenile salmonids are present (primarily between October 1 through June 1). DWR has previously conducted evaluations of a potential barrier at Georgiana Slough, which demonstrated the effectiveness of the barrier as described here.

The Georgiana Slough NPB consists of the following components:

- Bio-Acoustic Fish Fence: Install up to 31 steel piles (up to 24-inch-diameter) and 4 concrete pier blocks (up to 24-inch-diameter).
- Navigation Aids: Install up to 40 concrete anchor blocks for navigation aids, such as buoys and signs at the Sacramento River/Georgiana Slough location.
- Fish Tracking and other Data Collection Monitoring Equipment: Install up to 18 steel piles at Georgiana Slough (up to 24-inch-diameter) to attach equipment for hydroacoustic and hydrodynamic barrier operational monitoring.
- Barrier Construction and Operation Window: To limit the potential for impacts to listed fishes, marine construction, which is defined as pile driving and installation of anchors and pier blocks, would occur in August and September of each year, where feasible. The BAFF would be installed as early as December through January (conditions permitting) and be operational between January through April of each year. Removal of the barrier components would occur as early as May through September, with August and September being the optimal period for marine construction, each year. Mobilization, both land- and water-based, would occur within 15 days prior to and after each activity. Supporting infrastructure, including piles, would remain in place throughout the year during the duration of the study.
- Dolphin Structures: Each dolphin structure consists of three piles driven into the riverbed that anchor other elements of the barrier. DWR proposes to retain the two dolphin structures that were installed at the Georgiana Slough junction as part of the 2014 FFGS study. DWR may utilize the existing dolphin structures to anchor the BAFF; attach monitoring equipment; and temporarily moor work boats. Current authorization of the existing dolphin structures at Georgiana Slough by the U.S. Army Corps of Engineers (USACE) includes removal by March 17, 2022. DWR would request an amendment to the current Incidental Take Permit term.

- Staging Area Improvements: To prepare, install, and operate the BAFF at Georgiana Slough, DWR may need to conduct improvements, such as adding gravel and grading at the staging area near the Delta Cross Canal. To provide electricity to the Point Ranch Property staging area (adjacent to Georgiana Slough), DWR may install a new power pole.
- Conservation Measures: To avoid and minimize risk to aquatic resources, the following would be undertaken: workers will participate in an environmental awareness program approved by permitting fish agencies; all pile driving will be conducted with a vibratory hammer; preparation and implementation of an erosion control plan and hazardous materials management program; and monitoring of turbidity levels, with adjustment of work to ensure turbidity remains within basin plan thresholds; and implementation of standard construction best management practices related to site preparation/grading, such as wetting exposed surfaces, removing trackout mud/dirt with wet power vacuum street sweepers, limiting vehicle speed on unpaved roads, and keeping all construction equipment in proper working condition.

Marine construction is anticipated to take up to 30 days and would occur between August 1 and September 30 to avoid or minimize the potential for impacting Delta Smelt and salmon/steelhead migrating through the Delta. Barrier and study/data collection equipment, including fish tagging station and hydrophones installation is also anticipated to take up to 30 days and would typically occur between December 1–January 31. The BAFF is anticipated to be operational between January 1 and April 30 of each year.

5.4.3 Hydrology

The physical and non-physical barriers included in Alternative 3 would not substantially change hydrology compared to the proposed project. As the Georgiana Slough NPB would not affect hydrology, the effects described below specifically pertain to the installation of the Head of Old River Barrier. April-May Delta outflow would be similar to the proposed project in all water year types. Therefore, April-May Delta outflow under Alternative 3 would be less than outflows occurring under Existing Conditions. Delta outflow simulation results of Existing Conditions, proposed project and Alternative 3 are presented in Figures 5.4-2 and 5.4-3. Installation of the Head of Old River Barrier would reduce April-May Delta exports in above normal, below normal, dry and critical water years, compared to the proposed project (Figures 5.4-4 and 5.4-5). However, April-May Delta exports under Alternative 3 would still be greater than exports under Existing Conditions. Decreases in exports are necessary to maintain proposed Old and Middle River flow requirements while Head of Old River Barrier is installed. Old and Middle River flows under Alternative 3 remain similar to proposed project. Modeled results of Old and Middle River flow for Existing Conditions, proposed project and Alternative 3 are presented in Figures 5.4-6 and 5.4-7. Reduced south of Delta exports would tend to result in less difference in SWP south of Delta deliveries between Alternative 3 and Existing Conditions when compared to the differences in deliveries between the proposed project and Existing Conditions.

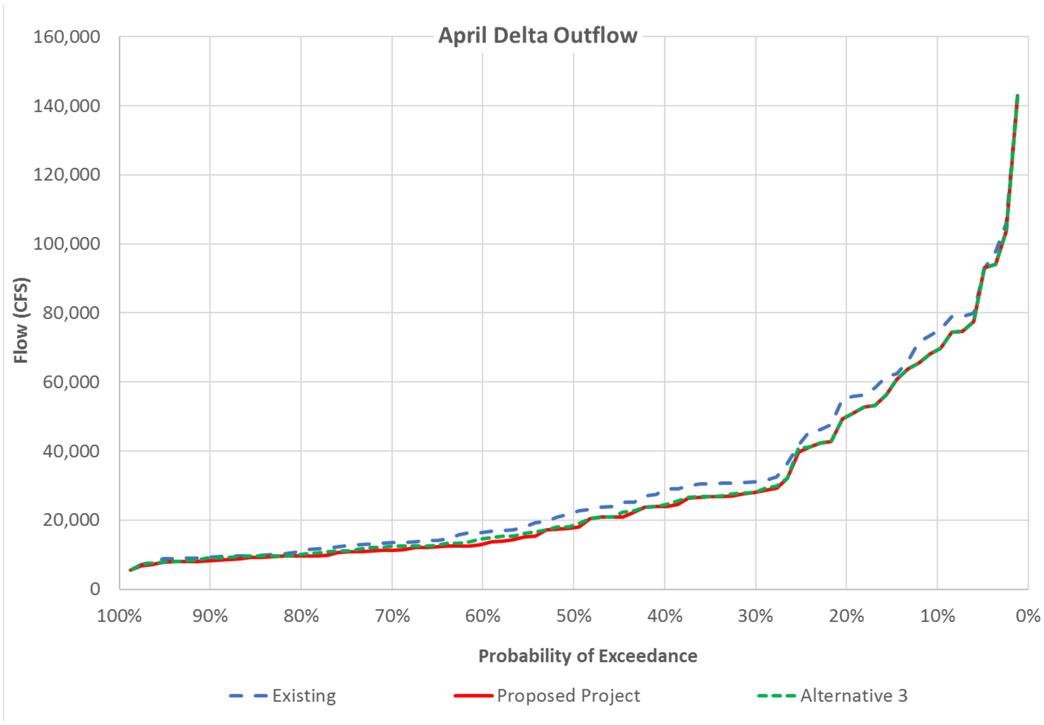


Figure 5.4-2. Exceedance Probability of April Delta Outflow

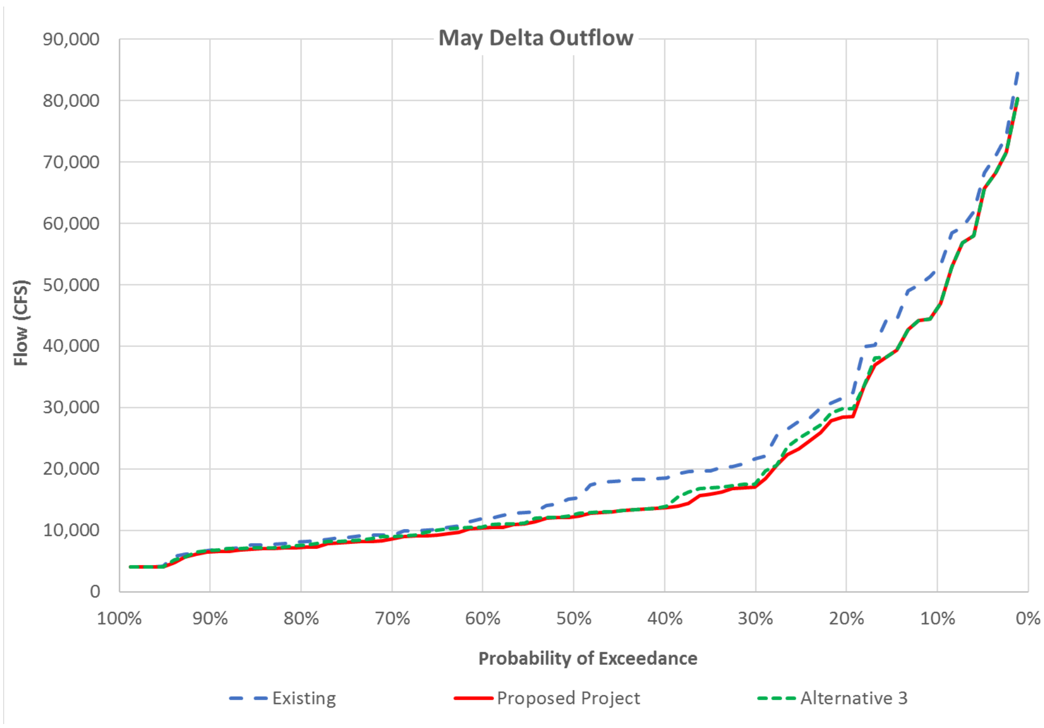


Figure 5.4-3. Exceedance Probability of May Delta Outflow

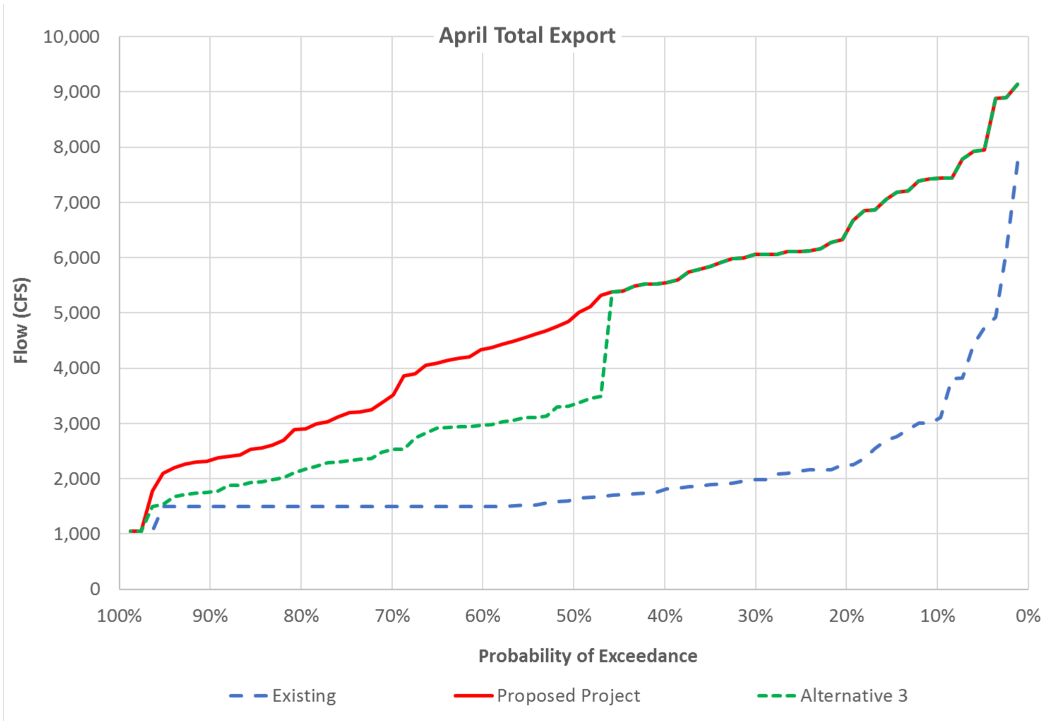


Figure 5.4-4. Exceedance Probability of April Total Exports

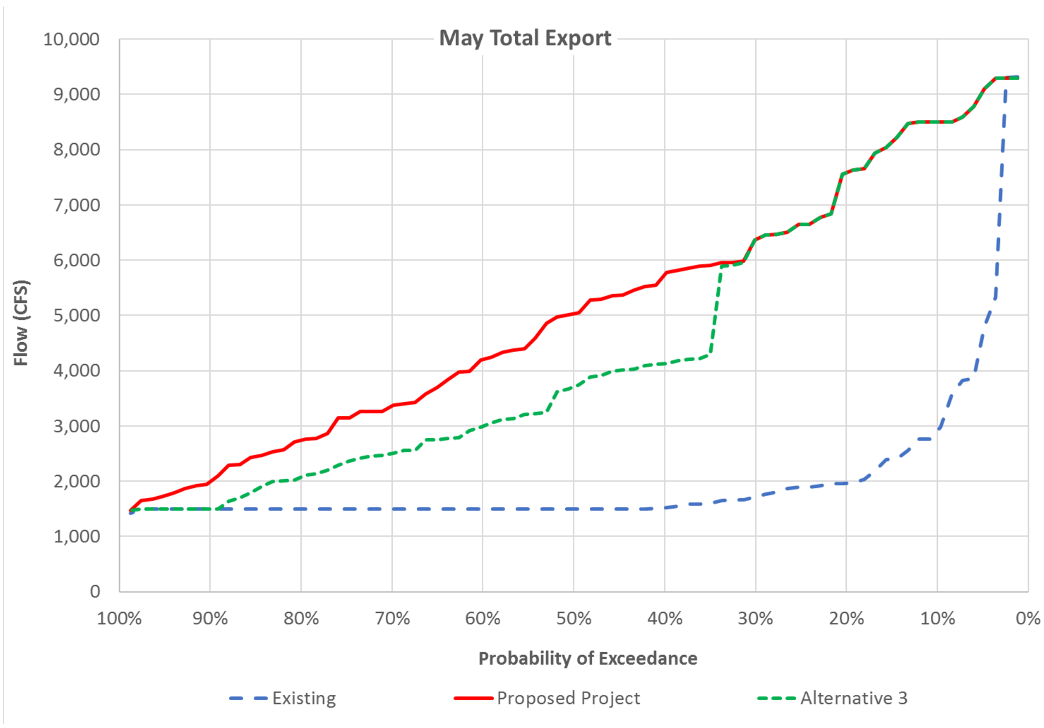


Figure 5.4-5. Exceedance Probability of May Total Exports

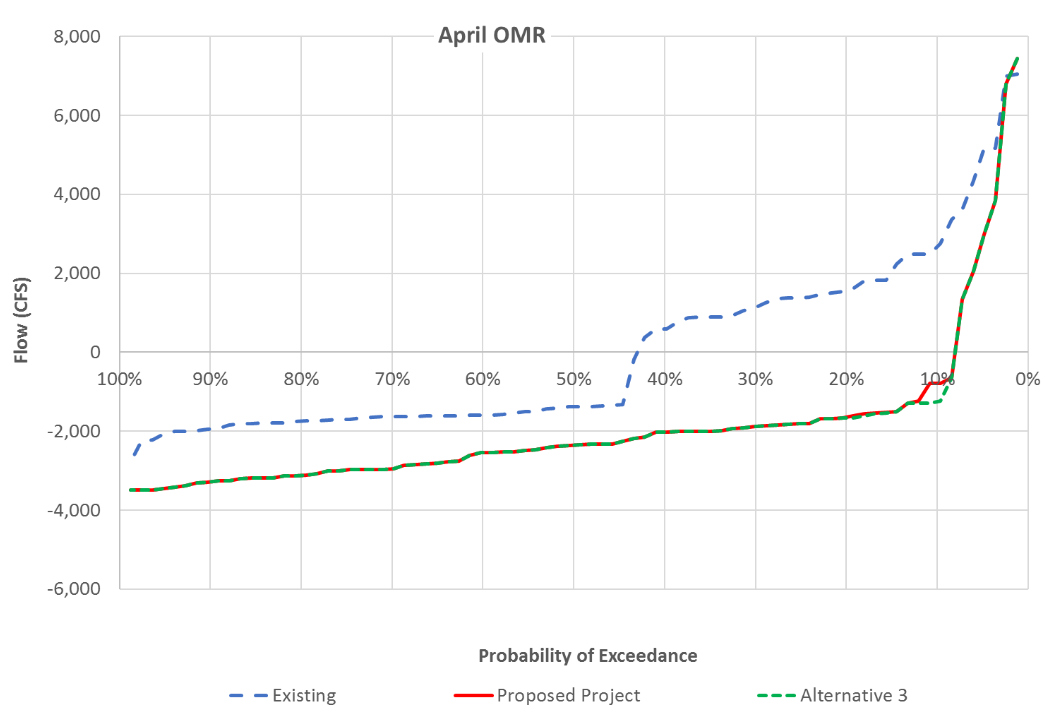


Figure 5.4-6. Exceedance Probability of April OMR Flow

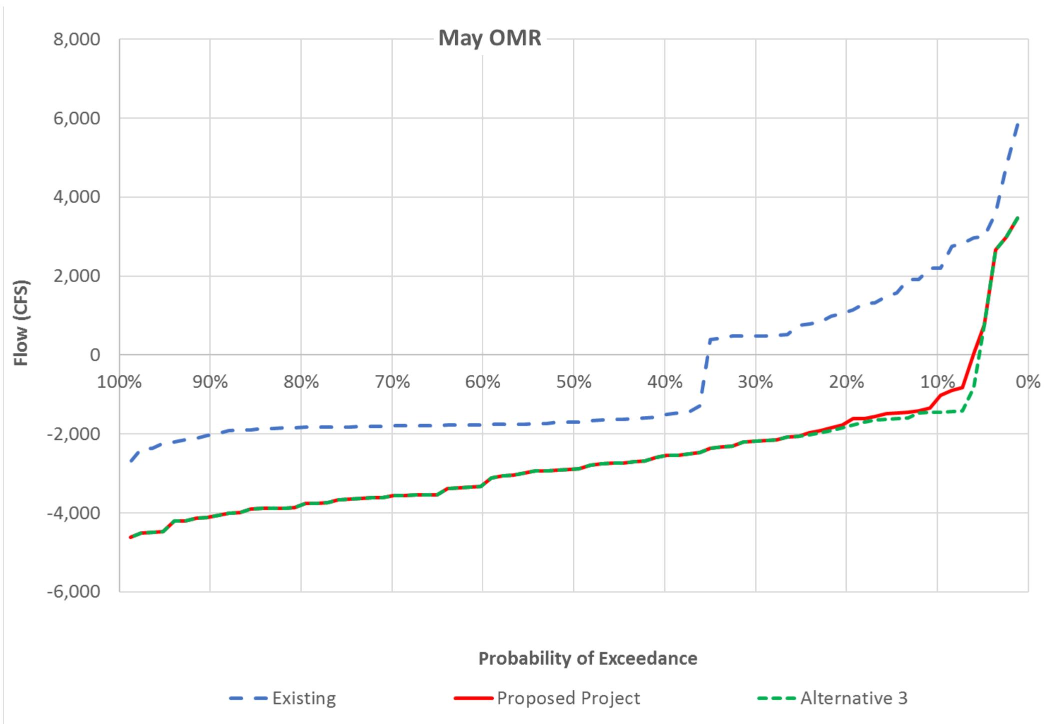


Figure 5.4-7. Exceedance Probability of May OMR Flow

5.4.4 Surface Water Quality

The predicted differences in surface water quality estimated for Alternative 3 when compared to Existing Conditions and the proposed project are due to the changes in Delta outflow and exports described in Section 5.4.3 above. Similar to the proposed project, Alternative 3 operations generally would increase salinity during the late fall and early winter in years following wet and above normal water years, as a result of the proposed Summer-Fall Delta Smelt habitat action. Modeling of Existing Conditions and the proposed project suggests the potential for D-1641 compliance exceedances, but these modeled exceedances are attributable to hydrologic modeling assumptions and limitations and are not expected to occur in real-time operations (Nader-Tehrani, 2016). Historically, SWP and CVP have a high degree of success in meeting D-1641 requirements (Leahigh, 2016). Operations to meet D-1641 requirements would be similar under Alternative 3. Surface water quality under Alternative 3 would be similar to surface water quality of Existing Conditions and proposed project. Therefore, impacts to surface water quality are expected to remain **less than significant**.

Construction of the proposed barriers could result in increased turbidity during in-water activities, including placement of gravel fill, pile driving and placement of concrete anchor blocks for navigation aids, and the installation of dolphin structures. The proposed conservation measures described above would substantially reduce the potential for increased turbidity so that the project would meet Basin Plan limits and other water quality standards. Therefore, potential water quality impacts of the proposed barriers would be **less than significant**.

5.4.5 AQUATIC RESOURCES

Potential impacts of Alternative 3 on aquatic resources generally would be similar to the proposed project because water operations would be the same, except for potentially somewhat lower south Delta exports under Alternative 3 in order to manage Old and Middle River flows in the presence of the Head of Old River during April/May. Lower south Delta exports would result in greater Delta outflow during April/May, but the differences would be only on the order of a few hundred cfs (Table 5.2-3 and 5.2-4) and therefore any Delta outflow-related effects would be expected to be essentially the same as the Proposed Project; these effects are not discussed in the sections below, which summarize the main potential effects of the Georgiana Slough barrier and the Head of Old River barrier, with the latter considered in relation to Old and Middle River flows (Tables 5.2-5 and 5.2-6). Implementation of the conservation measures described in Section 5.4.1~~5.5.1~~ would limit the potential for negative effects from Head of Old River barrier construction, so the analysis below focuses on operational effects.

5.4.5.1 DELTA SMELT

Operation of a non-physical barrier at Georgiana Slough would be expected to have limited effects on Delta Smelt because the species is generally found well downstream of the Georgiana Slough junction. Delta Smelt encountering the barrier would be expected to be early life stages (e.g., larvae) moving downstream to rear in areas such as the low salinity zone and would not be expected to be deterred from entering Georgiana Slough because of weak swimming ability.

Operation of a Head of Old River physical barrier in April/May would tend to lower Old and Middle River flows for a given level of exports, with the potential to increase entrainment risk as noted in the USFWS (2008, p.378) SWP/CVP BiOp, but exports would be managed in order to maintain protective criteria to limit entrainment risk, consistent with the proposed project.

Implementation of Alternative 3 would be **less than significant** for Delta Smelt, the same as the conclusion for the Proposed Project.

5.4.5.2 Longfin Smelt

Operation of a non-physical barrier at Georgiana Slough would be expected to have limited effects on Longfin Smelt because the species is generally found well downstream of the Georgiana Slough junction. Longfin Smelt encountering the barrier would be expected to be early life stages (e.g., larvae) moving downstream to rear as juveniles in higher salinity areas such as San Francisco Bay, and would not be expected to be deterred from entering Georgiana Slough because of weak swimming ability.

Operation of a Head of Old River physical barrier in April/May would tend to lower Old and Middle River flows for a given level of exports, but exports would be managed in order to maintain protective criteria to limit entrainment risk, consistent with the proposed project.

Implementation of Alternative 3 would be **less than significant** for Longfin Smelt, the same as the conclusion for the Proposed Project.

5.4.5.3 Winter-Run Chinook Salmon

Operation of a non-physical barrier at Georgiana Slough would have the potential to benefit Winter-Run Chinook Salmon juveniles by reducing entry into the interior Delta at Georgiana Slough. Modeling of through-Delta survival (e.g., with the Delta Passage Model) suggested little difference between Existing Conditions and the Proposed Project, so reducing entry into Georgiana Slough would have the potential to result in greater through-Delta survival than Existing Conditions based on available scientific studies (Perry et al. 2013; Perry et al. 2014). Upstream-migrating Winter-Run Chinook Salmon adults would have the potential to encounter the barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Operation of a Head of Old River physical barrier in April/May would tend to lower Old and Middle River flows for a given level of exports, but exports would be managed in order to maintain protective criteria to limit entrainment risk, consistent with the proposed project. Winter-Run Chinook Salmon juveniles also have limited temporal overlap with the period of Head of Old River barrier operations.

Implementation of Alternative 3 would be **less than significant** for Winter-Run Chinook Salmon.

5.4.5.4 Spring-Run Chinook Salmon

Operation of a NPB at Georgiana Slough would have the potential to reduce Spring-Run Chinook Salmon juvenile entry into the interior Delta at Georgiana Slough, thereby reducing the potential limited negative effects of greater south Delta exports under the Proposed Project compared to Existing Conditions that were suggested by the Delta Passage Model. Upstream-migrating Spring-Run Chinook Salmon adults would have the potential to encounter the barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Operation of a Head of Old River physical barrier in April/May would tend to lower Old and Middle River flows for a given level of exports, but consistent with the proposed project, it would be expected that entrainment risk would be limited for Spring-Run Chinook Salmon juveniles and the species may receive ancillary protection from Old and Middle River flow management for other species. The presence of the Head of Old River barrier would be likely to result in through-Delta survival of San Joaquin River basin Spring-Run Chinook Salmon juveniles that is similar to Existing Conditions because both Alternative 3 and Existing Conditions include the barrier. The Head of Old River physical barrier would potentially improve survival of San Joaquin River basin Spring-Run Chinook Salmon juveniles compared to the proposed project.

Implementation of Alternative 3 would be **less than significant** for Spring-Run Chinook Salmon, the same as the conclusion for the Proposed Project.

5.4.5.5 Fall-Run and Late Fall-Run Chinook Salmon

Operation of a NPB at Georgiana Slough would have the potential to reduce Fall-Run and Late Fall-Run Chinook Salmon juvenile entry into the interior Delta at Georgiana Slough, thereby further reducing the less-than-significant effects of greater south Delta exports under the Proposed Project compared to Existing Conditions that were suggested by the Delta Passage Model. Upstream-migrating Late Fall-Run Chinook Salmon adults would have the potential to encounter the barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Operation of a Head of Old River physical barrier in April/May would tend to lower Old and Middle River flows for a given level of exports, but consistent with the proposed project, it would be expected that entrainment risk would be limited for Fall-Run Chinook Salmon juveniles and the species may receive ancillary protection from Old and Middle River flow management for other species. The presence of the Head of Old River barrier would be likely to result in through-Delta survival of San Joaquin River basin Fall-Run Chinook Salmon juveniles that is similar to Existing Conditions, given that both Alternative 3 and Existing Conditions include the barrier. The Head of Old River physical barrier would potentially improve survival of San Joaquin River basin Fall-Run Chinook Salmon juveniles compared to the proposed project.

Implementation of Alternative 3 would be **less than significant** for Fall-Run and Late Fall-Run Chinook Salmon, the same as the conclusion for the Proposed Project.

5.4.5.6 Central Valley Steelhead

Operation of a NPB at Georgiana Slough would have the potential to reduce Central Valley Steelhead juvenile entry into the interior Delta at Georgiana Slough, as observed during the 2012 pilot study (DWR 2014), thereby reducing the less-than-significant effects of greater south Delta exports under the Proposed Project compared to Existing Conditions that were suggested by the salvage-density method. Upstream-migrating Central Valley Steelhead adults would have the potential to encounter the barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Operation of a Head of Old River physical barrier in April-May would tend to lower Old and Middle River flows for a given level of exports, but consistent with the proposed project, it would be expected that entrainment risk would be limited for Steelhead juveniles as a result of Old and Middle River management criteria specific to the species. Assuming juvenile Steelhead have similar through-Delta survival patterns as juvenile Chinook Salmon in relation to Old River vs. San Joaquin River routing, the presence of the Head of Old River barrier would be likely to result in through-Delta survival of San Joaquin River basin Steelhead juveniles that is similar to Existing Conditions, given that both Alternative 3 and Existing Conditions include the barrier. The Head of Old River physical barrier would potentially improve survival of San Joaquin River basin Steelhead juveniles compared to the proposed project.

Implementation of Alternative 3 would be **less than significant** for Central Valley Steelhead, the same as the conclusion for the Proposed Project.

5.4.5.7 Central California Coast Steelhead

Central California Coast Steelhead would not occur in areas that could be affected by the Georgiana Slough or Head of Old River barriers, so effects of Alternative 3 would be the same as the proposed project and **less than significant.**

5.4.5.8 North American Green Sturgeon and White Sturgeon

Operation of a NPB at Georgiana Slough would be expected to have little effect on Green Sturgeon and White Sturgeon because sturgeons generally have poor hearing ability (Lovell et al. 2005) and therefore would be unlikely to be deterred by the acoustic stimulus of the barrier. The near-bottom water column position of the sturgeons (Moyle 2002) also would tend to limit their potential to encounter the non-physical barrier because the sound/light/bubble deterrent would only be covering the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014).

Operation of a Head of Old River physical barrier in April/May would tend to lower Old and Middle River flows for a given level of exports, but consistent with the proposed project, it would be expected that entrainment risk would be limited the species may receive ancillary protection from Old and Middle River flow management for other species. The salvage-density analysis indicated that spring is not the main period of entrainment of the sturgeons.

Implementation of Alternative 3 would be **less than significant** for North American Green Sturgeon and White Sturgeon, the same as the conclusion for the Proposed Project.

5.4.5.9 Pacific Lamprey and River Lamprey

Operation of a NPB at Georgiana Slough would be expected to have little effect on Pacific Lamprey and River Lamprey because lampreys generally have poor hearing ability (Turnpenny pers. comm.) and therefore would be unlikely to deterred by the acoustic stimulus of the barrier.

Operation of a Head of Old River physical barrier in April/May would tend to lower Old and Middle River flows for a given level of exports, but consistent with the proposed project, it would be expected that entrainment risk would be limited and the species may receive ancillary protection from Old and Middle River flow management for other species, particularly the first flush action for Delta Smelt given that the salvage-density method indicated relatively high entrainment potential in the winter as opposed to the spring period of the barrier operation.

Implementation of Alternative 3 would be **less than significant** for Pacific Lamprey and River Lamprey, the same as the conclusion for the Proposed Project.

5.4.5.10 Other Special Status Native Fish Species

Of the other special status native fish species considered under the analysis of alternatives, only Sacramento Splittail would have considerable potential to be affected by barrier operation under Alternative 3. Juvenile Splittail migrating downstream could encounter the Georgiana Slough non-physical barrier but would only be expected to be deterred away from Georgiana Slough if sufficiently large to swim away from the acoustic stimulus. As with adult salmonids, upstream-migrant adult Splittail would be able to swim under the barrier as necessary to avoid passage obstruction.

Operation of a Head of Old River physical barrier in April/May would tend to lower Old and Middle River flows for a given level of exports, but consistent with the proposed project, it would be expected that entrainment risk would be expected that Splittail may receive ancillary protection from Old and Middle River flow management for listed species, and any differences in entrainment would be expected to have limited effects given that population dynamics appear to be driven by floodplain inundation rather than entrainment risk (Sommer et al. 1997).

Implementation of Alternative 3 would be **less than significant** for other special status native fish species, the same as the conclusion for the Proposed Project.

5.4.5.11 Special Status Non-native fish species

Effects of Alternative 3 on special status non-native fish species (Striped Bass, American Shad, and non-native freshwater bass) would be limited. Upstream-migrating Striped Bass and American Shad adults would have the potential to encounter the Georgiana Slough barrier but would be able to swim beneath the barrier because the sound/light/bubble deterrent would only cover the upper ~50% of the water column, consistent with pilot studies (DWR 2012, 2014). Non-native freshwater bass are largely resident in limited areas (DWR 2016) and therefore would not be expected to encounter the barrier as part of migratory movements, but as with Striped Bass and American Shad, would be able to pass beneath the barrier if necessary.

Operation of a Head of Old River physical barrier in April/May would tend to lower Old and Middle River flows for a given level of exports, but consistent with the proposed project, it would be expected that entrainment risk would be limited, and non-native fish species may receive ancillary protection from Old and Middle River flow management for other species.

Implementation of Alternative 3 would be **less than significant** for Striped Bass, American Shad, and non-native freshwater bass.

5.4.5.12 Killer Whale

Implementation of Alternative 3 would be **less than significant** for Killer Whale because Alternative 3 would have less than significant effects on Chinook Salmon (see previous analyses), which are consumed by Killer Whale.

5.4.6 OTHER RESOURCES

As described in Section 1.4 *Summary of Environmental Consequences* and discussed in detail in Appendix A, *Initial Study*, implementing the Proposed Project is not expected to result in a change in hydrologic conditions (i.e., reservoir storage and river flows) to such a degree that would result in an impact on the environment. Similar to the Proposed Project, Alternative 3 would also not change hydrologic conditions and would therefore not result in an impact on the environment upstream of the Delta. The small changes in modeled exports due to the physical barrier at Head of Old River would have less than significant impacts on deliveries to the 24 south of Delta State Water Contractors due to the small proportional change and the diversity of the water portfolios managed by the receiving water agencies.

Construction of the physical and non-physical barriers would require ground disturbance and vehicle ingress/egress in upland areas that are not addressed in the Initial Study presented in Appendix A. Activities associated with construction of the two barriers included in Alternative 3 would potentially impact the following resources:

- Air Quality
- Biological Resources (Terrestrial)
- Cultural Resources
- Greenhouse Gas Emissions
- Noise
- Transportation/Traffic
- Tribal Cultural Resources

Each of these resource topics are briefly described below.

Other resource topics that are not likely to be impacted by Alternative 3 include:

- Aesthetics
- Agriculture and Forestry Resources
- Energy
- Geology and Soils
- Hazards and Hazardous Materials
- Land Use and Planning
- Mineral Resources
- Population and Housing
- Public Services
- Recreation
- Utilities and Service Systems
- Wildfire

5.4.7 OTHER CONSIDERATIONS

The proposed CVP LTO does not include the HORB or the non-physical barrier at Georgiana Slough. Alternative 3 would potentially impact the ability of the CVP to divert water due to changes in Old and Middle River flows. The impacts to the CVP will be greater than described in the cumulative impacts section for the Proposed Project.

Construction and operation of the barriers included in Alternative 3 would require review and approval from the U.S. Army Corps of Engineers, the Regional Water Quality Control Board, the California Department of Fish and Wildlife. The U.S. Army Corps of Engineers approval would also require compliance with Section 7 of the Endangered Species Act, which would include issuance of a biological opinion from the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

5.5 ALTERNATIVE 4 – ALTERNATIVE SUMMER-FALL ACTION

Alternative 4 would replace the Summer-Fall action described in Section 3.3.3 of the Proposed Project. The objective of this alternative is to improve habitat availability for Delta smelt in areas of Suisun Bay and Suisun Marsh. This alternative is adapted from the proposed operations and environmental criteria developed by the California Department of Fish and Wildlife and presented in Appendix I. Table 5.5-1 summarizes the difference between the summer-fall action proposed in Alternative 4 versus the similar measure proposed for the Proposed Project.

Table 5.5-1. Comparison of Summer Fall Actions Included in Alternative 4 Compared to the Proposed Project

Criteria	Proposed Project	Alternative 4
X2 Location - Fall	Monthly average X2 at 80 km **Water Years**: Above Normal / Wet **Months**: Sept - October	Monthly average $\leq$ 80 km (Above Normal years), or < preceding August (Wet years) **Water Years**: Same as PP **Months**: Same as PP
X2 Location - Summer	N/A	14-day average $\leq$ 80 km **Water Years**: Below Normal/Above Normal/Wet **Months**: June - August
SMSCG Operation	60 days **Water Years**: Below Normal /Above Normal/Wet (if supported by preliminary analysis) **Months**: June - October	60 days **Water Years**: Below Normal / Dry **Months**: June - August
4 ppt salinity at Belden's Landing	N/A	**Years**: Below Normal/Dry **Months**: June - August
Food enhancement action	Included	Not included

Notes:
km = kilometer
N/A = not applicable
ppt = parts per thousand
SMSCG = Suisun Marsh Salinity Control Gates

Table 5.5-2 summarizes the proposed summer-fall actions included in Alternative 4 during each of the five water year types.

Table 5.5-2. Summary of Summer-Fall Actions Proposed for Alternative 4

Season	Month	Critically Dry Water Year Type	Dry Water Year Type	Below Normal Water Year Type	Above Normal Water Year Type	Wet Water Year Type
Summer Actions	June	N/A	Up to 60 days of SMSCG operation	X2 < 80 monthly average Up to 60 days of SMSCG operation	X2 < 80 14-day average	X2 < 80, 14-day average
Summer Actions	July	N/A	Up to 60 days of SMSCG operation	X2 < 80 monthly average Up to 60 days of SMSCG operation	X2 < 80 14-day average	X2 < 80, 14-day average
Summer Actions	August	N/A	Up to 60 days of SMSCG operation	X2 < 80 monthly average Up to 60 days of SMSCG operation	X2 < 80 14-day average	X2 < 80, 14-day average
Fall Actions	September	N/A	N/A[1]	N/A[1]	X2 < 80 monthly average	X2 < preceding August, monthly average
Fall Actions	October	N/A	N/A[1]	N/A[1]	X2 <80 monthly average	X2 < preceding August, monthly average

Notes:
[1]. SMSCG operation could be extended into September if within the 60 day of operations. October operations of the SMSCG would be as described in Section 3.1.2.5.
N/A = not applicable
SMSCG = Suisun Marsh Salinity Control Gates

Expanded descriptions of the operational and environmental criteria included in Alternative 4 and the rationale for the proposed criteria are provided below by water year type.

- Wet Years
  - **Summer Months:** X2 ≤ 80 km on a 14-day running average for the months of June, July, and August. The 14-day average would begin on June 1.
  - **Fall Months:** Average monthly X2 ≤ to what occurred in preceding August for the months of September and October.
- Above Normal Years
  - **Summer Months:** X2 ≤ 80 km on a 14-day running average for the months of June, July, and August. The 14-day average begins to run on June 1.
  - **Fall Months:** Average monthly X2 ≤ 80 km for the months of September and October.
- Below Normal Years
  - **Summer and Fall Months:** Based on advice from a real-time working group, and in coordination with CDFW, average monthly X2 ≤ 80 km for the months of June, July, and August or up to 60

days of operation of the SMSCG, or a combination of both. Action can be extended into the Fall if within the 60-days of SMSCG operations.

- Dry Years
  - **Summer and Fall Months:** Operation of the SMSCG for a period at least 60 days for the months of June, July, and August. A real-time working group will form in Dry years and meet regularly to determine when operation of the SMSCG is appropriate. Action can be extended into September if within the 60-days of SMSCG operations.

5.5.1 HYDROLOGY

Alternative 4 would replace the Summer-Fall action described in the Proposed Project with all other operations being the same. Therefore, this analysis focuses on the changed criteria. In general, Alternative 4 adds Delta Smelt habitat criteria to the Summer-Fall action described in the Proposed Project. These water quality criteria include the position of the 2 ppt isohaline from the golden gate bridge (X2) in wet and above normal, and a 4 ppt target at Belden's Landing from June to August in below normal and dry years.

Alternative 4 is generally consistent with the Summer-Fall action in the Proposed Project but would include the following additional criteria:

- Wet Years
  - Criteria: 14 day running average X2 of less than 80 km from June 1 to August 31
  - Criteria: Maintain average monthly X2 from preceding August
- Above Normal Years
  - Criteria: 14 day running average X2 of less than 80 km from June 1 to August 31
- Below Normal Years
  - Criteria: Maintain 4 ppt at Belden's Landing between June 1 and August 31 by implementing a combination of the following actions:
    - 14 day running average X2 of less than 80 km; or
    - Up to 60 days of SMSCG operation
- Dry Years
  - Criteria: Maintain 4 ppt at Belden's Landing between June 1 and August 31 by operating the SMSCG for up to 60 days

Additional outflow may be required to meet the 80 km X2 criteria under this alternative. The increased outflow would come from some combination of the following:

- SWP and CVP export reductions, or
- Increased reservoir releases from Oroville.
- Water purchases from other water users.

Actions available to meet the 4 ppt criteria at Belden's Landing under this alternative include:

- Operation of the SMSCG – This would require a compensating flow action of either export reduction or increase in reservoir release from the SWP and CVP to maintain D-1641 water quality standards.
- If salinity concentration at Collinsville (head of Montezuma Slough) is too high (e.g., greater than 4 ppt), additional outflow may be required in conjunction with SMSCG operation in order to meet the 4 ppt at Belden's Landing. Additional outflow would reduce salinity at Collinsville, freshening Montezuma Slough inflow through SMSCG operation. This additional outflow would likely come from SWP and CVP export reductions or increased reservoir releases.

5.5.1.1 Method of Analysis

Historical data (2009 to 2019) was analyzed to indicate if an additional action would have been required under historical conditions to meet the requirements under this alternative. In the last 11 years there have been three wet years, zero above normal years, four below normal years, two dry years, and two critical years.

When evaluating the historical conditions for periods where a modified operation would be required to meet the X2 criteria listed in the alternative, an estimated increment of additional Delta outflow needed to maintain the criteria was estimated with the following equation developed by Jassby et. al. 1995.

$$X2_{(t)} = 10.16 + 0.945 * X2_{(t-1)} - 1.487 \log QOUT_{(t)} \qquad (1)$$

5.5.1.2 Wet and Above Normal Years

Historical conditions from wet years 2011, 2017, and 2019 indicates that with the conditions under this alternative, the SWP and CVP would have been required to modify operations to meet the 80 km criteria in two of the three wet years used for this analysis, as shown in Figure 5.5-1. The required X2 criteria would likely be met from reducing exports, however, the X2 criteria could also be met through an increase in reservoir releases. There were no above normal years within the time period analyzed. Above normal years would be expected to have higher water costs compared to wet years because there would be less water available to meet the same X2 criteria.

As shown in Figure 5.5-1, the historical data indicates that 2011 would not have needed additional flow, however 2017 and 2019 would have required a relatively small amount of additional outflow to keep the X2 below 80 km. Using equation 1 the additional Delta outflow to maintain an X2 position at 80 km was estimated

Table 5.5-3. Estimated Additional Delta Outflow Needed to meet a 14-day average X2 of 80 km from June 1 to August 31

-	2011	2017	2019
Additional Delta Outflow (TAF)	0	12	67

Note: Dash "-" indicates blank cell
TAF = thousand acre feet

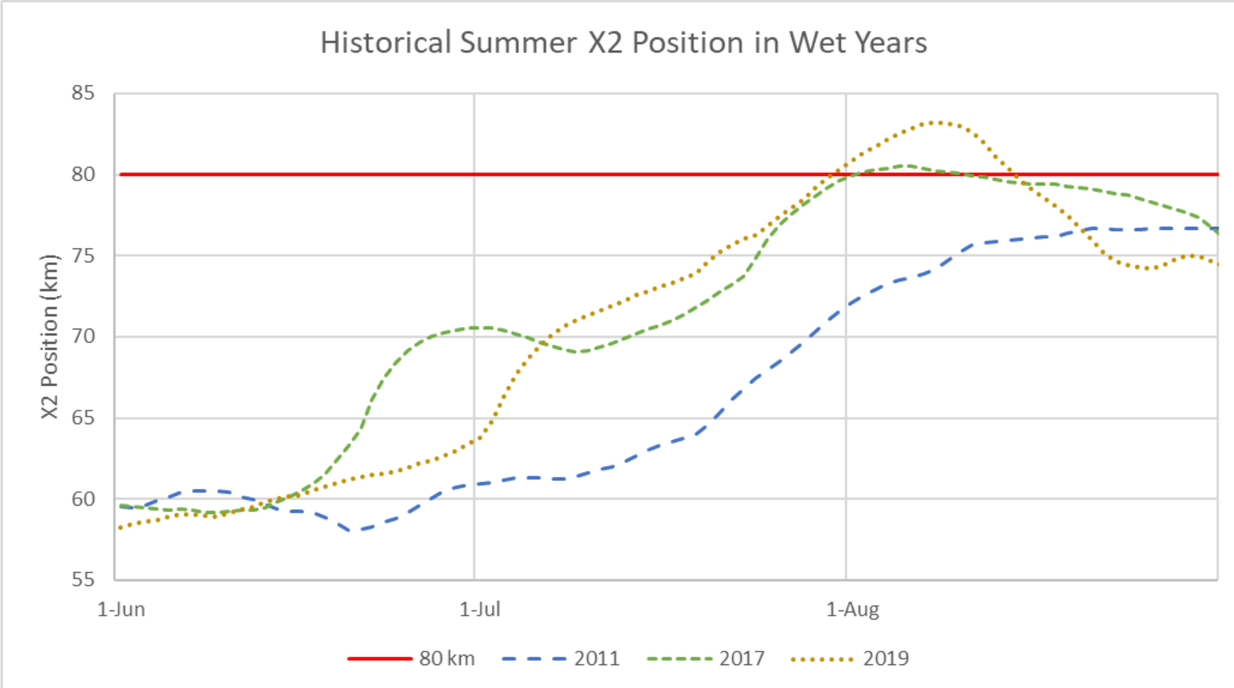


Figure 5.5-1. Historical Summer 14-day Running Average X2 Position in Wet Years.

In wet years, the SWP and CVP would need to meet the average X2 from the preceding August in September and October. The additional outflow required to meet the average X2 during this time period would be potentially greater than the quantity that was analyzed for the proposed project.

For wet and above normal years, the Proposed Project includes SMSCG gate operations up to 60 days to meet the criteria of 4 ppt salinity at Belden's landing. The estimated compensating flow needed for a 60-day SMSCG gate operation is roughly 80 TAF which is similar to the higher cost shown in Table 5.5-3. The water costs for the June through August period is expected to be similar. Above normal years are expected to perform the same as wet years and result in similar or greater water costs. The additional Delta outflow required in wet years could be greater than the water cost of the 60-day SMSCG operation depending on the average X2 during the preceding August. The additional outflow required to meet the average X2 during September and October of a wet year would be potentially greater than the quantity that was analyzed in the proposed project.

As shown in Table 5.5-4the monthly average X2 in the most recent historical wet years indicate that the required X2 in September and October would have been between 76 and 78 km which is greater than the 80 km in the proposed project. The additional X2 requirement would likely require additional outflow above that in the proposed project.

Table 5.5-4. Monthly average X2 in August would be used to Determine September and October criteria.

-	2011	2017	2019
Historical Monthly X2 (km)	76	78	77

Note: Dash "-" indicates blank cell
km = kilometer(s)

5.5.1.3 BELOW NORMAL YEARS

Historical conditions from below normal years 2010, 2012, 2016, and 2018 were used to evaluate the potential need for modifying SWP operations under this alternative. The historical X2 position indicates that maintaining the 80 km criteria in below normal years would have required modification to the SWP and CVP operations. As shown in Figure 5.5-2, 3 of the 4 below normal years would have required an action by mid-June. A year similar to 2010 would require an action beginning mid-July.

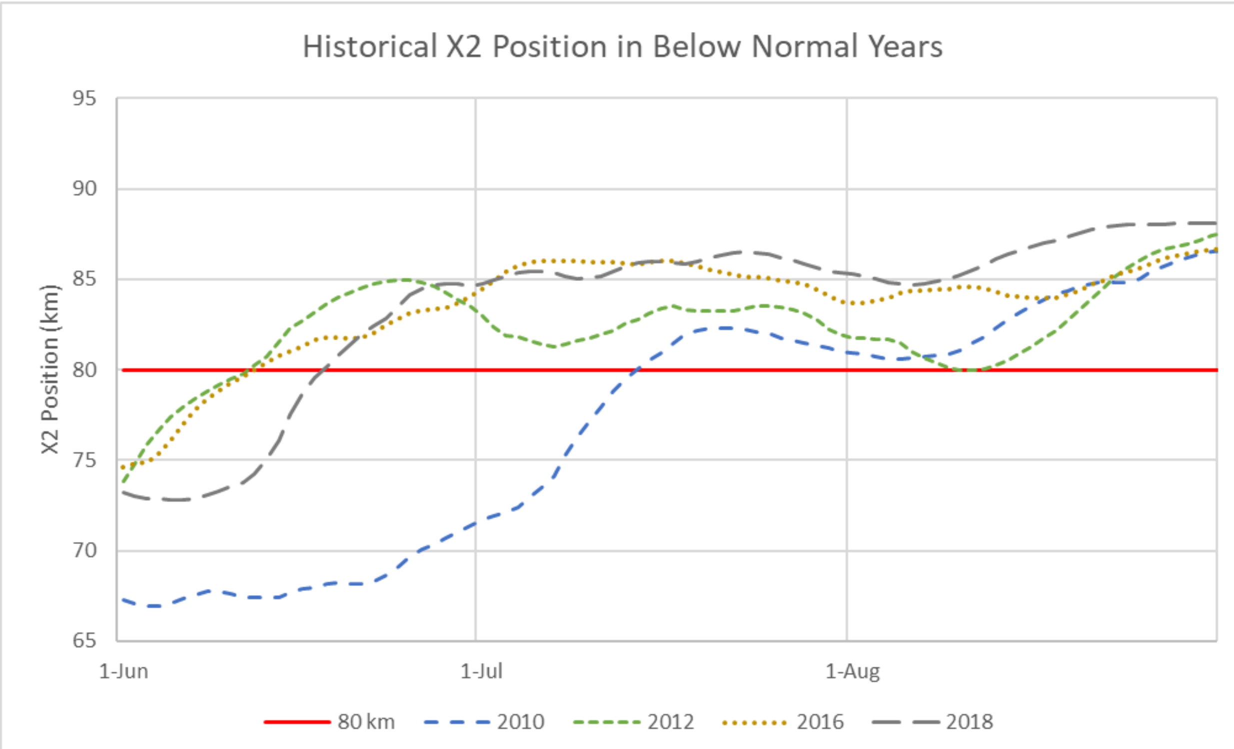


Figure 5.5-2. Historical summer 14-day running average X2 position in below normal years.

As shown in Figure 5.5-2, historical below normal years tend to exceed 80 km beginning mid-June. In below normal years an 80 km criteria would require substantial increases in outflow. Using equation 1, the water volume required to meet the 80 km criteria in each of these years was estimated in Table 5.5-5 shows that the potential water needed to maintain an X2 of 80 km in below normal years could be as high as 500 TAF in additional outflow.

Table 5.5-5. Estimated additional Delta outflow needed to meet a 14-day average X2 of 80 km from June 1 to August 31

-	2010	2012	2016	2018
Additional Delta Outflow (TAF)	218	329	440	499

Note: Dash "-" indicates blank cell
TAF = thousand acre feet

The historical salinity at Belden's Landing as shown in Figure 5.5-3, indicates that a SMSCG operation or additional X2 action would be required as early as mid-June in three out of four below normal years to potentially maintain a salinity of less than 4 ppt. Most of the years show an increasing trend, except for 2018 which shows a significant reduction in the early part of August and holding through the month.

The data from 2018 is reflecting a SMSCG operation where the gate was operated beginning August 2nd and continued until September 7th. That gate operation was estimated to have had a water cost of about 40 TAF of compensating flow to offset the water quality effects of the SMSCG operation.

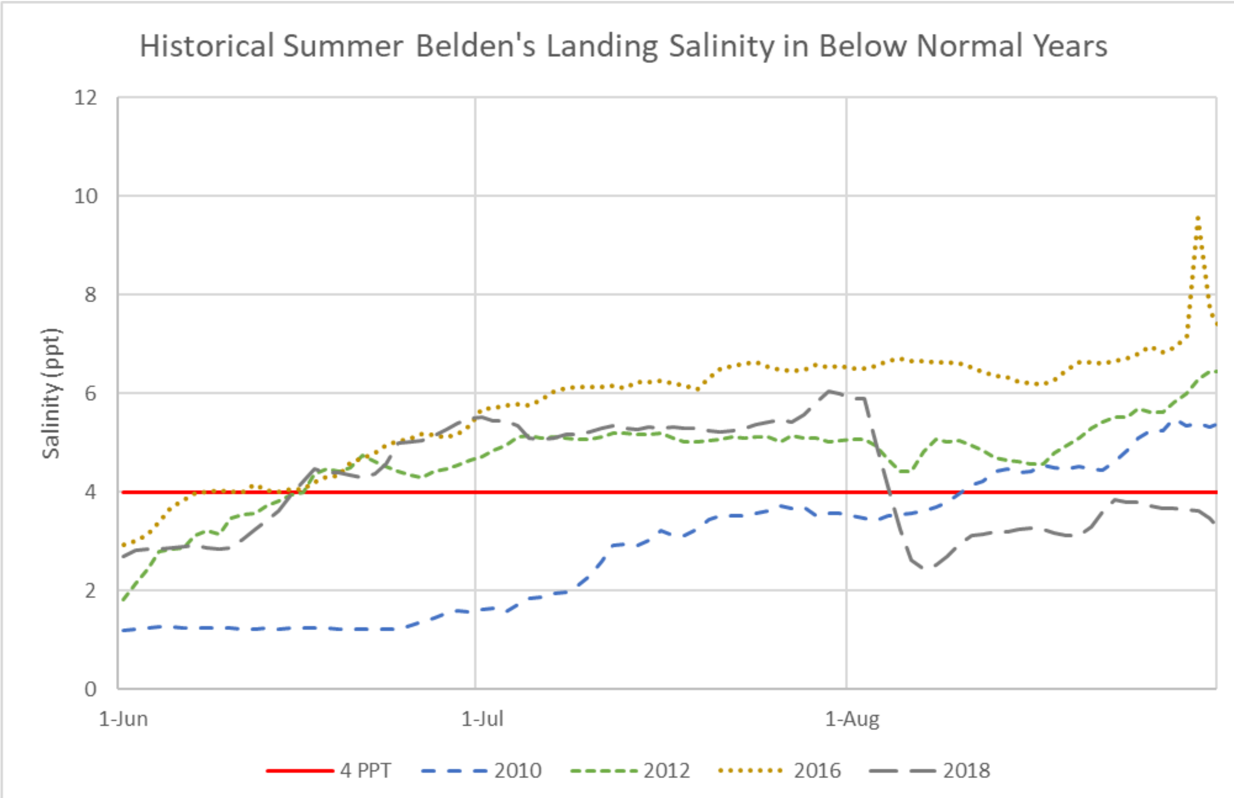


Figure 5.5-3. Historical daily average salinity at Belden's Landing in parts per thousand (ppt) in below normal years 2010, 2012, 2016, and 2018.

Alternative 4 would require a salinity at Belden's Landing of less than 4 ppt in below normal years. This criterion can generally be achieved by maintaining X2 near the confluence of the Sacramento and San Joaquin Rivers (80 km is located downstream of the confluence). As shown in Figure 5.5-2 the transition between less than 80 km and greater than 80 km occurs about the same time as the salinity transition to above 4 ppt at Belden's Landing, as shown in Figure 5.5-3. This occurs for years 2012, 2016, and 2018, however in 2010, Belden's Landing was less than 4 ppt while the X2 was greater than 80 km.

The Proposed Project includes 60 days of SMSCG operation which, based on the performance of 2018 would very likely be sufficient to meet the 4 ppt requirement at Belden's Landing. The historical data shown in Figure 5.5-3, indicates that the salinity at Belden's Landing for most below normal years exceeds 60 days. However, because of fresh starting conditions in mid-June and the performance of the 2018 August SMSCG operation it is expected that alternate day operation of SMSCG could maintain conditions within the 60 days allotted. Therefore, it is expected that below normal gate operations are consistent with the Proposed Project.

There are two options to meet the below normal criteria, 1) Operate the SMSCG to meet the 4 ppt salinity criteria at Belden's Landing, or 2) additional outflow to maintain 80 km X2. It is expected that SMSCG operations alone would maintain 4 ppt at Belden's Landing and would not result in an additional water cost above what was analyzed for the Proposed Project. However, if SMSCG operations are not available for some reason, then the water cost could be substantial. Historical data indicates that the additional outflow required could approach 500 TAF which would require either SWP and CVP export reductions or increase in SWP and CVP reservoir releases of a similar magnitude.

5.5.1.4 Dry Years

Historical conditions from dry years were used to evaluate the potential need for SMSCG operations. There is no historic data for SMSCG operations in the summer of dry years. Based on the historical data for two dry years, a SMSCG action would have been required by the end of June in both 2009 and 2013, as shown in Figure 5.5-4. Operating the SMSCG during this time period would have required a compensating action from the SWP and the CVP.

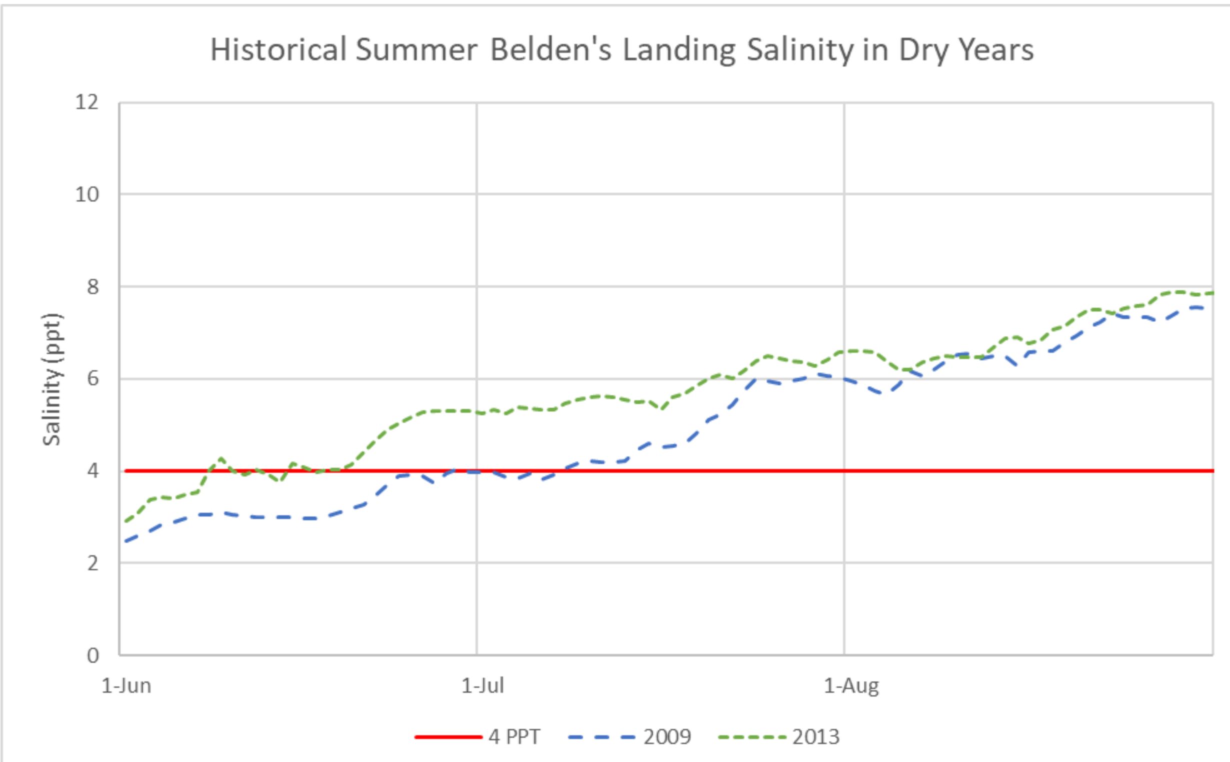


Figure 5.5-1. Historical daily average salinity at Belden's Landing in parts per thousand (ppt) in dry years 2009 and 2013.

Operation of the SMSCG is the only required action in dry years. The Proposed Project does not include any summer actions in dry years and so adding SMSCG operation would result in additional outflow compared to the proposed project. As shown in

Figure 5.5-1, historic data from two dry years, 2009 and 2013, indicate that gate operations would have been required for approximately 50 to 80 days. The water cost associated with operating the SMSCG for this duration is about 60 to 100 TAF. The compensating action most likely would have been in the form of export reductions but increases in reservoir release could have been used as well.

5.5.1.5 Conclusion

Based on historical data, it is expected that Alternative 4 would require the following operations:

1. **Wet Years** - SWP and CVP would need to adjust operations in the late summer to maintain the 80 km X2 criteria for the June through August time period. In addition, the average resulting X2 determined for August would be maintained through the months of September and October.
   a. Compared to the existing conditions this would slightly increase the Delta outflow in August and decrease outflow in September and October of wet years.
   b. Compared to the proposed project this would slightly increase the Delta outflow in August, September and October of wet years.
2. **Above Normal Years** - SWP and CVP would need to adjust operations in the late summer to maintain the 80 km X2 criteria.
   a. Compared to the existing condition this would slightly increase the Delta outflow in above normal years.
   b. Compared to the proposed project this would slightly increase the Delta outflow in above normal years.
3. **Below Normal Years** – The SMSCG would be operated as early as mid-June, however this is within the range of operations included in the Propose Project. It is expected that 60 days of SMSCG operations would likely enough to maintain salinity conditions below 4 ppt at Belden's Landing. However, in the event that SMSCG operations are not available, then the water cost could be substantial and upwards of 500 TAF.
   a. Compared to existing conditions the Delta outflow would be:
      i. Higher during the summer months with the SMSCG operation, or
      ii. Substantially higher with an 80 km X2 requirement
   b. Compared to the Proposed Project the Delta outflow would be:
      i. About the same during the summer months with the SMSCG operation, or
      ii. Substantially higher with an 80 km X2 requirement
4. **Dry Years** – The historical data indicates a SMSCG action would be needed starting in June. SWP and CVP export reductions or reservoir releases would need to be increased to compensate for the gate operation. The volume of water required to compensate for the gate operation could be as much as 100 TAF. This additional water would likely come from reductions in exports.
   a. Compared to existing conditions the Delta outflow would be higher during the summer months
   b. Compared to the Proposed Project the Delta outflow would be higher during the summer months.

5.5.2 Surface Water Quality

The predicted differences in surface water quality for Alternative 4 when compared to Existing Conditions and the proposed project are due to the changes in Delta outflow and exports described above. Alternative 4 operations would generally reduce salinity in the lower Delta compared to the proposed project during the summer and fall months. The reduced salinity would be due to the proposed X2 requirements and Belden's Landing salinity requirements in the Suisun Marsh.

The additional summer-fall operational criteria included in Alternative 4 could reduce exports during June-August in below normal water years and add additional SMSCG operations in dry water years from June through August. It is expected that SMSCG operations alone would maintain salinity at 4 ppt at Belden's Landing and would not add additional water requirements above what was analyzed for the Proposed Project. However, if SMSCG operations are not available, the water cost could be as high as 500 TAF.

The additional outflow requirements would be met by reducing exports to the extent possible, but large increases in outflow (up to 500 TAF) could require water from upstream storage releases that are not included in the proposed project. Increased water releases could originate from SWP reservoirs in the Feather River watershed rather than through shared releases across SWP and CVP reservoirs, because the proposed actions are not included in the CVP federal LTO project. Concentrating the releases in the Feather River watershed could substantially reduce storage and the cold water pool available for fisheries habitat management in the Feather River above the confluence with the Sacramento River in subsequent water years.

The potential impacts to surface water quality would be **potentially significant** under Alternative 4 due to the reduced availability of cold water and reservoir storage needed to meet water quality criteria during years following below normal water years. Mitigation Measure Alt 4-1 is proposed, which would reduce this impact to a **less than significant** level because it would limit the total water supply cost of meeting the salinity criteria at Belden's Landing during below normal water years.

Mitigation Measure Alt 4-1 is described below.

Mitigation Measure Alt. 4-1.

The water quality criteria of 4 ppt at Belden's Landing would be met during June through August in below normal water years using the SMSCG. Offsetting outflows would be provided up to a total water cost of 100 TAF.

5.5.3 AQUATIC RESOURCES

Alternative 4 would be expected to have similar impacts as the Proposed Project except during the Summer-Fall period when the operations and hydrology criteria described above would be implemented. Potential impacts of Alternative 4 relative to Existing Conditions are discussed in more detail below and focus on the following aquatic biological resources:

- Delta smelt and
- Aquatic resources upstream of the Delta

Delta smelt are evaluated in detail because a key objective of Alternative 4 is to improve habitat availability for Delta smelt. Upstream aquatic resources are evaluated because the water quality measures proposed for Alternative 4 in some water years could affect reservoir storage upstream of the Delta.

5.5.3.1 DELTA SMELT

As with the Proposed Project, Alternative 4 proposes to improve the overlap between dynamic and static components of habitat for Delta Smelt during the summer and fall. As described in Chapter 4, Section 4.4.1.4, important environmental characteristics of habitats utilized by Delta Smelt include:

- Salinity
- Turbidity
- Temperature
- Food availability
- Environmental toxins

In the Summer and Fall, Delta Smelt generally reside in the western Delta from Suisun Bay to the Deepwater Ship Channel and Yolo Bypass (north Delta arc). The quality of the habitat varies across regions (Hammock et al. 2015.) The primary difference between the Proposed Project and Alternative 4 is that Alternative 4 emphasizes the low salinity habitat conditions in Suisun Bay and Suisun Marsh and west of the confluence of the Sacramento and San Joaquin Rivers (confluence) in summer and fall in a greatly expanded range of water-year types by targeting 80 km X2, in addition to relying on the SMSCG operations in the dry years. In contrast, the Proposed Project includes a range of actions to improve Delta Smelt habitat conditions including SMSCG operations and food actions primarily in the summer months, in addition to the flow actions targeting the low salinity habitat conditions in Suisun Bay and west of the confluence in fall months.

Salinity

Low salinity zone habitat for Delta Smelt is defined as areas with salinities ≥ 0.5 PSU but ≤ 6 PSU. The location of X2 influences where low salinity habitat is located in relation to Suisun Marsh. Alternative 4 includes criteria for operations, including X2 averages that vary by month and water-year type. These differences in X2 would reflect differences in Delta outflow, resulting in varying extent of low salinity in the Bay-Delta (see example X2 = 74 km, 80 km, and 85 km in Figures 5.5-6, 5.5-7, and 5.5-8). Roy et al. (2014) evaluated the historical position of different surface salinity isohalines relative to the X2 position along the Sacramento and San Joaquin River transects. The data from Roy et al. (2014), was used to explore the extent which the 6 psu isohaline (the upper limit of low salinity habitat) overlaps with Suisun Bay region for varying X2 values. As shown in Figure 5.5-5, observed historical measurements from 1968-2012 indicate that when the X2 is at 81 km, there were many days when the upper bound of the low salinity range (6 psu) is in the Suisun Bay region.

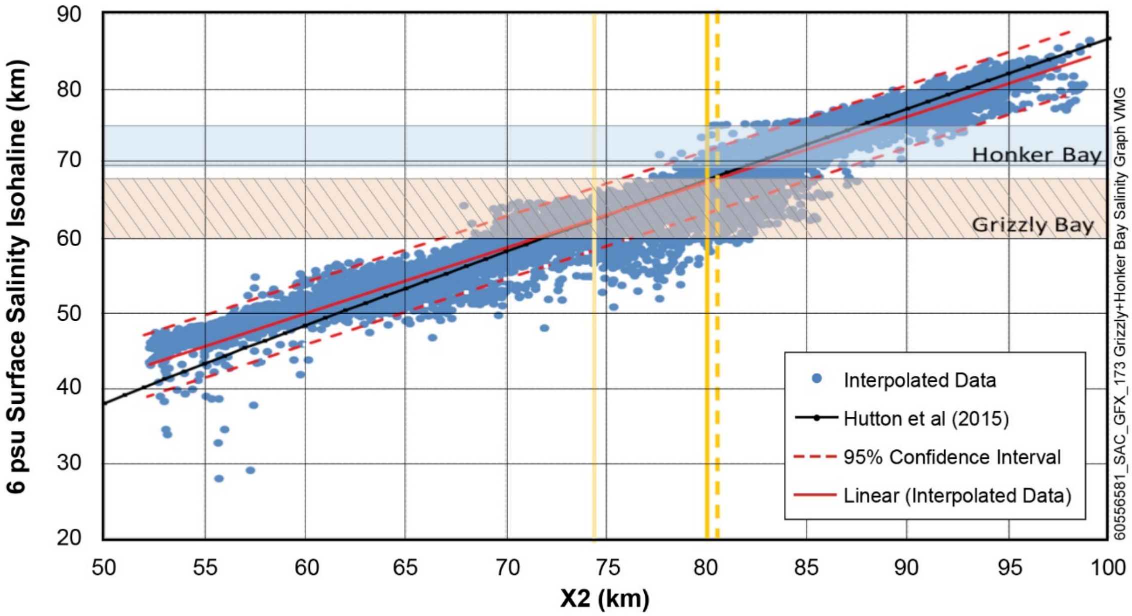
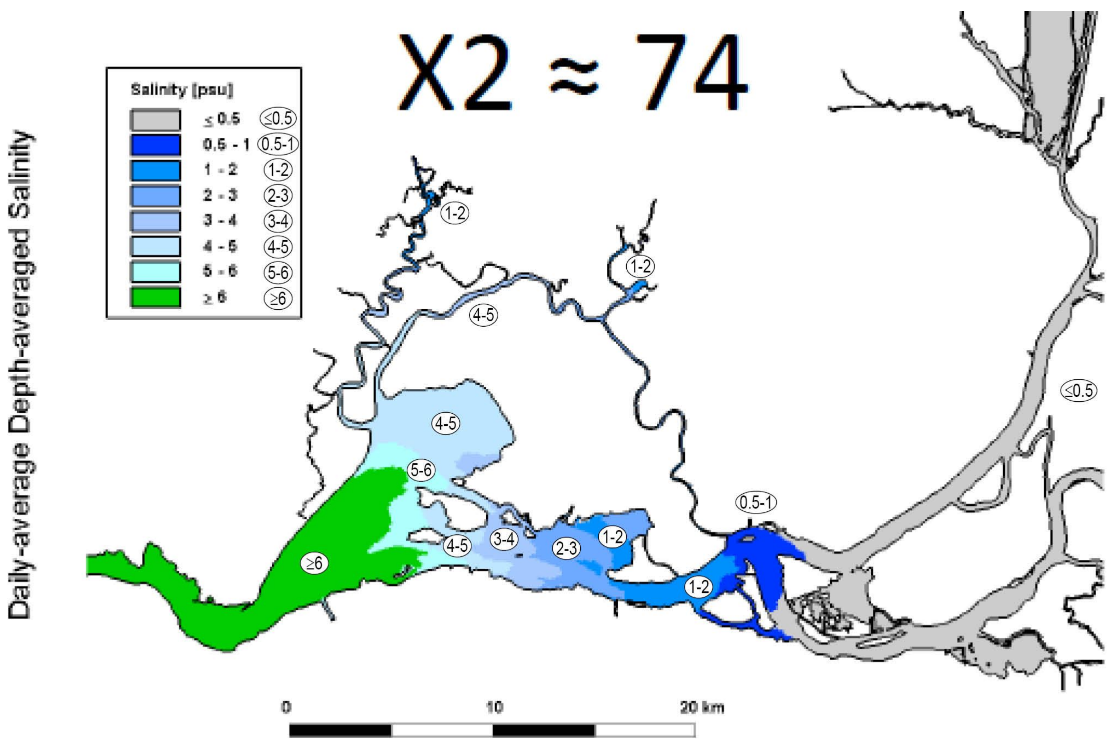
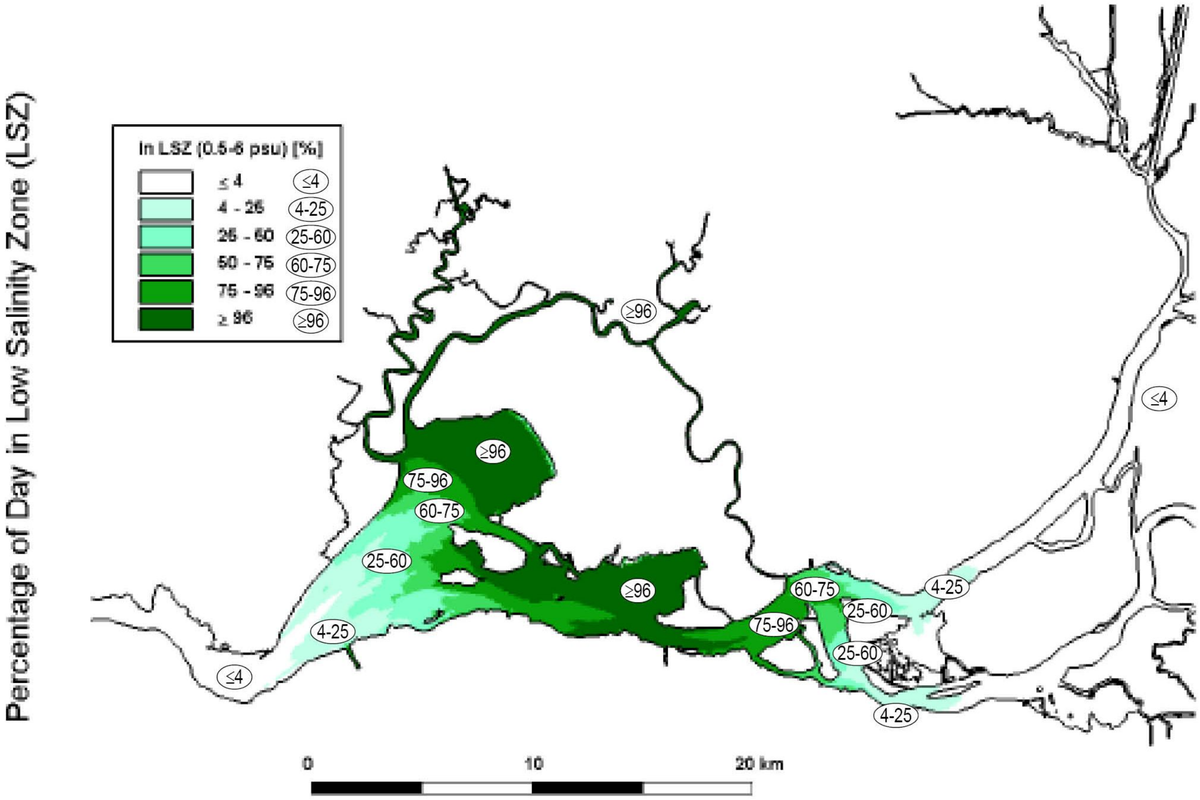


Figure 5.5-5. Daily average relationship between historically-observed X2 (2.64 mS/cm Surface Conductivity) and 6 psu (10 mS/cm) surface salinity isohaline position. (Source: Hutton et al. [2015]).



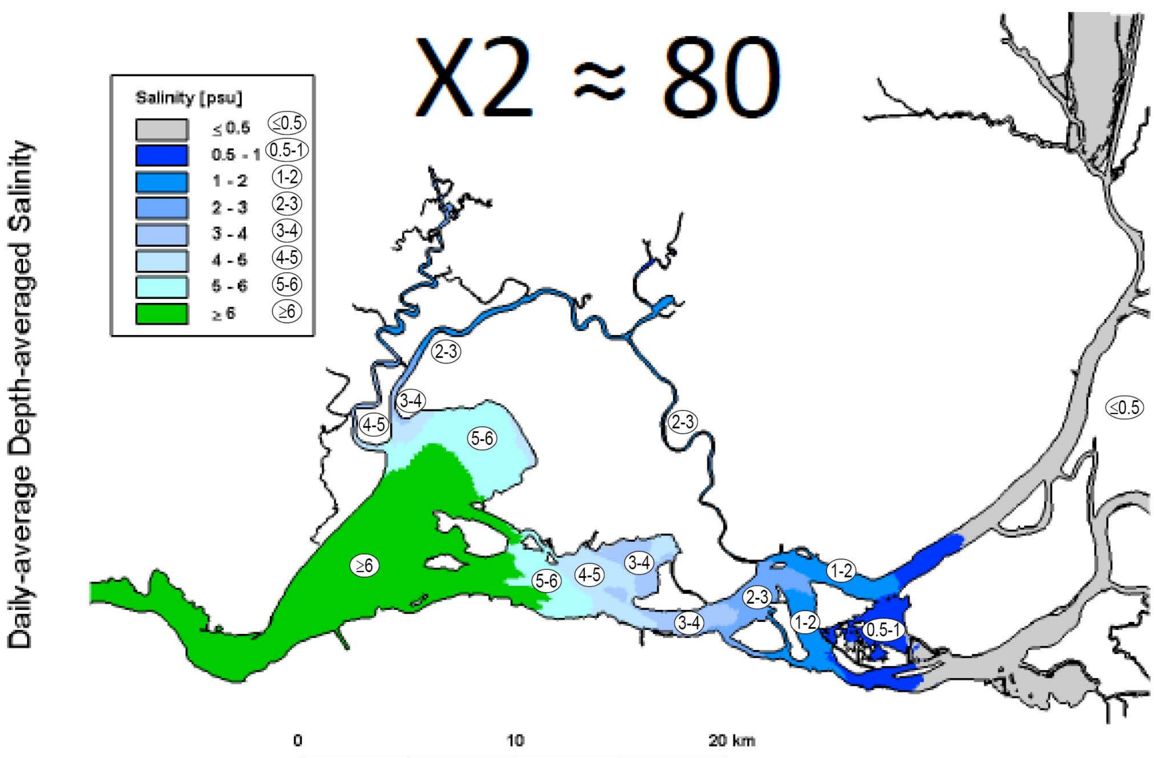
Source: Adapted from Delta Modeling Associates (2014).

Figure 5.5-6a. Modeled Salinity Habitat with X2 of Approximately 74 km.



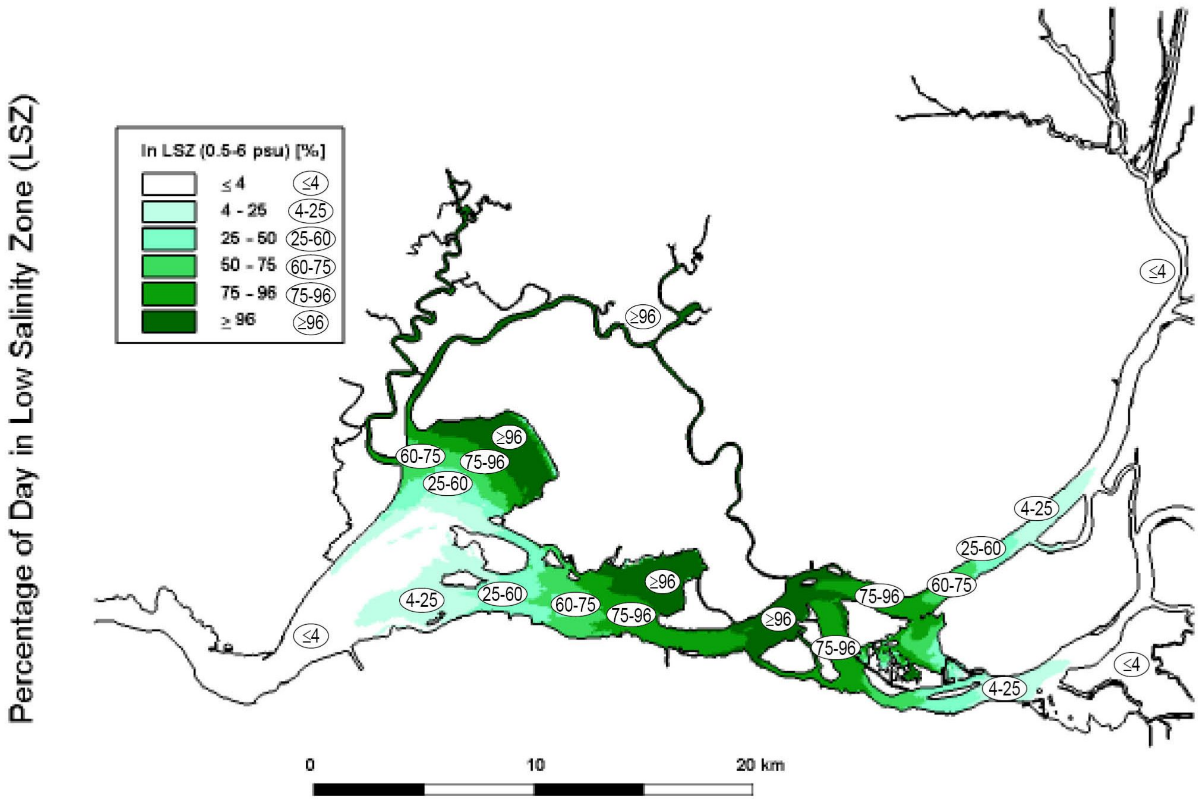
Source: Adapted from Delta Modeling Associates (2014).

Figure 5.5-6b. Modeled Salinity Habitat with X2 of Approximately 74 km.



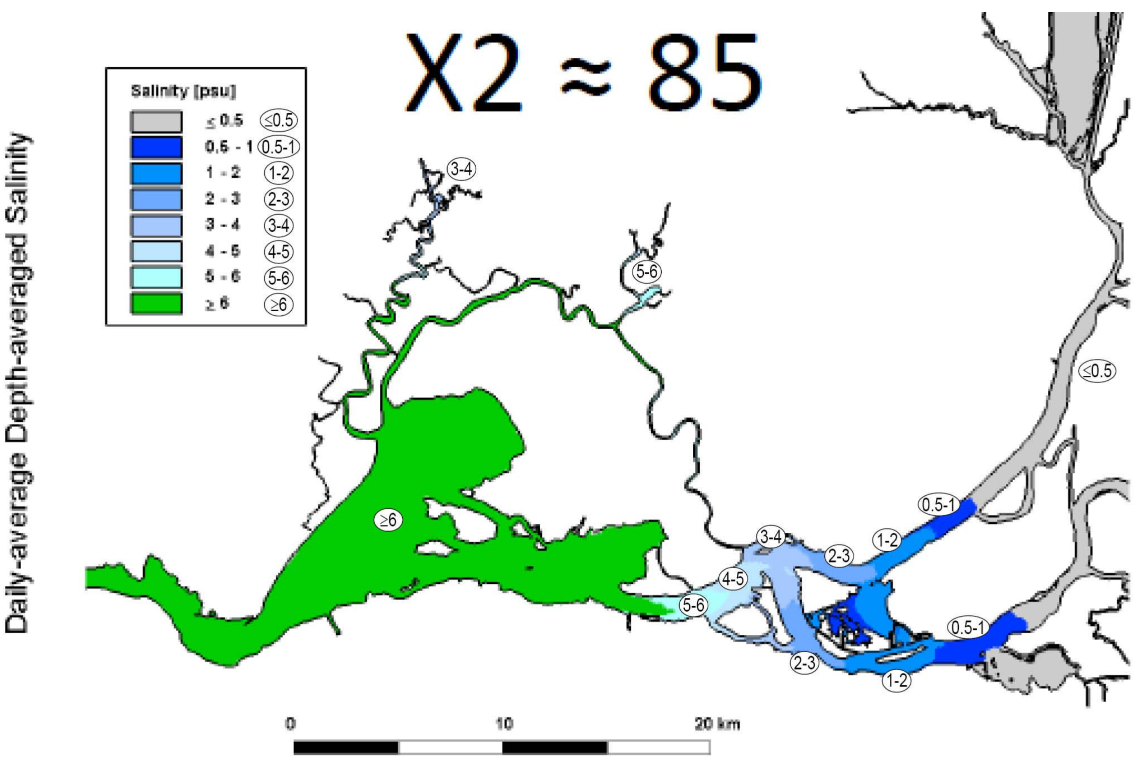
Source: Adapted from Delta Modeling Associates (2014).

Figure 5.5-7a. Modeled Salinity Habitat with X2 of Approximately 80 km.



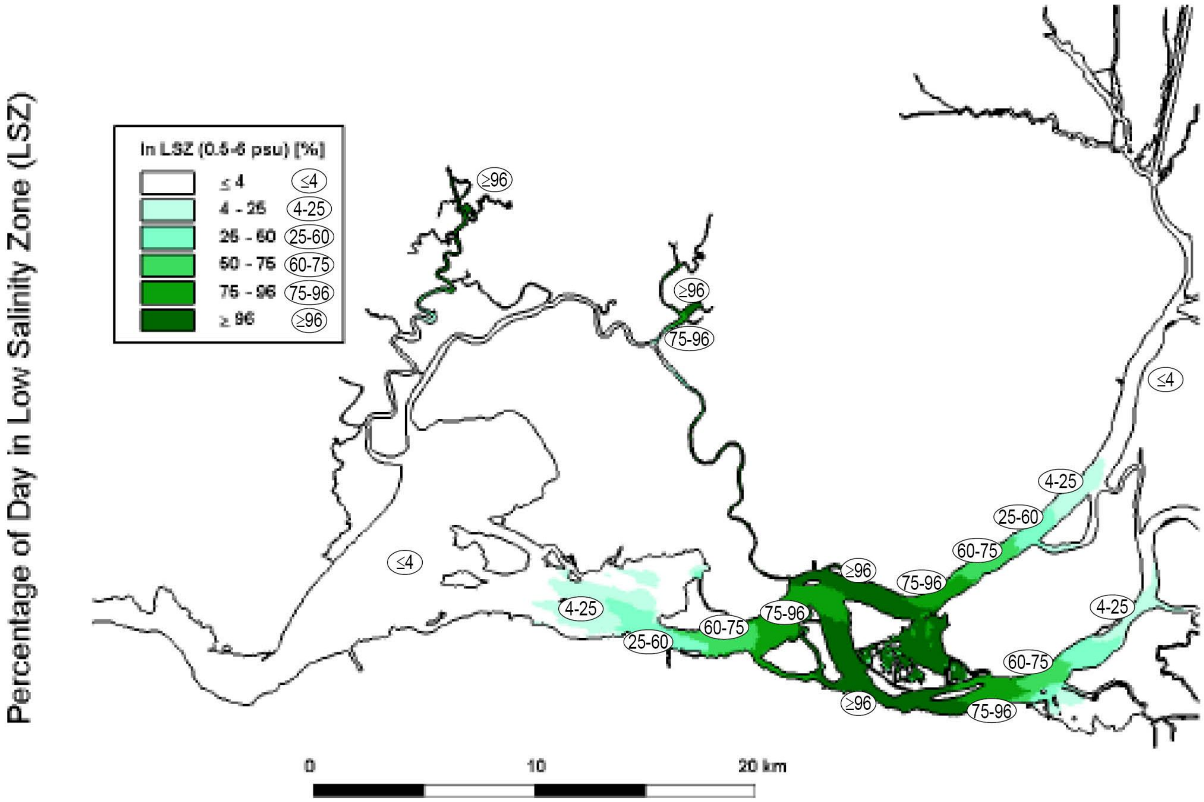
Source: Adapted from Delta Modeling Associates (2014).

Figure 5.5-7b. Modeled Salinity Habitat with X2 of Approximately 80 km.



Source: Adapted from Delta Modeling Associates (2014).

Figure 5.8a. Modeled Salinity Habitat with X2 of Approximately 85 km.



Source: Adapted from Delta Modeling Associates (2014).

Figure 5.8b. Modeled Salinity Habitat with X2 of Approximately 85 km.

As shown by Figures 5.5-5 through 5.5-8, the extent of low salinity conditions (<6 psu) in Grizzly Bay and Honker Bay would be expected to be similar or greater with lower X2 values.

Turbidity

Turbidity is an important feature of Delta Smelt habitat during the summer and fall (Feyrer et al. 2007; Nobriga et al. 2010). Turbidity is believed to reduce predation risk (Ferrari et al 2014). and may contribute to enhanced Delta Smelt feeding success (Hammock et al. 2015).

The primary factor that affects turbidity during the summer and fall is increased sediment re-suspension due from wind (Bever et al. 2016). It is hypothesized that Alternative 4 would provide benefits to Delta Smelt by shifting their habitat downstream where turbidity may be elevated.

Temperature

Wagner et al (2011) found that regional weather patterns including air temperature and insolation (sunlight), are the primary drivers of water temperature variations in the estuary. Therefore, summer – fall changes in flow would not be expected to change water temperatures. The data from Bush 2017 presented in Figure 5.5-9, indicates the absence of a direct relationship between high outflow and temperature (January-May). While high outflow and low temperatures co-occurred in 2011, the high outflow year of 2006 (as well as 2017) did not show the same relationship.

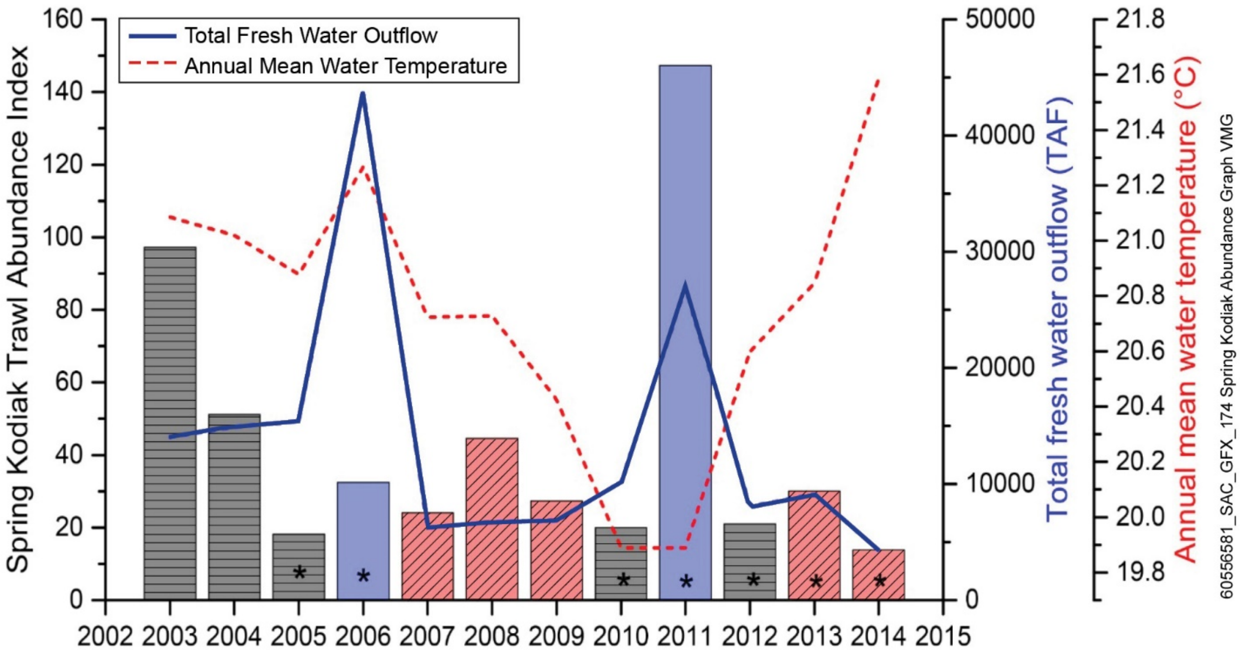


Figure 5.5-9. Relationship between high outflow and temperature (January-May). Source: Bush 2017.

Summer mean water temperatures in 2017 were 1-2°C higher than in 2011, which is consistent with similar years presented in Figure 5.5-9. These results would appear to suggest that temperatures can be elevated in wet water years as well as dry years. (Directed Outflow Project, p. 183, Hobbs et al. 2019, unpub.). The Directed Outflow Report (Hobbs et al. 2019, unpub.), found that temperatures are relatively uniform between Deepwater Ship Channel and Martinez, especially in fall months. As shown in Figure 5.5-10 there is a significant overlap in the water temperatures observed in the areas west of the confluence relative to the lower Sacramento and San Joaquin Rivers in all seasons. Although, as hypothesized by CDFW, the intent of additional outflow in Alternative 4 is to move the low salinity habitat to Suisun Bay and Suisun Marsh with cooler water temperatures than upstream locations. However, as shown above it is uncertain that Alternative 4 would provide additional habitat with cooler temperatures relative to the Existing Conditions and Proposed Project. Given that recent years indicate similar temperatures in the north Delta arc, it is uncertain that the Delta Smelt would experience lower water temperatures by locating the X2 at 80 km with additional Delta outflow.

Food Availability

The Suisun Marsh has been identified as an area with good food availability for Delta Smelt in some years. Therefore; to the extent that SMSCG operations are used to provide low salinity habitat in the marsh similar to the Proposed Project, there is a potential for increased utilization of existing food resources in Suisun Marsh. The Proposed Project also includes additional food actions in summer months as part of the summer-fall delta smelt habitat action that are not modified by Alternative 4.

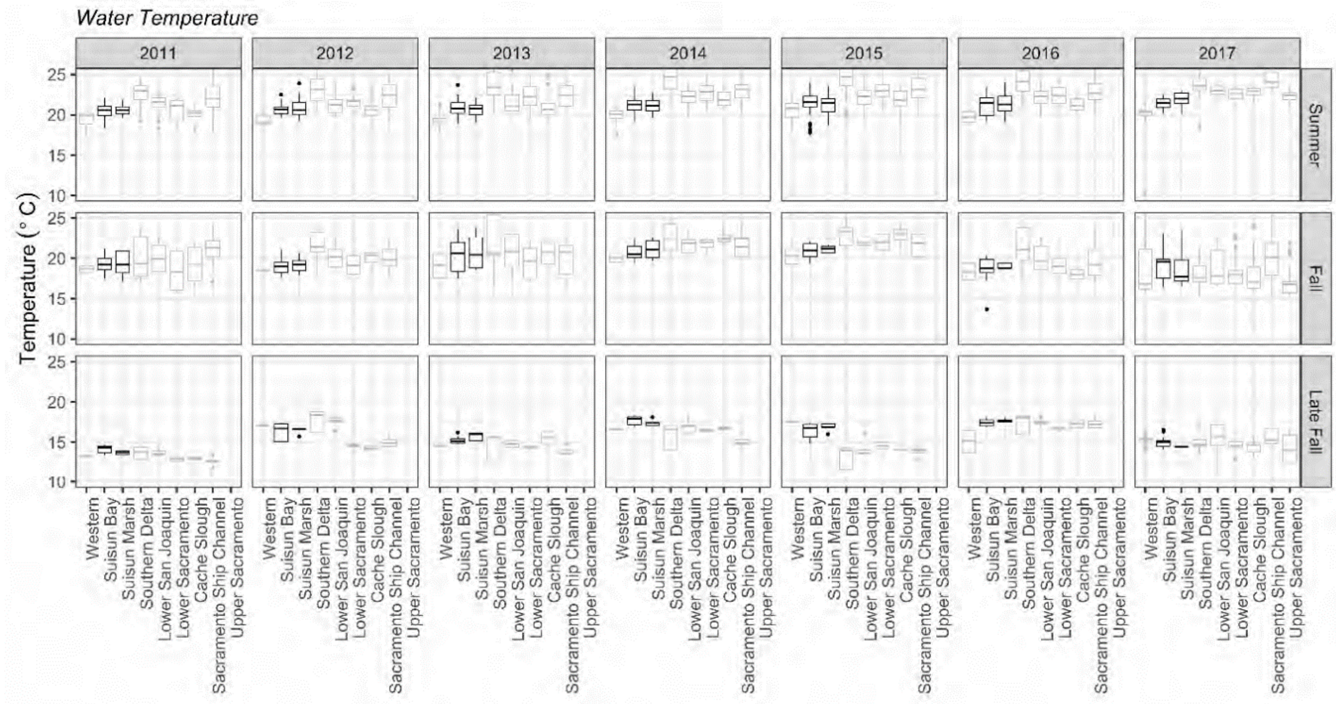


Figure 5.5-10. Variation in water temperature across years (2011-2017) for summer, fall and late-fall periods. Source: CDFW surveys for 2011-2016 and EDSM and DOP surveys for 2017.

Environmental Toxins

The Suisun Bay and the Sacramento-San Joaquin River confluence have been identified as areas with higher lesion scores as compared to Suisun Marsh, and lower conditions scores as compared to Suisun Marsh, Cache Slough, and the Deepwater Ship Channel, (Hammock et al. 2015). Hammock et al. 2015 reported no difference in toxic bluegreen cyanobacteria (Microcystis) by region and speculated that the high rate of lesions in the confluence and in Suisun Bay could have been caused by salinity changes during movement or tidal cycles. At Suisun Bay, it might also be due to low levels of contaminants. However, a subsequent study by Komoroske et al. 2016 did not find evidence of salinity stress in the range of salinity evaluated. Therefore, providing more consistent low salinity habitat within Suisun Bay and the confluence would not be expected to reduce exposure to toxins, but it might provide more consistent salinity in the Suisun Bay area, which would have an uncertain outcome for Delta smelt based on the studies by Hammock and Komoroske.

The Suisun Marsh has been identified as an area with the lowest lesion score and the best condition factor (Hammock et al. 2015) for Delta Smelt. To the extent that SMSCG operations are used to provide low salinity habitat in the marsh similar to the Proposed Project, there is a potential for increased utilization of existing food resources in Suisun Marsh in an area that has lower potential for exposure to toxins.

Based on the available studies described above, it is uncertain that Alternative 4 would reduce exposure of Delta Smelt to toxins compared to the Proposed Project or Existing Conditions.

5.5.3.2 Aquatic Resources Upstream of the Delta

As described in the hydrology discussion above, meeting the September and October salinity criteria at Belden's Landing during below normal years could require substantial increases in outflow if the SMSCG are not available. During these circumstances, the water volume required to meet the 80 km criteria in some below normal years could be as high as 500 TAF and this volume could come entirely from the Feather River watershed reservoirs controlled by the SWP.

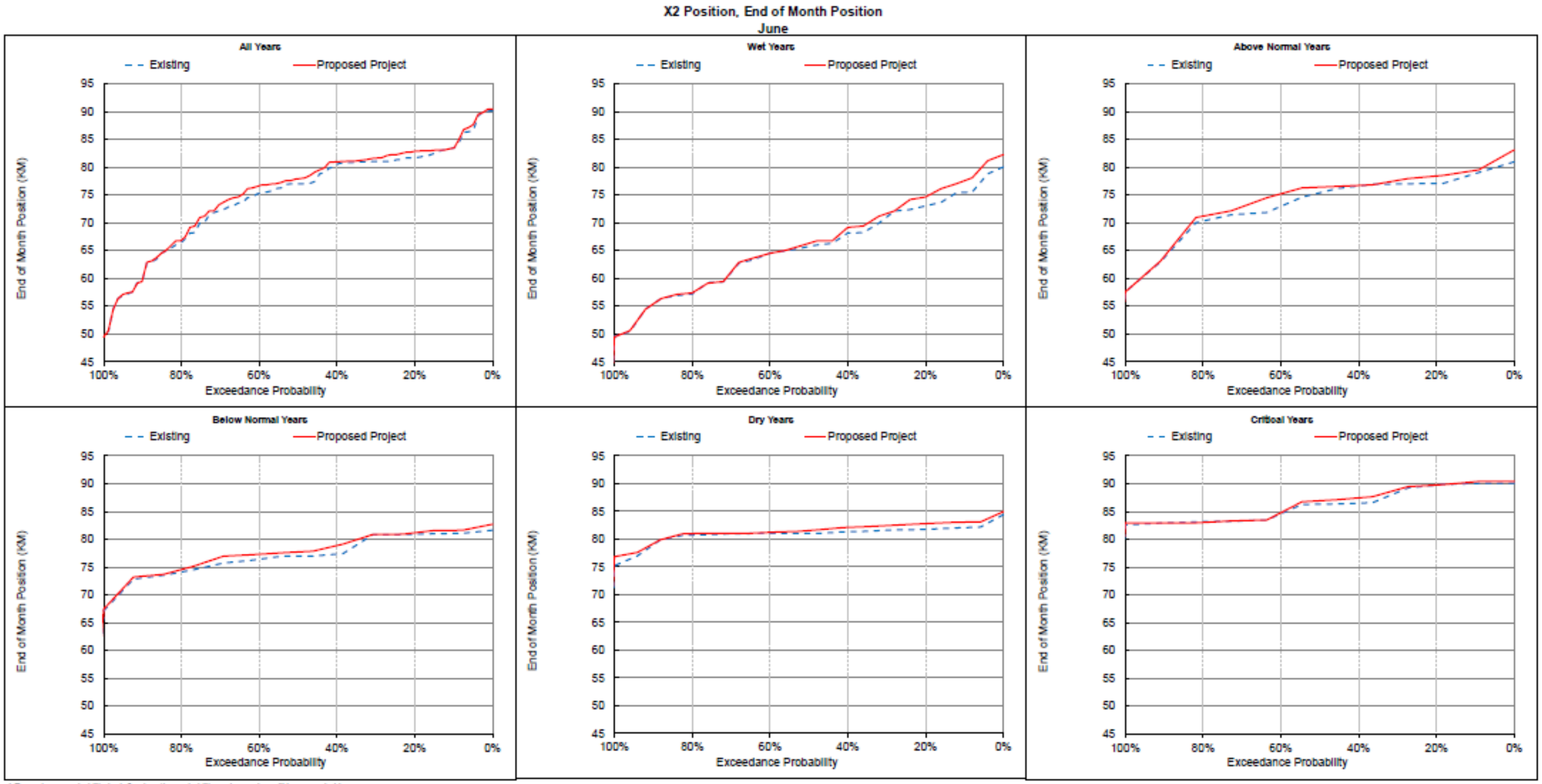
Under these circumstances, reservoir storage would be substantially reduced, which could adversely affect the SWP's ability to meet water quality and flow requirements if the subsequent water year is dry. Reduced flows and increased temperatures in the Feather River could result in reduced survival and success for several special status fish species that occur in the Feather River above the confluence with the Sacramento River. These species include Spring-run Chinook Salmon, Central Valley Steelhead DPS, and Green Sturgeon.

5.5.3.3 Conclusions

CalSim modeling X2 outputs for Existing Conditions and Proposed Project scenarios (Figures 5.5-11, 5.5-12, 5.5-13, 5.5-14 and 5.5-15) illustrate the potential differences in the X2 distances between Alternative 4 and Existing Conditions during the period of June through October. Based on lower X2 values during the summer fall months, the extent of low salinity zones suitable for Delta Smelt would be similar or more extensive under Alternative 4 relative to Existing Conditions (Table 5.5-5). The combination of low salinity conditions (<6 psu) when combined with factors such as relatively high turbidity, relatively low temperature, and food availability would have the potential to provide habitat for Delta Smelt consistent with Existing Conditions. Table 5.5-6 provides a qualitative summary of the main operations-related effects by analytical component to illustrate the similarities and differences between the Proposed Project and Alternative 4.

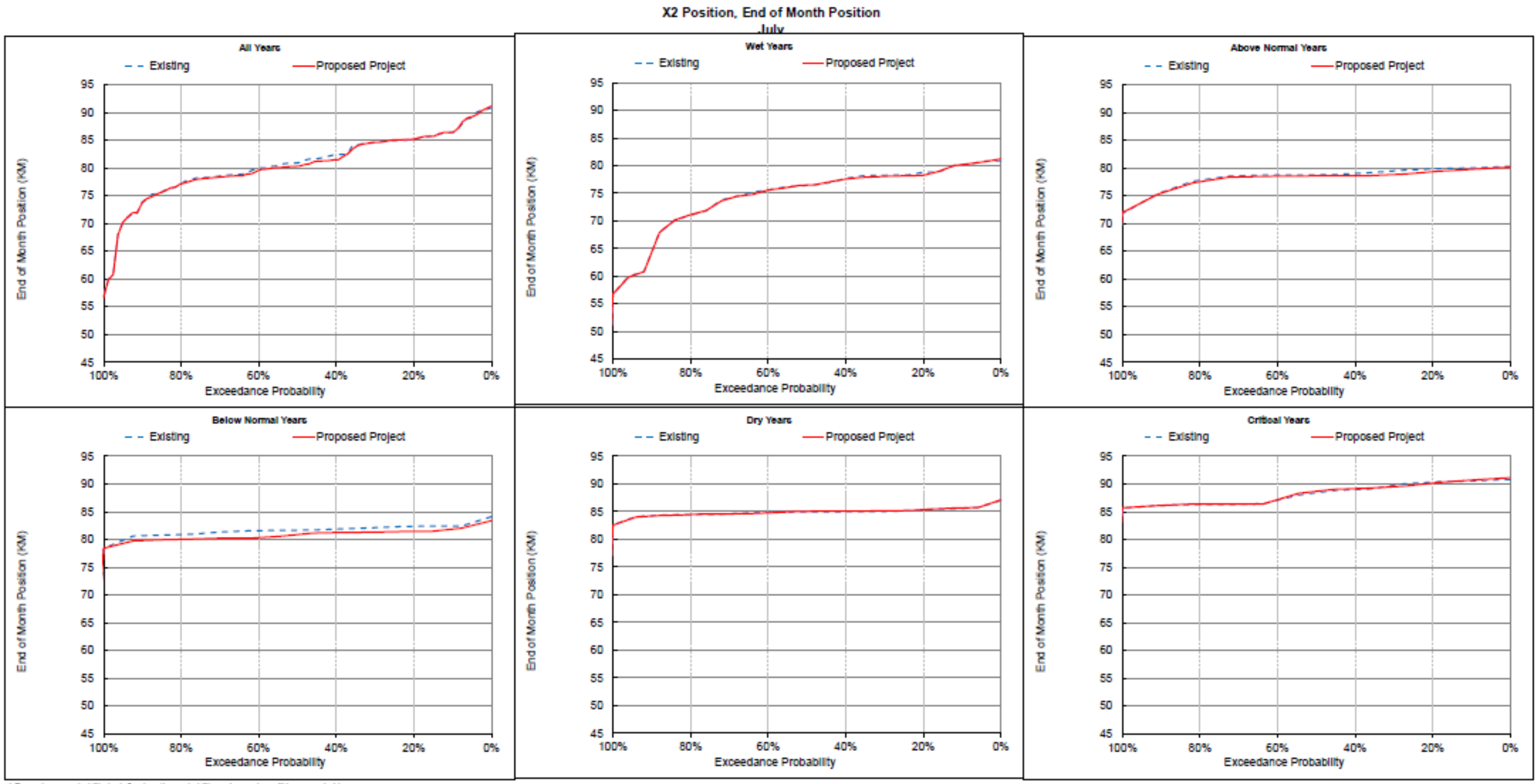
Consistent with the Proposed Project, the impact conclusions for Delta aquatic resources impacts under Alternative 4 remain **less than significant**. However, the potential impacts to other aquatic biological resources upstream of the Delta would be **potentially significant** under Alternative 4 due to the possibility of a substantial reduction in the cold water and reservoir storage needed to meet water quality criteria during years following below normal water years.

Measure Alt 4-1 is proposed (see above), which would reduce this impact to a **less than significant** level because it would limit volume of water that would be required from either export reductions or upstream flow releases during below normal water years.



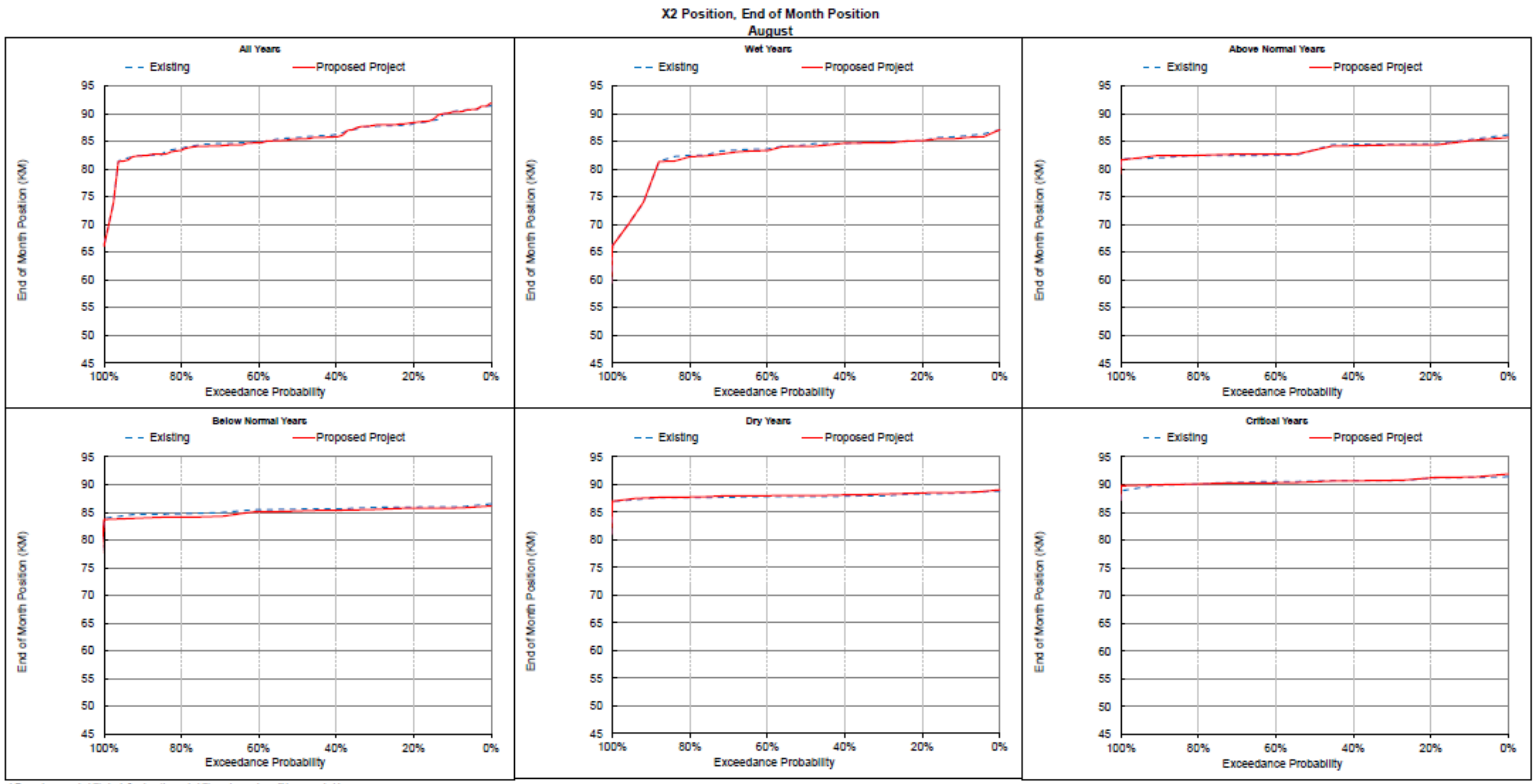
* Exceedance probability is defined as the probability a given value will be exceeded in any one year.
* Based on the 82-year simulation period.
* As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
* There are 26 wet years, 14 above normal years, 14 below normal years, 16 dry years, and 12 critical years.

Figure 5.5-11. Exceedance Plot of CalSim-modeled June X2 by Water-Year Type for Existing Conditions and Proposed Project Scenarios.



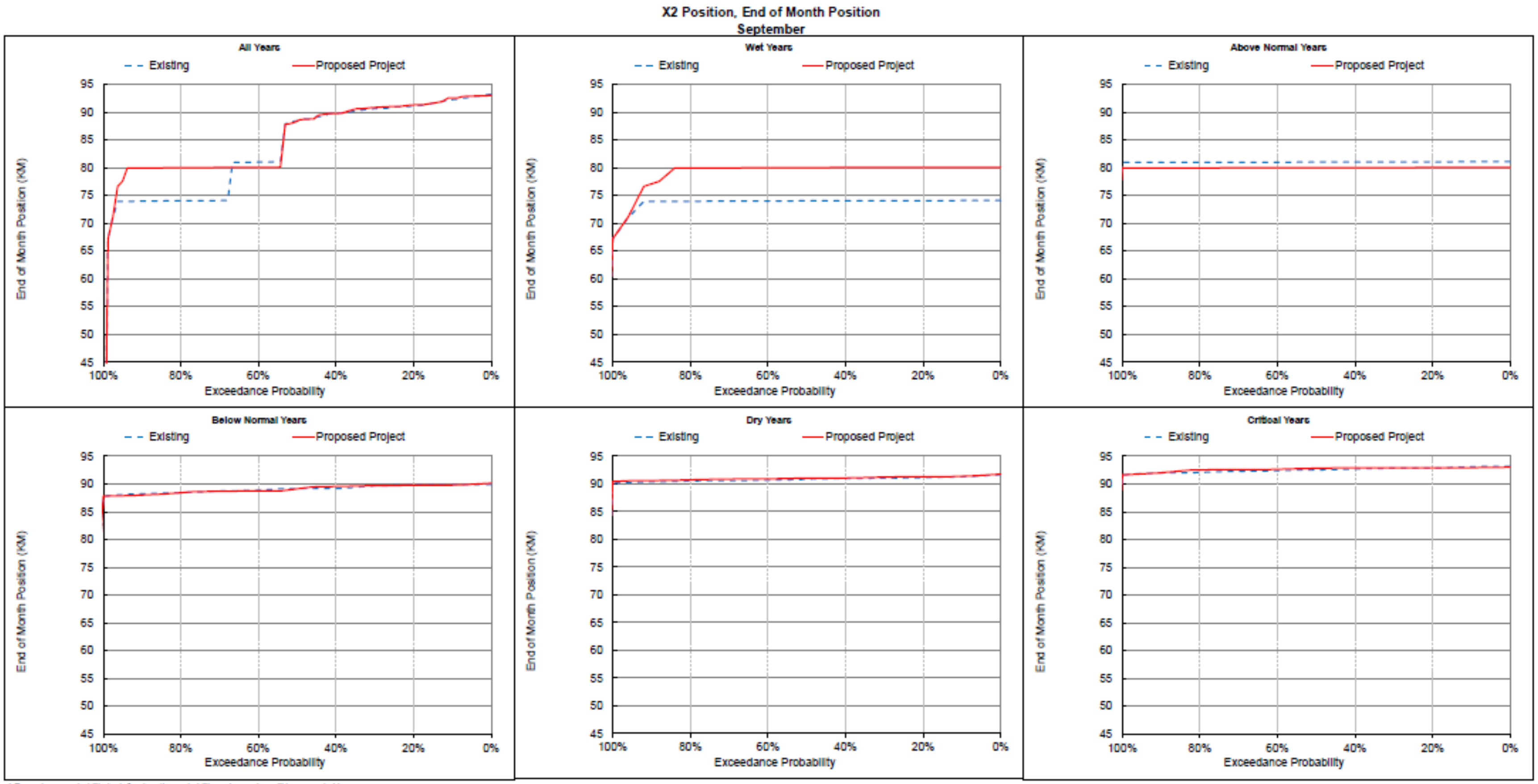
* Exceedance probability is defined as the probability a given value will be exceeded in any one year.
* Based on the 82-year simulation period.
* As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
* There are 28 wet years, 14 above normal years, 14 below normal years, 18 dry years, and 12 critical years.

Figure 5.5-12. Exceedance Plot of CalSim-modeled July X2 by Water-Year Type for Existing Conditions and Proposed Project Scenarios.



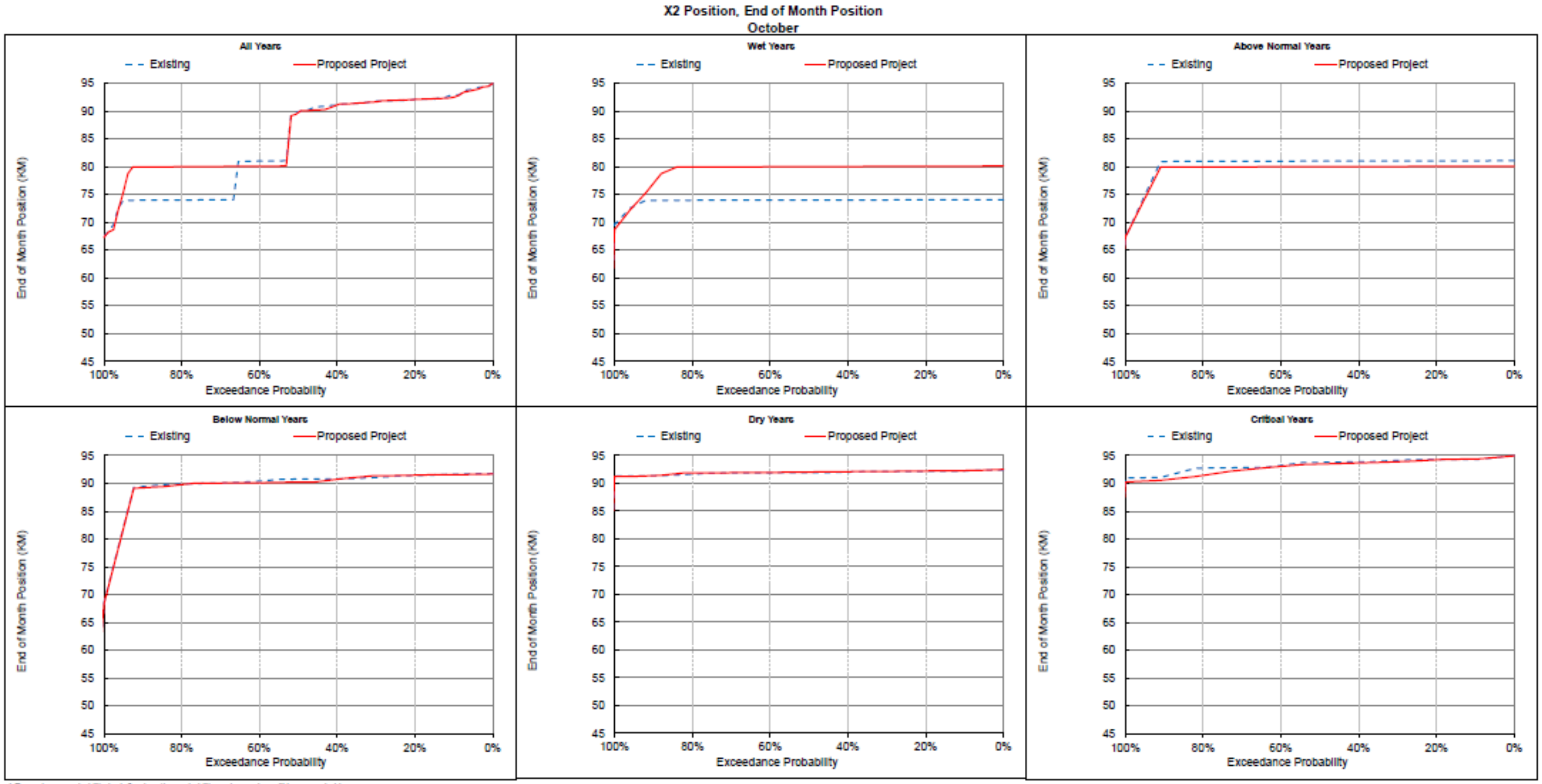
* Exceedance probability is defined as the probability a given value will be exceeded in any one year.
* Based on the 82-year simulation period.
* As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
* There are 26 wet years, 14 above normal years, 14 below normal years, 16 dry years, and 12 critical years.

Figure 5.5-13. Exceedance Plot of CalSim-modeled August X2 by Water-Year Type for Existing Conditions and Proposed Project Scenarios.



* Exceedance probability is defined as the probability a given value will be exceeded in any one year.
* Based on the 82-year simulation period.
* As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
* There are 26 wet years, 14 above normal years, 14 below normal years, 16 dry years, and 12 critical years.

Figure 5.5-14. Exceedance Plot of CalSim-modeled September X2 by Water-Year Type for Existing Conditions and Proposed Project Scenarios.



* Exceedance probability is defined as the probability a given value will be exceeded in any one year.
* Based on the 82-year simulation period.
* As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB D-1641, 1999).
* There are 26 wet years, 12 above normal years, 14 below normal years, 18 dry years, and 12 critical years.

Figure 5.5-15. Exceedance Plot of CalSim-modeled October X2 by Water-Year Type for Existing Conditions and Proposed Project Scenarios.

Table 5.5-5. Comparison of Alternative 4 Summer-Fall Criteria to Existing Conditions.

Season	Month	Critically Dry Water Year Type	Dry Water Year Type	Below Normal Water Year Type	Above Normal Water Year Type	Wet Water Year Type
Summer Actions	June	N/A	Up to 60 days of SMSCG operation →*lower salinity in Suisun Marsh*	X2 ≤ 80, monthly average→ *greater extent of low salinity in ~35% of years* Up to 60 days of SMSCG operation→ *lower salinity in Suisun Marsh*	X2 ≤ 80, 14-day average→ *generally similar extent of low salinity*	X2 ≤ 80, 14-day average→ *generally similar extent of low salinity*
Summer Actions	July	N/A	Up to 60 days of SMSCG operation →*lower salinity in Suisun Marsh*	X2 ≤ 80, monthly average→ *greater extent of low salinity in most years* Up to 60 days of SMSCG operation→ *lower salinity in Suisun Marsh*	X2 ≤ 80, 14-day average→ *generally similar extent of low salinity*	X2 ≤ 80, 14-day average→ *generally similar extent of low salinity*
Summer Actions	August	N/A	Up to 60 days of SMSCG operation →*lower salinity in Suisun Marsh*	X2 ≤ 80, monthly average→ *appreciably greater extent of low salinity in all years* Up to 60 days of SMSCG operation→ *lower salinity in Suisun Marsh*	X2 ≤ 80, 14-day average→ *appreciably greater extent of low salinity in all years*	X2 ≤ 80, 14-day average→ *appreciably greater extent of low salinity in ~90% of years*
Fall Actions	September	N/A	N/A[1]	N/A[1]	X2 ≤ 80, monthly average→ *modestly greater extent of low salinity in all years*	X2 ≤ preceding August, monthly average→ *potentially similar, greater, or lower extent of low salinity depending on antecedent conditions*
Fall Actions	October	N/A	N/A[1]	N/A[1]	X2 ≤ 80, monthly average→ *modestly greater extent of low salinity in all years*	X2 ≤ preceding August, monthly average→ *potentially similar, greater, or lower extent of low salinity depending on antecedent conditions*

Notes:
N/A = not applicable
SMSCG = Suisun Marsh Salinity Control Gates

Species	Life Stage	Analytical Component	Model Results (Proposed Project vs. Existing Conditions)	Analytical Discussion (Proposed Project)	Impact Conclusion (Proposed Project)	Exp
Delta Smelt	Adult to Eggs and Larvae	Food Availability	Similar flow through the Yolo Bypass	Similar food production and input to the Delta under both scenarios. This is a combined SWP and CVP result.	Less than Significant	Simil both This i
Delta Smelt	Adult to Eggs and Larvae	Predation	Similar Rio Vista Flows from December through May	Similar suspended sediment input to the Delta and low sediment removal from the Delta therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	Simil low s simil This i
Delta Smelt	Eggs and Larvae to Juveniles	Food Availability	Delta outflow from March through June is lower under the Proposed Project, and predicted *Eurytemora affinis* density is 2% to 4% lower under the Proposed Project.	Food availability might be slightly reduced under the Proposed Project, but uncertainty is high SWP responsibility for the impact is between approximately 40% to 60%	Less than Significant	Food Alter
Delta Smelt	Eggs and Larvae to Juveniles	Predation	Similar Rio Vista Flows from December through May. South Delta exports are higher from March through May under the Proposed Project. Delta inflow from June through September is slightly lower under the Proposed Project.	Similar predation potential associated with turbidity Potentially lower silverside cohort strength with high uncertainty, based on greater March–May south Delta exports Potentially higher silverside cohort strength with high uncertainty, based on lower June–September Delta inflow SWP contribution between approximately 40% to 60% during March May SWP responsibility for the June-September impact is between approximately between 20-50%	Less than Significant	Simil Poter unce Delta Poter unce inflov
Delta Smelt	Juveniles to Subadults	Food Availability	Delta outflow from July through September is similar most of the time (75% of the time) but is lower about 25% of the time, suggesting slightly lower predicted *Pseudodiaptomus forbesi* density. Similar QWEST under both scenarios in July and August. Higher (positive more often) QWEST in September under the Proposed Project.	Slightly lower *P. forbesi* density under the Proposed Project as a result of lower Delta outflow some of the time. Analysis has high uncertainty Similar *P. forbesi* subsidy to the LSZ from the San Joaquin River most of the time under both scenarios, but potentially slightly higher *P. forbesi* subsidy in September under the Proposed Project. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. This is a combined SWP and CVP result SWP responsibility for the change in Delta Outflow and QWEST that could affect *P. forbesi* subsidy to the LSZ is between approximately 23-28% in wet and above-normal water year types (when X2 requirements are not in place under the Proposed Project)	Less than Significant	The s unde than with years QWE analy

					Project)	
Delta Smelt	Juveniles to Subadults	Predation	Similar Rio Vista Flows from December through May.	Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and summer predation potential is unknown. Wind and water temperature, which are drivers of turbidity would be similar therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	Simil to th Delta relat winte unkn drive pred This i
Delta Smelt	Juveniles to Subadults	Harmful Algal Blooms	Similar probability of remaining below 1 foot per second (ft/sec) velocity Microcystis threshold at each of the 8 Delta locations.	Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations Similar potential for velocity conditions to affect harmful algal blooms under both scenarios This is a combined SWP and CVP result	Less than Significant	Nutri differ algal opera Simil harm This i
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat Qualitative Discussion	N/A	Manage overlapping suitable habitat based on the latest conceptual model of suitable habitat for Delta Smelt in summer-fall using multiple tools including outflow augmentation, Suisun Marsh Salinity Control Gates (SMSCG) operation, and food actions. LSZ would tend to be further upstream following wet years, without detailed consideration of SMSCG operation. Evidence from 2018 SMSCG pilot action showed that Delta Smelt had access to suitable low salinity habitat during the action.	Less than Significant	Pote habit
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2012 (salinity alone)	Limited benefits in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation period. Reduced habitat area in Suisun Bay.	Modeled benefits are greater when gates are operated starting in August rather than June Lower salinity in Suisun Marsh has the potential to increase habitat for Delta Smelt during the summer and fall.	Less than Significant	Pote the s
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2012 (salinity, temperature, and turbidity)	Limited benefits overall in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation.	Potentially beneficial overall because of improved Suisun Marsh Conditions	Less than Significant	Pote Suisu
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2017 (salinity alone)	Limited benefits overall in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun	Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under the Proposed Project	Less than Significant	Pote Suisu salini from

					Project)	
Delta Smelt	Juveniles to Subadults	Summer-Fall Habitat– SCHISM WY 2017 (salinity, temperature, and turbidity)	Limited benefits in the north Delta Arc or Cache to Montezuma Slough corridor. Improved conditions in Suisun Marsh extending beyond the SMSCG operation.	Potentially beneficial overall because of improved Suisun Marsh Conditions; no evidence of less low salinity habitat extent under the Proposed Project.	Less than Significant	Poter Suisu salini from
Delta Smelt	Subadults to Adults	Food Availability	Higher (positive more often) QWEST in September under the Proposed Project, although Delta outflow is lower.	Potentially slightly higher *P. forbesi* subsidy in September under the Proposed Project based on net flow on the San-Joaquin River at Jersey Point (QWEST), but slightly lower based on Delta outflow. Likely limited *P. forbesi* subsidy to the LSZ from the San Joaquin River under both scenarios with high uncertainty. Overall density of calanoid copepods in the low salinity not shown to be related to Delta outflow (X2) by other analyses. This is a combined SWP and CVP result	Less than Significant	The s unde than with years QWE analy
Delta Smelt	Subadults to Adults	Predation	Similar Rio Vista Flows from December through May.	Similar suspended sediment input to the Delta prior to this life stage and low sediment removal from the Delta. Although sediment input would be similar, the relationship between sediment input during winter/spring and fall predation potential is unknown. However, wind and water temperature, which are drivers of predation would be similar therefore similar predation potential under both scenarios This is a combined SWP and CVP result	Less than Significant	Simil to th Delta relat winte unkn which there scena This i
Delta Smelt	Subadults to Adults	Harmful Algal Blooms	Similar velocity conditions at 8 Delta locations Similar probability of remaining below 1 ft/sec threshold at each of the 8 Delta locations	Nutrients and water temperatures not expected to differ because these factors that influence harmful algal blooms are not affected by Delta water operations Similar potential for velocity conditions to affect harmful algal blooms under both scenarios This is a combined SWP and CVP result	Less than Significant	Nutri differ algal opera Simil harm This i

					Project)	
Delta Smelt	Entrainment	Consideration of OMR	During the March–June period of concern for larval/juvenile Delta Smelt entrainment risk, OMR flows would generally be lower (more negative) under the Proposed Project in April and May but would be similar under both scenarios in March and June. During this period, flows under both scenarios would be at or less negative than the -5,000 cfs inflection point at which entrainment tends to sharply increase.	Based on CalSim modeling estimated entrainment could increase for larvae/early juveniles (March – June) under the Proposed Project however there are number of measures that will keep entrainment risk at protective levels: • OMR flows during April and May under the Proposed Project are less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk. • Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts • Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles • SWP responsibility for the impact is between approximately 30-60%	Less than Significant	Estim larva Alter that • O A 5 S • R a S M t • In re ir e • S a
Delta Smelt	Entrainment	Particle Tracking Modeling	DSM2 PTM showed increases in Delta Smelt entrainment in April and May.	Based on DSM2 PTM modeling estimated entrainment is appreciably greater under the Proposed Project in April and May. However, there are number of measures that will keep entrainment risk at protective levels: • OMR flows during April and May under the Proposed Project are less negative than the -5000 inflection point deemed protective of Delta Smelt entrainment risk. • Real-time OMR management, United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM) and USFWS Life Cycle Model (LCM) guidance on take limits will minimize take and population impacts • Increased first flush protection for adults should result in less movement and spawning in the interior Delta, subsequently decreasing entrainment of larvae and juveniles	Less than Significant	Entra Alter numl at pr • O A 5 S • R a S M t • In re ir e
Delta Smelt	All Life Stages	Annual O&M Activities	N/A	Annual O&M activities likely would have limited impacts on Delta Smelt because work windows and best management practices (BMPs) would be implemented. Longer-term impacts of these maintenance activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	Annu impa mana imple Long woul Cond occu

					Project)	
Delta Smelt	All Life Stages	Project Environmental Protective Measures including: • Clifton Court Forebay (CCF) predator relocation and aquatic weed control; • Skinner Fish Facility performance improvements; • Longfin Smelt Science Program; • Continue Studies to Establish a Delta Fish Hatchery; and • Conduct further Studies to Prepare for Delta Smelt Reintroduction from the FCCL (see Table 3-3)	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Delta Smelt reintroduction and Delta Fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival	Less than Significant	In-wa beca and i Delta cons unde popu Clifto impr post-
Longfin Smelt	Population Abundance	Delta Outflow-Abundance	The results of the Nobriga and Rosenfield (2016) model application suggested that differences in the predicted fall midwater trawl abundance index between scenarios would be very small, with mean indices slightly lower under the Proposed Project and with some uncertainty, especially when considered in relation to the confidence intervals, as a result of high uncertainty in the outflow–abundance relationship.	Recruitment under the Proposed Project is modeled to slightly decrease under good survival (2% max difference) and poor survival (1% max difference) scenarios when confidence intervals are accounted for. The following measures should help reduce any potential small effects in real-time: • Increased measures to reduce entrainment losses for all Longfin Smelt life stages • A commitment to a Longfin Smelt Science program to understand mechanisms underlying flow-abundance relationships, and to identify and test additional options for Longfin Smelt management. • A commitment to support the Fish Culture Facility for Longfin Smelt culture for future study and adaptive management application. • This is a combined SWP and CVP result with the SWP responsibility of approximately 40% to 60%	Less than Significant	Recru slight reduc • Ir fo • A p fl te m • A fo a • T S
Longfin Smelt	Adult	Entrainment	Similar OMR flow from December February.	Modeled entrainment under the Proposed Project is similar to the existing project. Other measures should reduce real-time entrainment risk, including: • OMR management Dec-Feb • OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt • Existing adult Longfin Smelt entrainment is less than 1% of the population (all years except 2008 @ 3%) • SWP responsibility for slight differences in OMR is between approximately 40% to 60%	Less than Significant	Entra to be shou • O • O sl • E th @ • S b

					Project)	
Longfin Smelt	Larvae	Entrainment	DSM2-PTM results suggested that entrainment potential of Longfin Smelt larvae is similar between scenarios.	Modeled entrainment of larval Longfin Smelt does not increase under the Proposed Project. Other measures should reduce real-time entrainment risk, including: • OMR management Jan-Mar • OMR first flush actions for adult Delta Smelt that should provide benefits for adult Longfin Smelt, shifting spawning seaward of interior Delta. • Adult Longfin Smelt presence as detected by the surveys and salvage suggests spawning is limited in interior Delta, which reduces subsequent larval entrainment risk. • This is a combined SWP and CVP result	Less than Significant	Entra expe meas inclu • O • O sl sl • A su ir e • T
Longfin Smelt	Juvenile	Salvage	Based on the Grimaldo et al. (2009) salvage-Old and Middle River flow regression, the potential exists for large relative increases in entrainment under the Proposed Project.	Modeled juvenile Longfin Smelt salvage is increased under the Proposed Project. However, the following measures/considerations are expected to minimize entrainment: • OMR flows during April and May under the Proposed Project are less negative than the -5000 cfs inflection point deemed protective of entrainment risk for Longfin Smelt and other ESA species. • Real-time OMR management, PTM models and CDFW Smelt Larval Survey (SLS) monitoring will be used to assess entrainment risk in real-time. • Increased first flush protection actions should lead to less movement and spawning in the interior Delta, subsequently decreasing entrainment risk of larvae and juveniles • SWP responsibility for differences in OMR flows is between approximately 40-50%	Less than Significant	Juver incre meas entra • O P ct e sp • R C u • Ir le ir e • S' b
Longfin Smelt	All Life Stages	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	Annu impa mana imple Long woul Cond occu

					Project)	
Longfin Smelt	All Life Stages	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; • Skinner Fish Facility performance improvements; • Longfin Smelt Science Program; and • Continue Studies to Establish a Delta Fish Hatchery (see Table 3-3)	N/A	Longfin Smelt Science Program would improve understanding of Longfin Smelt ecology, population distribution, and abundance to better inform management decisions. Delta fish conservation hatchery studies would improve understanding of Delta Smelt population genetics and population dynamics Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival	Less than Significant	Long unde distri mana hatch Delta dyna Clifto impr post-
Winter-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during most months of the immigration period.	Similar flow conditions would likely result in similar habitat conditions including SAIL Conceptual Model habitat attributes of water temperature, dissolved oxygen concentrations, and other attributes that influence the timing, condition, and survival of adult Winter-run Chinook Salmon during their upstream migration. This is a combined SWP and CVP result	Less than Significant	Simil habit habit oxyg influe Wint migr This i
Winter-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment	Changes in hydrodynamic conditions (velocity distributions) indicate that juvenile winter run entering the interior Delta from Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor may be more likely to become entrained under the Proposed Project, if exports are greater at the time, they are present. There is little difference during the main December-February period when Winter-Run are most abundant in the Delta.	Although Chinook Salmon in the Old-Middle River Corridor could become entrained more often under the Proposed Project, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of winter run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile winter run Chinook salmon encounter the South Delta salvage facilities. Velocity changes that could occur in the Spring and Fall under the proposed project are less t likely to affect Winter-run Chinook Salmon because most Winter-run Chinook Salmon are expected to have exited the Delta by April and May and are generally present in low abundance in September and November. This is a combined SWP and CVP result Implementing OMR management, including factors such as cumulative loss thresholds, would limit entrainment of Winter-run Chinook Salmon that do enter the Old-Middle River corridor. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF could reduce pre-screen losses, which could increase observed salvage. Skinner Fish Facility Improvements also have the potential to improve survival of salvaged winter-run	Less than Significant	Altho Corri Alter confl for th prob simil incre Old-M indic Chino facili Veloc Fall u Wint run C Delta low a This i Imple such entra enter Actio weed redu whic Skinn

					Project)	
Winter-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Winter-run Chinook Salmon at the SWP south Delta export facility would be similar between the scenarios.	Entrainment loss would be similar under both scenarios, but the analysis is uncertain because it is not scaled by population size and there is uncertainty about the true racial identity of Chinook Salmon in salvage. The model does not include real-time management operations, which would reduce entrainment. The model does not include the genetic identity of salvaged Chinook salmon, and some fish in historical salvage could be misidentified, which would artificially increase the estimated salvage in the analysis.	Less than Significant	Entra scena mode real-t of sa
Winter-run Chinook Salmon	Juvenile	Salvage based on Zeug and Cavallo (2014)	Winter-run Chinook Salmon salvage is similar under both scenarios. Median salvage of the juvenile population at the SWP was 0.149% under the existing condition and 0.140% under the proposed project (≈ 0.01% lower under the proposed project). Median salvage at both the SWP and CVP combined was 0.353% under the proposed project and 0.380% under the existing condition.	The maximum annual proportion of juvenile Winter-run Chinook Salmon production predicted to be salvaged is low (<1.2%) for both the proposed project and the existing condition. Differences between scenarios in individual years were small (<0.5%). Additionally, small differences in predicted salvage occurred in certain months and water year types. However, there was high overlap in interquartile ranges and the scenario with greater salvage was not consistent across these comparisons.	Less than Significant	The r run C pred Alter betw expe
Winter-run Chinook Salmon	Outmigrant Survival	Delta Passage Model	Across the 82-year simulation period, mean through-Delta survival was 0.1% greater for the Proposed Project. Survival followed water year-type for both scenarios with the highest values in wet years and lowest values in critical years. Differences in individual model years were generally small (≤ 1.6%) as were differences within individual water year-types.	Through Delta survival of Winter-run Chinook Salmon was similar under both scenarios with some uncertainty. These results are similar to those of the STARS analysis described below which does not include an export-survival function which is included in the DPM. Together, these results suggest changes in export operations under the proposed project had little influence on through-Delta survival of winter run Chinook Salmon. Uncertainty in the modeled result will be addressed by implementing cumulative loss thresholds as part of OMR management would limit entrainment SWP responsibility for differences in Delta operations is between approximately 40% to 60%	Less than Significant	Thro woul with Prop oper little run C resul loss t woul SWP is bet

					Project)	
Winter-run Chinook Salmon	Outmigrant Survival	STARS	Generally similar proportions of Winter-run Chinook Salmon entered the interior Delta via Georgiana Slough and the DCC, resulting in similar through Delta survival under both scenarios except during November, when survival was predicted to be lower under the Proposed Project as a result of less river flow and greater Delta Cross Channel (DCC) opening as a result of model assumptions. However, abundance of Winter-run Chinook Salmon is generally low in November.	During most months of the outmigration period (October through June for this analysis) Winter-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the central Delta and reduced survival could occur in November. However, abundance of Winter-run Chinook Salmon is generally low in November. This is a combined result. During November when the largest differences in routing occur, the SWP is responsible for approximately 50-60% of operations-related impacts but note that the DCC is a CVP facility.	Less than Significant	Durir (Octo Chino Delta scena and r Howe is ger This i large respo relate facili
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	Annu impa mana imple Long woul Cond occu
Winter-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements could increase pre-screen survival and post-salvage survival.	Less than Significant	Clifto impro post-
Spring-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the January through June immigration period.	Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. SWP responsibility for differences in Delta operations is between approximately 30-60%.	Less than Significant	Simil habit habit

					Project)	
Spring-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	For juvenile spring-run Chinook Salmon migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the Old and Middle River corridors during April and May suggest entrainment of fish entering Old River at HOR would be higher. For juvenile spring-run Chinook Salmon originating from the Sacramento River, changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor in April and May are more likely to become entrained under the Proposed Project.	Greater frequency of routing San Joaquin-origin spring-run into Old River increases entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under the proposed project (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River. For Sacramento River-origin spring-run, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of spring run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May This is a combined SWP and CVP result. OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Grea sprin risk f have betw Joaqu mode Delta mode proje survi Old R For S the in chan the M of th movi Alter prop River smal from Delta Midd April This i OMR incid entra Actio weed reduc Skinn to im

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Spring-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Spring-run Chinook Salmon at the SWP south Delta export facility could be appreciably greater under the Proposed Project.	Entrainment loss of Spring-run Chinook Salmon could be higher under the Proposed Project, but the analysis is uncertain, and the model does not include genetic identity of salvaged Chinook salmon or account for the total number of juveniles that could potentially be salvaged (data are not scaled). Coded wire tag studies indicate that small fractions of Sacramento River Chinook Salmon encounter the South Delta salvage facilities, so entrainment-related impacts on the ESU would be small. OMR management for other listed species could incidentally limit Spring-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Entra be hi Code Sacra Soutl impa OMR incid entra Actio weed redu Skinr to im
Spring-run Chinook Salmon	Outmigrant Survival	Delta Passage Model	Across the 82-year simulation period, mean through-Delta survival was 0.6% lower under the Proposed Project. Differences in individual years were generally small (< 1.5%), with the largest difference occurring in the 1995 model year when survival under the Proposed Project was 1.6 % lower than the Existing Condition.	Through Delta survival of Spring-run Chinook Salmon was similar under both scenarios with some uncertainty. The Delta Passage Model contains an export-survival relationship. Thus, higher exports in April and May did not result in substantial changes in through-delta survival. Only a small fraction of Sacramento River-origin Spring-run enter the interior Delta and most of the juvenile population is not exposed to the hydrodynamic effect of exports. This is a combined SWP and CVP result	Less than Significant	Thro woul with This i
Spring-run Chinook Salmon	Outmigrant Survival	San Joaquin River Structured Decision Model	Across the 82-year simulation period, through-Delta survival was low (< 4%) under both scenarios. Survival was higher under the Proposed Project for all years, but the magnitude of the difference between scenarios was variable in specific years. Survival was more similar between scenarios in drier year types relative to wetter year types.	Survival of San Joaquin River-origin Spring-run Chinook Salmon has the potential to be higher under the Proposed Project. Although exports will be higher under the proposed project in April and May, the SDM includes the latest acoustic tagging data from the CVP and south Delta. These data and the model suggest that volitional migration survival from the facilities north can be lower than entrainment at CVP and trucking to the West Delta. Thus, more fish being routed into Old River and higher exports lead to a higher survival under the proposed project. However, overall through-delta survival for San Joaquin River-origin Chinook Salmon is low regardless of scenario (<4%).	Less than Significant	Survi Chinc Alter Alter lates Delta voliti can b the V River unde throu Chinc

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Spring-run Chinook Salmon	Outmigrant Survival	STARS	The STARS model results suggest little difference in predicted through-Delta survival of Spring-run Chinook Salmon between the scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December.	During most months of the outmigration period (November through May for this analysis) Spring-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Increased routing into the Delta and reduced survival could occur in November. Although the STARS model does not include an export-survival function, results generally followed those of the DPM which does. Only small fractions of Sacramento River Chinook Salmon encounter the South Delta facilities as indicated by coded wire tag studies. This likely explains the minor effect of increased exports during April and May on total through-Delta survival. The SWP responsibility for Delta water operations during the spring (~March–May) period of Spring-run Chinook Salmon entry into the Delta is approximately 40–60% depending on the month and water year type.	Less than Significant	Durir (Nov Chinc Delta scena reduc Altho Proje resul does Chinc as inc expla April The S durir Chinc 40–6 type.
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-wa beca and i Long simila scena woul
Spring-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifto impro scree
Fall-run and Late Fall-run Chinook Salmon	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the July through December Fall-run Chinook Salmon and October through April Late Fall-run Chinook Salmon adult immigration periods. No SWP influence on DCC operations.	Similar flow conditions would likely result in similar habitat conditions in the Sacramento River including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. SWP responsibility for differences in Freeport flows is between approximately 20-60% during the Fall-run Chinook Salmon Immigration Period. SWP responsibility for differences in Freeport flows is between approximately 40% to 60% during the Late Fall-run Chinook Salmon Immigration Period. There is no difference in straying rates of Mokelumne River Fall-run Chinook Salmon because there is no SWP influence on DCC operations.	Less than Significant	Simil habit SAIL olfac There Moke there

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Fall-run and Late Fall-run Chinook Salmon	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	For juvenile fall-run Chinook Salmon migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile salmon approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the Old and Middle River corridors during April and May suggest entrainment of fish entering Old River at HOR would be higher. For juvenile fall-run and late-fall run Chinook Salmon originating from the Sacramento River, Changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor in April and May (primarily fall run) and November (late-fall run) are more likely to become entrained under the Proposed Project.	Greater frequency of routing San Joaquin-origin fall-run into Old River increases entrainment risk for these fish. However, acoustic tagging studies have not reported significant differences in survival between the Head of Old River route and the San Joaquin mainstem route. The San Joaquin Delta SDM model incorporates acoustic tagging data in the south Delta including fish entrained into the facilities. This model found higher survival under the proposed project (see below) with uncertainty but suggests survival would not be impaired for fish routed into Old River. For Sacramento River-origin fall-run, and late fall-run that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of fall and late-fall run entering the Old-Middle River corridor. Coded wire tag data indicate that small fractions of juvenile Chinook salmon originating from the Sacramento River encounter the South Delta salvage facilities. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May (fall run) or November (late fall-run). This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the period evaluated for San Joaquin River basin Fall-run Chinook Salmon is approximately 40% to 60%. OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements would improve survival of salvaged fish.	Less than Significant	Grea fall-r incre acou differ route Joaqu Prop in the facili prop sugge route For S that the D confl for P prob simil incre enter tag d Chin River fish t entra or No This i respo perio Chin OMR incid Salm Actio weed redu Skinr survi
Fall-run and Late Fall-run Chinook Salmon	Juvenile	Mokelumne River Fall-run Chinook Salmon Qualitative Discussion	N/A	Coded wire tag analysis suggests that very small percentages of Mokelumne River Fall-run Chinook Salmon would be expected to be entrained, ranging from 0.4-0.6% of outmigrants.	Less than Significant	Code perce Salm from

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Fall-run and Late Fall-run Chinook Salmon	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Fall-run Chinook Salmon at the SWP south Delta export facility could be appreciably greater under the Proposed Project. Entrainment loss of Late Fall-run Chinook Salmon is similar between scenarios.	Entrainment loss could be higher under the Proposed Project, but the analysis is uncertain, and the model does not include genetic identity of salvaged Chinook salmon. Small percentages of juvenile Sacramento River Fall-run and Late Fall-run Chinook Salmon are estimated to encounter the south Delta export facilities, so entrainment-related impacts on the ESU would be small. Entrainment losses likely to be higher for San Joaquin River-origin fall run. However, the SDM model indicated higher survival under the proposed project due to poor volitional survival through Old River relative to salvage and trucking OMR management for other listed species could incidentally limit Fall-run and Late Fall-run Chinook Salmon entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Entra but t for th ident Smal run a to en entra smal Entra River indic due t relat OMR incid Salm Actio weed reduc Skinn to im
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	Delta Passage Model CV Fall-run and Late Fall-run Chinook Salmon	Across the 82-year simulation period, mean Fall-run Chinook Salmon through-Delta survival was 0.5% lower under the Proposed Project. Differences in individual years were generally small (< 1.5%). Across the 82-year simulation period, mean Late Fall-run Chinook Salmon through-Delta survival was 0.3% lower under the Proposed Project. Differences in individual years were generally small (< 1.0%).	Through Delta survival of Fall-run and Late Fall-run Chinook Salmon was similar under both scenarios with some uncertainty. These results were similar to those from the STARS model which does not include an export-survival relationship like to DPM. This suggests changes to exports did not have a substantial effect on through-Delta survival. This is a combined SWP and CVP result.	Less than Significant	Thro Chino unde This i
Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	San Joaquin River Structured Decision Model	Across the 82-year simulation period through-Delta survival was low (< 4%) under both scenarios. Survival was higher under the Proposed Project for all years, but the magnitude of the difference between scenarios was variable. Survival was higher under the	Greater proportions of fish would be routed into Old River relative to the San Joaquin River under the proposed project and exports will be higher in April and May when fall run are migrating. However, survival of San Joaquin River-origin Fall-run Chinook Salmon has the potential to be higher under the Proposed Project. The SDM uses the most recent survival data from acoustic tagging studies in the South Delta and at the CVP. This indicates survival is higher for fish in Old River that are salvaged and trucked rather than volitional migration.	Less than Significant	Survi Salm Alter studi survi salva

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Fall-run and Late Fall-run Chinook Salmon	Outmigrant Survival	STARS	The STARS model results suggest little difference in predicted through-Delta survival of Chinook Salmon between the scenarios in all months of the emigration period in all water year types, except for juveniles migrating before December.	During most months of the outmigration period (January through June) Fall-run Chinook Salmon could be directed toward the interior Delta and survive in a similar proportion under both scenarios. Late Fall-run Chinook Salmon could be exposed to increased routing into the Delta and reduced survival in November, although this is because of DCC operational assumptions related to Freeport flow. Small percentages of Sacramento River Fall-run Chinook Salmon and Late Fall-run Chinook Salmon enter the South Delta, so entrainment-related impacts on the ESU would be small. This is a combined SWP and CVP result. The SWP responsibility for Delta water operations during the periods of Fall-run Chinook Salmon peak entry into the Delta (February-May) and Late Fall-run Chinook Salmon entry into the Delta (November-July) is approximately 40% to 60%, depending on the month and water year type.	Less than Significant	Durir (Janu be di simil Late incre in No Prop assur Smal Chino enter impa This i
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-wa beca and i Long simila scena woul
Fall-run and Late Fall-run Chinook Salmon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifto impro scree
Central Valley Steelhead	Immigrating Adults	Qualitative Discussion of SAIL Conceptual Model Habitat Attributes	Similar flow conditions at Freeport during the July through March immigration period.	Similar flow conditions would likely result in similar habitat conditions, including SAIL Conceptual Model habitat attributes and olfactory cues for immigration. SWP responsibility for differences in OMR flows is between approximately 20-60%.	Less than Significant	Simil habit habit

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Central Valley Steelhead	Juvenile	Delta Hydrodynamic Assessment and Junction Entry	For juvenile steelhead migrating from the San Joaquin River, changes in hydrodynamic conditions (velocity) near the Head of Old River and flow proportion into Old River indicate juvenile fish approaching the Delta from the San Joaquin River basin during April and May are more likely to enter the Old River route. More negative velocity measurements in the Old and Middle River corridors during April and May suggest entrainment of fish entering Old River at HOR would be higher. For juvenile steelhead originating from the Sacramento River, Changes in hydrodynamic conditions (velocity distributions) indicate fish entering the interior Delta via Georgiana Slough and the DCC would experience almost identical water velocity magnitudes and directions. Juveniles that do enter the Old-Middle River corridor in April and May are more likely to become entrained under the Proposed Project	Greater frequency of routing San Joaquin-origin steelhead into Old River increases entrainment risk for these fish but it is unknown if this would translate into a population-level effect on survival. For Sacramento River-origin steelhead, that enter the interior Delta via Georgiana Slough and the DCC, changes in velocity distributions at the confluence of the Mokelumne and San Joaquin Rivers indicate that probabilities of moving south from that point are similar. Thus, the proposed project would be unlikely to increase the proportion of steelhead entering the Old-Middle River corridor. For fish that do enter the Old-Middle River corridor, entrainment could increase in April and May This is a combined SWP and CVP result. Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Grea steel incre unkn level For S the ir chan the M mode prob simil incre Old-M Old-M incre This i Imple year entra Actic weed reduc Skinr to im
Central Valley Steelhead	Juvenile	Entrainment Loss Density	Entrainment loss of juvenile Central Valley steelhead at the SWP south Delta export facility could be greater under the Proposed Project.	Entrainment loss of steelhead could be higher under the Proposed Project, but the analysis is uncertain. Implementing OMR management, including single year and cumulative loss thresholds, would limit entrainment. Actions to improve survival in CCF including aquatic weed control and continued evaluation of predator reduction in CCF would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Entra Alter Imple year entra Actio weed reduc Skinr to im

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Central Valley Steelhead	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	Annu impa mana imple Long woul Cond occu
Central Valley Steelhead	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifto impr scree
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Delta Outflow	Similar under both scenarios.	Similar Delta outflow during most of the year would result in similar impacts under both scenarios. This is a combined SWP and CVP result. SWP responsibility for differences in Delta operations is between approximately 20-60%.	Less than Significant	Simil resul a cor
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Annual O&M Activities	N/A	Annual O&M activities would not occur within the habitats occupied by Central California Coast Steelhead.	Less than Significant	Annu habit Steel
Central California Coast Steelhead	All Life Stages in San Francisco and San Pablo Bays	Project Environmental Protective Measures)	N/A	No project environmental protective measures occur in San Francisco Bay and San Pablo Bay, and no impacts on Central California Coast Steelhead would occur.	Less than Significant	No p in Sa impa occu
Green Sturgeon	Immigrating Adults and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on Green Sturgeon habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	Simil simila Redu woul frequ conse peric impa This i

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Green Sturgeon	Juvenile	Daily Salvage Loss Density	Green Sturgeon salvage is low and is similar under both scenarios.	Green Sturgeon salvage would be expected to be similar under both scenarios.	Less than Significant	Gree simil
Green Sturgeon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities could result in improved survival because removing aquatic weeds could reduce predator habitat, and fish screen maintenance could result in improved salvage efficiency.	Less than Significant	In-wa beca and i Long impr coulc main effici
Green Sturgeon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Cliftc impr scree
White Sturgeon	Immigrating Adults and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions and during April and May.	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months of the year-round potential period of presence) to result in substantial long-term impacts on White Sturgeon habitat attributes. Reductions in Delta outflow in April/May have the potential to reduce year-class strength based on observed correlations, although there is uncertainty in the mechanism and differences would be expected to be small relative to variability in estimates that may reflect hydrological conditions as opposed to operations. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%, and for Delta outflow in April/May is approximately 40-50%.	Less than Significant	Simil simil Redu are n and c mont prese on W Redu pote obse in the to be may oper This i

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White Sturgeon	Juvenile	Daily Salvage Loss Density	White Sturgeon salvage is low and is similar under both scenarios.	White Sturgeon salvage is low and is similar under both scenarios.	Less than Significant	Whit and s
White Sturgeon	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-wa beca and i Long impr coulc main effici
White Sturgeon	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifto impr scree
Pacific Lamprey and River Lamprey	Immigrating Adults, Ammocoetes, and Migrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on lamprey habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	Simil simila Redu are n and c mont lamp This i
Pacific Lamprey and River Lamprey	Juvenile	Daily Salvage Loss Density	Lamprey salvage is similar under both scenarios in wet and above-normal water years but is higher under the Proposed Project in below-normal, dry, and critical water years.	Lamprey salvage is similar under both scenarios in wet and above-normal water years but is higher under the Proposed Project in below-normal, dry, and critical water years. Real-time OMR management for other listed species, particularly first flush protections for Delta Smelt, may incidentally limit lamprey salvage. Actions to improve survival in the CCF including aquatic weed control and continued evaluation of predator reduction in the CCF, could limit pre-screen loss. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Lamp unde years belov Real- parti may Actio aqua preda loss. Skinr to im

					Project)	
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-wa beca and i Long impr coulc main effici
Pacific Lamprey and River Lamprey	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifto impr scree
Native Minnows	Native Minnow Residence	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident native minnow habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	Simil simil Redu are n and c mont resid comb
Native Minnows	Splittail Spawning Hardhead Spawning Central California Roach Spawning	Flow Analysis	Similar flow conditions at Freeport during the native minnow spawning periods and into the Yolo Bypass during the Splittail spawning period.	Similar flows would not result in substantial long-term impacts on native minnow spawning habitat attributes. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 30-60%.	Less than Significant	Freep

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Native Minnows	Juvenile	Splittail Salvage Loss Density	Appreciable increases in entrainment of Sacramento Splittail could occur under the Proposed Project.	Although salvage could be higher under the Proposed Project, the main driver of Sacramento Splittail population dynamics appears to be inundation of floodplain habitat, such as the Yolo Bypass, which would not change. Sacramento Splittail may receive some ancillary protection from the risk assessment-based approach for OMR flow management included in the Proposed Project that would be implemented to protect listed salmonids and smelts. Actions to improve survival in the CCF, including aquatic weed control and continued evaluation of predator reduction in CCF, would reduce pre-screen losses. Skinner Fish Facility Improvements have the potential to improve survival of salvaged fish.	Less than Significant	Altho the n dyna habit chan Sacra prote for O that salm Actio aqua preda losse Skinn to im
Native Minnows	Juvenile	Hardhead Salvage Loss Density	Hardhead salvage is similar under both scenarios and is low.	Similar and low salvage loss would not be expected to substantially affect Hardhead.	Less than Significant	Simil subst
Native Minnows	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-wa beca and i Long impr could main effici
Native Minnows	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival.	Less than Significant	Clifto impro scree

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Striped Bass	Immigrating and Spawning Adults, Rearing and Emigrating Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year, particularly during the immigration, spawning, and larvae dispersal period (April through June). Less Delta outflow (greater fall X2) in fall following wet years; greater fall outflow (lower fall X2) in fall following above-normal years.	Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on Striped Bass. Differences in young-of-the-year abundance as a result of differences in fall Delta outflow/X2 may result in potentially limited population-level impacts because of density dependence later in the life cycle. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	Simil woul impa Diffe resul resul beca This i
Striped Bass	Juvenile Entrainment	Entrainment Loss Density	Similar salvage of juvenile Striped Bass under both scenarios.	Similar and low salvage loss would not be expected to substantially affect Striped Bass. Potential for greater entrainment loss of early life stages (eggs/larvae) during spring may be limited by ancillary protection for listed salmonids and smelts, with limited population-level impacts because of density dependence later in the life cycle.	Less than Significant	Simil subst Poter stage ancil with dens
Striped Bass	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-wa beca and i Long impro could main effici
Striped Bass	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	Clifto impro scree
American Shad	Immigrating and Spawning Adults	Flow Analysis	Similar flow conditions at Freeport during most months of the year, particularly during the immigration, spawning, and larvae dispersal period (April through June).	Similar flows under both scenarios most of the time would not likely result in substantial long-term impacts on American Shad. This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%.	Less than Significant	Simil woul impa This i
American Shad	Juvenile Entrainment	Entrainment Loss Density	Similar salvage of juvenile American Shad under the both scenarios during most years, with higher salvage occurring under the Proposed Project during critical water years.	Similar salvage loss would not be expected to result in substantial impacts on American Shad under the Proposed Project. Loss of earlier life stages may be limited because most early rearing is upstream of the Delta, and there may be ancillary protection from OMR management for listed fish in spring.	Less than Significant	Simil in su Alter Loss most may for li

					Project)	
American Shad	All Life Stages Present in the Delta	Annual O&M Activities	N/A	Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-wa beca and i Long impr coulc main effici
American Shad	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	Cliftc impr scree
Non-Native Freshwater Bass	Resident Adults and Juveniles	Flow Analysis	Similar flow conditions at Freeport during most months of the year except during September and November when flows are lower under the Proposed Project. Reductions occur during higher flow conditions.	Similar flows during most of the year would result in similar impacts under both scenarios. Reductions in flow during September and November are not anticipated to occur with sufficient frequency and duration (i.e., occurring in two non-consecutive months) to result in substantial long-term impacts on resident non-native freshwater bass habitat attributes This is a combined SWP and CVP result. SWP responsibility for differences in Freeport flows is between approximately 20-60%	Less than Significant	Simil simila Redu are n and c mont resid attrib This i
Non-Native Freshwater Bass	Juvenile Entrainment	Entrainment Loss Density	The salvage-density method suggested the potential for entrainment of Largemouth Bass to moderately increase under the Proposed Project, particularly in intermediate water years. Similar salvage of juvenile Spotted Bass and Smallmouth Bass under the both scenarios.	Increased salvage loss of Largemouth Bass could occur but may be mediated because Grimaldo et al. (2009) did not find a significant relationship between Largemouth Bass salvage and OMR flows. Similar, very low salvage of juvenile Spotted Bass and Smallmouth Bass would be expected under both scenarios	Less than Significant	Incre occu beca signit salva Simil Smal scena
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Annual O&M Activities	N/A	In-water activities would have limited impacts because DWR would use appropriate work windows and implement BMPs. Longer-term impacts of O&M activities would be similar to those under the Existing Conditions scenario because these activities currently occur and would continue under the Proposed Project.	Less than Significant	In-wa beca and i Long impr coulc main effici

					Project)	
Non-Native Freshwater Bass	All Life Stages Present in the Delta	Project Environmental Protective Measures including: • Clifton Court Forebay predator relocation studies and aquatic weed control; and • Skinner Fish Facility performance improvements (see Table 3-3)	N/A	Clifton Court Forebay and Skinner Fish Facility improvements have the potential to improve pre-screen survival and post-salvage survival	Less than Significant	Clifto impr scree
Killer Whale	All Life Stages	Food Source Discussion	See model results for Fall-run and Late Fall-run Chinook Salmon.	Because impacts on Fall-run and Late Fall-run Chinook Salmon are less than significant, impacts on killer whales resulting from prey reductions would be minimal	Less Than Significant	Beca Chino killer minir

Sources: Nobriga and Rosenfield 2016; Grimaldo et al. 2009 ;Zeug and Cavallo 2014

Notes:
BMPs = best management practices
CCF = Clifton Court Forebay
CDFW = California Department of Fish and Wildlife
cfs = cubic feet per second
CVP = Central Valley Project
DCC = Delta Cross Channel
Delta = Sacramento–San Joaquin Delta
DPM = Delta Passage Model
DSM2 = Delta Simulation Model II
DWR = California Department of Water Resources
EDSM = Enhanced Delta Smelt Monitoring
ESU = Evolutionary Significant Unit
FCCL = Fish Conservation and Culture Laboratory
ft/sec = foot per second
HOR = Head of Old River
LCM = USFWS Life Cycle Model
LSZ = low salinity zone
N/A = not applicable
O&M = operations and maintenance
OMR = Old and Middle River
PTM = Particle Tracking Modeling
QWEST = Net flow on the San-Joaquin River at Jersey Point
SAIL = Salmon and Sturgeon Assessment of Indicators by Life Stage
SCHISM = Semi-implicit Cross-scale Hydroscience Integrated System Model
SDM = Structured Decision Model
SLS = Smelt Larval Survey
SMSCG = Suisun Marsh Salinity Control Gates
STARS = Survival, Travel Time, and Routing Simulation
SWP = State Water Project
TAF = thousand acre feet
USFWS = United States Fish and Wildlife Service
WY = water year

5.5.4 Other Resources

Section 1.4 *Summary of Environmental Consequences* and the information and analyses presented in the Initial Study, Appendix A concluded that the proposed project would not result in impacts to the following resource topics:

- Aesthetics
- Agriculture and Forestry Resources
- Air Quality
- Biological Resources (Terrestrial)
- Cultural Resources
- Energy
- Geology and Soils
- Greenhouse Gas Emissions
- Hazards and Hazardous Materials
- Land Use and Planning
- Mineral Resources
- Noise
- Population and Housing
- Public Services
- Recreation
- Transportation/Traffic
- Tribal Cultural Resources
- Utilities and Service Systems
- Wildfire

Alternative 4 adds additional summer-fall habitat actions that are not included in the Proposed Project. The additional summer-fall operational criteria could reduce exports during June-August in below normal water years and add additional SMSCG operations in dry water years from June through August. It is expected that SMSCG operations alone would maintain 4 ppt at Belden's Landing and would not add additional water requirements above what was analyzed for the Proposed Project. However, if SMSCG operations are not available, the water cost could be substantial. Historical data indicates that additional outflow during a below normal water year could result in a water cost up to 500 TAF which would require export reductions or increases in reservoir releases.

The additional outflow requirements would be met by reducing exports to the extent possible, but large increases in outflow (up to 500 TAF) could require water from upstream storage releases that were not evaluated in the Initial Study. Increased water releases could originate from SWP reservoirs in the Feather River watershed rather than through shared releases across SWP and CVP reservoirs, because the proposed actions are not included in the CVP federal LTO project. Concentrating the releases in the Feather River watershed could substantially reduce storage and the cold water pool available for fisheries habitat management in the Feather River above the confluence with the Sacramento River.

Reservoir releases could result in impacts to recreation and utilities and service systems that are not addressed in the Initial Study. Each of these impact topics are briefly discussed below.

5.5.4.1 RECREATION

Additional Delta outflow of up to 500 TAF during Below Normal water years could potentially originate from upstream storage. Reservoir releases of up to 500 TAF could substantially reduce the water surface elevation if the water originated from a single reservoir, such as Oroville Reservoir. Oroville Reservoir and other potential sources of the additional water are utilized for water-based recreation, including boating, fishing, and swimming that could be impacted if the water surface elevations were substantially reduced during below normal water years compared to Existing Conditions. The impact of reservoir releases for June-August X2 reductions would be **potentially significant** because of the reduced access to recreation at reservoirs and impacts on recreational facilities, including boat ramps, boat docks and similar facilities.

Mitigation Measure Alt 4-1 is proposed (see above), which would reduce this impact to a **less than significant** level because it would limit the total water cost of meeting the salinity criteria at Belden's Landing during below normal water years.

5.5.4.2 UTILITIES AND SERVICE SYSTEMS

Increased releases from upstream reservoirs could affect the timing and availability of water supplies and power during below normal water years and subsequent dry years. These changes could reduce DWR's ability to meet water quality standards and contractual obligations for delivery of water and power. Water service providers that contract with the SWP include a variety of municipal and agricultural water providers. The amount of water available to these providers is defined by water contract agreements.

One of the objectives of the project is to continue the coordinated long-term operation of the SWP for water supply and power generation, consistent with applicable laws, contractual obligations, and agreements. The potential reduction in water availability from upstream storage reservoirs in dry years following below normal years is a **potentially significant** impact. Mitigation Measure Alt 4-1 is proposed (see above), which would reduce this impact to a **less than significant** level because it would limit the total water cost of meeting the salinity criteria at Belden's Landing during below normal water years.

5.5.5 OTHER CONSIDERATIONS

Outflows intended for maintenance of the 80 km X2 would be available for diversion by the CVP, because the flows would not be protected from recapture. The addition of summer salinity criteria at Belden's Landing during below normal water years would require upstream releases of up to 500 TAF from the Feather River watershed if an agreement with the CVP cannot be reached. The implications of a large upstream release during this time period could adversely affect the SWP's ability to meet water quality requirements if the subsequent water year is dry.

As described in the aquatic biological resource section above, the potential benefits of Alternative 4 for Delta Smelt abundance compared to the Proposed Project are not completely understood based on recent studies that evaluated multiple habitat parameters, including temperature, turbidity and salinity in the vicinity of the Suisun Marsh, Suisun Bay and Honker Bay.

5.6 ENVIRONMENTALLY SUPERIOR ALTERNATIVE

Based on the analysis of the Proposed Project in Chapter 4 and the alternatives summarized above in Chapter 5, the environmentally superior alternative would be Refined ~~either the proposed project or~~ Alternative 2b. The ~~D~~EIR evaluations presented above in Chapters 4 and 5 conclude that both the Proposed Project and Refined Alternative 2b ~~options~~ would result in less than significant impacts to water quality and aquatic biological resources and no impacts to other resource areas. However, Refined Alternative 2b~~2B~~ would include additional actions to benefit CESA-listed fish species in the Delta that would not be implemented by the Proposed Project or Alternatives 2a, 3, or 4. ~~includes some refinements of the summer-fall action plus additional water for adaptive management testing and evaluation of components identified in the Delta smelt resiliency strategy. These outflow components of Alternative 2B may provide some potential benefits to Delta Smelt , Longfin Smelt and other resources in the Delta, but those potential benefits are not proven. Therefore, the DEIR concludes that the impacts of proposed project and Alternative 2b are essentially equivalent and both the proposed project and Alternative 2b are considered to be the environmentally superior alternatives.~~

With implementation of Refined Alternative 2b, seasonal timing of exports differs from the Existing Condition, but the total volume of exports would generally be expected to remain the same. Additionally, Refined Alternative 2b includes a collaborative real-time risk assessment approach to Old Middle River (OMR) management that provides CDFW with greater authority to curtail exports to minimize entrainment-related effects on CESA-listed fish species. Refined Alternative 2b also commits DWR to implementing its proportional share of OMR restrictions when such restrictions are recommended by the Water Operations Management Team (WOMT) or required by CDFW.

Refined Alternative 2b includes additional adaptive management actions not included in the Proposed Project or Alternatives 2a, 3, and 4. These adaptive management actions include convening an Adaptive Management Team (AMT) that will develop and implement an Adaptive Management Plan (AMP). The AMT will oversee efforts to monitor and evaluate SWP operations and related activities, use structured decision-making to assess the relative costs and benefits of those operations and activities, and will identify changes to those operations and activities.

The major environmental benefits associated with implementing the AMP include the curtailment of exports by up to 150 thousand acre feet (TAF) in Above Normal, Below Normal, and Dry water years to maintain the current SWP spring outflow contribution and provide an adaptively-managed 100 TAF block of Delta outflow in June through November of Wet and Above Normal water years, which may be deferred to the following year.

Therefore, Refined Alternative 2b is the environmentally superior alternative selected by DWR for the long-term operations of the SWP.

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