APPLICANT-PREPARED
DRAFT BIOLOGICAL ASSESSMENT
CALIFORNIA CENTRAL VALLEY STEELHEAD
(*Oncorhynchus mykiss*)
DISTINCT POPULATION SEGMENT
DON PEDRO HYDROELECTRIC PROJECT
FERC NO. 2299

Prepared for:
Turlock Irrigation District – Turlock, California
Modesto Irrigation District – Modesto, California

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List of Acronyms

ac	acres
ACOE	U.S. Army Corps of Engineers
AF	acre-feet
AFLA	Amendment to the Final License Application
AFRP	Anadromous Fish Restoration Program
AN	above normal
BA	Biological Assessment
BLM	U.S. Department of the Interior, Bureau of Land Management
BN	below normal
BO	Biological Opinion
C	critical
CALFED	CALFED Bay-Delta Program
CCSF	City and County of San Francisco
CCV steelhead	California Central Valley steelhead
CDEC	California Data Exchange Center
CDFG	California Department of Fish and Game (as of January 2013, Department of Fish and Wildlife)
CDFW	California Department of Fish and Wildlife
CDPR	California Department of Pesticide Regulation
CDWR	California Department of Water Resources
CFR	Code of Federal Regulations
cfs	cubic feet per second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CWA	Clean Water Act
D	dry
Districts	Turlock Irrigation District and Modesto Irrigation District
DO	dissolved oxygen
DPS	Distinct Population Segment
EFH	Essential Fish Habitat
EPA	U.S. Environmental Protection Agency
ERP	Ecosystem Restoration Program

ESA............................Federal Endangered Species Act
ESRCD.......................East Stanislaus Resource Conservation District
ESU............................Evolutionary Significant Unit
eWUA.........................Effective Weighted Useable Area
FERC..........................Federal Energy Regulatory Commission
FOT............................Friends of the Tuolumne
FPC............................Federal Power Commission
g.................................grams
GIS.............................Geographic Information System
HGMP........................Hatchery Genetic Management Plan
HSRG.........................California Hatchery Scientific Review Group
ILP..............................Integrated Licensing Process
ISR.............................Initial Study Report
LWD..........................large woody debris
m................................meters
M&I...........................municipal and industrial
mg/L..........................milligrams per liter
MID............................Modesto Irrigation District
msl.............................mean sea level
MW............................megawatt
MWh..........................megawatt hour
NEPA.........................National Environmental Policy Act
NGOs.........................Non-Governmental Organizations
NMFS.........................National Marine Fisheries Service
NOAA........................National Oceanic and Atmospheric Administration
NRCS.........................National Resource Conservation Service
NTU...........................nephelometric turbidity unit
NWIS.........................National Water Information System
NGVD 29...................National Geodetic Vertical Datum of 1929
mi...............................miles
mi^2..............................square miles
mm.............................millimeter
PAD............................Pre-Application Document
PBF............................physical or biological feature

PCE ....Primary Constituent Elements
PHABSIM..................Physical Habitat Simulation
PM&E ....Protection, Mitigation and Enhancement
PSP.............................Proposed Study Plan
RM ....River Mile
RPA............................reasonable and prudent alternative
RSP ....Revised Study Plan
SD2 ....Scoping Document 2
SJPL ....San Joaquin Pipeline
SJRRP ....San Joaquin River Restoration Program
SPD ....Study Plan Determination
SRP ....Special Run Pools
STORET ....EPA storage-and-retrieval water quality database
SWP ....State Water Project
SWRCB......................State Water Resources Control Board
TAC............................Tuolumne River Technical Advisory Committee
TID.............................Turlock Irrigation District
TMDL ....Total Maximum Daily Load
TROm ....Tuolumne River *O. mykiss* model
TRT ....Tuolumne River Trust
USFWS ......................U.S. Department of the Interior, Fish and Wildlife Service
USGS .........................U.S. Department of the Interior, Geological Survey
USR............................Updated Study Report
W&AR ....Water and Aquatic Resource
W................................wet
WQO ....water quality objective
WUA ....weighted usable area
WWTP ....Wastewater Treatment Plant
WY.............................water year
yd^3 ....cubic yard
YSS ....Yosemite Stanislaus Solutions
7DADM ....seven-day average of the daily maximum

PREFACE

On April 28, 2014, the co-licensees of the Don Pedro Hydroelectric Project, Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts), timely filed with the Federal Energy Regulatory Commission (Commission or FERC) the Final License Application (FLA) for the Don Pedro Hydroelectric Project, FERC No. 2299. As noted in the filing and acknowledged by FERC at the time, several studies were ongoing which were likely to inform the development of additional protection, mitigation, and enhancement (PM&E) measures. The Districts have now completed these studies and herein submit this Amendment of Application (Amendment to the Final License Application or AFLA). For ease of review and reference, this AFLA replaces the Districts' April 2014 filing in its entirety.

The Don Pedro Project provides water storage for irrigation and municipal and industrial (M&I) use, flood control, hydroelectric generation, recreation, and natural resource protection (hereinafter, the "Don Pedro Project"). The environmental analysis contained in this AFLA considers all the components, facilities, operations, and maintenance that make up the Don Pedro Project and certain facilities proposed to be included under the new license. The Don Pedro Project is operated to fulfill the following primary purposes and needs: (1) to provide water supply for the Districts for irrigation of over 200,000 acres of Central Valley farmland and M&I use, (2) to provide flood control benefits along the Tuolumne and San Joaquin rivers, and (3) to provide a water banking arrangement for the benefit of the City and County of San Francisco (CCSF) and the 2.6 million people CCSF supplies in the Bay Area. The original license was issued in 1966. In 1995, the Districts entered into an agreement with a number of parties, which resulted in greater flows to the lower Tuolumne River for the protection of aquatic resources.

Hydroelectric generation is a secondary purpose of the Don Pedro Project. Hereinafter, the hydroelectric generation facilities, recreational facilities, and related operations will be referred to as the "Don Pedro Hydroelectric Project," or the "Project". With this AFLA to FERC, the Districts are seeking a new license to continue generating hydroelectric power and implement the Districts' proposed PM&E measures. Based on the information contained in this AFLA, and other sources of information on the record, FERC will consider whether, and under what conditions, to issue a new license for the continued generation of hydropower at the Districts' Don Pedro Project. The Districts are providing a complete description of the facilities and operation of the Don Pedro Project so the effects of the operation and maintenance of the hydroelectric facilities can be distinguished from the effects of the operation and maintenance activities of the overall Don Pedro Project's flood control and water supply/consumptive use purposes.

Being able to differentiate the effects of the hydropower operations from the effects of the flood control and consumptive use purposes and needs of the Don Pedro Project will aid in defining the scope and substance of reasonable PM&E alternatives. As FERC states in Scoping Document 2 in a discussion related to alternative project operation scenarios: "…alternatives that address the consumptive use of water in the Tuolumne River through construction of new structures or methods designed to alter or reduce consumptive use of water are…alternative mitigation strategies that could not replace the Don Pedro *hydroelectric* [emphasis added] project. As such, these recommended alternatives do not satisfy the National Environmental

Policy Act (NEPA) purpose and need for the proposed action and are not reasonable alternatives for the NEPA analysis."

1.0 INTRODUCTION

This document contains the Turlock Irrigation District's (TID) and Modesto Irrigation District's (MID) (henceforth the Districts') Draft Biological Assessment (BA) for the Don Pedro Hydroelectric Project (FERC No. 2299). This Draft BA assesses Project-related effects on threatened and endangered species listed under the Endangered Species Act of 1973, amended in 1988, 16 U.S.C. § 1531-1544 (ESA), as well as their designated critical habitat. This Draft BA is part of the AFLA, submitted to FERC in accordance with their application for a new license for continued hydroelectric power generation at the Don Pedro Hydroelectric Project (Project). FERC is the federal agency authorized to issue licenses for the construction, operation, and maintenance of the nation's non-federal hydroelectric facilities.

The ESA requires that federal agencies ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species, or result in the destruction or adverse modification of designated critical habitat of such species. When a federal action agency authorizes, funds, or carries out an action, it must consult with the National Marine Fisheries Service (NMFS) if the agency determines that the action may affect ESA-listed species under NMFS's jurisdiction. The issuance of a license to generate hydropower is a federal action that requires FERC to consult with NMFS under Section 7 of the ESA. Consultation is required to make certain that FERC's action (i.e., issuance of a new license for continued hydroelectric power generation) does not jeopardize the continued existence of California Central Valley (CCV) steelhead (*Oncorhynchus mykiss*; henceforth *O. mykiss*) and its designated critical habitat[1] in the Tuolumne River downstream of the La Grange Diversion Dam (LGDD) to the confluence of the Tuolumne and San Joaquin rivers (i.e., the Action Area for this Draft BA; see Section 2.3). This Draft BA is intended to serve as the basis for consultation under Section 7 of the ESA for ESA-listed species under the jurisdiction of NMFS.

1.1 Proposed Action and FERC Authority

In accordance with the Federal Power Act (FPA), FERC is able to issue such licenses for a period not less than 30 years, but no more than 50 years. Under the FPA, FERC issues licenses that are best adapted to a comprehensive plan for improving or developing a waterway. As the federal "action agency," FERC must also comply with the requirements of the National Environmental Policy Act (NEPA), under which FERC must define the specific action it is considering and the purpose and need for the Proposed Action. In the case of the Project, the Proposed Action under review by FERC is the issuance of a new license to the Districts to authorize the continued generation of renewable hydroelectric power at Don Pedro Dam. Also included under the Proposed Action is the implementation of a series of measures proposed by

[1] Critical habitat is designated to include the areas defined in specific CALWATER Hydrologic Units. Relative to the Tuolumne River, this includes the *Montpelier Hydrologic Sub-area 553560.* Outlet(s) = Tuolumne River (Lat 37.6401, Long –120.6526) upstream to endpoint(s) in: Tuolumne River (37.6721, –120.4445). NMFS defines the lateral extent of designated critical habitat as the width of the stream channel defined by the ordinary high water line as defined by the COE in 33 CFR 329.11. In areas for which ordinary high-water has not been defined pursuant to 33 CFR 329.11, the width of the stream channel shall be defined by its bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain (Rosgen 1996) and is reached at a discharge which generally has a recurrence interval of 1 to 2 years on the annual flood series (Leopold et al. 1992).

the Districts to enhance conditions for aquatic resources, including *O. mykiss,* in the lower Tuolumne River.

During NEPA scoping conducted by FERC, issues were raised regarding the effects of the Proposed Action on ESA-listed species and their designated critical habitats. One ESA-listed fish occurs in the Tuolumne River downstream of the Project, i.e., the threatened California Central Valley (CCV) Distinct Population Segment (DPS) of steelhead (*O. mykiss*) (henceforth referred to as CCV steelhead).

1.1.1 Regulatory Framework

Under provisions of Section 7(a)(2) of the ESA, FERC is required to consult with NMFS regarding the relicensing of the Don Pedro Hydroelectric Project (Project) to ensure that the Districts' Proposed Action and resource measures (see Section 2.0) will not jeopardize the continued existence of CCV steelhead or adversely modify the species' critical habitat (16 United States Code [U.S.C.] Section 1536(c)).

This Draft BA develops determinations of effects for the Proposed Action on CCV steelhead and the species' critical habitat. Based on the conclusions contained herein, NMFS will either prepare a concurrence letter or issue a Biological Opinion (BO) presenting NMFS's determination as to whether or not the Proposed Action and resource measures are likely to jeopardize CCV steelhead or adversely modify critical habitat in the Action Area. If a "jeopardy" or "adverse modification" determination is made, the BO must identify any reasonable and prudent alternative (RPA) actions that avoid jeopardizing the continued existence of CCV steelhead or destroying or modifying its critical habitat.

If NMFS issues either a "no jeopardy" opinion or a "jeopardy" opinion that includes RPAs, the BO may include an incidental take statement. NMFS must anticipate the quantity of take that could result from the Proposed Action and authorize such take along with a statement that the CCV steelhead DPS will not be jeopardized. The incidental take statement would contain terms and conditions designed to reduce the effect of the anticipated take. These terms and conditions would then be considered by FERC and, if adopted, become conditions of the FERC license.

1.2 Project Background

The Districts are the co-licensees of the 168-megawatt (MW) Project located on the Tuolumne River in western Tuolumne County in the Central Valley region of California. Don Pedro Dam is located at river mile (RM) 54.8, and Don Pedro Reservoir, formed by the dam, extends 24 miles upstream at the normal maximum water surface elevation of 830 feet (ft) above mean sea level (msl; NGVD 29). At elevation 830 ft, the reservoir stores over 2,000,000 acre-feet (AF) of water and has a surface area slightly less than 13,000 acres (ac). The watershed above Don Pedro Dam is approximately 1,533 square miles (mi^2). Both TID and MID are local public agencies authorized under the laws of the State of California to provide retail electric service.

1.2.1 Project Boundary and Facilities

The Project Boundary extends from RM 53.2, which is 1 mile below the Don Pedro powerhouse, upstream to RM 80.8 at an elevation corresponding to the 845-ft contour (31 FPC 510 [1964]). The current Project Boundary encompasses approximately 18,370 ac, with 78 percent of the lands owned jointly by the Districts and the remaining 22 percent (approximately 4,000 ac) owned by the United States and administered as a part of the U.S. Bureau of Land Management (BLM) Sierra Resource Management Area.

The primary Project facilities include the 580-ft-high Don Pedro Dam and Reservoir, completed in 1971; a four-unit powerhouse situated at the base of the dam; related facilities including the Project spillway, outlet works, and switchyard; four dikes (Gasburg Creek Dike and Dikes A, B, and C); and three developed recreational facilities (Fleming Meadows, Blue Oaks, and Moccasin Point Recreation Areas). The location of the Project and its primary facilities are shown in Figure 1.2-1.

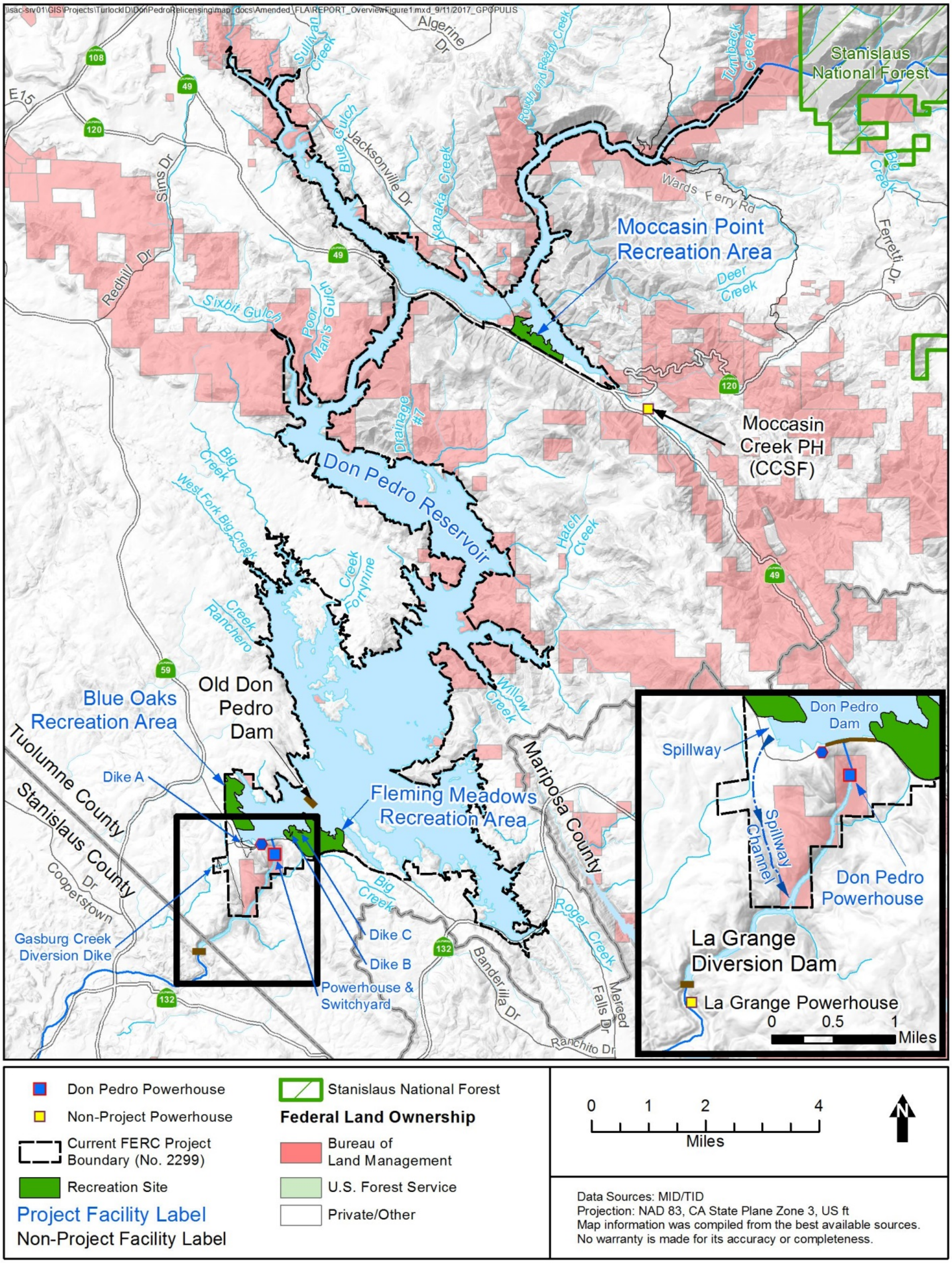

Figure 1.2-1. Don Pedro Project location.

1.3 Public Review and Consultation during Relicensing

1.3.1 Notice of Intent and Pre-Application Document

Prior to filing the Notice of Intent (NOI) and Pre-Application Document (PAD) in February 2011, the Districts commenced relicensing discussions with a series of meetings with resource agencies and the public. The Districts met with NMFS on August 30, 2010, USFWS on August 31, 2010, and CDFW on October 19, 2010. In September 2010, the Districts conducted three public information meetings to seek additional sources of existing information, familiarize interested parties with the Don Pedro Project facilities, features, and operations, and review the Districts' relicensing plans and the overall relicensing schedule.

The Districts exercised due diligence in acquiring information to be included in the PAD. The Districts contacted governmental agencies, Indian Tribes, and other parties potentially having relevant information, conducted extensive searches of publicly available databases and their own records, and broadly distributed a request for information designed specifically to identify existing, relevant, and available information related to the Don Pedro Hydroelectric Project and any potential effects on resources within the Project Boundary.

Pursuant to 18 C.F.R. §5.6, the Districts prepared a NOI and PAD and filed them with FERC on February 11, 2011. The Districts also distributed the PAD to federal and state resource agencies, NGOs, local governments, Indian Tribes, and other relicensing participants. The PAD included information the Districts had gathered to date as well as 10 proposed study plans, which addressed water quality, terrestrial, wildlife, historic properties, and cultural resources.

1.3.2 Scoping and Study Plan Development

FERC issued a Scoping Document 1 (SD1) and NOI on April 8, 2011, to solicit comments on the scope of environmental studies in the relicensing process, and to encourage participation in the relicensing process. The SD1 was noticed in the Federal Register on April 14, 2011. FERC staff conducted a public site visit of the Don Pedro Project on May 10, 2011, which included an overview of the Don Pedro Project and its operations and a tour of the Don Pedro Reservoir and adjacent recreation facilities and wildlife areas. On May 11, 2011, FERC staff conducted a daytime public scoping meeting in the city of Turlock, California and an evening public scoping meeting in the city of Modesto, California. Attendees included representatives from federal, state and local agencies, elected officials, business leaders, and community members.

After filing the PAD, the Districts held a series of resource work group (RWG) meetings to solicit input on the relicensing study plans. On July 25, 2011, the Districts filed their Proposed Study Plan (PSP) document with FERC. The PSP presented 30 draft study plans that the Districts proposed in response to study requests received from relicensing participants. On that same day, FERC filed its SD2, incorporating relicensing participants' comments received on the SD1, the PAD, and study requests. FERC issued a minor clarification to its SD2 on July 29, 2011.

Between filing the PSP on July 25, 2011 and the October 24, 2011 deadline for filing comments on the PSP, the Districts hosted 13 additional RWG meetings to resolve differences regarding the proposed studies. Through these meetings, all 30 of the Districts' draft study proposals were discussed and two new study plans were formulated. On October 13, 2011, the Districts filed an Updated Study Plan with FERC to provide the most up-to-date version of the PSP. Based on the RWG meetings and comments received on the PSP, the Districts revised many of the original study plans and added five additional studies, bringing the total number of studies to 35. On November 22, 2011, the Districts filed a Revised Study Plan containing the 35 study plans.

On December 22, 2011, FERC issued its Study Plan Determination (SPD) for the Don Pedro Project, approving or approving with modifications 33 studies proposed in the RSP, adding one study recommended by the BLM (Bald Eagle Study), and recommending that two studies not be undertaken (the Chinook Salmon Fry Movement Study and the Temperature Criteria Study). As required by the SPD, and after further consultation with the resource agencies and other relicensing participants, the Districts filed three revised study plans with more detailed methodologies on February 28, 2012 and one modified study plan on April 6, 2012. FERC approved or approved with modifications these studies on July 25, 2012. In addition, the Districts chose to conduct the Temperature Criteria Study (Farrell et al. 2017, W&AR-14).

Following FERC's issuance of the SPD, a total of seven studies (and associated study elements) that were either not adopted in the SPD or were adopted with modifications, formed the basis of Study Dispute proceedings. On April 17, 2012, in response to study disputes, FERC convened a Dispute Resolution Panel technical conference in Sacramento, California. The Panel issued its findings on May 4, 2012. On May 24, 2012, FERC issued its Formal Study Dispute Determination, with additional clarifications related to the Formal Study Dispute Determination issued on August 17, 2012. The Study Dispute Determination resulted in two modifications to the SPD and six clarifications. Studies were implemented consistent with this determination.

In addition to studies required under the relicensing proceedings, the Districts' instream flow incremental methodology (IFIM) study provides information in support of this license application and its associated documents. On July 16, 2009, FERC directed the Districts to develop and implement an IFIM study to determine instream flows necessary to maximize Chinook salmon and *O. mykiss* production and survival in the Tuolumne River. The lower Tuolumne River Instream Flow Studies – Final Study Plan (Stillwater Sciences 2009) was filed on October 14, 2009 and approved by FERC on May 12, 2010.

In order to examine the broad flow ranges identified in FERC's July 2009 Order, the study plan separated the study into two separate investigations: (1) a conventional 1-D Physical Habitat Simulation (PHABSIM) model (Lower Tuolumne Instream Flow Study), which examines in-channel habitat conditions at flows from approximately 100–1,000 cfs, and (2) a 2-D hydraulic model of overbank areas, as well as adjacent in-channel locations, for flows of 1,000–5,000 cfs, developed as part of the Pulse Flow Study. Following approval of the original Study Plan, in its December 22, 2011 SPD, FERC required the scope of the Lower Tuolumne River Instream Flow Study be expanded to include Pacific lamprey (*Entosphenus tridentatus*) and Sacramento splittail (*Pogonichthys macrolepidotus*), if existing habitat suitability criteria (HSC) were available. In its April 8, 2013 comments on the Draft Lower Tuolumne Instream Flow Study Report, the

USFWS provided references to existing criteria, developed for the lower Merced River. More recently, FERC's May 21, 2013 Determination on Requests for Study Modifications and New Studies required the scope of the Lower Tuolumne Instream Flow Study be expanded to assess habitat for non-native predatory fish, including smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), and striped bass (*Morone saxatilis*) using existing HSC data, where available. All components of the Lower Tuolumne River Instream Flow Study have now been filed with FERC.

1.3.3 Pre-Filing Consultation Workshop Process

Prior to filing the FLA, the Districts conducted, with FERC concurrence, a series of workshops and meetings associated with the studies listed below to share and discuss relevant data with relicensing participants:

- W&AR-02: Project Operations/Water Balance Model,
- W&AR-03: Reservoir Temperature Model,
- W&AR-05: Salmonid Population Information Integration and Synthesis Study,
- W&AR-06: Chinook Population Model,
- W&AR-10: *O. mykiss* Population Model,
- W&AR-16: Lower Tuolumne River Temperature Model, and
- W&AR-21: Lower Tuolumne River Floodplain Hydraulic Assessment.

The purpose of the workshops was to provide an opportunity for relicensing participants and the Districts to discuss relevant data sources, methods of data use and development, and modeling parameters at specific points in the development of these study plans. The goal of the workshop process was for relicensing participants and the Districts to reach agreement, where possible, after thorough discussion of data and methods. In the December 2011 SPD, FERC directed the Districts to formalize the workshop process. The Districts submitted for review and comment a draft Workshop Consultation Process to relicensing participants in March 2012, and filed the final Workshop Consultation Process with FERC on May 18, 2013.

Throughout 2012, 2013, and 2014, the Districts conducted a total of 18 Workshops. In addition, the Districts conducted model training sessions for several of the studies that involved the development of quantitative models. For each workshop, an agenda and materials were provided prior to the meeting date, draft meeting notes were provided for 30-day comment by relicensing participants, and final workshop notes and responses to comments received were filed with FERC to maintain a record of interim study plan decisions. A summary of all consultation documentation related to these Workshops is included as Attachment B to the AFLA for the Don Pedro Hydroelectric Project.

1.3.4 Initial and Updated Study Reports

On January 17, 2013, the Districts filed their Initial Study Report (ISR). Included in the ISR was the Districts' NOI to file a DLA rather than a Preliminary Licensing Proposal under the ILP. The Districts held the ISR meeting on January 30 and 31, 2013, in Modesto, California. On February 8, 2013, the Districts filed an ISR meeting summary.

Following the ISR meeting, relicensing participants filed requests for new studies and study modifications. The Districts responded to these comments on April 9, 2013, and agreed to a new model and three new studies. On May 21, 2013, FERC issued its Determination on Requests for Study Modifications and New Studies. The determination approved five study modifications and five new studies or study elements. The Districts filed an Updated Study Report (USR) for the Don Pedro Project on January 6, 2014, held a USR Meeting on January 16, 2014, and filed a summary of the meeting on January 27, 2014. On March 28, 2014, the Districts filed a response to USR comments received from relicensing participants.

1.3.5 Draft License Application

The DLA was filed on November 26, 2013, which was followed by a 90-day public comment period. Comments on the DLA were received from FERC, American Whitewater, USFWS, Conservation Groups, NMFS, Restore Hetch Hetchy, Tuolumne County Water Agency, Stanislaus National Forest, ARTA, SWRCB, BLM, CDFW, and OARS Rafting. The Districts' responses to these comments are provided as Attachment A to Don Pedro Hydroelectric Project AFLA.

1.3.6 Post-Filing Consultation and Alternatives Analysis

Since the filing of the FLA in April 2014, and in accordance with the FERC-approved schedule, the following studies involving the resources of the lower Tuolumne River were completed. The results of these studies, along with some of the aforementioned models and existing studies, were used to assess Project impacts on aquatic resources and conduct the analysis of proposed alternative PM&E measures contained in this Draft BA.

- W&AR-11: Fall-Run Chinook Salmon Otolith Study
- W&AR-12: *Oncorhynchus mykiss* Habitat Survey
- W&AR-14: Thermal Performance of Wild Juvenile *Oncorhynchus mykiss* in the Lower Tuolumne River: A Case for Local Adjustment to High River Temperature
- W&AR-21: Lower Tuolumne River Floodplain Hydraulic Assessment
- Lower Tuolumne River Instream Flow Study Effective Weighted Usable Area Estimate for *O. mykiss*
- Lower Tuolumne River Instream Flow Study Evaluation of Non-Native Predatory Fish
- Tuolumne River Flow and Water Temperature Model: Without Dams Assessment

On May 18, 2017, the Districts hosted a Modeling Tools Update Workshop with relicensing participants to provide a status update on models developed to support the relicensing. The following studies were discussed during the meeting:

- W&AR-02: Project Operations/Water Balance Model,
- W&AR-03: Reservoir Temperature Model,
- W&AR-06: Chinook Population Model,
- W&AR-10: *O. mykiss* Population Model,
- W&AR-16: Lower Tuolumne River Temperature Model, and
- W&AR-21: Lower Tuolumne River Floodplain Hydraulic Assessment.

2.0 DESCRIPTION OF THE PROPOSED ACTION

2.1 Proposed Action

FERC is the federal agency authorized to issue licenses for the construction, operation, and maintenance of the nation's non-federal hydroelectric facilities. In accordance with the Federal Power Act (FPA), FERC is able to issue such licenses for a period not less than 30 years, but no more than 50 years. Upon expiration of an existing license, FERC must decide whether, and under what terms, to issue a new license. Under the FPA, FERC issues licenses that are best adapted to a comprehensive plan for improving or developing a waterway, and in so doing, must consider a suite of beneficial public uses including, among others, water supply, flood control, irrigation, and fish and wildlife. As the federal "action agency," FERC must also comply with the requirements of NEPA, under which FERC must clearly define the specific proposed action it is considering and define the purpose and need for the proposed action.

In the case of the Don Pedro Project, the Proposed Action under review by FERC is the issuance of a new license to the Districts to authorize the continued generation of hydroelectric power at Don Pedro Dam and the implementation of an accompanying suite of resource measures proposed by the Districts. As such, and as generally described in FERC's Scoping Document 2 (SD2) issued on July 25, 2011, any alternatives to mitigate the Project's effects ("mitigation strategies") must be reasonably related to the purpose and need for the Proposed Action, which in this case is whether, and under what terms, to authorize the continuation of hydropower generation at the Don Pedro Project and the proposed resource measures.

Flow releases through the powerhouse from Don Pedro Reservoir are scheduled based on requirements for (1) flood flow management, including pre-releases in advance of anticipated high flows during wet years, (2) the Districts' irrigation and municipal and industrial (M&I) demands, including flows to maintain water storage in Turlock Lake and Modesto Reservoir, and (3) protection of aquatic resources in the lower Tuolumne River in accordance with the terms of the existing FERC license. Once the weekly and daily flow schedules are established based on these demands, outflows from the Don Pedro powerhouse are scheduled to deliver these flows. During periods of greater electrical demand, outflows may be shaped to generate more electricity during on-peak periods and less during off-peak periods, subject to meeting the requirements of the pre-established flow schedule. In accordance with the Districts' "water-first" policy, flow releases are scheduled around the three primary Project requirements listed above, then delivered via the generation units up to their capacity and availability. Hydropower generation at the Don Pedro Project is a secondary consideration with respect to flow scheduling and does not affect flow regime downstream of La Grange Diversion Dam.

Issuing a new license will allow the Districts to continue generating electricity at the Project for the term of the new license, producing low-cost electric power from a non-polluting, renewable resource. Clean, renewable hydropower generation is a valuable benefit of the Project. The average annual generation from the Project from 1997 to 2012 was 535,000 megawatt hours (MWh) of electricity. The current maximum hydraulic capacity of the four turbines is 5,500 cfs, and the current FERC-authorized capacity is 168 MW.

The electricity generated at the Project is important to the State of California and will be increasingly important as the demand for electric power grows in the future. In January 2016, the California Energy Commission issued the California Energy Demand 2016–2026, Revised Electricity Forecast. The updated low, mid, and high average annual growth rate forecasts for electricity consumption in the state for the period 2014–2026 are 0.54 percent, 0.97 percent, and 1.27 percent, respectively (Kavalec et al. 2016).

As noted above, this Draft BA includes an analysis of the direct and cumulative effects on *O. mykiss* that would result from the Districts' proposed measures for the lower Tuolumne River, which are described below. Some of these measures are specifically designed to benefit *O. mykiss,* while others are intended to benefit fall-run Chinook salmon or the aquatic ecosystem in general. One measure is proposed to enhance recreation. In many instances, actions designed for other purposes would improve conditions for *O. mykiss*. The effects of the proposed measures are discussed under Effects of Proposed Aquatic Resource Measures and Cumulative Effects of the Proposed Action (Sections 5.3 and 5.4, respectively, of this Draft BA).

2.1.1 Improve Spawning Gravel Quantity and Quality

2.1.1.1 Augment Current Gravel Quantities through a Coarse Sediment Management Program

The results of the Spawning Gravel in the Lower Tuolumne River study (TID/MID 2013g) demonstrate that the Tuolumne River downstream of the La Grange tailrace has sufficient gravel now, and for the foreseeable future, to provide habitat for *O. mykiss* spawning. However, although availability of spawning gravel is not currently a limiting factor, Don Pedro Reservoir's capture of gravel prevents its movement downstream, which has contributed to the net loss of gravel supply to the lower Tuolumne River. Based on the results of TID/MID (2013g) estimated total coarse sediment storage loss in the lower river was approximately 8,000 tons, based on differencing of 2005 and 2012 DTM data over a 13-mile study reach, which included the reach of the lower Tuolumne River where nearly all salmonid spawning occurs. Distributed over the channel within the study area, this equates to an average bed lowering of 13 mm, or less than half the average median grain size of the coarse channel bed (approximately 51 mm). The total estimated gravel volume lost from storage in the reach is comparable in magnitude to the quantity of coarse sediment added during any one of the augmentation projects that have occurred since 2002 (approximately 7,000–14,000 tons). Also, the reservoir's ongoing operations affect flow magnitude and frequency downstream, and this affects gravel mobilization, which can lead to gravel filling in with fines, which in turn impacts the suitability of gravel for *O. mykiss* spawning (TID/MID 2013g).

To improve spawning habitat conditions, the Districts propose to conduct coarse sediment augmentation from RM 52 to RM 39 over a 10-year period following issuance of a new license. Because spawning preferences are more heavily weighted towards upstream habitats, the highest priority for the gravel augmentation is upstream of Old La Grange Bridge. Coarse sediment to be added to the river channel would range in size from 0.125 to 5.0 inches in diameter (Preliminary Gravel Augmentation Designs for Don Pedro Hydroelectric Project (Appendix E-1, Attachment A, Stillwater Sciences [2017]). Taking biological needs, geomorphic needs, and sensitive habitat into consideration, the recommended short-term coarse sediment augmentation sites, in order of priority, would be: (1) Riffle A3/4, (2) Riffle A5/6, (3) Basso Pool, and (4) Riffle A1/2[2] (Stillwater Sciences 2017). Preliminary augmentation designs are provided in the Appendix E-1, Attachment A, and estimated coarse sediment volumes and spawning gravel areas are shown in Table 2.1-1.

Table 2.1-1. Preliminary coarse augmentation volumes and spawning gravel areas (at 320 cfs) downstream of La Grange Diversion Dam (RM 52) in the Tuolumne River.

Riffle Location	RM	Volume (yd^3)	Tons	Wetted Area (ft^2)
A2	51.7	450	585	6,450
A3	51.5	4,300	5,590	43,640
A5	51.2	11,500	14,950	120,960
A6	51.0	18,600	24,180	100,460
Basso Upper	46.5	20,500	26,650	190,890
Basso Lower	46.2	2,300	2,990	80,269
Totals		**57,650**	**74,945**	**542,669**

Coarse sediment would be clean, non-angular stone obtained from an upland source outside of the channel and riparian area and, as noted above, properly sized for the augmentation reach. Sediment would be of the same lithology as that found in the watershed, i.e., not transported to the site from a distant location. After sediment placement, the river would be allowed to naturally sort and distribute the material. Sediment placement would occur from August through October, following fry rearing, to minimize short-term implementation-related impacts on *O. mykiss*. All coarse sediment would be transported and placed using the existing road network and staging area along the lower Tuolumne River, i.e., no new roads or staging areas would be created. Placement of coarse sediment might require instream use of loaders to position gravel where it is considered to be most advantageous for enhancement of spawning habitat. There would be no significant modifications to riparian vegetation adjacent to the placement locations. BMPs required by NMFS and other regulatory agencies would be employed to avoid effects on the river and its biota due to the use and storage of heavy equipment.

Monitoring associated with this measure would include (1) a spawning gravel evaluation in Year 12 of the augmentation program using methods comparable to those employed for the Spawning Gravel in the Lower Tuolumne River Study (TID/MID 2013g) and (2) annual snorkel surveys of *O. mykiss* spawning use of new gravel patches for five years following completion of gravel augmentation.

2.1.1.2 Gravel Mobilization Flows of 6,000 to 7,000 cfs

Flows ranging from 6,000-7,000 cfs (measured at USGS gage 11289650 below La Grange Diversion Dam) would be released to mobilize gravel and fines. These flows would be provided for at least two days at an estimated average frequency of once every three to four years, i.e., during years when sufficient spill is projected to occur (see the Districts' Preferred Plan in Section 5.0 of Exhibit E) (TID/MID 2017f). In years when the La Grange gage spring (March

[2] Riffle A1/2 is located just downstream of the confluence of the mainstem Tuolumne River and the La Grange Powerhouse tailrace.

through June) spill is projected to exceed 100,000 ac-ft, the Districts would plan to release a flow of 6,500 cfs for two days within the spill period, with down-ramping not to exceed 300 cfs/hr.

Monitoring associated with this measure would consist of conducting substrate surveys at designated test sites located upstream of RM 43 prior to a high-flow event, then examining the same test sites following the flow event to evaluate whether there are corresponding changes in channel morphology or improvements to the quality of spawning gravel, i.e., a reduction in interstitial fines. Flow magnitude and/or duration may be adjusted based on these observations.

2.1.1.3 Gravel Cleaning

The Districts would conduct a five-year program of experimental gravel cleaning using a gravel ripper and pressure wash operated from a backhoe, or equivalent methodology. Each year of the program would consist of two to three weeks (during May) of cleaning select gravel patches. This action would involve the use of an excavator in the river channel, which would, by design, disrupt the substrate substantially for a short period. The Districts would conduct *O. mykiss* spawning and redd surveys in areas planned for gravel cleaning prior to commencing any gravel cleaning. Subject to the findings of these surveys, the gravel cleaning may coincide with May pulse flows to benefit Chinook smolt outmigration by providing increased turbidity to reduce predator sight feeding effectiveness.

Monitoring associated with this measure would consist of substrate surveys at designated test sites. Monitoring would be implemented prior to and following gravel cleaning to evaluate changes in substrate composition, particularly reductions in interstitial fines.

2.1.2 Improve Instream Habitat Complexity

Under this measure, $2 million would be provided for the collection and placement of boulder-size stone (approximately 0.7–1.5 yd^3) between RM 42 and 50. The boulder placement program would take place over four years and proceed by conducting placement in select sub-reaches each summer (after July 15). Placement locations would be selected through collaboration with parties having fisheries and recreational interests in the lower Tuolumne River. A maximum of 200 boulders would be placed. The preferred locations for materials installation would be in run/glide habitats to create velocity diversity and feeding stations. Enhancing an area downstream of a riffle would likely have the greatest benefit. Smaller boulders (12-24 inch) may be placed along stream margins in similar run/glide habitat. This would provide interstitial velocity refuges for rearing juveniles during winter and high flows throughout the year. Locations between RM 48 and 50 that are run/glide habitats would be tested first. Boulders would be put into place with heavy equipment, and the size of the boulders and their positioning would provide for their stability, i.e., no permanent anchoring, including rebar or cabling, would be used. Boulders would be positioned so that they are completely overtopped during channel-forming flow events. All boulders would be transported, stored, and placed using the existing road network and staging areas along the lower Tuolumne River, i.e., no new roads or staging areas would be created. There would be no significant modifications to riparian vegetation adjacent to the placement locations. BMPs required by NMFS and other regulatory agencies would be employed to avoid effects on the river and its biota due to the use and storage of heavy equipment. Unlike placement of large wood in the channel, suitably placed boulders would represent a minimal hazard to recreational boaters using the lower river.

Biological monitoring would consist of bounded *O. mykiss* count estimates in the treatment habitat units and untreated areas nearby that are hydraulically similar to the pre-treatment habitats. The Districts would collect data for at least two years prior to boulder placement and three years after placement. Annual snorkeling surveys would be conducted to assess differences in units with and without bordering boulders (see above), and evaluate changes in fish densities through time in response to boulder placement. In addition, a one-time monitoring event within five years following the completion of the boulder placement program would be conducted to examine the stability of the placed boulders and to map smaller gravel accumulations linked to the placement of the boulders.

2.1.3 Contribute to CDBW's Efforts to Remove Water Hyacinth

The Districts would contribute $50,000 per year to the California Division of Boating and Waterways (CDBW, the State agency responsible for implementing an Aquatic Pest Control Program to control hyacinth) to assist with the removal of water hyacinth and other non-native flora. The contribution would be made regardless of the level of water hyacinth infestation occurring in the lower Tuolumne River. The Districts would coordinate with CDBW when water hyacinth infestations occur on the Tuolumne River to schedule removal efforts.

There would be no monitoring conducted by the Districts in association with this measure. CDBW employs herbicides to treat water hyacinth and other invasive aquatic plants in Central Valley rivers and the Delta. CDBW uses herbicides that are registered for aquatic use with the EPA and the California Department of Pesticide Regulation (CDPR). Treated areas are typically monitored weekly to ensure that herbicide levels do not exceed allowable limits and that herbicide treatments have no adverse environmental impacts.

2.1.4 Fall-Run Chinook Spawning Improvement Superimposition Reduction Program

To reduce superimposition of fall-run Chinook redds, the Districts propose to develop and install a temporary barrier to encourage spawning on less used, but still suitable, riffles. The temporary barrier would be installed each year below the new La Grange Bridge (RM 49.9) after November 15 once the number of Chinook passing the proposed RM 25.5 fish counting weir (see Section 2.1.5.1) exceeds 4,000 total spawners. The temporary barrier would be similar to the Alaska-type counting weir currently used on the Tuolumne River at RM 24.5 or a picket-weir type. Final design and configuration of the temporary barrier would be based on consultation with state and federal resource agencies.

2.1.5 Predator Control and Suppression Plan

The Districts' proposed predator control and suppression program would consist of two elements: (1) construction and operation of a barrier weir and (2) active predator control and suppression (see descriptions of measures below).

Studies demonstrate that predation on salmonids by non-native black bass (largemouth and smallmouth bass) and striped bass is substantial in the lower Tuolumne River (TID/MID 2013e, 2017a, 2013d; and results of rotary screw-trap monitoring). The Predator Control and Suppression Plan developed as part of the Districts' Proposed Action identifies a target reduction in predation of 10 percent below RM 25.5 and 20 percent above RM 25.5. An effective predator control and suppression program would mainly improve fall-run Chinook salmon outmigration survival, but would also reduce predation risk for *O. mykiss*, especially if there are any migrating downstream.

2.1.5.1 Construct a Fish Counting and Barrier Weir

The Districts are proposing to construct and operate a small barrier weir (less than 5 ft of head at normal flows) at approximately RM 25.5, about 1 mile upriver of the current counting weir. The barrier weir will be a reinforced concrete structure consisting of, from river-right to river-left (looking downstream), the components listed below. A planview of the weir is provided in Figure 2.1-1.

- A concrete abutment merging with natural grade;
- A fishway and counting structure equipped with a viewing window and fish sorting capability;
- An 8-ft long by 5-ft high bottom drop gate with a maximum hydraulic capacity of 75 cfs providing attraction flow to the fishway entrance;
- Spillway section;
- Middle abutment;
- Non-motorized craft (kayak/canoe/raft) bypass structure with flap-gate control and concrete chute; and
- Left concrete abutment merging with natural grade.

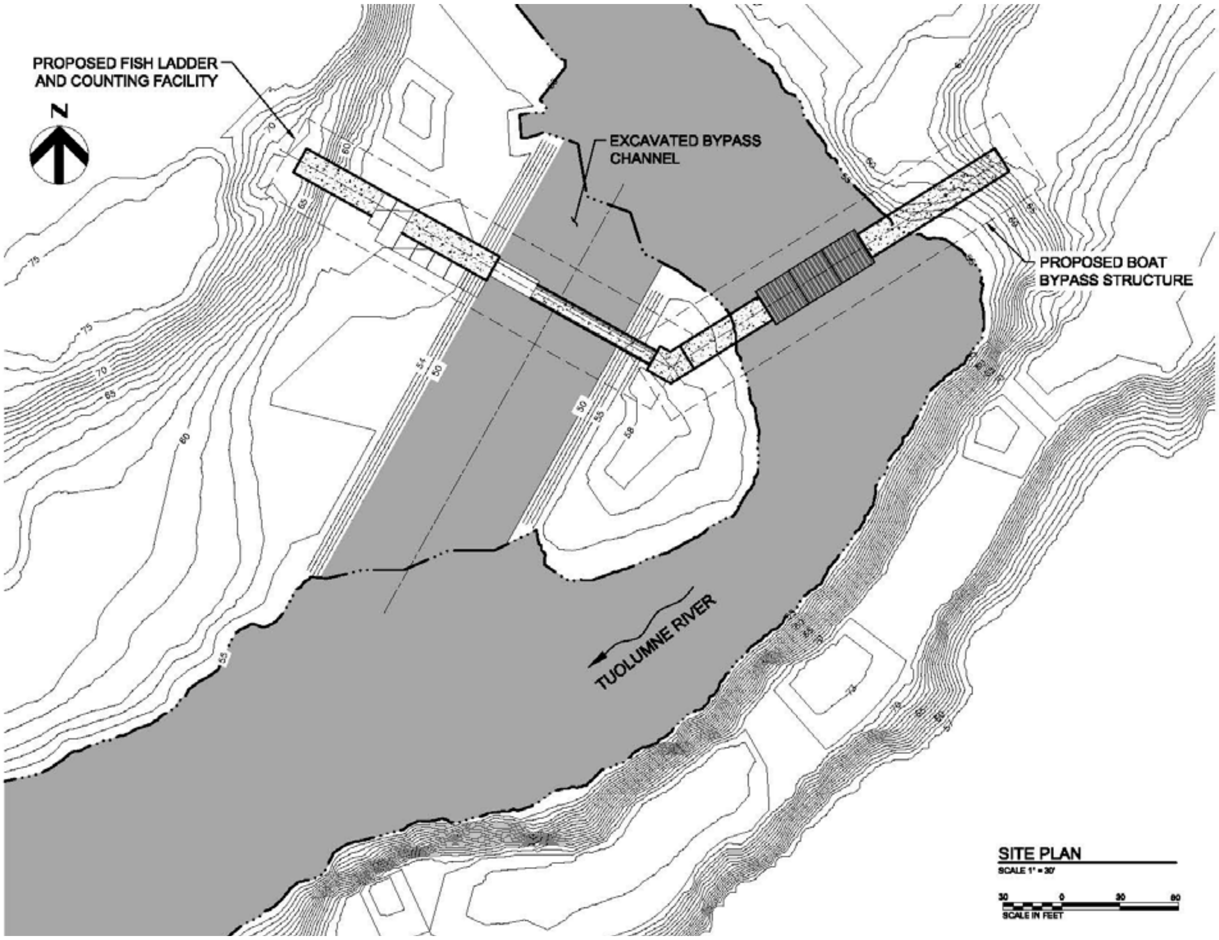

Figure 2.1-1. Planview of the fish counting and barrier weir at RM 25.5.

The fish counting and barrier weir would serve the following purposes:

- Provide a permanent upstream migrant counting weir to replace the temporary seasonally-operated Alaska-type counting weir located at RM 24.5. The seasonal weir must be removed when flows reach 1,500 cfs; the new counting weir would be capable of being operated year-round and in river flows up to at least 3,000 cfs.
- Provide a Denil-type fishway and counting window to conduct fish counts, fish species separation, and potentially public viewing. The ability to collect fish would also permit broodstock selection, if desired by fisheries agencies.
- Provide a barrier to exclude striped bass from upstream habitats used for rearing by juvenile fall-run Chinook salmon, while at the same time providing a location where striped bass are likely to congregate, which would enable their removal or isolation at key times during smolt outmigration. Striped bass are known to be voracious predators and have been observed in all seasons throughout the entire lower Tuolumne River.
- Provide for elimination of black bass movement into sections of river upstream of RM 25.5 and provide for significant long-term reductions in black bass populations above RM 25.5.

2.1.5.2 Predator Suppression and Removal

The Districts are proposing to implement a comprehensive predator suppression and control program consisting of the following components.

- Specific incentives and measures to target an annual reduction in the population of black bass and striped bass, based on levels documented in 2012, by approximately 20 percent above the proposed barrier weir (at RM 25.5) and 10 percent below the barrier weir. These measures would include, but would not be limited to, sponsoring and promoting black bass and striped bass derbies and reward-based angling in locations both above and below the barrier weir to substantially diminish the sizes of the bass populations over time. Other removal and/or isolation methods would include electrofishing, seining, fyke netting, and other collection methods.[3] Based on the 2012 population of black bass between the two Tuolumne River rotary screw-traps (RM 30 and RM 5), a 10 percent removal black bass would amount to a total of about 660 fish (roughly equal numbers of smallmouth and largemouth bass).[4] To provide context, this level of removal would take four anglers about 80 days of fishing. There are more efficient means of removal, including electrofishing, and the seasonal timing of such removal would influence its effectiveness at increasing salmonid smolt survival. To ensure compliance with this measure, the Districts propose to file an annual report on black bass and striped bass reduction efforts undertaken during the prior calendar year. The Districts propose to conduct a survey every five years to identify the number of fish to be targeted in order to reduce the bass population by 10 percent in succeeding years.
- The Districts will seek and advocate for changes to current fishing regulations for the lower Tuolumne River (e.g., length of season, bag limit, catchable size, required removal of black bass/striped bass caught, allowing a bounty program) to reduce black and striped bass numbers. In addition, the Districts propose to (1) establish a fund to carry out the activities contemplated above and to educate the public on the adverse effects of predation on O. mykiss in the Tuolumne River to encourage participation in the removal program and (2) advocate for changes to fishing regulations that facilitate such removal. Activities could include, but would not be limited to, developing educational materials about the effects of predatory fish, community outreach, or kiosks. To monitor compliance with this measure, the Districts propose to file an annual report describing the specific educational and advocacy measures undertaken during the preceding year.

Evaluating the success of predator control would be based on a set of metrics that describe predator populations before and after implementation of control measures. The following metrics could be used to assess the effectiveness of the program: (1) predator densities per unit area and unit bank length, (2) estimates of absolute predator abundance, (3) relative abundances of black and striped bass, (4) demographic statistics including age-class structure, size-at-age,

[3] Such incentives could include expansion on the Tuolumne River of the current CDFW Free Fishing Days program, which currently allows free fishing on the Labor Day and July 4 holidays, expansion of CDFW's current Fishing in the City program to promote urban youth fishing, promotion of fishing derbies and competitions similar to the Nor-Cal Guides' and Sportsmen's Association (NCGASA) pikeminnow derby on the Feather River, and/or sport-reward program for striped bass and black bass similar to pikeminnow programs currently carried out in Washington and Oregon.

[4] See Districts' *Predator Control Plan* (appended to Exhibit E of the AFLA) for more details. The barrier weir will eliminate striped bass access to important Chinook rearing areas upstream of RM 25.5. Striped bass are estimated to be responsible for approximately 15-20 percent of the total predation on fall-run Chinook juveniles in the lower Tuolumne River.

and recruitment (see the *Predator Control and Suppression Plan* attached to Exhibit E of the AFLA).

2.1.6 Fall-Run Chinook Salmon Restoration Hatchery Program

The Districts propose to build a fall-run Chinook restoration hatchery, in cooperation with CDFW, in the general vicinity of the current location of the CDFW offices below La Grange Diversion Dam. The restoration hatchery would be operated by CDFW. The Districts would pay for hatchery construction and O&M for the first 20 years, after which the success of the hatchery would be evaluated. The hatchery is not intended to be a permanent facility. The weir described above would allow for the collection of fall-run Chinook broodstock. The proposed supplementation program, like state and federal programs, would be implemented in accordance with procedures that prevent or minimize adverse impacts on the fitness, size, abundance, run-timing, and distribution of wild fish.

2.1.7 Infiltration Galleries 1 and 2

The Districts are proposing to complete construction of TID's infiltration gallery (IG1) (at RM 25.9) and undertake construction of a second infiltration gallery (IG2) at the same general location. IG1 has a design capacity of approximately 100 cfs, and IG2 would have a capacity of 100-125 cfs. The purpose and operation of the infiltration galleries are discussed in Section 2.1.8 below. The locations of the proposed infiltration galleries are shown in Figure 2.1.2.

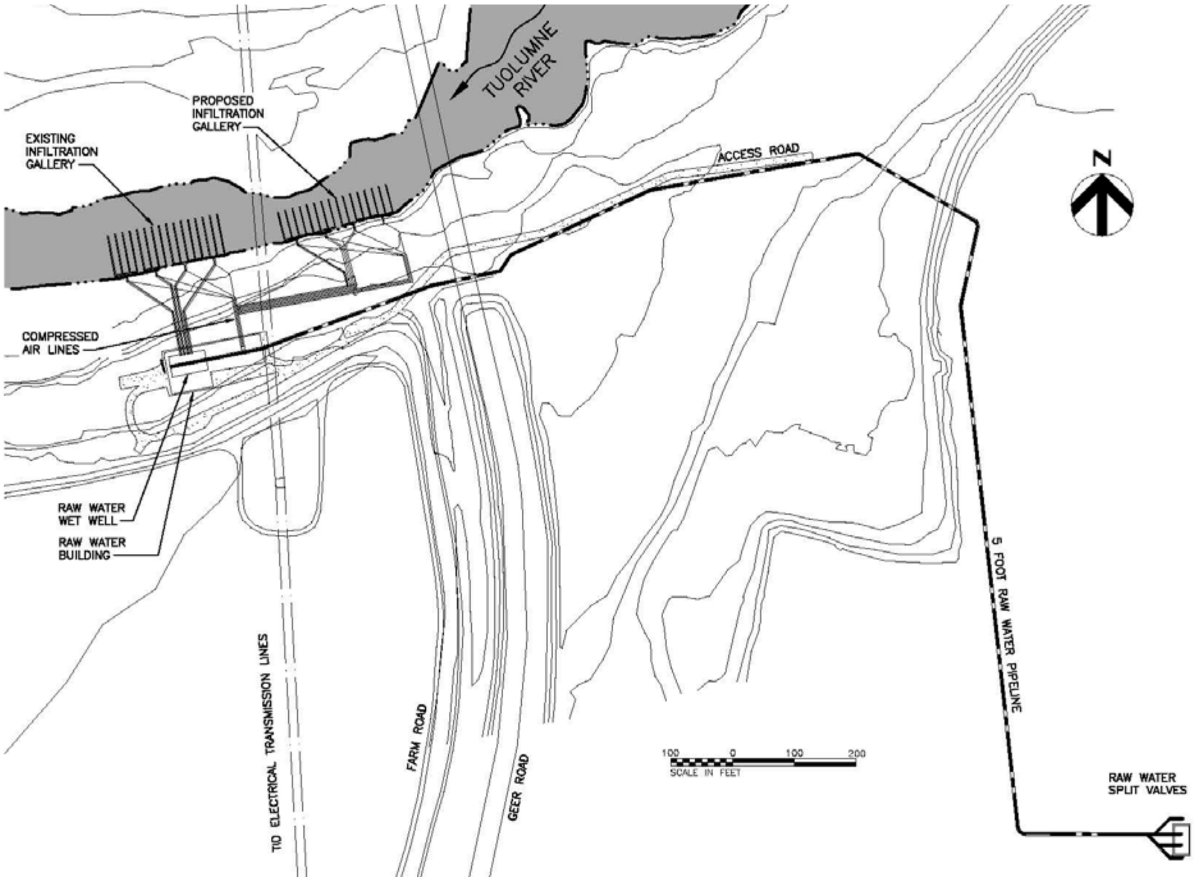

Figure 2.1-2. Site location of the infiltration galleries downstream of the Geer Road Bridge at approximately RM 25.9.

2.1.8 Flow-Related Measures for Fish and Aquatic Resources

The Proposed Action includes flow-related measures during all water-year types. The flow measures include a set of base flows designed for specific salmonid life stages in the Tuolumne River, and a set of pulse flows, which were designed based on 20 years of rotary screw-trapping results and other related studies specific to the Tuolumne River. An adaptive management approach to pulse-flow timing and duration is part of these measures.

For all flow-related measures, the flow schedules are based on five water-year types determined using the 60-20-20 San Joaquin River Index (SJI). The five types are wet (W), above normal (AN), below normal (BN), dry (D), and critical (C). Table 2.1-2 provides the classification of each water year for the 1971–2012 modeling period of record.

All proposed flow-related measures identified below are based on five water-year types determined using the 60-20-20 San Joaquin River Index. The current method used by TID operators to determine the water year type and the required flow release schedule would remain unchanged.[5] There would be two flow monitoring locations for compliance: (1) the existing

[5] TID operators currently determine the water-year type in early April and issue, after consultation with resource agencies, the schedule of releases for April 15 of the current year through April 14 of the next calendar year.

USGS Tuolumne River at La Grange gage and (2) a new USGS gage measuring the flow in the two infiltration galleries' (see Figure 2.1-2) pipelines. The La Grange gage would be used to monitor compliance for flows between the La Grange gage and RM 25.5. Subtracting the infiltration gallery pipelines gage from the La Grange gage would yield the instream flows to be provided downstream of RM 25.5, and this difference would constitute the second point of compliance. Compliance would be achieved if flows equaled or exceeded the amounts identified below over monthly timeframes, with no deficit of more than 10 percent below the minimum for more than 60 minutes, and no flow deficit allowed that is greater than 20 percent below the flows described below and shown in Table 2.1-3. With the two compliance points being located about 25 miles apart, during days where scheduled flow changes are to occur, time of travel would be taken into account when determining compliance. Any outage of the infiltration galleries that prevents the planned flow from being withdrawn and lasting for more than three consecutive days would result in the minimum instream flows required at the La Grange gage to be reduced by two-thirds of the amount that would have been withdrawn.

Table 2.1-2. Classification of each water year for the 1971–2012 modeling period of record.

Water Year	San Joaquin Index	Water Year	San Joaquin Index
1971	BN	1992	C
1972	D	1993	W
1973	AN	1994	C
1974	W	1995	W
1975	W	1996	W
1976	C	1997	W
1977	C	1998	W
1978	W	1999	AN
1979	AN	2000	AN
1980	W	2001	D
1981	D	2002	D
1982	W	2003	BN
1983	W	2004	D
1984	AN	2005	W
1985	D	2006	W
1986	W	2007	C
1987	C	2008	C
1988	C	2009	BN
1989	C	2010	AN
1990	C	2011	W
1991	C	2012	D

Table 2.1.3. Proposed lower Tuolumne River flows to benefit aquatic resources and accommodate recreational boating.

Water Year/Time Period	Flow (cfs)	
	La Grange Gage	Downstream of IGs (RM 25.5)
Wet, Above Normal, Below Normal		
June 1 – June 30	200	100[1]
July 1 – October 15[3]	350	150[2]
October 15 – December 31	275	275
January 1 – February 28/29	225	225
March 1 – April 15	250	250

Water Year/Time Period	Flow (cfs)	
	La Grange Gage	**Downstream of IGs (RM 25.5)**
April 16 – May 15[4]	275	275
May 16 – May 31[4]	300	300
Dry		
June 1 – June 30	200	75
July 1 – October 15	300	75[2]
October 15 – December 31	225	225
January 1 – February 28/29	200	200
March 1 – April 15	225	225
April 16 – May 15[4]	250	250
May 16 – May 31[4]	275	275
Critical		
June 1 – June 30	200	75
July 1 – October 15	300	75
October 15 – December 31	200	200
January 1 – February 28/29	175	175
March 1 – April 15	200	200
April 16 – May 15[4]	200	200
May 16 – May 31[4]	225	225

1 Cease IG withdrawal for one pre-scheduled weekend.
2 200 cfs for three-day July 4 holiday, for three-day Labor Day holiday, and for two pre-scheduled additional weekends in either June, July, or August.
3 The Preferred Plan also includes a flushing flow amounting to 5,950 AF of water for the period October 5 through October 7. Ramping of this flow would likely occur on October 4 and 8 as part of the flushing flow volume.
4 Fall-run Chinook outmigration pulse flows: 150,000 ac-ft (Wet, Above Normal), 100,000 ac-ft (Below Normal), 75,000 ac-ft (Dry), 45,000 ac-ft (sequential Dry[s]), 35,000 ac-ft (first Critical), and 11,000 ac-ft (sequential Critical[s]).[6]

2.1.8.1 Early Summer *O. mykiss* Fry Rearing (June 1–June 30)

Except for wet years, when high flows may extend well into June, most fall-run Chinook salmon juveniles have left the Tuolumne River by the end of May (TID/MID 2013e), so increased summer flows are aimed at enhancing habitat conditions for *O. mykiss*. The Districts are proposing to provide an instream flow of 200 cfs at the La Grange gage from June 1–June 30 of all water year types to benefit *O. mykiss* fry rearing. Downstream of RM 25.5 (i.e., downstream of the infiltration galleries) instream flows during this period would be 100 cfs during Wet, Above Normal, and Below Normal water years and 75 cfs in Dry and Critical years.

Based on redd surveys, *O. mykiss* in the lower Tuolumne River spawn from late December through early April (TID/MID 2013f; FISHBIO 2017a). Years of monitoring studies indicate that *O. mykiss* are predominantly found upstream of RM 42, with peak fry densities occurring into June. For the period of June 1 to June 30, base flows would be provided to support *O. mykiss* fry rearing. Flow management for the benefit of *O. mykiss* fry would balance hydraulic habitat suitability and temperature suitability for fry and adult life stages. Flows higher than those proposed by the Districts in June would tend to displace weaker-swimming *O. mykiss* fry to downstream areas with lower quality physical habitat, higher water temperatures, and greater predator densities.

6 This reduced pulse flow, while still greater than or equal to Base Case pulse flows, would also occur in a sequence of "D" and "C" years. For example, in a sequence of the years C, D, C, D, C, D, the second and third "critical" years and the second and third "dry" years would each have pulse flows of 11 TAF and 45 TAF, respectively.

2.1.8.2 Late Summer *O. mykiss* Juvenile Rearing (July 1–October 15)

The Districts are proposing to provide an instream flow of 350 cfs at the La Grange gage from July 1–October 15 of Wet, Above Normal, and Below Normal water-year types to benefit *O. mykiss* juvenile rearing. During Dry and Critical water years, flow at the La Grange gage would be reduced to 300 cfs. Downstream of RM 25.5 (i.e., downstream of the infiltration galleries) instream flows during this period would be 150 cfs during Wet, Above Normal, and Below Normal water years and 75 cfs in Dry and Critical years.

During this period, the Districts would provide a flushing flow to clean gravels of accumulated algae and fines prior to the onset of substantial spawning. The Districts would provide an instream flow of 1,000 cfs (not to exceed 5,950 AF) on October 5, 6, and 7, with appropriate up and down ramps and IGs shut off. These flows would be provided in Wet, Above Normal, and Below Normal water years only. In Dry and Critical years, the flows at La Grange would continue to be 300 cfs, with withdrawals of 225 cfs at the infiltration galleries, leaving 75 cfs in the river below RM 25.5.

By July, *O. mykiss* in the lower Tuolumne River consist predominantly of juvenile and adult life-stages. Juveniles are stronger swimmers than fry and can maintain position at higher flows. The primary habitat concern during this period is the maintenance of adequate water temperatures from just downstream of the La Grange Project to approximately RM 42.

2.1.8.3 Fall-Run Chinook Spawning Flows (October 16–December 31)

To provide habitat for fall-run Chinook spawning, the Districts propose to provide the following minimum instream flows for the October 16 – December 31 spawning period: 275 cfs (BN, AN, and W water years), 225 cfs (D water years), and 200 cfs (C water years).

2.1.8.4 Fall-Run Chinook Fry Rearing (January 1–February 28/29)

To provide habitat for fall-run Chinook fry rearing, the Districts propose to provide the following minimum instream flows for the period of January 1–February 28/29: (1) 225 cfs (BN, AN, and W water years), (2) 200 cfs (D water years), and (3) 175 cfs (C water years). February and March are the periods of peak *O. mykiss* spawning in the lower Tuolumne River. It is important that flows do not decline substantially following the fall-run Chinook spawning period (see previous section), which would result in the dewatering of established redds. The flows identified here represent a balance between protecting Chinook redds while still providing substantial *O. mykiss* habitat. Based on the rating curve for the USGS gage at La Grange, the change in flow from 275 cfs to 225 cfs would result in a 0.4-ft stage change, and from 225 cfs to 200 cfs a 0.2 ft stage change.

2.1.8.5 Fall-run Chinook Juvenile Rearing (March 1–April 15)

To provide habitat for Chinook juvenile rearing, the Districts propose to provide the following minimum instream flows for the period of March 1–April 15: (1) 250 cfs (BN, AN, and W water years), (2) 225 cfs (D water years), and (3) 200 cfs (C water years). As noted above, February and March are the periods of peak *O. mykiss* spawning in the lower Tuolumne River.

2.1.8.6 Fall-run Chinook Outmigration Base Flows (April 16–May 15)

The Districts propose to provide the following outmigration base flows for the period of April 16–May 15: (1) 275 cfs (BN, AN, and W water years), (2) 250 cfs (D water years), and (3) 200 cfs (C water years). Increasing base flows above those in the March 1–April 15 period would maintain favorable water temperatures during the mid-April through mid-May period, which is expected to benefit salmonids. As explained below, these base flows could be augmented by outmigration pulse flows (see below), depending on the timing of pulse flows, which would further reduce water temperatures at a given location and extend the plume of colder water farther downstream.

2.1.8.7 Outmigration Base Flows (May 16–May 31)

To maintain lower water temperatures during the latter half of May, the Districts are proposing the following base flow releases: (1) 300 cfs (BN, AN, and W water years), (2) 275 cfs (D water years), and (3) 225 cfs (C water years). These base flows could be augmented by outmigration pulse flows, as explained below.

2.1.8.8 Outmigration Pulse Flows (April 16–May 31)

To encourage fall-run Chinook smolt outmigration and increase survival, pulse flows would be provided to coincide with periods when large numbers of parr- or smolt-size fish are occurring in the river. The available pulse flow volumes will be substantially increased over baseline levels, except in the second (and subsequent to the second) Critical water year. The Districts are proposing to allocate the following volumes of water for pulse flow releases: 150,000 ac-ft (AN and W water years), 100,000 ac-ft (BN water years), 75,000 ac-ft (D water years), 45,000 ac-ft (sequential D water years), 35,000 ac-ft (initial C water year), and 11,000 ac-ft (sequential C water years).[7]

2.1.8.9 Flow Hydrograph Shaping

In spill years, the Districts would make reasonable efforts to shape the descending limb of the snowmelt runoff hydrograph to mimic natural conditions. Floodplain inundation along the lower Tuolumne River is initiated at a flow of approximately 1,100 cfs. Based on flows in the 1971–2012 period, the Proposed Action would result in flows at the La Grange gage greater than 1,500 cfs from February through July in 28 years (or more than 60 percent of the years). Flows exceeding 2,500 cfs would occur in 45 percent of the years in that period.

[7] This reduced pulse flow, while still greater than or equal to Base Case pulse flows, would also occur in a sequence of "D" and "C" years. For example, in a sequence of the years C, D, C, D, C, D, the second and third "critical" years and the second and third "dry" years would each have pulse flows of 11 TAF and 45 TAF, respectively.

2.1.9 Flows to Enhance Recreational Boating

The Districts propose to provide flows to enhance conditions for canoeing and kayaking on the lower Tuolumne River.

From April 1–May 31 of all water years, a flow of 200 cfs or greater would be provided at the LaGrange gage. During this time, the infiltration galleries would be either be shut off, or additional flows to be withdrawn for water supply purposes would be released to the La Grange gage.

From June 1–June 30, a flow of 200 cfs would be provided at the La Grange gauge in all water years. In Wet, Above Normal, and Below Normal water years, withdrawal of water at the infiltration galleries would cease for one pre-scheduled weekend in June to provide additional flow to the river downstream of RM 25.5.

From July 1–October 15, a flow of 350 cfs in Wet, Above Normal, and Below Normal water years and 300 cfs in Dry and Critical water years would be provided at the LaGrange gauge. In all but Critical water years, the Districts would provide a flow of 200 cfs at RM 25.5 for the three-day July 4 holiday, the three-day Labor Day holiday, and for two pre-scheduled additional weekends in either July or August. In Wet, Above Normal, and Below Normal water years this would represent an incremental increase of 50 cfs downstream of RM 25.5 (over the background of 150 cfs), and in Dry water years this would represent an incremental increase of 125 cfs (over the background of 75 cfs), as measured at the La Grange gauge.

2.2 Interrelated and Interdependent Actions

Interrelated actions are actions that are part of a larger action and depend on the larger action for their justification (50 CFR § 402.02), whereas interdependent actions are actions with no independent utility apart from a proposed action (50 CFR § 402.02). If a private activity would not occur in the absence of a proposed federal action, the effects of that private activity are interdependent and/or interrelated with the proposed action, and the effects of the private activity are considered attributable to the proposed federal action for consultation purposes.

In contrast, actions that would occur with or without the occurrence of the proposed action are not interdependent or interrelated with the Proposed Action. The U.S. Fish and Wildlife Service (USFWS) and NMFS (1998) state that if a project would exist independent of a proposed action, it cannot be considered “interrelated” or “interdependent” and included in the effects of the proposed action.

As noted above, the Proposed Action being assessed in the Districts’ AFLA is the issuance of a FERC license for the continuation of the hydroelectric generation conducted at the Project. Water storage and releases for the Project’s primary purposes, i.e., irrigation, M&I uses, the City and County of San Francisco’s (CCSF) water bank, and flood control in cooperation with the US Army Corps of Engineers (ACOE), are not dependent on the issuance of a FERC license for the Project, and will occur with or without the licensing of the Proposed Action. As such, these primary purposes are *not* interrelated or interdependent with the issuance of a FERC license for hydroelectric power generation. Because the Districts are consulting with NMFS on the Proposed Action, analysis of the potential effects associated with the aforementioned non-hydropower uses are addressed only in the context of cumulative effects, i.e., there are no direct or indirect effects. This Draft BA does include an analysis of the direct effects on *O. mykiss* associated with the Districts' suite of resource measures proposed for the lower Tuolumne River, some of which are specifically designed to benefit *O. mykiss*.

2.3 Action Area

Section 7 of the ESA requires the identification of an "Action Area" for use in determining the environmental baseline and evaluating the potential effects of an action. The Action Area is defined as the area likely to be affected by the direct[8] and indirect[9] effects of the proposed action (50 CFR § 402.02; USFWS and NMFS 1998). For this Draft BA, the Action Area includes the lower Tuolumne River from La Grange Diversion Dam (RM 52.2) to the confluence with the San Joaquin River.

8 Direct effect: the direct or immediate effects of the project on the species or its habitat (Final ESA § 7 Handbook at 4-25).

9 Indirect effects: those effects that are caused by or will result from the proposed action and are later in time, but are still reasonably certain to occur. [50 CFR § 402.02].

3.0 CALIFORNIA CENTRAL VALLEY STEELHEAD DPS

3.1 ESA Listing of the CCV Steelhead[10]

The term "CCV steelhead" refers to all naturally spawned populations of anadromous steelhead below natural and human-made impassable barriers in the Sacramento and San Joaquin rivers and their tributaries, except for steelhead from San Francisco Bay and San Pablo Bay and their tributaries (63 FR 13347). CCV steelhead also includes anadromous fish from certain fish hatcheries, as explained below.

NMFS proposed to list CCV steelhead (anadromous *O. mykiss*) as endangered on August 9, 1996 (61 FR 41541). NMFS concluded that the ESU was in danger of extinction because of habitat degradation and destruction, loss of access to historical freshwater habitats, water allocation issues, genetic introgression resulting from widespread stocking of hatchery steelhead and the potential ecological interaction between introduced stocks and native stocks, and because steelhead had been extirpated from most of their historical range.

On March 19, 1998, NMFS listed the CCV steelhead as a threatened species (63 FR 13347), based on the observation that threats to steelhead had diminished since the completion of the 1996 status review and because of recently implemented state conservation efforts and federal management programs (e.g., Central Valley Project Improvement Act [CVPIA] Anadromous Fish Restoration Program [AFRP], CALFED Bay-Delta Program [CALFED]) that address key factors for the decline of the species (NMFS 2016). NMFS also found that additional actions benefiting CCV steelhead included efforts to enhance fisheries monitoring and conservation measures to address artificial propagation.

On September 8, 2000, pursuant to a July 10, 2000 rule issued by NMFS under Section 4(d) of the ESA (16 USC § 1533(d)), statutory take restrictions that apply to listed species began to apply, with certain limitations, to CCV steelhead (65 FR 42422) (NMFS 2016).

On June 28, 2005, NMFS announced its final policy addressing the role of artificially propagated Pacific salmon and steelhead in listing determinations under the ESA (70 FR 37204), and on January 5, 2006, NMFS reaffirmed the threatened status of CCV steelhead and decided to apply the joint U.S. Fish and Wildlife Service-National Marine Fisheries Service DPS policy (61 FR 4722) rather than the NMFS ESU policy to populations of West Coast steelhead (NMFS 2016). This policy requires a DPS to be discrete from other conspecific populations and significant to its taxon. A group of organisms is considered to be discrete if it is ''markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, and behavioral factors" (61 FR 4722).

Based on the January 5, 2006 listing determination, NMFS concluded that two of the four CCV steelhead artificial propagation programs are considered to be part of the DPS: the Coleman National Fish Hatchery and Feather River Hatchery steelhead programs. NMFS determined that these stocks are no more divergent from local natural population(s) than what would be expected

[10] The status of Central Valley steelhead in the Action Area is described in Section 4.0, Environmental Baseline.

between closely related natural populations within the DPS (NMFS 2016). The CCV steelhead hatchery programs at Nimbus Fish Hatchery and Mokelumne River Hatchery were not included in the DPS because of the ongoing use of out-of-basin broodstock (NMFS 2016). In 2011 NMFS completed a status review of CCV steelhead and determined that available information continued to support inclusion of the Coleman National Fish Hatchery and Feather River Hatchery steelhead stocks as part of the DPS, while continuing to exclude stocks from Nimbus Fish Hatchery and Mokelumne River Hatchery. However, according to NMFS (2016), current analyses show that steelhead from the Mokelumne River Hatchery are nearly genetically identical to those from the Feather River Hatchery (Pearse and Garza 2015), because the Mokelumne River Hatchery received all of its eggs from the Feather River Hatchery in the final years before it terminated the acquisition of eggs from out-of-basin sources. Because steelhead from the Feather River Hatchery are listed as part of the DPS, NMFS (2016) recommends that the Mokelumne River Hatchery steelhead be added to the CCV DPS. As of this writing, Mokelumne River Hatchery steelhead have not been added to the listed DPS.

In 2014 NMFS released its Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. In 2016, NMFS completed its Central Valley Recovery Domain 5-Year Review: Summary and Evaluation California Central Valley Steelhead Distinct Population Segment and Viability Assessment for Pacific Salmon and Steelhead Listed under the Endangered Species Act (conclusions of which are cited previously and subsequently, as appropriate).

3.1.1 Status of the CCV Steelhead DPS

It is difficult to estimate historical CCV steelhead run sizes due to insufficient data. By the early 1960s, however, the overall run size is estimated to have declined to about 40,000 (McEwan and Jackson 1996). In 1996, NMFS estimated that the total Central Valley run size had probably declined to fewer than 10,000 individuals. During the past three decades, steelhead populations in the upper Sacramento River have declined substantially (NMFS 2014).

As noted, there is a paucity of steelhead population monitoring data available for most Central Valley river systems (NMFS 2009). Lindley et al. (2007) stated that there are almost no data upon which to base a status assessment of any of the CCV steelhead populations, except for those in Battle Creek and the Feather, American, and Mokelumne rivers (due to hatchery programs in those systems).

NMFS (2016) determined that the status of CCV steelhead has changed little since the 2011 status review, in which the Technical Recovery Team concluded that the DPS was in danger of extinction. However, several hatcheries in the Central Valley have experienced increased steelhead returns in recent years. In addition, there has been a minor increase in the percentage of wild steelhead found during salvage operations at fish facilities in the south Delta (NMFS 2016). However, the catch of unmarked (wild) steelhead at Chipps Island is still less than 5 percent of the total smolt catch, which confirms that natural production of steelhead throughout the Central Valley remains low.

3.1.2 Life History and Ecology

Steelhead is the name applied to the anadromous form of *O. mykiss*. Resident *O mykiss* are generally referred to as rainbow trout. Steelhead spend one to five years in freshwater prior to smolting and then spend up to three years in the ocean prior to returning to freshwater to spawn. CCV steelhead are considered a winter-run (i.e., ocean-maturing) reproductive type, but in the past, before the construction of large dams, the summer-run type might also have been present in the Central Valley (Moyle 2002). Both life-history forms can produce offspring that exhibit the alternate form (i.e., resident rainbow trout can produce anadromous progeny and vice versa) under some conditions (Hallock 1989, Zimmerman et al. 2009). However, there is no evidence of a steelhead run in the Tuolumne River. Zimmerman et al. (2008) examined the otolith chemistry of 147 *O. mykiss* from the lower Tuolumne River. Results showed that only one (0.7 percent) of these fish was a steelhead (had displayed anadromy) and eight were spawned by a steelhead (i.e., of anadromous maternal origin). Of the eight *O. mykiss* with an anadromous parent, the range of age classes indicated that not all of them were spawned at the same time (i.e., not all of them originated from the same parent). Parental origin of these fish was unknown due to historical planting operations and straying of steelhead.

Almost no information is available to document the life-history strategies of CCV steelhead in the San Joaquin River basin (Busby et al. 1996). In addition, much of the data used to describe behavior and habitat use are derived from steelhead studies conducted in smaller stream systems (e.g., Everest and Chapman 1972, Everest et al. 1986). Therefore, descriptions of life history for SJR rivers are not well-founded.

O. mykiss periodicities for the lower Tuolumne River are presented in Table 3.1-1. The periodicities shown for adult upstream migration and smolt outmigration are estimates, because there is no evidence that existing conditions in the lower Tuolumne River support a steelhead run, i.e., nearly all *O. mykiss* express a resident life-history. See Section 4.6 of this draft BA for more detail on *O. mykiss* life history in the lower Tuolumne River.

Table 3.1-1. Periodicities of *O. mykiss* in the lower Tuolumne River (periods of peak activity are indicated by dark gray shading).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Upstream Migration												
Adult Holding/Rearing												
Adult Spawning												
Incubation/Emergence												
Fry Rearing												
Juvenile Rearing												
Smolt Outmigration												

3.1.2.1 Adult Upstream Migration and Spawning

CCV steelhead use the Sacramento River as a migration corridor to access spawning grounds in tributaries. Historically, steelhead probably used the Sacramento River downstream from the current location of Shasta Dam, and the Feather River below the current location of Oroville Dam, solely as migration corridors. According to NMFS (2014), CCV steelhead are reported to spawn downstream of dams on every major tributary in the Sacramento and San Joaquin river basins.

Adult steelhead typically immigrate into Central Valley rivers from August through March (McEwan 2001; NMFS 2004), and immigration peaks in January and February (Moyle 2002). Optimal immigration and holding temperatures have been reported to range from 8 to 11°C (46–52°F) (CDFW 1991, as cited in NMFS 2014). However, the *O. mykiss* (>400 mm or 16 inches) observed at an existing weir in the lower Tuolumne River (at RM 24.5) from 2011–2016 passed at temperatures ranging from 11.6°C to 20.5°C (53°F–69°F). These temperatures were the instantaneous readings on the days of passage (FISHBIO 2011, 2012, 2013, 2014, 2015, 2016a).

During studies conducted to support the Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework process, steelhead thermal preferences in the Tuolumne River were estimated based on a comprehensive literature review of regional and site-specific information to inform the selection of a water temperature index (WTI) in the reaches of the upper Tuolumne River. For steelhead migration in the upper Tuolumne River, the Framework Temperature Criteria Matrix review identified 17.8°C (64°F) and 20°C (68°F) for Upper Optimal and Upper Tolerance values, respectively (Bratovich et al. 2012, TID/MID 2017f). The Upper Optimal WTI reflects the temperature at which physiological processes (growth, disease resistance, normal development of embryos) are not stressed by temperature, while the Upper Tolerance WTI identifies the sustained (chronic) tolerance/no tolerance boundary.

Female steelhead select spawning sites with ample inter-gravel flow and dissolved oxygen. The female excavates a redd with her tail, typically in the coarse gravel of riffles and pool tailouts. Eggs are deposited while being fertilized by the male. Fertilized eggs in the excavated redd are then covered with loose gravel. Water velocities over redds typically range from 20 to 155 cm/sec (0.7-5.2 feet/second), and depths range from 10 to 150 cm (0.3-4.9 feet) (Moyle 2002). For steelhead spawning in the upper Tuolumne River, the Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework Temperature Criteria Matrix review identified 12.2°C (54°F) and 13.9°C (57°F) for Upper Optimal and Upper Tolerance values, respectively (Bratovich et al. 2012, TID/MID 2017f).

Post-spawn survival is assumed to be about 40 percent for resident *O. mykiss* (Satterthwaite et al. 2009) and steelhead. This rate is similar to that found during steelhead kelt reconditioning programs conducted at the Coleman National Fish Hatchery on Battle Creek (Provencher 2012, as cited in NMFS 2014).

3.1.2.2 Egg Incubation and Fry Emergence

CCV steelhead eggs survive in water temperatures ranging from 2 to 15°C (35.6-59°F), but egg survival is reported to be highest at water temperatures ranging from 7 to 10°C (44.6-50.0°F) (Myrick and Cech 2001, as cited in NMFS 2014). The eggs hatch in three to four weeks at 10 to 15°C (50-59°F), and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). For steelhead embryo incubation and emergence in the upper Tuolumne River, the Framework Temperature Criteria Matrix identified 12.2°C (54°F) and 13.9°C (57°F) for Upper Optimum and Upper Tolerable values, respectively (Bratovich et al. 2012; TID/MID 2017f). At

13.9°C (57°F), embryonic mortality increases sharply and development severely degrades at incubation temperatures greater than or equal to 13.9°C (57°F).

3.1.2.3 Freshwater Rearing and Smolt Outmigration

Regardless of life history strategy (i.e., anadromy versus residency), *O. mykiss* typically spend their first one to two years of life in cool, clear, fast-flowing streams and rivers. Preferred streams have gradients at which riffles predominate over pools, there is abundant cover provided by riparian vegetation and/or undercut banks, and invertebrate food sources are abundant (Moyle 2002). The smallest fish are typically found in riffles, intermediate size fish in runs, and larger fish in pools. Predators also influence microhabitat selection by juvenile *O. mykiss*, increasing the juveniles' affinity for areas located near cover (NMFS 2014).

Juvenile steelhead occur where daytime water temperatures range from near freezing to 27°C (81°F), although mortality may result at low (i.e., <4°C [39°F]) or high (i.e., ≥23°C [73°F]) temperatures if fish have not been acclimated (Moyle 2002, as cited in NMFS 2014). For steelhead fry and juveniles rearing in the upper Tuolumne River, the Framework Temperature Criteria Matrix identified 20°C (68°F) and 22.2°C (72°F) for Upper Optimal and Upper Tolerance values, respectively (Bratovich et al. 2012; TID/MID 2017f).

A swim tunnel study conducted on the lower Tuolumne River (Verhille et al. 2016) generated high quality field data on the physiological performance of Tuolumne River *O. mykiss* acutely exposed to a temperature range of 13 to 25°C (55.4°F to 77°F). The data indicated that wild juvenile *O. mykiss* represents an exception to the expected 7DADM criterion for juvenile rearing established by EPA (2003) for Pacific Northwest *O. mykiss*. The study recommended a conservative upper aerobic performance limit of 71.6°F, instead of 64.4°F (EPA 2003), be considered for the 7DADM for this population. The recommended thermal range for peak performance for Tuolumne River *O. mykiss* corresponds to local high river temperatures, but represents an unusually high temperature tolerance compared with conspecifics and congeneric species from northern latitudes (Verhille et al. 2016).

Juvenile steelhead typically outmigrate from April through June, with peak migration through the Delta occurring in March and April (Reynolds et al. 1993). Outmigration appears to be more closely linked to fish size than age. Larger, faster-growing parr tend to smolt earlier than smaller members of the same cohort (Peven et al. 1994). Hallock et al. (1961) found that juvenile steelhead in the Sacramento River Basin migrate downstream during most months of the year, but the peak emigration period occurs in spring, with a much smaller peak in autumn.

3.1.2.4 Ocean Phase

Steelhead grow more rapidly in the ocean than in freshwater (Shapovalov and Taft 1954, Barnhart 1991). Most steelhead spend one to three years in the ocean, with individuals that leave freshwater as smaller smolts tending to remain in the ocean longer than those that leave as larger smolts (Chapman 1958; Behnke 1992). Larger smolts typically have higher ocean survival rates than smaller smolts (Ward and Slaney 1988). Steelhead in the southern part of the species' range tend to remain close to the continental shelf, whereas populations in the north can migrate throughout the northern Pacific Ocean (Barnhart 1991). In some regions of the ocean, steelhead do not appear to form schools, although coordinated behavior has been documented in some studies (McKinnell et al. 1996).

3.1.2.5 Anadromy Versus Residency in *Oncorhynchus mykiss*

O. mykiss exhibit the most complex life history variation of all *Oncorhynchus* species (Quinn 2005). The expression of a given life history type is influenced by both genetic (Martyniuk et al. 2003; Beakes et al. 2010; Thrower et al. 2004) and environmental (Zimmerman and Reeves 2000; Sloat 2013; McMillan et al. 2012; Beakes et al. 2010) factors. In addition, the relatively low survival rate of any emigrating smolts can contribute to the relative abundance of resident variants in a population regardless of its genetic predisposition towards residency (Beakes et al. 2010; Satterthwaite et al. 2010).

The probability of *O. mykiss* smolting has been shown to vary with parental (i.e., anadromous versus resident) origin, water temperature, and food availability (Satterthwaite et al. 2010). In one recent study, *O. mykiss* held in warm thermal regimes had higher rates of smolting because they were able to grow to larger total sizes but had lower body lipid stores than fish held in cold thermal regimes (Sloat 2013). These findings relate to both fish size (larger fish tend to survive at higher rates in the ocean than smaller fish) as well as fat stores (fish with higher lipid content have higher energy reserves required for sexual maturation). McMillan et al. (2012) found that higher body lipid stores were significantly correlated with an increased probability of maturation in freshwater. In other words, if a juvenile *O. mykiss* has sufficient lipid reserves to allow maturation in freshwater, there is no need to undergo smoltification and migrate to the ocean to gain sufficient lipid stores to mature (TID/MID 2017e). It appears that flow and temperature management downstream of many dams in the Central Valley have the potential to influence the relative rates of residency and anadromy, preferentially selecting for resident rainbow trout over anadromous steelhead where flows are more stable and summer temperatures are cooler than they would be in the absence of reservoir releases (TID/MID 2013e). NMFS (2014) reports that a large resident rainbow trout population has developed in the upper Sacramento River possibly as a result of management actions undertaken for coldwater species.

3.1.3 Historical and Current Distribution of CCV Steelhead

The historical range of the CCV steelhead is believed to have extended from the upper Sacramento River and Pit River basins south to the Kings River and possibly the Kern River basins. Steelhead were found in both eastside and westside Sacramento River tributaries (Yoshiyama et al. 1996). Lindley et al. (2006) estimate that there were at least 81 CCV steelhead populations distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin rivers.

Impassable dams now preclude access to a portion of the habitat historically available to CCV steelhead (Lindley et al. 2006). The California Advisory Committee on Salmon and Steelhead (CDFG 1988) stated that there has been a reduction in CCV steelhead habitat from about 6,000 river miles historically to approximately 300 miles under then-current conditions.

Currently, wild populations of CCV steelhead exist in the upper Sacramento River and its tributaries, including Cottonwood, Antelope, Deer, and Mill creeks and the Yuba River. Other populations may exist in Big Chico and Butte creeks, and a few wild steelhead occur in the American and Feather rivers (McEwan 2001). Recent information indicates that steelhead are present in Clear Creek and Battle Creek (NMFS 2014).

Until recently, steelhead were thought to be extirpated from the San Joaquin River system, but monitoring has detected small self-sustaining populations in the Stanislaus, Mokelumne, and Calaveras rivers (McEwan 2001). Zimmerman et al. (2008) examined the otolith chemistry of 147 *O. mykiss* from the lower Tuolumne River. Results indicated that only one (0.7 percent) of these fish was a steelhead (had displayed anadromy) and eight were spawned by a steelhead (i.e., of anadromous maternal origin). Of the eight *O. mykiss* with an anadromous parent, the range of age classes indicated that not all of them were spawned at the same time (i.e., not all of them originated from the same parent). Parental origin of these fish was unknown due to historical planting operations and straying of steelhead.

A hatchery-supported population of steelhead occurs in the Mokelumne River, which flows directly into the Delta between the Sacramento and San Joaquin rivers (NMFS 2014).

3.1.4 Designated Critical Habitat in the San Joaquin River Basin

NMFS proposed critical habitat for CCV steelhead on February 5, 1999 (64 FR 5740) in compliance with Section 4(a)(3)(A) of the ESA, which requires that, to the maximum extent prudent and determinable, NMFS must designate critical habitat concurrently with a determination that a species is endangered or threatened (NMFS 1999). On February 16, 2000, NMFS published a final rule (65 FR 7764) designating critical habitat for CCV steelhead. Critical habitat was designated to include all river reaches accessible to listed steelhead in the Sacramento and San Joaquin rivers and their tributaries in California. For the Tuolumne River, critical habitat includes the Tuolumne River from the confluence with the San Joaquin River (Lat 37.6401, Long –120.6526) upstream to an endpoint in the Tuolumne River near LGDD (37.6721, –120.4445) (70FR 52605) (Figure 3.1-1).

NMFS (70 FR 52522) defines the lateral extent of designated critical habitat as the width of the stream channel defined by the ordinary high-water line, as defined by the USACE in 33 CFR 329.11. This approach is consistent with the specific mapping requirements described in agency regulations at 50 CFR 424.12(c). In areas for which ordinary high-water has not been defined pursuant to 33 CFR 329.11, the width of the stream channel is defined by its bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain (Rosgen 1996) and is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series (Leopold et al., 1992 as cited in 70 FR 52522).

The designation establishes protection of Primary Constituent Elements (PCE), i.e., areas essential for supporting one or more life stages of the DPS (i.e., sites for spawning, rearing, migration, and foraging). Areas of critical habitat have characteristics essential to the conservation of the DPS, such as suitable spawning gravels, water quality, rearing microhabitats, and food availability.

Critical Habitat PCEs in the Action Area are as follows:

- Freshwater spawning sites with water quantity and quality and substrate supporting spawning, incubation, and larval development.
- Freshwater rearing sites with (1) water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, (2) water quality and forage supporting juvenile fish development, and (3) natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
- Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult fish mobility and survival.

The degree to which conditions in the Action Area are consistent with the characterizations listed above is addressed in sections 4.2–4.7. It should be noted that the Districts recognize that the USFWS and NMFS have removed the term “primary constituent elements” from designated critical habitat regulations (50 CFR 424.12) and have returned to the statutory term “physical or biological features” (PBFs; 79 FR 27066). Considering this, the previous term, PCE, will be replaced henceforth with PBF to describe the physical and biological features that define critical habitat for listed species (81 FR 7214). As noted in 81 FR 7214, “the shift in terminology does not change the approach used in conducting a ‘destruction or adverse modification’ analysis, which is the same regardless of whether the original designation identified primary constituent elements, physical or biological features, or both.”

3.1.5 Stressors and Limiting Factors

Widespread degradation, destruction, and blockage of freshwater habitats within the Central Valley, and continuing habitat impacts due to water management are identified by NMFS (2014) as reasons for the listing of CCV steelhead under the ESA (61 FR 41541, August 9, 1996; 63 FR 13347, March 19, 1998). Threats to CCV steelhead have been brought about by loss of historical spawning habitat, degradation of remaining habitat, and threats to the genetic integrity of wild spawning populations from hatchery steelhead programs. In addition, climate change is a current and future threat to the species and its recovery.

According to NMFS (2014), primary stressors to the CCV steelhead DPS include (1) fish passage impediments and barriers, (2) warm water temperatures during juvenile rearing, (3) introgression from and competition with hatchery stocks (4), limited quantity and quality of physical rearing habitat, (5) predation, including that resulting from introduced piscivorous fish species, and (6) entrainment (NMFS 2014). Also according to NMFS (2014), relevant stressors to steelhead that spend a portion of their life cycle in the Tuolumne River basin include (1) limited habitat availability for spawning and juvenile rearing, (2) lack of access to historical habitat because of an absence of fish passage at La Grange Diversion Dam and Don Pedro Dam, (3) entrainment at the Jones and Banks Pumping Plants, (4) losses from predation, and (5) inadequate summer flow in the Tuolumne River. Specific stressors identified by NMFS (2014) for Tuolumne River CCV steelhead are shown, by life-stage, in Table 3.1-2.

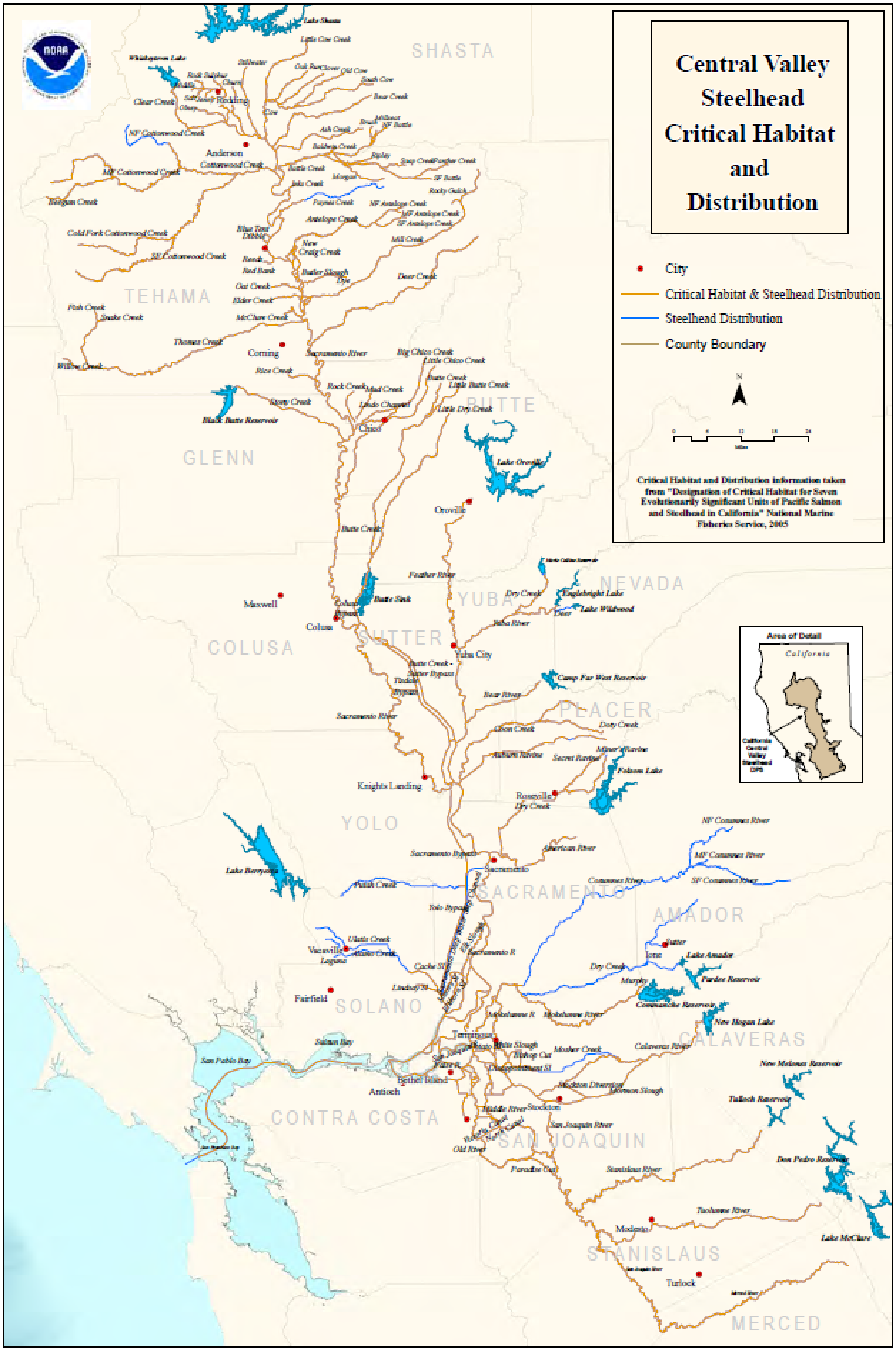

Figure 3.1-1. **CCV Steelhead Designated Critical Habitat and Distribution (Source NMFS 2014).**

Table 3.1-2. Stressors to Tuolumne River CCV steelhead, by life-stage, as identified by NMFS (2014).

Life Stage	Stressor Category	Primary Stressor/Stressor Location
Adult Immigration and Holding	Passage Impediments/Barriers	Don Pedro Dam
		La Grange Diversion Dam
		Stockton Deep Water Ship Channel
		Suisun Marsh Salinity Control Structure
	Flow Conditions	Tuolumne River: effects of low flows on attraction and migratory cues
		San Joaquin River: effects of low flows on attraction and migratory cues
		San Joaquin River: effects of flood flows on non-natal area attraction
	Water Quality	Tuolumne River: agricultural and urban pollutants
		San Joaquin River: agricultural and urban pollutants
		Delta: dissolved oxygen, agricultural and urban pollutants, heavy metals
	Water Temperature	Tuolumne River
		San Joaquin River
		Delta
	Harvest/Angling	Tuolumne River
		San Joaquin River
		Delta
		San Pablo Bay/San Francisco Bay
		Ocean
	Short-Term In-Water Construction	Tuolumne River: turbidity, sedimentation, hazardous spills, acoustic effects
		San Joaquin River: turbidity, sedimentation, hazardous spills, acoustic effects
		Delta: turbidity, sedimentation, hazardous spills, acoustic effects
Spawning	Migration Barriers	Tuolumne River: habitat limitation resulting in competition for habitat, redd superimposition, and effects on genetic integrity due to hybridization
	Habitat Availability	Tuolumne River: habitat suitability
	Physical Habitat Alteration	Tuolumne River: limited instream gravel supply
	Water Quality	Tuolumne River
	Water Temperature	Tuolumne River
	Harvest/Angling	Tuolumne River: recreational and poaching impacts
	Hatchery Effects	Tuolumne River: habitat limitation resulting in

Life Stage	Stressor Category	Primary Stressor/Stressor Location
		competition for habitat, redd superimposition, and effects on genetic integrity due to hybridization
Embryo Incubation	Flow Conditions	Tuolumne River: flow fluctuations
	Water Quality	Tuolumne River: pollutants
	Water Temperature	Tuolumne River
	Harvest/Angling	Tuolumne River: redd disturbance
	Short-Term In-Water Construction	Tuolumne River: turbidity, sedimentation, hazardous spills, acoustic effects
Juvenile Rearing and Outmigration	Passage Impediments/Barriers	Don Pedro Dam
		La Grange Diversion Dam
		Tributary barriers
	Flow Conditions	Tuolumne River: flow-dependent habitat availability
		San Joaquin River: flow-dependent habitat availability
		Changes in hydrology
		Reverse flows caused by CVP and SWP export pumping
		Diversion into Central Delta
	Loss of Floodplain Habitat	Tuolumne River
		San Joaquin River
		Delta
	Loss of Natural River Morphology	Tuolumne River
		San Joaquin River
		Delta
	Loss of Tidal Marsh Habitat	Delta
		San Pablo Bay/San Francisco Bay
	Loss of Riparian Habitat and Instream Cover	Tuolumne River
		San Joaquin River
		Delta
	Entrainment	Individual diversions in the Tuolumne River
		Individual diversions in the San Joaquin River
		Contra Costa Power Plant
		Pittsburg Power Plant
		Jones and Banks pumping plants
		Individual diversions in the Delta
	Water Quality	Tuolumne River: agricultural and urban pollutants
		San Joaquin River: agricultural and urban pollutants

Life Stage	Stressor Category	Primary Stressor/Stressor Location
		Delta: dissolved oxygen, agricultural and urban pollutants, heavy metals
		San Pablo Bay/San Francisco Bay: agricultural and urban pollutants, heavy metals
	Water Temperature	Tuolumne River
		San Joaquin River
		Delta
	Hatchery Effects	Tuolumne River
		San Joaquin River
		Delta
		San Pablo Bay/San Francisco Bay
	Predation	Tuolumne River
		San Joaquin River
		Delta
		San Pablo Bay/San Francisco Bay
	Invasive Species/Food Web Disruption	Delta: Asian clam, *A. aspera*, and *Microcystis* (a toxic cyanobacterium)
		San Pablo Bay/San Francisco Bay: Asian clam, A. aspera, and *Microcystis* (a toxic cyanobacterium)
	Short-Term In-Water Construction	Tuolumne River: turbidity, sedimentation, hazardous spills, acoustic effects
		San Joaquin River: turbidity, sedimentation, hazardous spills, acoustic effects
		Delta: turbidity, sedimentation, hazardous spills, acoustic effects
		San Pablo Bay/San Francisco Bay: turbidity, sedimentation, hazardous spills, acoustic effects

3.1.6 Recovery Criteria

The Final Central Valley Salmon and Steelhead Recovery Plan (NMFS 2014) includes recovery criteria to address the five ESA listing factors: (1) current or potential destruction or modification of the species' habitat or curtailment of its range, (2) overuse for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) inadequate regulatory mechanisms, and (5) other natural or human-induced factors affecting the species' continued existence. The purpose of these threat-based criteria is to attempt to address the factors that caused the species to become threatened, with the ultimate aim of delisting the species.

NMFS (2016) ESU/DPS level criteria call for the establishment of two CCV steelhead populations at low risk of extinction within the Southern Sierra Diversity Group (which includes any steelhead in the Tuolumne River). The criteria specify that for a steelhead population to be at low risk of extinction it must be characterized by (1) a census population size greater than 2,500 adults or an effective population size greater than 500[1], (2) an absence of apparent productivity decline, (3) an absence of catastrophic events within the past 10 years, and (4) a low level of hatchery influence.

3.1.7 Conservation Initiatives

The CALFED Program, which commenced in June 1995, was aimed at developing a "long-term Bay-Delta solution" (NMFS 2014). A primary component of the CALFED Program is the Ecosystem Restoration Program (ERP), which was developed to provide a foundation for long-term ecosystem and water quality restoration and protection. Among the non-flow factors targeted by the program to reduce adverse effects on steelhead are unscreened diversions, wastewater discharges, other water pollution, poaching, land-derived salts, introduced species, fish passage barriers, channel alterations, and loss of riparian wetlands.

Approximately $15 million per year of CVPIA restoration funds are to be used to protect, restore, and enhance special-status species and their habitats in areas directly or indirectly affected by the CVP. Through the AFRP, federal funding was allocated for spawning gravel augmentation, instream flow management (i.e., use of 800 thousand acre feet of water from the CVP), and habitat restoration projects, including the Bobcat Flats project on the Tuolumne River. The AFRP also includes elements aimed at obtaining funds for fish screening projects.

The San Joaquin River Restoration Program (SJRRP) calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam and releases of water from Friant Dam to the confluence of the Merced River. Although this SJRRP is focused on spring-run Chinook salmon, it has the potential to also improve habitat for steelhead. The first flow releases from Friant Dam as part of the SJRRP occurred in October 2009. All high priority channel and structural construction activities were to be completed by December 2013, and full restoration flows were to be released by 2014. However, the complexity of habitat restoration and the ongoing drought have delayed these goals (NMFS 2016). There is a small population of

[1] Effective population size is the size of an idealized population considered to lose genetic heterozygosity at a rate equivalent to that of the larger, observed population. A population characterized by a high level of heterozygosity for a given genetic trait contains much genetic variability for that trait.

resident *O. mykiss* in the San Joaquin River below Friant Dam, so additional flow and increased connectivity to the ocean have the potential to reestablish steelhead in this section of the San Joaquin River (NMFS 2016).

California WaterFix would, if implemented, represent an attempt to modernize California's antiquated water delivery system to save water and thereby provide opportunities to protect sensitive fish species (NMFS 2016). A proposed CWF water conveyance system would include new points of diversion in the north Delta together with improvements to the water export system in the south Delta. Actions being discussed include operation of a dual conveyance system and measures to reduce other stressors to the Delta ecosystem.

California EcoRestore is an initiative under development to help coordinate and advance short-term habitat restoration in the Delta. This restoration is not associated with any habitat restoration required as part of the construction and operation of any new Delta water conveyance.

To protect wild steelhead in California, all hatchery steelhead receive an adipose fin-clip, although they are not coded-wire tagged, so hatchery of origin and straying rates for particular stocks cannot be discerned (NMFS 2014). The State of California also works closely with NMFS to review and improve inland fishing regulations (NMFS 2014). These include zero bag limits for unmarked steelhead, gear restrictions, closures, and size limits designed to protect smolts.

3.1.7.1 Existing FERC-Mandated Flow Regime for the Lower Tuolumne River

FERC's 1996 order (FERC 1996) amending the Don Pedro Project license required the incorporation of the lower Tuolumne River minimum flow provisions contained in the 1995 settlement agreement between the Districts, CCSF, resource agencies, and environmental groups. The revised minimum flows in the lower Tuolumne River range from 50 to 300 cfs, depending on water year hydrology and time of year. The water year classifications are recalculated each year to maintain an approximately consistent frequency distribution of water year types. The settlement agreement and license order also specify certain pulse flows, the amount of which also varies with water-year type. The downstream flow schedule provided for by the settlement agreement and subsequent FERC Order is shown in Table 3.1-3.

Table 3.1-3. Schedule of flow releases from the Don Pedro Project to the lower Tuolumne River by water year type contained in FERC's 1996 order.

Schedule	Units	# of Days	Critical and Below	Median Critical[1]	Interm. CD	Median Dry	Interm. D-BN	Median Below Normal	Interm. BN-AN[1]	Median Above Normal	Interm. AN-W	Median Wet/Max
Occurrence	%		6.4%	8.0%	6.1%	10.8%	9.1%	10.3%	15.5%	5.1%	15.4%	13.3%
October 1-15	cfs	15	100	100	150	150	180	200	300	300	300	300
	AF		2,975	2,975	4,463	4,463	5,355	5,950	8,926	8,926	8,926	8,926
Attraction Pulse	AF		none	none	None	none	1,676	1,736	5,950	5,950	5,950	5,950
October 16-May 31	cfs	228	150	150	150	150	180	175	300	300	300	300
	AF		67,835	67,835	67,835	67,835	81,402	79,140	135,669	135,669	135,669	135,669
Outmigration Pulse Flow	AF		11,091	20,091	32,619	37,060	35,920	60,027	89,882	89,882	89,882	898
June 1-Sept 30	cfs	122	50	50	50	75	75	75	250	250	250	250
	AF		12,099	12,099	12,099	18,149	18,149	18,149	60,496	60,496	60,496	60,496
Volume (total)	AF	365	94,000	103,000	117,016	127,507	142,502	165,003	300,923	300,923	300,923	300,923

[1] Between a Median Critical Water Year and an Intermediate Below Normal-Above Normal Water Year, the precise volume of flow to be released by the Districts each fish flow year is to be determined using accepted methods of interpolation between index values.

Source: FERC 1996.

3.1.7.2 District-Funded Existing Non-Flow Measures in the Lower Tuolumne River

Conditions in the lower Tuolumne River have been improved by the involvement of the Tuolumne River Technical Advisory Committee (TAC), the role of which was formalized in the Districts' 1995 settlement agreement. Since the early 1990s, the TAC has been engaged in developing, reviewing, and participating in activities to improve and protect the fisheries of the Tuolumne River downstream of La Grange Diversion Dam. In addition to the Districts, the TAC includes members from state and federal resource agencies, CCSF, and Non-Governmental Organizations (NGOs).

As directed under the 1995 Settlement Agreement, the TAC developed 10 priority habitat restoration projects aimed at improving geomorphic and biological aspects of the lower Tuolumne River corridor (listed below), which have the potential to benefit CCV steelhead at one or more times during the species' life cycle.

- Channel and Riparian Restoration Projects (RM 34.3-RM 40.3)
  - Gravel Mining Reach Phase I - 7/11 Gravel Mining Reach Restoration (restored channel and floodplain along 1.5 river miles) (RM 38-39.5) (completed in 2003)
  - Gravel Mining Reach Phase II (not completed)[12]
  - Gravel Mining Reach Phase III (not completed)
  - Gravel Mining Reach Phase IV (not completed)
- Predator Isolation Projects
  - Special Run Pool (SRP) 9 Channel and Floodplain Restoration (restored channel and floodplain along 0.2 river miles) (RM 25.7-25.9) (completed in 2001)
  - SRP 10 (RM 25.5) (not completed)
- Sediment Management Projects (RM 43.0-RM 51.8)
  - River Mile 43 Channel Restoration (restored channel and floodplain along 0.5 river miles) (completed in 2005)
  - Gasburg Creek Fine Sediment Retention Project (RM 50) (completed in 2008)
  - Gravel Augmentation (coarse sediment) (not completed)
  - Riffle Cleaning (fine sediment) (not completed)

Other restoration efforts have been implemented in the lower Tuolumne River corridor by various groups, including Friends of the Tuolumne (FOT), Tuolumne River Trust (TRT), Natural Resource Conservation Service (NRCS), East Stanislaus Resource Conservation District (ESRCD), USFWS, California Department of Fish and Wildlife (CDFW), Stanislaus County, and the cities of Waterford, Ceres, and Modesto.

[12] By the terms of the 1995 Settlement Agreement, the Districts and CCSF pledged $500,000 and an additional $500,000 in matching funds for Tuolumne River restoration projects. Also by the terms of the agreement, CDFW and USFWS were responsible for actively pursuing state and federal funding. After securing funding and constructing the initial four priority projects identified by the TAC, CDFW, while supporting additional restoration projects at the TAC, actively opposed using CALFED funding for additional projects. Consequently, approved CALFED funding of over $14.75 million for three additional TAC projects, designed to benefit fall-run Chinook and *O. mykiss*, was never able to be used and the projects were never implemented due to factors outside the control of the Districts.

CDFW placed about 27,000 cubic yards (yd^3) of gravel in the river near the Town of La Grange from 1999 to 2003 to increase spawning gravel area to help offset gravel losses due to the 1997 flood. The FOT, TRT, NRCS, and ESRCD implemented several large floodplain restoration projects on the lower Tuolumne River near Modesto, including the Grayson River Ranch project, which resulted in the restoration of 140 acres of floodplain between RM 5 and RM 6. The TRT, in partnership with the NRCS, California Department of Water Resources (CDWR), the National Oceanic and Atmospheric Association (NOAA), and the ESRCD, acquired approximately 250 ac on both sides of the Tuolumne River from RM 5.8 to 7.4 ("Big Bend"). The Big Bend project site, which involved restoration of 240 acres of floodplain between RM 5.5 and RM 7.0, was completed from 2004 to 2006. FOT, funded by the California Bay-Delta Authority (CBDA), acquired about 250 ac of river and floodplain habitat at Bobcat Flat (RM 42.4 to 44.6). A restoration plan was developed, with the goal of enhancing natural floodplain function at the parcel. The Bancroft-Ott Floodplain and Wetland project resulted in 56 acres of restored floodplain along 0.5 river miles at approximately RM 4.

The Adaptive Management Forum (AMF) was initiated in 2001 to review designs for restoration projects in Central Valley rivers and assist resource agencies and tributary restoration teams. The AMF panel of technical experts reviewed and made recommendations concerning tributary restoration projects and called for incorporating adaptive management into projects to maximize restoration success.

4.0 ENVIRONMENTAL BASELINE IN THE ACTION AREA

4.1 Studies Related to *O. mykiss* in the Action Area

The Don Pedro Project and its potential environmental effects have undergone continuous study and evaluation since the early 1970s. The Districts, in cooperation with state and federal resource agencies and environmental groups, have conducted over 200 individual resource investigations since the Don Pedro Project began commercial operation in 1971. The first 20 years of study led in 1995 to the development of a FERC-mediated settlement agreement with resource agencies and NGOs, whereby the Districts agreed to modify their operations to increase the flows released to the lower Tuolumne River for the benefit of salmonids.

On an annual basis, the Districts file with FERC, and share with the TAC, results of ongoing monitoring downstream of the Project Boundary. The up-to-date record created by the continuous process of environmental investigation and resource monitoring has produced detailed baseline information. Pre-relicensing studies pertaining specifically to *O. mykiss* are listed below, but numerous other studies have addressed, directly or indirectly, aspects of *O. mykiss* abundance, life-history dynamics, and habitat.

- 2008 July *Oncorhynchus mykiss* Population Estimate Report (Report 2008-6)
- Tuolumne River *Oncorhynchus mykiss* Monitoring Report (submitted January 15) (Report 2010)
- March and July 2009 Population Estimates of *Oncorhynchus mykiss* Report (Report 2010)
- Tuolumne River *Oncorhynchus mykiss* Monitoring Summary Report (submitted January 15) (Report 2011)
- 2010 *Oncorhynchus mykiss* Population Estimate Report (Report 2010-6)
- 2010 *Oncorhynchus mykiss* Acoustic Tracking Report (Report 2010-7)
- 2011 *Oncorhynchus mykiss* Population Estimate Report (Report 2011-6)
- 2011 *Oncorhynchus mykiss* Acoustic Tracking Report (Report 2011-7)

As part of the FERC relicensing of the Don Pedro Project, the Districts conducted the following studies that pertain specifically to *O. mykiss* in the Action Area.

4.1.1 Spawning Gravel in the Lower Tuolumne River (W&AR-04)

In 2012, the Districts conducted a spawning gravel survey (TID/MID 2013g) on the lower Tuolumne River. The reach evaluated included the Tuolumne River from just downstream of La Grange Diversion Dam at RM 52.1 to RM 23, which accounts for the extent of riffle habitats documented in historical surveys (TID/MID 1992a). The spawning gravel survey involved the application of a variety of analyses and modeling to (1) estimate average annual sediment yield to Don Pedro Reservoir, (2) estimate changes in the volume of coarse bed material in the lower Tuolumne River channel from 2005 to 2012, (3) map fine bed material in the lower Tuolumne River and compare the results with previous surveys, (4) develop a reach-specific coarse sediment budget to evaluate the Project's contribution to cumulative effects on river sediment in the lower Tuolumne River, and (5) map current riffle, spawning gravel, and suitable spawning habitat areas in the lower Tuolumne River and compare the results with previous surveys.

4.1.2 Salmonid Population Information Integration and Synthesis (W&AR-05)

The Districts conducted a Salmonid Population Information Integration and Synthesis Study in 2012 (TID/MID 2013e) to collect, compile, and summarize existing information to characterize *O. mykiss* populations in the Tuolumne River and develop hypotheses related to factors potentially affecting those populations. The study area included the lower Tuolumne River from La Grange Diversion Dam (RM 52.2) downstream to the confluence with the San Joaquin River (RM 0), the lower San Joaquin River from the Tuolumne River confluence (RM 84) to Vernalis (RM 69.3), the Delta, the San Francisco Bay/San Pablo Bay estuary, and the Pacific Ocean. Local and regional information, as well as broader scientific literature sources, were reviewed to examine issues affecting habitat use and life history progression of Tuolumne River *O. mykiss*.

4.1.3 Salmonid Redd Mapping (W&AR-08)

The purpose of the Salmonid Redd Mapping study (TID/MID 2013f) was to document the spatial distribution of *O. mykiss* redds to assist with quantifying the current spawning capacity and redd/recruit relationships of the lower Tuolumne River. The study area, which extended from La Grange Diversion Dam (RM 52) to Santa Fe Bridge (RM 22), was divided into four reaches, which correspond to reach designations used by CDFW. Bi-weekly redd mapping surveys were conducted to evaluate redd characteristics, redd status, redd superimposition, and fish presence on or near redds. Surveys were conducted during the 2012-2013 and 2014-2015 spawning seasons.

4.1.4 *Oncorhynchus mykiss* Population Study (W&AR-10)

The Tuolumne River *O. mykiss* model (TROm) (TID/MID 2017e) was developed to examine the relative influences of various factors on the production of in-river life stages of *O. mykiss*, identify life-stages that may represent a life-history "bottleneck," and compare relative changes in the population among potential alternative resource management scenarios. The model was also developed to compare relative *O. mykiss* production in the Tuolumne River under different water year types, using existing literature and additional information identified in the Salmonid Population Information Integration and Synthesis Study (TID/MID 2013e), including previously conducted Tuolumne River studies and interrelated relicensing studies. Independent life-stage-specific sub-models were developed to predict life-history progression from adult upstream migration through spawning, egg incubation, fry and juvenile rearing, and smolt outmigration. However, in the absence of reliable information on the numbers and timing of any anadromous *O. mykiss* spawning and the factors contributing to anadromy in the Tuolumne River, the relative changes in the production of *O. mykiss* smolts resulting from different flow and temperature conditions in the Tuolumne River should be interpreted with caution. To allow for the evaluation of *O. mykiss* production under a variety of water-year types, the calibrated TROm model was used to evaluate a Base Case simulation period (1971-2009), which provides a 37-year time series of varying hydrologic conditions. Using water temperature estimates provided by the Reservoir Temperature Model (TID/MID 2017g) and Lower Tuolumne River Temperature Model (TID/MID 2017c), juvenile and adult productivity were estimated at three population sizes of resident *O. mykiss*: 500, 2,000 and 10,000 fish.

4.1.5 *Oncorhynchus mykiss* Habitat Survey (W&AR-12)

The *O. mykiss* habitat survey (TID/MID 2017d) conducted in 2012-2013 consisted of an inventory of instream habitat types and physical habitat characteristics and an appraisal of the distribution, abundance, and function of LWD. The habitat survey was conducted in the *O. mykiss* spawning and rearing reach, which extends from La Grange Diversion Dam to Roberts Ferry Bridge (approximately RM 52 to 39), and the LWD evaluation was conducted from RM 52 to RM 24.

4.1.6 Temperature Criteria Assessment (W&AR-14)

The Temperature Criteria Assessment (Farrell et al. 2017, W&AR-14) included the following tasks related to *O. mykiss*: (1) a literature review of available temperature tolerances of *O. mykiss*, (2) an empirical study of local acclimation of temperature tolerance of wild *O. mykiss* juveniles in the lower Tuolumne River, (3) an analysis of existing empirical information on the spatial distribution of juvenile *O. mykiss* in response to temperature, and (4) a study of wild juvenile *O. mykiss* behavior and metabolic capability in reaches with a range of water temperatures.

The results of the empirical study of metabolic capability of wild Tuolumne River *O. mykiss* are provided in the report entitled Thermal Performance of Wild Juvenile *Oncorhynchus mykiss* in the Lower Tuolumne River: A Case for Local Adjustment to High River Temperature (Farrell et al. 2017, W&AR-14) (the “swim tunnel study”). The purpose of this study was to investigate the thermal performance of juvenile *O. mykiss* from the lower Tuolumne River in response to seasonal maximum water temperatures that they experience during the summer months. The study tested the hypothesis that the Tuolumne River *O. mykiss* population below LGDD is locally adapted to the relatively warm thermal conditions that exist in the river during summer. Wild juvenile *O. mykiss* used in the study were locally caught and tested and then returned safely to the Tuolumne River within approximately one day of capture. To build upon the findings of the Farrell et al. (2017) swim tunnel study (FISHBIO 2017b) conducted a study to integrate the temperature responses of aerobic scope into an ecological framework, accounting for factors that interact with temperature effects on *O. mykiss* metabolic capacity in the lower Tuolumne River. One objective of this study was to quantify in-river tail-beat frequency of juvenile *O. mykiss* to estimate field metabolic rates. A second objective was to quantify in-river prey strike frequencies of juvenile lower Tuolumne River *O. mykiss*.

4.1.7 *Oncorhynchus mykiss* Scale Collection and Age Determination (W&AR-20)

In 2012, the Districts conducted the *Oncorhynchus mykiss* Scale Collection and Age Determination Study (TID/MID 2013c), Fish scales were used to estimate the age-at-length relationship of *O. mykiss* in the lower Tuolumne River. Fish were collected in the reach that extends from La Grange Diversion Dam (RM 52.2) to Turlock Lake (RM 42), and a single sample was taken from the rotary screw trap deployed near Waterford (RM 30).

4.1.8 Lower Tuolumne River Floodplain Hydraulic Assessment (W&AR-21)

The July 16, 2009 FERC Order (128 FERC 61,035) required the Districts to conduct a two-dimensional (2-D) pulse flow study. The purpose of the 2-D Pulse Flow Study (Stillwater Sciences 2012a) was to assess habitat suitability for lower Tuolumne River fish species, including *O. mykiss*, at conditions above bankfull discharge, and gather empirical data on the relationship between water temperature and flow during pulse flow events (i.e., >1,200 cfs). The study included the development of a 2-D hydraulic model at three study sites to assess the habitat suitability of overbank inundation areas during flows up to 5,000 cfs.

The Lower Tuolumne River Floodplain Hydraulic Assessment (TID/MID 2017b) was undertaken by the Districts to supplement the 2-D modeling described above and the USFWS (2008) assessment of floodplain inundation (i.e., Flow-Overbank Inundation Relationship for Potential Fall-Run Chinook Salmon and Steelhead/Rainbow Trout Juvenile Outmigration Habitat in the Tuolumne River, USFWS 2008).

The goal of the floodplain hydraulic assessment (TID/MID 2017b) was to develop a hydraulic model to simulate the interaction between flow in the main channel and floodplain inundation in the reach between La Grange Diversion Dam (RM 52.2) and the confluence with the San Joaquin River. The assessment addressed the following objectives: (1) determine floodplain inundation extents for flows between 1,000 and 3,000 cfs at 250 cfs intervals and between 3,000 cfs and 9,000 cfs at 500 cfs intervals, (2) estimate the area, frequency, and duration of inundation over a range of flows for base case (WY 1971–2012) hydrology, and (3) apply modeled water depths and velocities to quantify the amount of suitable rearing habitat for juvenile Chinook salmon and *O. mykiss* at the designated flow increments.

4.1.9 One-Dimensional (1-D) PHABSIM model (Stillwater Sciences 2013)

A number of instream flow studies have been conducted on the lower Tuolumne River. The most recent study was filed with FERC in April 2013 (Stillwater Sciences 2013). The purpose of this latest 1-D Physical Habitat Simulation (PHABSIM) model, conducted per a July 16, 2009 FERC Order (128 FERC 61,035), was "to determine instream flows necessary to maximize…*O. mykiss* production and survival throughout their various life stages." The instream flow assessment methodology (Bovee 1982) applied a mesohabitat and transect-based approach (i.e., 1-D model) for implementing the PHABSIM component of the USFWS Instream Flow Incremental Methodology (IFIM) to address flow-habitat relationships in the lower Tuolumne River from RM 51.7 to RM 29.0.

The Districts conducted the Lower Tuolumne River Instream Flow Study–Evaluation of Effective Usable Habitat Area for Over-Summering *O. mykiss* (Stillwater Sciences 2015) to estimate the "effective" weighted usable area (eWUA) of select lower Tuolumne River habitat reaches for various life history-stages of *O. mykiss* during June–September). Unlike the traditional WUA computed for stream habitat analysis, which is based on the relationship between physical (i.e., depth, velocity, and/or substrate and cover) parameters and flow (Bovee 1982), the eWUA evaluation accounts for temperature as well. Depending on thermal conditions, the total usable habitat area in a river reach at a given flow may be less than that depicted by the standard WUA-versus-flow relationship if temperatures are unsuitable.

4.1.10 Tuolumne River Flow and Water Temperature Model: Without Dams Assessment (Jayasundara et al. 2017)

The purpose of the Tuolumne River Flow and Water Temperature Model: Without Dams Assessment study (Jayasundara et al. 2017) was to develop a flow and water temperature model to simulate water temperatures in the Tuolumne River without the existing Hetch Hetchy (including Cherry and Eleanor reservoirs), Don Pedro, and La Grange projects in place. The model was developed to complement detailed models developed for Don Pedro Reservoir and the La Grange headpond (TID/MID 2013d) and the lower Tuolumne River (TID/MID 2013f). Supporting data included the characterization of long-term flow and meteorological conditions to assess flow and water temperatures over a multi-decade period, i.e., 1970-2012. In its December 2011 Study Plan Determination, FERC indicated that EPA (2003) temperature guidance would be considered to be applicable to the lower Tuolumne River, absent the availability of site-specific, empirical information on the aquatic resources of the Tuolumne River. The “without dams” model developed by this study, along with results of the Temperature Criteria Assessment Study (Farrell et al. 2017), provide such site-specific, empirical information.

4.2 Fish Assemblage in the Action Area

Fish species composition in the lower Tuolumne River is shown in Table 4.2-1 (Ford and Brown 2001; TID/MID 2010a, b, c), with a notation as to whether a species is native or non-native and resident or migratory. The distributions of native and non-native fishes are influenced by water temperature and velocity, which vary by location, season, and in response to flow. Most native resident fish species are riffle spawners and are generally more abundant in the gravel-bedded reach (RM 24-52). Existing data show that the Sacramento sucker is the most abundant and widespread native fish species in the lower river. Non-native fishes are present throughout the lower river but are typically most abundant in the sand-bedded reach and the lower 6-7 miles of the gravel-bedded reach, where water temperatures are warmer and SRPs provide habitat (Ford and Brown 2001). Sunfishes are the most abundant and widespread non-native fish in the lower river. The non-native predator fish community in the lower river includes largemouth, smallmouth, and striped bass (*Morone saxatilis*) (TID/MID 1992a, 2007).

Of the 22 non-native fish species documented in the lower Tuolumne River, 18 were introduced by state or federal agencies (CDFW, NMFS, USFWS, and the State Board of Human Health) between 1874 and 1954, and one was introduced with permission from CDFW in 1967 (Dill and Cordone 1997; Moyle 2002). The remaining three were introduced by aquarists (goldfish [*Carassius auratus*] in 1862), catfish farms (red shiner [*Cyprinella lutrensis*] in 1954), or private individuals (common carp in 1877, although released in the same year by CDFW) (Dill and Cordone 1997). Sixteen of the fish species released by state or federal agencies were introduced intentionally for sport or commercial fisheries, as a prey base for sport fish, or for mosquito control; two were introduced incidentally with shipments of sport fish (Dill and Cordone 1997).

The most abundant and widespread non-native fish species in the lower Tuolumne River (bluegill, redear sunfish, and green sunfish) were first released in California between 1891 and 1954. Largemouth and smallmouth bass were first released in California by CDFW between 1874 and 1891 (Dill and Cordone 1997; TID/MID 1992a).

Table 4.2-1. Fish species documented in the lower Tuolumne River.

Family/Common Name	Scientific Name	Native (N) Or Introduced (I)	Resident (R) Or Migratory (M)
Lampreys (*Petromyzontidae*)			
Pacific lamprey	Entosphenus tridentatus	N	M
Shad and Herring (*Clupeidae*)			
Threadfin shad	Dorosoma petenense	I	R
Salmon and Trout (*Salmonidae*)			
Chinook salmon	Oncorhynchus tshawytscha	N	M
Rainbow trout/steelhead	Oncorhynchus mykiss	N	R/M
Minnows (*Cyprinidae*)			
Common carp	Cyprinus carpio	I	R
Fathead minnow	Pimephales promelas	I	R
Golden shiner	Notemigonus crysoleucas	I	R
Goldfish	Carassius auratus	I	R
Hardhead	Mylopharodon conocephalus	N	R
Hitch	Lavinia exilicauda	N	R
Red shiner	Cyprinella lutrensis	I	R
Sacramento blackfish	Orthodon microlepidotus	N	R
Sacramento splittail	Pogonichthys macrolepidotus	N	M
Sacramento pikeminnow	Ptychocheilus grandis	N	R
Suckers (*Catostomidae*)			
Sacramento sucker	Catostomus occidentalis	N	R
Catfish (*Ictaluridae*)			
Black bullhead	Ameiurus melas	I	R
Brown bullhead	Ameiurus nebulosus	I	R
Channel catfish	Ictalurus punctatus	I	R
White catfish	Ameiurus catus	I	R
Livebearers (*Poeciliidae*)			
Western mosquitofish	Gambusia affinis	I	R
Silversides (*Atherinidae*)			
Inland silverside	Menidia beryllina	I	R
Temperate Basses (*Percichthyidae*)			
Striped bass	Morone saxatilis	I	M
Basses and Sunfish (*Centrarchidae*)			
Black crappie	Pomoxis nigromaculatus	I	R
Bluegill	Lepomis macrochirus	I	R
Green sunfish	Lepomis cyanellus	I	R
Largemouth bass	Micropterus salmoides	I	R
Redear sunfish	Lepomis microlophus	I	R
Smallmouth bass	Micropterus dolomieu	I	R
Warmouth	Lepomis gulosus	I	R
White crappie	Pomoxis annularis	I	R
Perch (*Percidae*)			
Bigscale logperch	Percina macrolepida	I	R
Surf Perch (*Embiotocidae*)			
Tule perch	Hysterocarpus traski	N	R

Family/Common Name	Scientific Name	Native (N) Or Introduced (I)	Resident (R) Or Migratory (M)
Sculpins (*Cottidae*)			
Prickly sculpin	Cottus asper	N	R
Riffle sculpin	Cottus gulosus	N	R

Sources: Ford and Brown 2001; TID/MID 2010a, b, c.

4.3 Existing Physical Habitat Conditions in the Action Area

Physical habitat conditions in the Action Area (i.e., the lower Tuolumne River from La Grange Diversion Dam [RM 52.2] to the confluence with the San Joaquin River) have been affected by a wide range of human actions conducted over many decades. Prior to widespread European settlement, channel form in the gravel-bedded zone of the lower Tuolumne River (RM 24.0 to 52.1) consisted of a combination of single-thread and split channels that migrated and avulsed (McBain and Trush 2000). Anthropogenic changes that have occurred in the lower Tuolumne River corridor since the mid-1800s include gold mining, aggregate mining, grazing, agriculture, water management, and more recently urban encroachment.

Riverbed material was excavated to depths well below the thalweg to mine gold and aggregate, eliminating active floodplains and terraces and creating large in-channel and off-channel pits. A historical timeline of mining in the San Joaquin River's tributaries includes placer mining (1848–1880), dredge mining (1880–1960s), and sand and gravel mining (1940s–present) (McBain & Trush 2000). On the Tuolumne River, dredge mining during the early 1900s resulted in the excavation of channel and floodplain sediments and left dredger tailings deposits between RM 38.0 and 50.5. Large-scale, off-channel aggregate mining continues today.

Historically, sand and gravel were mined directly from the active river channel, creating large, in-channel pits now referred to as Special Run Pools (SRPs). These SRPs are as much as 400 ft wide and 35 ft deep, occupying 32 percent of the channel length in the gravel-bedded reach of the lower Tuolumne River. The SRPs are characterized by much lower velocities and greater depths than the un-mined sections of river. More recent aggregate mining operations have excavated sand and gravel from floodplains and terraces immediately adjacent to the river channel at several locations downstream of Roberts Ferry Bridge (RM 39.5) (TID/MID 2011). Floodplain and terrace pits in this reach are typically separated from the channel by narrow berms that can breach during high flows, resulting in capture of the river channel. The January 1997 flood caused extensive damage to dikes separating deep gravel mining pits from the river, breaching or overtopping nearly every dike along the 6-mile-long reach (TID/MID 2011).

Agricultural and urban encroachment along the lower river, combined with a reduction in high flows and coarse sediment supply, have resulted in a relatively static channel within a floodway confined by dikes and agricultural uses. Many miles of river bank have been leveed and stabilized with rip rap by agencies or landowners. Levees and bank revetment extend along portions of the river bank from near Modesto (RM 16) downstream to the San Joaquin River confluence.

The relative abundances of habitat types documented in the lower Tuolumne River during the spawning gravel survey (TID/MID 2017d) were as follows: 14 percent riffle, 61 percent flat water, and 25 percent pool. Sediment model simulations indicate that without gravel augmentation, the channel bed from RM 52 to 39.7 would be slowly degrading and coarsening in response to a reduction in coarse sediment supply due to sediment retention in Don Pedro Reservoir and other upstream reservoirs. Gravel augmentation, however, has helped to increase coarse sediment storage in this area (TID/MID 2013g). Although the results of sediment modeling and topographic differencing indicate little overall change in storage from RM 52 to 45.5 during the period 2000 to 2012, high flows in water year (WY) 2006 and WY 2011 resulted in substantial pool scour, with coarse sediment re-deposited in pool tails and riffles and fine bed material mobilized to channel margins (TID/MID 2013g). Most riffle mesohabitat units (i.e., 84 percent of total riffle habitat) mapped in 2012 from RM 52.1 to 23 contained spawning gravel suitable for use by salmonids (TID/MID 2013e).

The lower Tuolumne River has limited LWD (TID/MID 2017d. In 2012, there was a total of 118 pieces of wood in the 16,905 linear ft of habitat surveyed in 2012, which when extrapolated to the reach extending from RM 39 to RM 52, is an estimated 453 pieces (TID/MID 2017d). This translates into about 35 pieces per mile. However, nearly all the catalogued pieces of wood were less than 26 feet long, most pieces were less than 13 feet long, and more than half of the pieces were less than 8 inches in diameter. Based on many common indices, much of the wood observed would not qualify as LWD.

The importance of LWD in habitat formation decreases with increasing channel width. The lower Tuolumne River between RM 26 and 52 has channel widths averaging 119 ft, and LWD has a limited effect on channel morphology in this reach (TID/MID 2017d). Bilby and Bisson (1998) noted that wood has less effect on channel form in larger rivers than it does in small streams, which is consistent with the W&AR-12 surveyors' observations that LWD had little effect on channel morphology within the Action Area.

Most wood captured in Don Pedro Reservoir originates upstream of the reservoir, and given the size of this wood, a majority of it would pass through the lower Tuolumne River during high flows if it were not trapped in the reservoir (TID/MID 2017d). It is unknown to what extent smaller pieces of wood might add to existing log accumulations or initiate small woody debris jams in the lower river.

Although LWD provides habitat for *O. mykiss* in some systems, there are no data available for the Tuolumne River or neighboring Merced River that specifically address the role of LWD on steelhead or resident *O. mykiss* abundance (TID/MID 2017d). Of the 121 locations within the W&AR-12 study reach where wood was recorded, about 80 percent of it was located in or adjacent to runs or pools, which are not typically the preferred habitat of juvenile or adult *O. mykiss* in the lower Tuolumne River. Because most wood in the lower Tuolumne River is partially or wholly out of the channel, and due to its small size, it does not provide significant habitat value or cover for *O. mykiss*, which in turn limits its value as protection from avian and aquatic predators.

The 2012 Lower Tuolumne River Riparian Information and Synthesis Study (TID/MID 2013b) shows that native riparian vegetation occupies 2,691 ac along a nearly continuous but variable-width band along the lower Tuolumne River corridor (TID/MID 2013b). In addition, the number of locations and areal extent of lands dominated by non-native plants has decreased over the past 15 years.

Overall, the average value of 52 ac/river mile of native riparian vegetation is on the rise, with a 419-ac increase in the net extent of native vegetation between 1996 and 2012, brought about primarily through active restoration projects. The highest relative abundance of native riparian vegetation per river mile was mapped along the 12 miles immediately downstream of La Grange Diversion Dam. Closer to the confluence with the San Joaquin River, several large restoration projects have also increased the extent of native riparian vegetation. However, there is limited natural replacement of mature and senescent plants with younger cohorts outside the restored areas. Areas with the least riparian vegetation and narrowest riparian corridors occur from RM 10.5 to 19.3, i.e., the section of river that runs through the urban areas of Modesto and Ceres. The river corridor between RM 19.3 and 40.3 includes large areas that are sparsely vegetated due to historical mining and the presence of dredger tailings deposits.

4.4 Hydrology in the Action Area

Mean monthly flows in the lower Tuolumne River from 1975-2012 are shown in Table 4.4-1. Records for these locations are available from the U. S. Geological Survey (USGS) National Water Information System (NWIS) website for October 1, 1970 to September 30, 2012.

Table 4.4-1. Mean monthly flows from 1975-2012 in the lower Tuolumne River at four locations.

Month	Below La Grange Diversion Dam (cfs)	Modesto Canal near La Grange (cfs)	Turlock Canal near La Grange (cfs)	Don Pedro Project Release (cfs)
Jan	1,491	74	140	1,705
Feb	1,812	66	183	2,061
Mar	1,952	267	604	2,823
Apr	1,962	543	1,069	3,574
May	1,790	660	1,211	3,661
Jun	1,034	786	1,474	3,294
Jul	537	878	1,798	3,213
Aug	327	782	1,568	2,677
Sep	481	513	786	1,780
Oct	618	288	400	1,306
Nov	348	174	196	718
Dec	881	122	208	1,211

Source: USGS 11289650, USGS 11289000, USGS 11289500, and USGS 11289651.

USGS also reports flows for a gage located farther downstream in the Action Area, near the City of Modesto (Table 4.4-2).

Table 4.4-2. Mean monthly flows for the 1975-2012 period for Tuolumne River at Modesto, below Dry Creek.

Month	Mean Monthly Flow (cfs)	Lowest Mean Monthly Flow (cfs)	Highest Mean Monthly Flow (cfs)
Jan	1,837	154	15,500
Feb	2,138	166	8,782
Mar	2,293	239	7,658
Apr	2,192	169	9,268
May	1,992	138	10,420
Jun	1,216	95	5,683
Jul	716	79	4,244
Aug	501	68	2,415
Sep	680	73	4,041
Oct	848	78	4,760
Nov	647	93	2,089
Dec	1,129	110	5,431

Source: USGS 11290000.

4.4.1 Unimpaired Flow

The unimpaired flow of the Tuolumne River is calculated on a daily basis at La Grange Diversion Dam (Station ID TLG) by the CDWR. The drainage area at this location, according to CDWR's California Data Exchange Center (CDEC) system, is approximately 1,548 mi^2. Historical computed flows are available from CDEC on a daily basis beginning in April 1986, and on a monthly basis from October of 1900 through the present. Unimpaired flows are not intended to mimic or represent natural flows. Because these data are computed on a daily basis using a number of different gages for an arithmetic water-balance (including changes in storage in Don Pedro Reservoir), unimpaired flows for the Tuolumne River can vary considerably from day to day and occasionally show negative flows. Table 4.4-3 presents a summary of average monthly unimpaired flows for 1975 to 2012.

Table 4.4-3. Tuolumne River at La Grange Diversion Dam mean monthly unimpaired flow, 1975-2012.

Month	Unimpaired Flow Monthly Average (AF)
January	146,465
February	156,184
March	227,960
April	279,811
May	449,940
June	354,796
July	143,172
August	33,145
September	16,926
October	24,289
November	46,374
December	83,581
Total	**1,946,116**

Source: TID/MID 2017f.

4.4.2 Flood Hydrology

Since completion of the new Don Pedro Dam in 1971, the flood of record occurred in January 1997. The peak inflow was 120,935 cfs and peak outflow was 59,462 cfs, as measured at the La Grange gage. Prior to 1971, the unregulated historical flood of record occurred in January 1862, with an estimated discharge of 130,000 cfs. A more recent flood, occurring in December 1950 (i.e., after construction of the original Don Pedro Dam), had an estimated discharge of 61,000 cfs. On February 20, 2017, the reservoir level reached 830 feet and the Don Pedro Project spilled for just the second time, with the maximum release being 19,100 cfs.

4.4.3 Drought Hydrology

The annual minimum unimpaired runoff of the Tuolumne River above Don Pedro Reservoir occurred in WY 1977, at 0.38 million AF (0.34 cfs/mi^2), or just 19 percent of the mean value. Since 1971, several drought periods have occurred: WYs 1976-1977, 1987-1992, 2001-2004, and 2012-2015. During the 1976-1977 drought, the combined two-year unimpaired flow was 1 million AF, or 26 percent of the two-year mean of 3.9 million AF. These are the driest two consecutive years in recorded history. The longest drought occurred during WYs 1987-1992. The unimpaired flow over these six years averaged 0.9 million AF, or 48 percent of the mean. In the entire 1987-1992 WY period, not a single year exceeded 70 percent of the long-term mean annual flow. The successive four-year low flow period from 2001-2004 had a mean unimpaired flow of 1.35 million AF, or 69 percent of the mean, without a single-year's flow being above the mean.

The majority of groundwater recharge in both the Turlock and Modesto groundwater basins comes from groundwater storage provided by greater irrigation occurring during wet years. Recent studies have indicated that groundwater storage has been reduced and may no longer be in a state of equilibrium as it had been in the 1990s (TID 2008). Pumping of groundwater for irrigation has significantly increased in both the Turlock and Modesto groundwater basins, primarily due to the substantial increase in orchards in areas outside the surface-water irrigation territories served by the Districts.

Two years during the 2012–2015 drought were among the five driest years on record. During the 2012–2015 period, annual runoff was less than 60 percent of the average annual runoff for the basin. Water supply to the Districts' customers was cut back by up to 50 percent in 2015, and the reservoir level dropped to elevation 671.2 ft in October 2015. Groundwater use rose sharply during this period. However, this source of supplemental water supply is unlikely to be as available as it has been under the recently enacted Sustainable Groundwater Management Act regulations in California.

4.5 Temperature and Water Quality in the Action Area

4.5.1 Temperature

The Tuolumne River between Don Pedro Dam and La Grange Diversion Dam is directly affected by discharges from the Project. The La Grange headpond does not thermally stratify because of its small size relative to the flow passing through it. Releases from Don Pedro Dam, which reflect temperatures in the hypolimnion of Don Pedro Reservoir, rarely exceed 13 ºC (55.4ºF) and are typically significantly cooler (Table 4.5-1). Temperatures warm slightly, about 1 ºC or less, within the La Grange headpond.

The Basin Plan water quality objective (WQO) for temperature states that "at no time or place shall the temperature of any cold water be increased by more than 5 °F above natural receiving water temperature" (CVRWQCB 1998, as amended). Temperatures in the reach downstream of the Don Pedro Project are dominated by the cold water released from depth at the Project. Comparison of modeled 7DADM temperatures under with- and without-dams conditions (Jayasundara et al. 2017) indicate that immediately below Don Pedro Dam (RM 54), with-dams 7DADM temperatures are relatively cool year-round, with little variability (Figure 4.5-1), because water is released from the reservoir's hypolimnion. Because of the thermal mass of the reservoir, water at depth is to a large degree buffered from the influence of seasonal and diel variability in air temperature and other climatic factors. At this location, with-dams 7DADM temperatures are much cooler than without-dams temperatures in summer but are slightly warmer from November through February (Figure 4.5-1).

Table 4.5-1. Don Pedro hypolimnion, Project outflow, and La Grange impoundment temperature comparison.

	Average Temperature (°C)								
	Don Pedro Hypolimnion Upstream of Don Pedro Dam (DPDAM) Elevation 535 ft msl[1]; approx. RM 55.1			Don Pedro Project Outflow RM 54.3			Tuolumne River above La Grange Diversion Dam RM 52.2		
	8/2004 – 11/2012 (most of 2009 missing)			1/1987 - 9/1988 and 5/2010 - 2/2013			8/2011 – 12/2012		
Month	**Mean**	**Highest**	**Lowest**	**Mean**	**Highest**	**Lowest**	**Mean**	**Highest**	**Lowest**
January	10.8	11.4	10.2	10.5	11.7	8.9	11.3	11.3	11.3
February	10.1	11.0	9.5	9.7	11.4	8.5	10.8	10.8	10.8
March	10.1	10.7	9.3	9.3	11.1	7.8	10.8	10.8	10.8
April	10.2	11.4	9.3	9.4	10.9	8.3	10.9	10.9	10.9
May	10.4	10.8	9.8	9.8	11.1	8.6	11.0	11.0	11.0
June	10.7	11.6	10.0	10.2	11.7	9.0	11.2	11.2	11.2
July	11.0	12.1	10.4	10.6	11.7	9.4	11.5	11.5	11.5
August	11.3	12.2	10.6	10.9	12.2	9.4	11.8	11.8	11.8
September	11.4	11.9	10.8	11.1	12.2	10.0	12.0	12.0	12.0
October	11.5	11.9	11.0	11.3	12.2	10.0	12.1	12.1	12.1
November	11.4	12.0	10.7	11.3	13.3	9.3	11.2	11.2	11.2
December	11.5	12.3	11.1	11.2	12.2	10.1	11.2	11.2	11.2

[1] When profile did not extend down to 535 ft msl, the temperature measured at the bottom of the Don Pedro Reservoir profile was used for calculating averages.

Key: ft = feet, msl = mean sea level, RM = river mile.

With-dams temperatures during summer rise significantly with increasing distance downstream of the Don Pedro Project. Under Base Case conditions, by RM 46, summer 7DADM temperatures have climbed back to 20 °C (Figure 4.5-2), very close to the 7DADM temperatures experienced above Don Pedro Reservoir. However, this is still 5 °C below simulated without-dams temperatures. By RM 40 (circa Roberts Ferry Bridge), average with-dam 7DADM temperatures in July reach 22 °C (Figure 4.5-3). Also, except immediately below Don Pedro Dam, there is a decrease in daily average water temperatures from mid-April to mid-May under the with-dams condition, which is the result of pulse flow releases scheduled to benefit fall-run Chinook outmigration downstream of La Grange Diversion Dam.

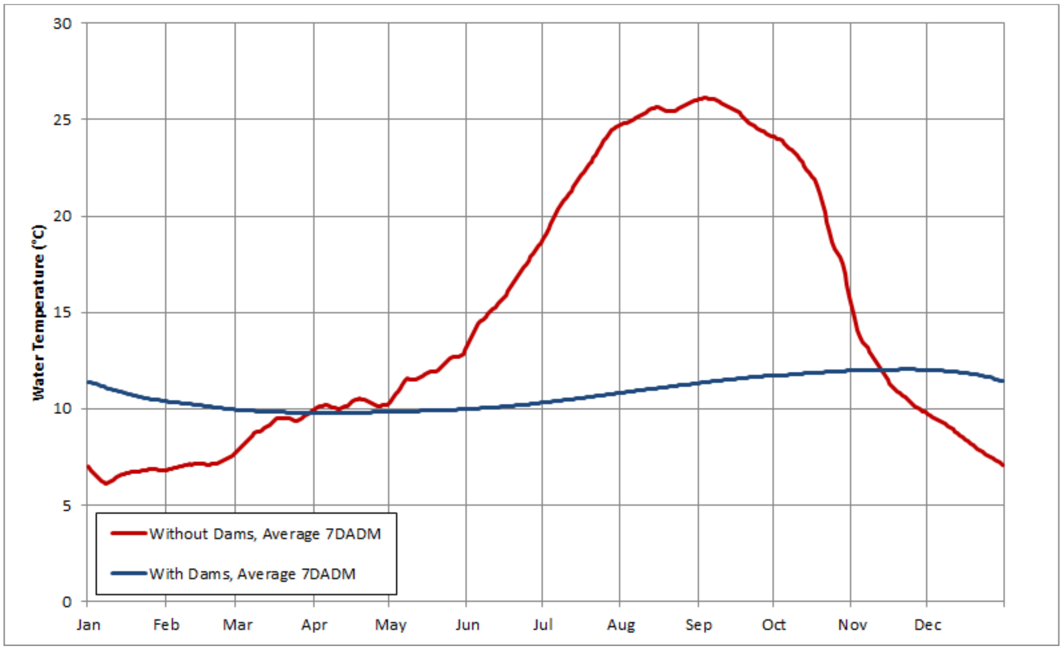

Figure 4.5-1. Comparison of modeled 7DADM water temperatures under with- and without-dams conditions in the Tuolumne River below Don Pedro Dam (≈RM 54). Without-dams temperatures (Jayasundara et al. 2017) and with-dams (Base Case) temperatures (TID/MID 2017c) are simulated based on the period 1970-2012. With-dams temperatures are based on current FERC-required instream flows.

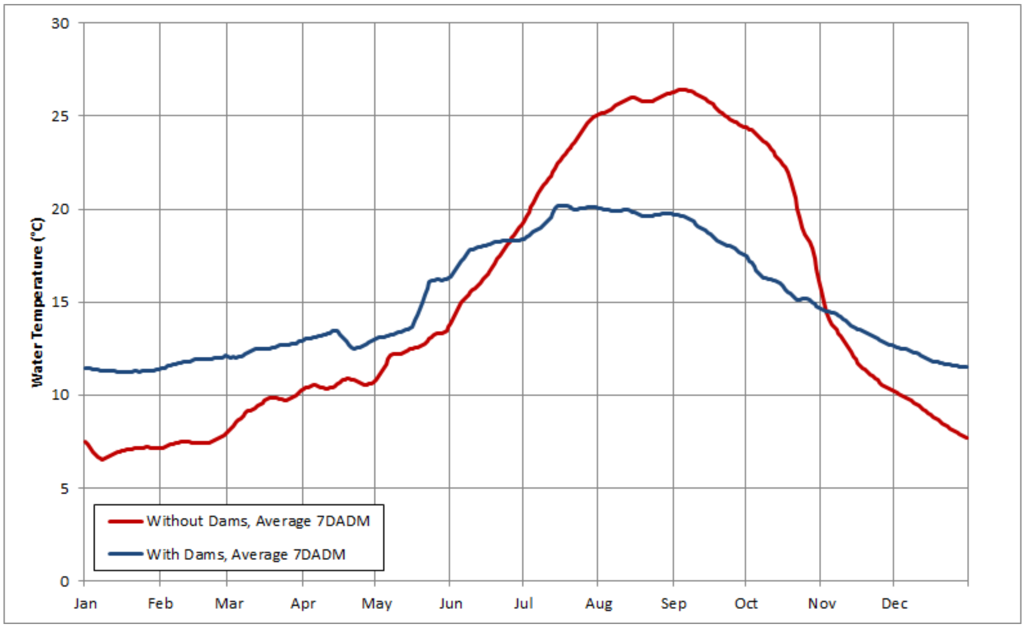

Figure 4.5-2. Comparison of 7DADM water temperatures under with- and without-dams conditions in the lower Tuolumne River at RM 46. Without-dams temperatures (Jayasundara et al. 2017) and with-dams (Base Case) temperatures (TID/MID 2017c) are simulated based on the period 1970 - 2012. With-dams temperatures are based on current FERC-required instream flows.

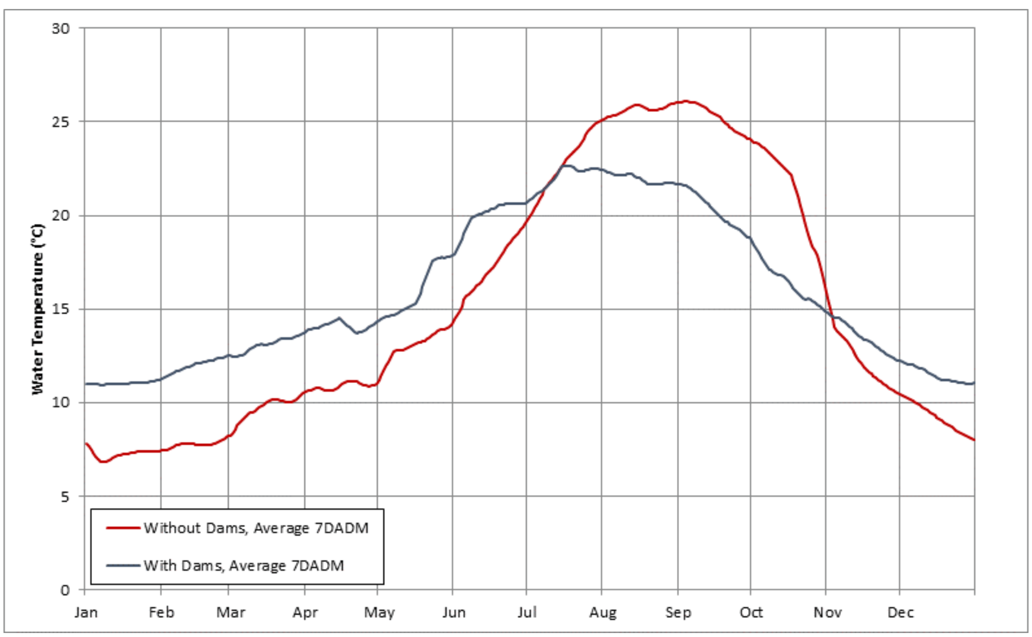

Figure 4.5-3. Comparison of 7DADM water temperatures under with- and without-dams conditions in the lower Tuolumne River at RM 40. Without-dams temperatures (Jayasundara et al. 2017) and with-dams (Base Case) temperatures (TID/MID 2017c) are simulated based on the period 1970 - 2012. With-dams temperatures are based on current FERC-required instream flows.

4.5.2 Water Quality

The Districts have collected hourly DO data in the Tuolumne River downstream of Don Pedro Dam and powerhouse. Table 4.5-2 shows the monthly minimum, average, and maximum hourly DO concentrations for 2012. In all but two months, i.e., October and November, each hour's DO concentration measured downstream of the dam is above the Basin Plan WQO of 7 mg/L. In October and November there were 17 days when at least one hourly recording was below 7 mg/L, with the lowest concentration being 5.8 mg/L. However, there were zero days in 2012 when the average of the day's 24 hourly DO measurements was below 7 mg/L.[13]

Table 4.5-2. Monthly minimum, average and maximum dissolved oxygen concentrations (mg/L) in the Tuolumne River downstream of Don Pedro Dam and powerhouse in 2012.

Month	Minimum DO (mg/L)	Average DO (mg/L)	Maximum DO (mg/L)
2012			
January	8.6	10.1	11.4
February	8.2	10.0	12.4
March	8.4	9.2	12.1
April	8.4	9.3	10.9
May	8.8	9.6	10.6
June	8.6	9.6	10.7
July	8.3	9.2	10.3
August	8.2	9.1	10.4
September	7.4	8.8	10.3
October	6.8	8.4	10.7
November	5.8	8.7	11.0
December	8.6	8.9	9.1

Key: DO = dissolved oxygen; mg/L = milligram per liter.

Surface water quality data collected in the Tuolumne River downstream of La Grange Diversion Dam are summarized in Table 4.5-3. The sources of the data are provided in the far right column of the table.

[13] The Districts collected DO data in the La Grange Powerhouse tailrace channel as part of the Fish Barrier Assessment (FISHBIO 2017c) conducted in support of the La Grange Hydroelectric Project licensing. Data generally indicate satisfactory conditions for aquatic life. However, during the first year of the assessment (2015), there was a brief period from late September through October during which daily instantaneous measurements of DO as low as 4.3 mg/L were recorded at the La Grange Powerhouse tailrace channel weir location. The low instantaneous DO levels appeared to be a localized event because DO levels at the main channel weir ranged from 9.1-11.1 mg/L during the same time period.

Table 4.5-3. Summary of water quality data downstream of La Grange Diversion Dam.

Location	Sampling Period	RM	Temperature (°C)	Turbidity NTU	Dissolved Oxygen (mg/L)	pH	Nitrate Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)	Orthophosphate (mg/L)	Source
Tuolumne River at Old La Grange Bridge	1952-1988; 2003-2004	51.4	7.0-15.0	0-18	7.3-12.7	6.4-8.4	0.01-1.20	0.00-0.20	0.00-0.46	0.00-0.10	STORET 2010 CVRWQCB 2010
Tuolumne River at Hickman Bridge near Waterford	1951-1977	31.6	7.8-29.4	--	5.3-19.4	6.0-8.6	0.00-6.00	--	0.08	0.04-0.16	STORET 2010
Tuolumne River at Legion Park	2003-2004	17.6	9.1-26	2.1-45	7.8-15.7	7.3-8.2	--	--	--	--	CVRWQCB 2010
Dry Creek at La Loma Road	2003-2004	18.7	5.8-26	1.2-54	6.0-16.0	7.2-8.1	--	--	--	--	CVRWQCB 2010
Dry Creek near Modesto	1976-1989	--	5.0-29.0	--	4.6-12.0	7.1-8.0	0.0-7.1	0.90	0.22-1.8	0.16-1.60	STORET 2010
Dry Creek at Gallo Bridge	2001	--	16.0-23.0	--	6.8-10.6	7.4-8.1	0.18-0.40	0.96-1.54	0.42-0.21	0.46-0.58	Kratzer et al. 2004
Tuolumne River at Modesto	1993-1995	16.0	8.0-27.2		8.2-11.6	6.3-8.4	--	--	--	0.01-0.41	USGS 1993-1995
Tuolumne River at Audie Peeples	2003-2004	12.9	8.7-26	1.7-16	7.3-15.7	7.4-8.4	--	--	--	--	CVRWQCB 2010
Tuolumne River at Shiloh Road	2000-2005	3.7	7.7-27.9	0.8-52.3	7.8-15.1	6.7-9.0	--	0.30-3.69	0.06-0.40	0.04-0.50	CVRWQCB 2009 CVRWQCB 2010 Kratzer et al. 2004

Section 303(d) of the federal Clean Water Act (CWA) requires each state to submit to the EPA a list of rivers, lakes, and reservoirs for which pollution control and/or requirements have failed to provide adequate water quality. Based on a review of this list, the surface water bodies identified by the State Water Resources Control Board (SWRCB) as CWA § 303(d) State Impaired including and adjacent to the lower Tuolumne are listed in Table 4.5-4. There are currently no approved Total Maximum Daily Load (TMDL) plans for the Tuolumne River.

Table 4.5-4. Clean Water Act Section 303(d) List for the lower Tuolumne River and associated water bodies.

Water Body	Pollutant	Final Listing Decision
Lower Tuolumne River (Don Pedro Reservoir to San Joaquin River)	Chlorpyrifos	List on 303(d) list (TMDL required list)
	Diazinon	Do Not Delist from 303(d) list (TMDL required list)
	Escherichia coli	List on 303(d) list (TMDL required list)
	Mercury	List on 303(d) list (TMDL required list)
	Temperature	List on 303(d) list (TMDL required list)
	Unknown Toxicity	List on 303(d) list (TMDL required list)
Turlock Lake	Mercury	List on 303(d) list (TMDL required list)
Modesto Reservoir	Mercury	List on 303(d) list (TMDL required list)
Dry Creek (tributary to Tuolumne River at Modesto)	Chlorpyrifos	List on 303(d) list (TMDL required list)
	Diazinon	List on 303(d) list (TMDL required list)
	Escherichia coli	List on 303(d) list (TMDL required list)
	Unknown Toxicity	List on 303(d) list (TMDL required list)

Source : http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2012.shtml (accessed June 2016).

4.6 Status of the *O. mykiss* Population in the Action Area

4.6.1 Anadromy Versus Residency

The tendency for anadromy or residency in sympatric populations of resident *O. mykiss* and any steelhead in the Tuolumne River is poorly understood (TID/MID 2017e), and there is no empirical evidence of a self-sustaining "run" or population of steelhead currently occupying the Action Area (TID/MID 2013e, 2017e; CDFW 2017). Zimmerman et al. (2008) examined the otolith chemistry of 147 *O. mykiss* from the lower Tuolumne River. Results indicated that only one of these fish was a steelhead (had displayed anadromy) and eight were spawned by a steelhead (i.e., of anadromous maternal origin). Of the eight *O. mykiss* with an anadromous parent, the range of age classes indicated that not all were spawned at the same time (i.e., not all of them originated from the same parent). Parental origin of these fish was unknown due to historical planting operations and straying of steelhead.

Most steelhead and resident rainbow trout in the Central Valley are genetically similar (Pearse et al. 2009) and of common hatchery origin (Garza and Pearse 2008). Nielsen et al. (2005) examined the relatedness and origins of Central Valley *O. mykiss* using genetic techniques and determined that *O. mykiss* populations downstream of dams in Central Valley rivers, including the Tuolumne River, are not genetically distinct from one another.

The results of recent investigations suggest that flow and temperature management of tailwater fisheries downstream of many dams in the Central Valley may be preferentially selecting for resident rainbow trout over anadromous steelhead (TID/MID 2013e). In its final recovery plan for the Central Valley Steelhead DPS, NMFS (2014) notes that large resident rainbow trout populations have developed in parts of the Central Valley as a result of actions undertaken for the management of coldwater species.

The probability of *O. mykiss* smolting also has been observed to vary with water temperature, with fish held in cold thermal regimes more likely to mature in freshwater than fish held in warm thermal regimes (Sloat 2013). These findings relate to both fish size (larger fish tend to survive at higher rates in the ocean than do smaller fish) as well as fat stores (fish with higher lipid content have higher energy reserves required for sexual maturation). Fish held in warm thermal regimes may have higher rates of smolting because they may be able to grow to larger total sizes but have lower body lipid stores than fish held in cold thermal regimes (Sloat 2013). McMillan et al. (2012) found that higher body lipid stores were significantly correlated with an increased probability of maturation in freshwater. In other words, if a juvenile *O. mykiss* has sufficient lipid reserves to allow maturation in freshwater, there is no need for it to undergo smoltification and migrate to the ocean to gain sufficient lipid stores to mature (TID/MID 2017c, W&AR-10). In some instances, decreased survival associated with downstream migration to and through the Delta and ocean rearing may not be offset by increased size (fecundity) of steelhead relative to resident *O. mykiss*.

It appears that increased summer flows since 1996 have resulted in large increases in the abundance of resident rainbow trout in the Action Area (TID/MID 2017e). Returning steelhead are rare in the Tuolumne River. Data collected at the Tuolumne River weir at RM 24.5 included only six detections of *O. mykiss* longer than 16 inches during escapement monitoring from 2009 through 2016 (FISHBIO 2017d). Four of the six detections occurred during 2011, and, based on observed body length and depth, these four detections were likely two fish each counted twice.

The extremely low numbers of anadromous *O. mykiss* adults entering the Tuolumne River (Zimmerman et al. 2008) suggest that increased cold water releases from the Project during summer reduce the probability of smoltification (TID/MID 2017e). However, as discussed by Yoshiyama and Moyle (2012), poor migration survival along the migratory pathway (e.g., lower San Joaquin River and south Delta) of any juveniles that do smolt would result in a low probability of their returning to spawn. Narum et al. (2008) and Satterthwaite et al. (2010) suggested that reduced smolt survival through the Delta was the greatest management concern, if the goal was to preserve or enhance expression of anadromy among Central Valley *O. mykiss* populations.

4.6.2 Absence of Anadromous *O. mykiss* in the Lower Tuolumne River

Data collected at the Tuolumne River weir at RM 24.5 included only six detections of *O. mykiss* longer than 16 inches during escapement monitoring from the 2009 through 2016 run years (see Table 4.6-1). Three of the six detections occurred during 2011, and, based on observed body length and depth, likely represent two fish.

Table 4.6-1. *O. mykiss* counts at the RM 24.5 counting weir for the 2009–2016 run years.

Run Year	*O. mykiss* <16 in	*O. mykiss* > 16 in
2009-2010	1	0
2010-2011	0	0
2011-2012	13	3
2012-2013	3	1
2013-2014	0	0
2014-2015	0	0
2015-2016	3	1
2016-2017	0	1

Source: FISHBIO 2012-2016a, unpublished data.

In addition to the detections discussed above, 12 individual *O. mykiss* that were less than 16 inches long were observed passing upstream or downstream of the weir (at RM 24.5) during the 2009-2016 monitoring period. Although these fish were less than 16 inches in length, they lacked adipose fins (ad-clipped), which indicates that these fish were hatchery-origin steelhead, because all hatchery steelhead produced in the Sacramento and San Joaquin basins are ad-clipped. However, the likelihood that these hatchery steelhead are part of the ESA-listed CCV steelhead DPS is low. As noted previously, steelhead produced at the Coleman National Fish Hatchery, located on Battle Creek in Shasta County, and the Feather River Hatchery, located on the Feather River in Butte County, are included as part of the listed DPS. These hatchery programs are located along tributaries of the Sacramento River, on average about 200 miles north of LGDD. Therefore, although straying is a possibility, it is unlikely that ad-clipped steelhead detected at the Tuolumne River weir are part of the listed DPS. Rather, based on proximity, these individuals were likely from hatchery programs in the Mokelumne and American rivers. To date, however, there has been no assessment of hatchery origin for the few ad-clipped *O. mykiss* observed at the Tuolumne River weir.

As part of ongoing juvenile fall Chinook Salmon monitoring at rotary screw traps, the Districts have conducted evaluation of the physical stage of *O. mykiss* juveniles collected at two locations in the lower Tuolumne River: the Grayson River Ranch (RM 5.2), and a site downstream of the City of Waterford (RM 29.8). Sampling at the Grayson and Waterford sites has taken place annually from 1999-2017 and 2006-2017, respectively. Twelve individual *O. mykiss* were considered to be smolts based on their appearance (J. Guignard, pers. comm., 8/1/2017). Two smolts were captured at Grayson since 2005 (and both were captured in 2008), and 10 smolts were captured at Waterford (2006-2008) (J. Guignard, pers. comm., 8/1/2017; FISHBIO 2016).

4.6.3 *O. mykiss* Spawning in the Action Area

O. mykiss spawning in the Tuolumne River occurs from mid-December through April, with peak activity occurring in February and March. The Districts conducted redd mapping surveys between October and April in the 2012-2013 and 2014-2015 spawning seasons (TID/MID 2013f). River conditions were similar between the two study years, with a relatively consistent flow of about 165 cfs. During the 2012-2013 study period, 38 *O. mykiss* redds were observed from October 1, 2012 through April 19, 2013. The first *O. mykiss* redds were observed on January 7, 2013, and peak observations occurred during the week of April 1, when 10 new redds were identified (Table 4.6-2). The majority (63 percent) of *O. mykiss* redds were observed between RM 47.4 and RM 52.0, and 97 percent were observed upstream of RM 42. *O. mykiss* were observed to be actively constructing only two of the identified redds. No *O. mykiss* redds were identified below RM 39 during the 2012–2013 study period, and there was no evidence of *O. mykiss* redd superimposition (TID/MID 2013f).

O. mykiss redds at recent gravel augmentation sites accounted for 31.6 percent (12 of 38) of the total number of observed redds during the 2012–2013 survey period (TID/MID 2013f). Eleven of these were observed at the CDFW 2011 gravel augmentation site near La Grange Diversion Dam (RM 51), and a single *O. mykiss* redd was identified at the Bobcat Flat augmentation site (RM 43).

Table 4.6-2. New *O. mykiss* redds identified by reach and date during the 2012-2013 survey period.

Week[1]	Survey Dates	Reach				Grand Total	Percent
		1 (52.0-47.4)	2 (47.4-42.0)	3 (42.0-31.6)	4 (31.6-22.0)		
1	10/1–10/4/12	0	0	0	0	0	0.0%
3	10/15–10/18/12	0	0	0	0	0	0.0%
5	10/29–11/2/12	0	0	0	0	0	0.0%
6	11/5–11/9/12	0	0	0	0	0	0.0%
7	11/12–11/15/12	0	0	0	0	0	0.0%
8	11/18–11/21/12	0	0	0	0	0	0.0%
9	11/26–11/29/12	0	0	0	0	0	0.0%
11	12/10–12/13/12	0	0	0	0	0	0.0%
14	1/2–1/5/13	0	0	0	0	0	0.0%
15	1/7–1/10/13	5	0	0	0	5	13.2%
17	1/21–1/24/13	3	2	0	0	5	13.2%
19	2/5–2/8/13	5	2	1	0	8	21.1%
21	2/18–2/21/13	0	1	0	0	1	2.6%
23	3/4–3/7/13	5	2	0	0	7	18.4%
25	3/18–3/21/13	0	2	0	0	2	5.3%
27	4/1–4/4/13	6	4	0	0	10	26.3%
29	4/17–4/19/13	0	0	0	0	0	0.0%
Grand Total		24	13	1	0	38	--
Percent		63.2%	34.2%	2.6%	0.0%	--	100%

During the 2014-2015 surveys, 41 redds were identified (Table 4.6-3) (FISHBIO 2017a). The first *O. mykiss* redds were observed on December 29, 2014, and peak observations occurred during the week of February 22, 2015, when 11 new redds were identified. *O. mykiss* spawning activity declined rapidly after mid-March, and the last redd was documented on March 26, 2015. The highest number of observed *O. mykiss* redds occurred in Reach 2 (RM 47.4 to RM 42.0), accounting for 56.1 percent of the *O. mykiss* redds identified (Table 4.6-3). Seventy-six percent of *O. mykiss* redds were observed above RM 42, and no *O. mykiss* redds were identified below RM 34. There was no evidence of *O. mykiss* redd superimposition during the 2014-2015 study period. *O. mykiss* spawning at recent gravel augmentation sites accounted for 19.5 percent (8 of 41 total) of the redds observed during the 2014-2015 spawning season. All of these redds were observed at the CDFW augmentation sites near the Town of La Grange (RMs 50 and 51).

Table 4.6-3. New *O. mykiss* redds identified by reach and date during the 2014-2015 survey period.

Week[1]	Survey Dates	Reach 1 (52.0-47.4)	Reach 2 (47.4-42.0)	Reach 3 (42.0-31.6)	Reach 4 (31.6-22.0)	Grand Total	Percent
6	10/7	0	--	--	--	0	0.0%
8	10/22- 10/23	0	0	--	--	0	0.0%
10	11/3- 11/6	0	0	0	--	0	0.0%
12	11/18- 11/21	0	0	0	0	0	0.0%
14	12/1- 12/5	0	0	0	0	0	0.0%
16	12/15- 12/18	0	0	0	0	0	0.0%
18	12/28- 12/30	0	3	0	0	3	7.3%
20	1/13- 1/15	4	3	2	--	9	22.0%
23	1/26- 1/28	0	1	1	--	2	4.9%
24	2/9- 2/11	0	5	3	--	8	19.5%
26	2/24- 2/26	2	8	1	--	11	26.8%
28	3/10- 3/13	2	3	0	--	5	12.2%
30	3/24- 3/26	0	0	3	--	3	7.3%
33	4/14- 4/16	0	0	0	--	0	0.0%
Grand Total		8	23	10	--	41	--
Percent		19.5%	56.1%	24.4%	--	--	100%

[1] Survey week refers to the number of weeks starting the first full week of September (Week of September 7, 2014).

Thirty-six *O. mykiss* redds were observed between October 14, 2015, and April 6, 2016 (Table 4.6-4) (FISHBIO 2017a). The first *O. mykiss* redds were observed on December 30, and peak observations occurred during the week of March 9, when nine new redds were identified (Table 4.6-4). *O. mykiss* spawning activity declined after mid-March, and the last redd was documented on April 5. Spring pulse flow operations began the following week and continued through June, which prevented further redd surveys. The highest number of observed *O. mykiss* redds occurred in Reach 2 (RM 47.5 to RM 42.0), accounting for 52.8 percent of the *O. mykiss* redds identified (Table 4.6-4). Seventy-eight percent of *O. mykiss* redds were observed above RM 42, and no *O. mykiss* redds were identified below RM 34 during the 2015-2016 study period. There was no evidence of *O. mykiss* redd superimposition during the 2015-2016 study period, and no *O. mykiss* spawning activity was recorded at recent gravel augmentation sites in 2015-2016.

The PHABSIM study (Stillwater Sciences 2013) indicates that flows mandated by the current FERC license provide 91-100 percent of the maximum suitable habitat available for *O. mykiss* spawning. The TROm indicates that spawning habitat is not limiting the *O. mykiss* population, an inference corroborated by the lack of *O. mykiss* redd superimposition observed during surveys (TID/MID 2013f). Given the high availability of potential spawning habitat documented as part of the Spawning Gravel Study (TID/MID 2013g), it is unlikely that existing gravel availability is limiting *O. mykiss* productivity under current conditions. TROm results also indicate that the existing population of adult *O. mykiss* is insufficient to fully saturate available rearing habitat under current conditions in most years.

Table 4.6-4. New *O. mykiss* redds identified by reach and date during the 2015-2016 survey period.

Survey Week[1]	Survey Dates	Reach 1 (52.0-47.5)	Reach 2 (47.5-42.0)	Reach 3 (42.0-31.6)	Reach 4[2] (31.6-22.0)	Grand Total	Percent
7	10/14	0	--	--	--	0	0.0%
9	10/27–10/28	0	0	--	--	0	0.0%
10	11/3–11/5	0	0	0	--	0	0.0%
12	11/16–11/18	0	0	0	--	0	0.0%
14	11/30–12/2	0	0	0	--	0	0.0%
16	12/14–12/16	0	0	0	--	0	0.0%
18	12/30–12/31	0	1	0	--	1	2.8%
20	1/11–1/15	1	2	2	--	5	13.9%
22	1/26–1/28	0	0	2	--	2	5.6%
24	2/8–2/9	1	1	3	--	5	13.9%
26	2/22–2/23	1	6	1	--	8	22.2%
28	3/9–3/10	4	5	0	--	9	25.0%
30	3/21–3/22	2	2	0	--	4	11.1%
32	4/5–4/6	0	2	0	--	2	5.6%
Grand Total		**9**	**19**	**8**		**36**	
Percent		**25.0%**	**52.8%**	**22.2%**	**0.0%**	**--**	**--**

1 Survey week refers to the number of weeks starting the first full week of September (Week of September 6, 2015).
2 Reach 4 was not surveyed due to excessive water hyacinth growth that blocked boat passage.

4.6.4 *O. mykiss* Rearing in the Action Area

Estimated juvenile (< 150 mm) and adult (> 150 mm) *O. mykiss* population sizes (Stillwater Sciences 2012b) in the lower Tuolumne River from July 2008 to September 2011 are shown in Table 4.6-5. Results of instream flow studies (Stillwater Sciences 2013) show that *O. mykiss* fry weighted usable area (WUA) is maximized at 50 cfs, is 90 percent of maximum at 75 cfs, and then declines as flow increases. Adult WUA is maximized at 500 cfs and is at 90 percent of maximum at 275 cfs, and then declines as flow decreases. Stillwater Sciences (2012b) reported that *O. mykiss* in the lower Tuolumne River were observed primarily in habitats with cobble-dominated substrates. Adult fish were concentrated upstream of RM 43.0 and occurred primarily in transitional run-head and pool-head habitats. Juvenile fish had a similar longitudinal distribution and occurred primarily in riffles and transitional run-head and pool-head habitats.

Table 4.6-5. Population estimates of *O. mykiss* for the lower Tuolumne River, from 2008 to 2009.

Survey Date	*O. mykiss* <150 mm No. Obs.[1]	Est.	St. Dev.	95% CI[2]	*O. mykiss* ≥150 mm No. Obs.[1]	Est.	St. Dev.	95% CI[2]
Jul 2008	128	2,472	616.9	1,263–3,681	41	643	217.7	217–1,070
Mar 2009	5	63	--	--	7	170	86.3	7–339
Jul 2009	641	3,475	1,290.5	945–6,004	105	963	254.4	464–1,461
Mar 2010	1	1	0.3	1–2	13	109	30	50–168
Aug 2010	313	2,405	908.1	625–4,185	324	2,139	720.6	727–3,552
Sep 2011	4,913	47,432	5,662.2	36,334–58,530	813	9,541	1,200.9	7,188–11,895

1 Largest numbers seen in any single dive pass for each unit, summed over units.
2 Nominal confidence intervals (CI) calculated as ± 1.96 standard deviations (SD).
Source: Adapted from Stillwater Sciences 2012b

Low levels of instream cover might increase predation risk for juvenile *O. mykiss* in the lower Tuolumne River. As noted previously, because of its generally small size, location in the channel, and lack of complexity, most wood in the lower Tuolumne River is unlikely to provide significant cover and habitat for *O. mykiss* (TID/MID 2017d). In addition, the amount of shelter in the form of boulders, aquatic vegetation, overhanging banks, and terrestrial vegetation is low. During a 2012 survey, riffles, flat water, main channel pools, and scour pools had shelter ratings (on a scale of 0–300) of 10, 31, 49, and 40, respectively (TID/MID 2017d).

Results of the Pulse Flow Study (Stillwater Sciences 2012a) suggested that flows above bankfull discharge have the potential to increase habitat area for juvenile salmonids in the Tuolumne River. However, results of the Lower Tuolumne River Floodplain Hydraulic Assessment (TID/MID 2017b) confirm that only a portion of the inundated floodplain area provides habitat with hydraulic characteristics suitable to salmonid fry and juveniles. However, data from California steelhead streams indicate that juvenile steelhead are not known to rear in floodplain habitats to any great degree at any time of year (Bustard and Narver 1975, Swales and Levings 1989, Keeley et al. 1996, Feyrer et al. 2006, Moyle et al. 2007). Based on multi-year studies in the Cosumnes River, Moyle et al. (2007) concluded that steelhead were not adapted for floodplain use, and the few steelhead observed were inadvertent floodplain users (i.e., uncommon and highly sporadic in occurrence) that were “presumably...carried on to the floodplain by accident.” Furthermore, Tuolumne River floodplains do not provide favorable rearing and growth conditions for *O. mykiss* due to topography and inundation timing.

The downstream extent of suitable water temperatures has been thought to limit habitat for age 0+ *O mykiss*. However, location along the lower Tuolumne River corridor (river mile) was a stronger predictor of *O. mykiss* habitat occupancy then any of the temperature metrics evaluated during the Temperature Criteria Assessment study (Farrell et al., W&AR-14). The lower Tuolumne River provides, on average, up to 12.2 miles of suitable *O. mykiss* rearing habitat and nearly 28.2 miles of stream with tolerable rearing conditions year round. Water temperatures do not appear to exceed thermal tolerance limits of juvenile *O. mykiss* in the riverine reaches occupied by the species, and the absence of juvenile *O. mykiss* in some sections of the lower Tuolumne River is likely attributable to an array of factors rather than temperature alone (Farrell et al., W&AR-14).

As noted previously, investigation of thermal performance (“swim tunnel” study) (Farrell et al. 2017) showed that wild *O. mykiss* from the lower Tuolumne River can maintain 95 percent of peak aerobic capacity over a temperature range of 17.8 to 24.6 °C (64-76 °F), and all fish tested could maintain sufficient aerobic capacity to properly digest a meal at temperatures up to 23 °C (73 °F). Video analysis of *O. mykiss* swimming activity in the Tuolumne River indicates that fish at ambient water temperatures have an excess aerobic capacity well beyond that needed to swim and maintain station against the river current in their usual habitat.

These thermal performance results are consistent with those derived for *O. mykiss* populations known to be tolerant of high temperatures, such as the redband strain of rainbow trout (*O. mykiss gairdneri*) that occurs in the high deserts of Idaho and eastern Oregon. Whether the high thermal performance that was demonstrated for *O. mykiss* in the Tuolumne River downstream of La

Grange Diversion Dam arose through genetic selection or physiological acclimatization was beyond the scope of the thermal performance study.

Results of the study (Farrell et al. 2017) support the hypothesis that the thermal performance of wild *O. mykiss* from the Tuolumne River represents an exception to that expected based on the 18 °C (64.4°F) 7DADM criterion set out by EPA (2003) for Pacific Northwest *O. mykiss*. Given that lower Tuolumne River *O. mykiss* can maintain 95 percent of peak aerobic capacity at temperatures up to 24.6 °C, a more reasonable upper performance limit is likely to be 22 °C (71.6 °F), rather than the established 18 °C.

Results from a CDFW (2014) drought stressor monitoring case study are consistent with the general findings of the thermal performance study (i.e., that *O. mykiss* in California tolerate temperatures greater than 18 °C). From May through October 2014, 453 juvenile steelhead were caught in the lower American River (83 [18 percent] were of natural origin and 370 [82 percent] were of hatchery origin). A portion of these fish were PIT tagged (14 of natural origin and 59 of hatchery origin). Average monthly water temperature from July through September 2014 was 20°C (68°F), and the maximum observed temperature during this period was 22.8°C (73°F). Growth rates of recaptured fish were high (1.23-1.38 mm/day), but CDFW reports that "there were no visible signs of stress in the captured fish."

4.6.5 Adult *O. mykiss* Upstream Migration

Information reviewed as part of the Salmonid Population Information Integration Study (TID/MID 2013e) suggests that there are very low rates of *O. mykiss* immigration into the Tuolumne River, either as resident or anadromous life-history types. Only 26 *O. mykiss* passed the Tuolumne River weir (RM 24.5) during escapement monitoring from 2009–2016, and of these only six detections were of fish longer than 16 inches (see Table 4.6-1). Three of these six detections occurred during 2011, and, based on observed body length and depth, likely represent two fish.

Because the counting weir operations are limited to flows below approximately 1,400 cfs, immigration of anadromous *O. mykiss* as well as residents from nearby river locations might occur during flood control releases such as those that occurred during winter/spring 2011.

Based on *O. mykiss* redd surveys conducted during 2012-2013 and again during 2014-2015 (TID/MID 2013f), spawning of *O. mykiss* in the Tuolumne River occurs from December through April. Based on this timing, the majority of any adult upstream migrants that enter the Tuolumne River likely do so when water temperatures are relatively low. No occurrences of pre-spawn mortality due to elevated water temperatures have been identified for *O. mykiss* in the Tuolumne River.

Annual fishing report cards (Jackson 2007) do not provide adequate data to quantitatively assess hooking mortality or other sport fishing impacts on any steelhead that may occur in the Action Area, and no data are available to evaluate the potential impacts of poaching.

4.6.6 *O. mykiss* Growth and Productivity

Results of the 2012 *Oncorhynchus mykiss* Scale Collection and Age Determination Study (TID/MID 2013c) were combined with those of Zimmerman et al. (2009) to develop fish age-at-length relationships (Table 4.6-6).

Annual growth observed for each age group of *O. mykiss* was similar within and among years: mean annual growth ranged from 74 mm (age 2) to 78 mm (age 4) in 2011, 69 mm (age 4) to 72 mm (age 3) in 2010, and 2009 values for both the age 3 and age 4 groups were the same as 2010. The combined mean annual growth rate for all age groups ranged from 70 mm in 2010 to 76 mm in 2011.

Table 4.6-6. Combined Zimmerman et al. (2009) and TID/MID 2013c age and size ranges of *O. mykiss*.

Age	No. Sampled	Fork Length Range (mm)
0	1	78
1	38	145–199
2	53	194–315
3	54	267–395
4	12*	365–450

* Includes only results from the TID/MID 2013c age 4 fish.

Results of the TROm model suggest that juvenile productivity (i.e., ratio of end-of-year Age 0+ juveniles to spawners) is consistently lower at higher population sizes and generally higher during "wet" water-year scenarios than during "dry" water-year scenarios. During "wet" water year types, summer water temperatures upstream of RM 39.5 are cooler, which might increase productivity relative to what occurs in dry years. As discussed in the Salmonid Population Information Integration Study (W&AR-05), these model results are generally consistent with water temperature effects on over-summering young-of-the-year fish as well as historical information that shows increased habitat use farther downstream and increased abundance of *O. mykiss* in years with larger flood control releases in the lower Tuolumne River.

4.6.7 Effects of Existing Flow Regime

Results of the TROm suggest that *O. mykiss* production is affected by the relative influences of flow magnitude and timing on life stage progression. As noted above, Base Case modeling shows that juvenile productivity and adult replacement are generally higher with increased discharge downstream of La Grange Diversion Dam. In comparing results by water year type, it is apparent that juvenile productivity is generally higher in "wet" water years than in "dry" water years. Adult replacement is also higher in "wet" years. For juveniles, early fry displacement during higher flows in "wet" water years reduces subsequent movement-related mortality that would occur due to exceedance of local rearing carrying capacity.

4.6.8 Effects of Existing Water Temperatures

Water temperature is an important factor controlling egg incubation rates as well as juvenile and adult *O. mykiss* growth rates. The temperature of water discharged from Don Pedro Reservoir is cool (<14 °C) year round. Farther downstream, however, over-summering *O. mykiss* are exposed to warmer temperatures. Figures 4.5-1 through 4.5-3 show simulated existing annual temperature regimes at various locations in the lower Tuolumne River, both with and without the dams in place. The approximate temperature ranges for each of these locations, under both with and without dams conditions, during the June through September period are shown in Table 4.6-7.

Table 4.6-7. Simulated existing annual temperature regimes at various locations in the lower Tuolumne River, both with and without the dams in place (based on Jayasundara et al. 2017).

With Dams		Without Dams	
River Mile	**Temperature °C**	**River Mile**	**Temperature °C**
54	10.0–12.5	54	15.0–25.0
46	17.5–20.0	46	16.0–25.0
40	18.5–22.0	40	17.0–25.0

Because adult and juvenile *O. mykiss* in the lower Tuolumne River are typically found upstream of RM 43, they experience maximum temperatures that are cooler than what they would experience if Don Pedro Dam and Reservoir were not in place. As shown in Figure 4.5-1, 7DADM temperatures immediately below Don Pedro Dam (RM 54) are relatively cool year-round with little variability, because water is released from the reservoir's hypolimnion. With-dams 7DADM temperatures are much cooler than without-dams temperatures in summer but are slightly warmer from November through February.

With-dams temperatures during summer rise significantly with increasing distance downstream of the Don Pedro Project. Under Base Case conditions, by RM 46, summer 7DADM temperatures have climbed back to 20 °C (Figure 4.5-2), very close to the 7DADM temperatures experienced above Don Pedro Reservoir. However, this is still 5 °C below simulated without-dams temperatures. By RM 40 (circa Roberts Ferry Bridge), average with-dam 7DADM temperatures in July reach 22 °C (Figure 4.5-3).

TROm results suggest that under existing conditions summer water temperatures may limit juvenile *O. mykiss* productivity and adult replacement in "dry" water years, based on generalized temperature criteria. The territoriality of *O. mykiss* adults (Grant and Kramer 1990) suggests that fish excluded from rearing habitats due to exceedance of maximum rearing densities or exceedances of presumed water temperature preference limits may be unable to locate undefended territories in other portions of the river with cool temperatures. These results are consistent with summaries of historical monitoring data provided in the Synthesis Study (TID/MID 2013e), which show reduced relative abundance of *O. mykiss* and reduced extent of habitat use downstream of La Grange Diversion Dam (RM 52.2) in "dry" water years. For the progeny of any steelhead that may migrate into the lower Tuolumne River, the TROm suggests that smolt emigration may also be affected by water temperature.

As noted previously, however, the investigation of thermal performance (Farrell et al. 2017) showed that wild *O. mykiss* from the lower Tuolumne River can maintain 95 percent of peak aerobic capacity over a temperature range of 17.8 °C to 24.6 °C, and all fish tested could maintain sufficient aerobic capacity to properly digest a meal at temperatures up to 23 °C. Video analysis of *O. mykiss* swimming activity in the Tuolumne River indicates that fish at ambient water temperatures have an excess aerobic capacity well beyond that needed to swim and maintain station against the river current in their usual habitat. These thermal performance results are consistent with those derived for *O. mykiss* populations known to be tolerant of high temperatures, such as the redband strain of rainbow trout that occurs in the high deserts of Idaho and eastern Oregon.

Results of the thermal performance study (Farrell et al. 2017) support the hypothesis that the thermal performance of wild *O. mykiss* from the Tuolumne River represents an exception to that expected based on the 18 °C 7DADM temperature guidelines in EPA (2003) for Pacific Northwest *O. mykiss*. Given that lower Tuolumne River *O. mykiss* can maintain 95 percent of peak aerobic capacity at temperatures up to 24.6 °C, a more reasonable upper performance limit is likely to be 22°C, rather than the established 18°C.

4.6.9 Potential Upstream Sources of Adult *O. mykiss* Recruitment

Reproducing resident *O. mykiss* populations occur in and above Don Pedro Reservoir (TID/MID 2013e) and in the reach between Don Pedro Dam and La Grange Diversion Dam (TID/MID 2013a). The September 2011 population estimates for larger fish (150–200 mm) were substantially higher than in 2010 (Stillwater Sciences 2012c). The larger population in 2011 relative to 2010 may be the result of an influx of fish that originated upstream of La Grange Diversion Dam (RM 52.2) during a year with substantial spill, although there is no empirical evidence of this occurrence. The potential interaction of these resident *O. mykiss* with the population downstream of La Grange Diversion Dam is poorly understood and complicates any future monitoring of population response to potential management measures.

4.7 Designated Critical Habitat in the Action Area

Designated Critical Habitat for Central Valley Steelhead in the San Joaquin River basin is shown in Figure 3.1-1. With respect to the Action Area in this Draft BA, Designated Critical Habitat in the lower Tuolumne River includes the Tuolumne River from the confluence with the San Joaquin River (Lat 37.6401, Long –120.6526) upstream to an endpoint in the Tuolumne River near LGDD (37.6721, –120.4445) (70FR 52605). As demonstrated by the information presented in Section 4.5 and Section 4.6, PBF #1 (freshwater spawning sites; see Section 4.6.2), PBF#2 (freshwater rearing sites; see Section 4.6.3), and PBF#3 (freshwater migration corridors; see Section 4.6.4) for *O. mykiss* are all present in the Action Area.

Moreover, the resource enhancement measures identified by the Districts as part of the Proposed Action would have positive effects on designated critical habitat, because they would result in improvements to freshwater spawning habitat (PBF #1; see sections 5.3.1.1, 5.3.1.2, 5.3.1.3, 5.3.2, 5.3.7.5, 5.3.7.6), freshwater rearing habitat (PBF#2; see sections 5.3.2, 5.3.5, 5.3.7.2, 5.3.7.3, 5.3.7.5, 5.3.7.6, 5.3.7.7, 5.3.7.8), and freshwater migration corridors (PBF#3; see sections 5.3.3, 5.3.5).

5.0 EFFECTS OF PROPOSED ACTION

5.1 Interrelated and Interdependent Actions

As noted in Section 2 of this Draft BA, the Districts are seeking a new FERC license to allow for the continuation of hydroelectric power generation at existing facilities at Don Pedro Dam. Water storage and releases for irrigation, M&I uses, the CCSF's water bank, and flood control coordinated with the ACOE are in no way dependent on the issuance of a FERC license for the Project, and will occur with or without the licensing of the Proposed Action. As such, these uses are *not* interrelated or interdependent with the issuance of a FERC license for hydroelectric power generation.

Because the Districts are consulting with NMFS on the Proposed Action, and under the new license power would be generated as it has been historically (i.e., the effects of generation would be equivalent to those occurring under existing conditions, so there would be no incremental effects on resources in the lower river), the effects of the aforementioned non-hydropower water uses are addressed as independent actions in the cumulative effects analysis of this Draft BA (see Section 5.4). Other than their proposed aquatic resource measures (addressed in Section 5.3 and Section 5.4), the Districts are aware of no other actions that have the potential to affect *O. mykiss*, including and CCV steelhead, in the Action Area that could be considered related to or interdependent with the Proposed Action to continue hydroelectric power generation at the Project.

5.2 Direct and Indirect Effects of the Proposed Action

There would be no direct or indirect adverse effects on *O. mykiss*, including CCV steelhead and its Critical Habitat, in the Action Area as the result of continued hydroelectric power generation at the Project. For the reasons described below, continued hydropower operations at Don Pedro Dam would have no adverse effect on flows, temperature, water quality, or any other environmental conditions in the lower Tuolumne River, and as a result no effect on *O. mykiss* or the species' critical habitat. There would, however, be direct effects on *O. mykiss* as the result of aquatic resource measures proposed by the Districts for implementation under the new FERC license (see Sections 5.3 and 5.4).

Electric power is generated at the Don Pedro Hydroelectric Project using flows released for other purposes. Irrigation, municipal, and industrial water deliveries and high-flow releases are pre-scheduled based on forecasted demands and actual projected inflow and then released through the powerhouse up to its hydraulic capacity. Scheduling of these releases is adjusted, when consistent with water supply needs, to release flows for hydroelectric energy generation with a preference for on-peak power demand rather than off-peak hours. However, these "peaking" flows are modulated, being subject to water supply demand and limits on water fluctuations in the Districts main canals. Flows in the reach of the Tuolumne River below La Grange Diversion Dam are not subject to such fluctuations as the fluctuations travel down and are absorbed by the Districts' main canals and irrigation water needs, which are unrelated and non-interdependent actions e.g., providing water for irrigation and M&I uses. Hydroelectric generation at the Don Pedro Project cannot impact *O. mykiss* in the Action Area, because the flows released into the lower Tuolumne River are not linked to power production and, absent power production at Don Pedro Dam, the flow release schedule, including flows to the lower Tuolumne River, would remain the same as it is under existing conditions, i.e., driven by uses other than hydroelectric power production.

5.3 Effects of Proposed Aquatic Resources Measures

As described in Section 2.0, the Districts are proposing to implement a set of proposed measures for the benefit of aquatic and recreation resources in the lower Tuolumne River, including measures designed particularly for *O. mykiss*. The effects of these measures on *O. mykiss* are described in the following subsections. Taken together these measures would have positive effects on designated critical habitat, as they would result in improvements to freshwater spawning habitat (PBF #1), freshwater rearing habitat (PBF#2), and freshwater migration corridors (PBF#3) (see following sections).

5.3.1 Improve Spawning Gravel Quantity and Quality

5.3.1.1 Augment Current Gravel Quantities through a Coarse Sediment Management Program

To improve spawning habitat conditions, the Districts propose to conduct coarse sediment augmentation from RM 52 to RM 39 over a 10-year period following issuance of a new license (see Section 2.1.1.1 for description of the measure).

Potential benefits of gravel augmentation would include (1) an increase in *O. mykiss* egg-to-emergence survival, (2) increased benthic macroinvertebrate production, and (3) possibly improved hyporheic flow and cold water habitat downstream of La Grange Diversion Dam.

As noted above, gravel would be placed following the fry rearing period, which would minimize the risk of smothering *O. mykiss* fry within substrate interstices. Juvenile *O. mykiss* would be able to more readily move away from the augmentation area during sediment placement, thereby minimizing impacts to juveniles. Because gravel would be clean, as noted above, release of fines would be minimized, and along with it, potential adverse effects on *O. mykiss*, such as gill abrasion resulting from pulses of suspended sediment. BMPs required by NMFS and other regulatory agencies would be employed to avoid effects on the river and its biota due to the use and storage of heavy equipment. Snorkel surveys conducted to assess *O. mykiss* spawning use of new gravel patches could result in short-term disturbance of *O. mykiss* juveniles and adults, but no injury or mortality would be expected as a result of these surveys. This action would be Not Likely to Adversely Affect (i.e., the action would benefit) *O. mykiss* or CCV steelhead critical habitat.

5.3.1.2 Gravel Mobilization Flows of 6,000 to 7,000 cfs

Flows ranging from 6,000-7,000 cfs (measured at USGS gage 11289650 below La Grange Diversion Dam) would be released to mobilize gravel and fines (see Section 2.1.1.2 for description of the measure).

Potential benefits of this measure would include (1) reduced fine sediment storage in the low-flow channel and in spawning gravels, which could increase *O. mykiss* egg-to-emergence survival and fry production, and benthic macroinvertebrate production, (2) increased fine sediment storage on floodplains, which could improve regeneration of native riparian plant species during wetter water years, and (3) a net increase in lateral channel migration, bar formation, and large wood introduction, which together could create new floodplain habitat and complex hydraulic environments for improved adult *O. mykiss* holding, spawning, and juvenile rearing.

This measure could cause localized, short-duration pulses in turbidity, but no significant associated effects on *O. mykiss* are anticipated. These flows would be released at a time when high-flows naturally occur (i.e., March–June of Wet and Above Normal water years), and would have effects similar to what would take place in a natural system during a minor channel-forming event. Substrate surveys conducted to assess gravel quality would have no significant effects on *O. mykiss* juveniles and adults. This action would be Not Likely to Adversely Affect (i.e., the action would benefit) *O mykiss* or CCV steelhead critical habitat.

5.3.1.3 Gravel Cleaning

The Districts would conduct a five-year program of experimental gravel cleaning using a gravel ripper and pressure wash operated from a backhoe, or equivalent methodology (see Section 2.1.1.3 for description of this measure).

Gravel cleaning has the potential to expand the availability of high quality gravel by reducing the amount the fine material in spawning areas, which could increase gravel permeability that in turn could lead to higher intragravel dissolved oxygen concentrations. These improvements to gravel quality are expected to improve *O. mykiss* egg-to-fry survival and enhance habitat for aquatic invertebrates. Conducting gravel cleaning after April 30 would minimize disturbance of *O. mykiss* redds (peak spawning activity occurs in February and March).

Gravel-cleaning operations are intrusive, as heavy equipment would enter the channel and physically disrupt the substrate. As such, mechanically cleaning spawning gravels would temporarily destabilize the spawning environment, resulting in potential short-term effects on juvenile *O. mykiss*. As noted above, gravel cleaning would take place in May, during the tail end of the *O. mykiss* fry emergence period and well within the fry rearing period. There would likely be adverse effects on fry within substrate interstices at the cleaning site, but these would be outweighed by the potential medium- and long-term benefits associated with improved spawning habitat. Localized turbidity pulses would occur but it is not clear what, if any, effects these might have on *O. mykiss*. BMPs required by NMFS and other regulatory agencies would be employed to avoid effects on the river and its biota due to the use and storage of heavy equipment. Substrate surveys conducted to assess gravel quality could result in short-term, disturbance of *O. mykiss* juveniles and adults, but no injury or mortality would be expected as a result of these surveys.

During short periods, increased turbidity associated with cleaning activities might exceed state water quality standards. The Districts would coordinate with the SWRCB to secure necessary permits and conduct any required turbidity monitoring. If gravel cleaning is judged to be successful, the program would continue, adjusted as needed to comply with any water-quality related concerns of the SWRCB. Overall, this measure would be Not Likely to Adversely Affect (i.e., the action would benefit) *O. mykiss* or CCV steelhead critical habitat.

5.3.2 Improve Instream Habitat Complexity

Under this measure, $2 million would be provided for the collection and placement of boulder-size stone (approximately 0.7-1.5 yd^3) between RM 42 and 50 (see Section 2.1.2 for description of this measure).

This measure is expected to provide favorable microhabitats for *O. mykiss* (TID/MID 2017d) by increasing structural and hydraulic complexity in the channel, and improve spawning habitat for *O. mykiss* as localized scour displaces fines from gravel beds. Boulder placement has been shown to reduce territory size needed by rearing *O. mykiss* by up to 50 percent (Imre et al. 2002) due to visual isolation, thereby supporting higher fish densities and carrying capacity (Grant and Kramer 1990). Overwintering habitat may also be enhanced through boulder/cobble placement (Meyer and Griffith 1997).

Short-duration disturbance of juvenile *O. mykiss* could occur during boulder placement, but no significant injury or mortality is anticipated. As noted above, boulders would be placed after July 15, i.e., following the fry rearing period, which would minimize the risk of disturbance of *O. mykiss* fry within substrate interstices. Juvenile *O. mykiss* would be able to move away from the placement area during boulder installation, thereby minimizing impacts to juveniles. Snorkel surveys conducted to assess *O. mykiss* spawning use of new gravel patches would result in short-term, disturbance of *O. mykiss* juveniles and adults, but no injury or mortality would occur as a result of these surveys. This action would be Not Likely to Adversely Affect (i.e., the action would benefit) *O. mykiss* and Not Likely to Adversely Affect CCV steelhead critical habitat.

5.3.3 Contribute to CDBW's Efforts to Remove Water Hyacinth

The Districts would contribute $50,000 per year to the California Division of Boating and Waterways (CDBW) for the removal of water hyacinth in the lower Tuolumne River (see Section 2.1.3 for description of this measure).

Because dense mats of water hyacinth can alter water quality by reducing dissolved oxygen and affecting pH and turbidity (Penfound and Earle 1948; Center and Spencer 1981, as cited in Cal-IPC 2014), removal of these introduced plants would likely benefit aquatic biota where water hyacinth infestations occur. However, water hyacinth occurs far downstream in the Tuolumne River, well below the reach occupied by resident *O. mykiss*. As noted above, there are almost no

CCV steelhead entering or exiting the lower Tuolumne River, as evidenced by weir and screw-trap counts, respectively, so *O. mykiss* are not expected to come into contact with herbicide used to treat water hyacinth, and, as noted previously, CDBW applies herbicide at levels that do not exceed allowable limits so that treatments have no adverse environmental impacts. As a result. this action would be Not Likely to Adversely Affect *O. mykiss* or CCV steelhead critical habitat.

5.3.4 Fall-Run Chinook Spawning Improvement Superimposition Reduction Program

To reduce superimposition of fall-run Chinook redds, the Districts propose to develop and install a temporary barrier to encourage spawning on less used, but still suitable, riffles (see Section 2.1.4 for description of this measure).

Short-duration adverse effects on juvenile *O. mykiss* could occur during barrier placement in the channel. Chinook salmon spawning in the lower Tuolumne River occurs primarily from October through December (with peak activity in November), i.e., outside the *O. mykiss* fry rearing period and most of the incubation and emergence period, which would minimize the risk of disturbance of *O. mykiss* eggs, alevins, or fry within substrate interstices. Juvenile *O. mykiss* would be able to move away from the placement area during installation, thereby minimizing impacts to juveniles. Because suitable *O. mykiss* habitat is available both upstream and downstream of the potential placement locations of the barrier, i.e., at or upstream of approximately RM 47, seasonal installation of the weir is not expected to affect resident *O. mykiss*. As explained in previous sections, migratory *O. mykiss* (steelhead or resident) are extremely rare in the lower river (see Table 4.6-1). Given the low numbers of migratory *O. mykiss* and the availability of habitat downstream of the expected placement location, effects of the barrier on adult *O. mykiss* would be insignificant. This action would be Not Likely to Adversely Affect *O. mykiss* or CCV steelhead critical habitat.

5.3.5 Predator Control and Suppression Plan

The Districts' proposed predator control and suppression program would consist of two elements: (1) construction and operation of a barrier weir and (2) active predator control and suppression (see Section 2.1.5 for a description of this measure).

Studies demonstrate that predation on salmonids by non-native black bass (largemouth and smallmouth bass) and striped bass is substantial in the lower Tuolumne River (TID/MID 2013e, 2017a, 2013d; and results of rotary screw-trap monitoring).

The construction and operation of a small barrier weir at RM 25.5 would prevent striped and black bass from moving into upstream habitats used by rearing juvenile *O. mykiss*, while providing a location where striped bass would be likely to congregate, thereby allowing them to be removed or isolated. Excluding introduced piscivores from the reach of river that supports resident *O. mykiss* would increase survival rates of *O. mykiss*, especially juveniles. The barrier weir would be installed well downstream of where resident *O. mykiss* occur (*O. mykiss* are predominantly found upstream of RM 42 in the lower Tuolumne River). As noted previously, migratory *O. mykiss* are rare in the lower Tuolumne River (see Table 4.6-1). As a result, construction-related impacts on *O. mykiss* during weir installation would be insignificant to non-existent. This action would be Not Likely to Adversely Affect juvenile *O. mykiss* during installation of the barrier weir and Not Likely to Adversely Affect (i.e., the action would benefit) the species over the long-term as predators are excluded from the reach occupied by resident *O. mykiss*. The action would be Not Likely to Adversely Affect CCV steelhead critical habitat.

Reducing black bass and striped bass abundance by approximately 20 percent above the barrier weir (RM 25.5) and 10 percent below the barrier weir would lead to substantial increases in the survival of juvenile *O. mykiss*. However, the actual removal efforts, depending on where they are conducted, could disturb juvenile and adult *O. mykiss*, potentially displacing them to less favorable habitats. If electrofishing, seining, or fyke netting are used to collect predators, there could be inadvertent adverse effects on nearby *O. mykiss*, even if these effects are sub-lethal. Also, depending on the methods employed to conduct monitoring, which would likely require capture of bass, some *O. mykiss* could be disturbed. Overall, this action would be Not Likely to Adversely Affect *O. mykiss*, which would benefit, potentially greatly, from reduced numbers of introduced predators. The action would be Not Likely to Adversely Affect CCV steelhead critical habitat.

5.3.6 Fall-Run Chinook Salmon Restoration Hatchery Program

The Districts propose to build, in cooperation with CDFW, in the general vicinity of the current location of the CDFW offices below La Grange Diversion Dam, a fall-run Chinook restoration hatchery to be operated by CDFW (see Section 2.1.6 for description of this measure). The proposed supplementation program, like state and federal programs, would be implemented in accordance with procedures that prevent or minimize adverse impacts on wild salmonids in the Tuolumne River.

Implementation of this measure would be a complicated and long-term undertaking, which would require a great deal of planning and coordination. As a result, the Districts anticipate the need for a separate, individual Section 7 consultation to address the potential effects of this measure on *O. mykiss*. This consultation would take place after a design for the facility and a description of its operating procedures are developed, including information on intake and outfall locations and operation, intake screening to prevent *O. mykiss* entrainment into the facility, broodstock selection and genetics management, holding capacities, effluent management, disease prevention and mitigation, release schedules and locations, and effectiveness monitoring, among other factors. This action would be Not Likely to Adversely Affect the *O. mykiss* and Not Likely to Adversely Affect CCV steelhead critical habitat.

5.3.7 Flow-Related Measures for Fish and Aquatic Resources

The Proposed Action involves a set of flow-related measures designed to benefit salmonids in the lower Tuolumne River (see Section 2.1.8 for description of this measure). The flows shown in Table 5.3-2 would be provided by the Districts, with no deficit allowed of more than 10 percent below the minimum for more than 60 minutes, and no deficit allowed that is greater than 20 percent below the minimum.

5.3.7.1 Infiltration Galleries 1 and 2

The Districts are proposing to complete construction of TID's IG1 (RM 25.9) and undertake construction of a second infiltration gallery (IG2) at the same general location. IG1 has a design capacity of approximately 100 cfs, and IG2 would have a capacity of 100-125 cfs (see Section 2.1.7 for description of this measure). Construction of the infiltration galleries would result in minimal impacts to the stream channel, and as a result minimal disturbance to any *O. mykiss* in the vicinity. However, most *O. mykiss* complete their life cycle well upstream of this location, and there are very few migratory *O. mykiss* that pass through this reach. This action would be Not Likely to Adversely Affect *O. mykiss* (i.e., benefits would accrue to *O. mykiss* by allowing the Districts to maintain higher flows in the channel upstream of the infiltration galleries). The action would be Not Likely to Adversely Affect CCV steelhead critical habitat.

Table 5.3.2. Proposed lower Tuolumne River flows to benefit aquatic resources and accommodate recreational boating.

Water Year/Time Period	Flow (cfs)	
	La Grange Gage	RM 25.5
Wet, Above Normal, Below Normal		
June 1 – June 30	200	100[1]
July 1 – October 15[3]	350	150[2]
October 15 – December 31	275	275
January 1 – February 28/29	225	225
March 1 – April 15	250	250
April 16 – May 15[4]	275	275
May 16 – May 31[4]	300	300
Dry		
June 1 – June 30	200	75
July 1 – October 15	300	75[2]
October 15 – December 31	225	225
January 1 – February 28/29	200	200
March 1 – April 15	225	225
April 16 – May 15[4]	250	250
May 16 – May 31[4]	275	275
Critical		
June 1 – June 30	200	75
July 1 – October 15	300	75
October 15 – December 31	200	200
January 1 – February 28/29	175	175
March 1 – April 15	200	200
April 16 – May 15[4]	200	200
May 16 – May 31[4]	225	225

[1] Cease IG withdrawal for one pre-scheduled weekend.
[2] 200 cfs for three-day July 4 holiday, for three-day Labor Day holiday, and for two pre-scheduled additional weekends in either June, July, or August.
[3] The Preferred Plan also includes a flushing flow amounting to 5,950 AF of water for the period October 5 through October 7. Ramping of this flow would likely occur on October 4 and 8 as part of the flushing flow volume.
[4] Fall-run Chinook outmigration pulse flows: 150,000 ac-ft (Wet, Above Normal), 100,000 ac-ft (Below Normal), 75,000 ac-ft (Dry), 45,000 ac-ft (sequential D water years), 35,000 ac-ft (first Critical), and 11,000 ac-ft (sequential Critical[s]).[14]

[14] This reduced pulse flow, while still greater than or equal to Base Case pulse flows, would also occur in a sequence of "D" and "C" years. For example, in a sequence of the years C, D, C, D, C, D, the second and third "critical" years and the second and third "dry" years would each have pulse flows of 11 TAF and 45 TAF, respectively.

5.3.7.2 Early Summer *O. mykiss* Fry Rearing (June 1 – June 30)

Except for wet years, most fall-run Chinook salmon juveniles have left the Tuolumne River by the end of May (TID/MID 2013e), so increased summer flows are aimed at enhancing habitat conditions for *O. mykiss*. The Districts are proposing to provide an instream flow of 200 cfs at the La Grange gage from June 1–June 30 of all water year types to benefit *O. mykiss* fry rearing. Downstream of RM 25.5 (i.e., downstream of the infiltration galleries) instream flows during this period would be 100 cfs during Wet, Above Normal, and Below Normal water years and 75 cfs in Dry and Critical years.

Based on redd surveys, *O. mykiss* in the lower Tuolumne River spawn from late December through early April (TID/MID 2013f; FISHBIO 2017a). Years of monitoring studies indicate that *O. mykiss* are predominantly found upstream of RM 42, with peak fry densities occurring into June. For the period of June 1 to June 30, base flows would be provided to support *O. mykiss* fry rearing. Flow management for the benefit of *O. mykiss* fry would balance hydraulic habitat suitability and temperature suitability for fry and adult life stages. Flows higher than those proposed by the Districts in June would tend to displace weaker-swimming *O. mykiss* fry to downstream areas with lower quality physical habitat, higher water temperatures, and greater predator densities.

IFIM study results (Stillwater Sciences 2013) indicate that at 100 cfs, hydraulically suitable habitat for *O. mykiss* fry is 85 percent of maximum, at 150 cfs it is 78 percent of maximum, and at 200 cfs it is 71 percent of maximum (Figure 5.3-1). Water temperature modeling shows that at RM 47, a flow of 200 cfs would maintain average daily water temperatures at less than 18°C, and at RM 43, a flow of 200 cfs would maintain average daily water temperatures at less than 20 °C, except when maximum daily ambient air temperatures exceed 100 °F (38 °C) (Figure 5.3-2), which on average occurs only one day in June (Figure 5.3-3). At 150 cfs, average daily water temperatures at RM 43 would be less than 20°C until maximum daily air temperature exceeds 95°F (Figure 5.3-2), which occurs on average three days in June (Figure 5.3-3). Adult *O. mykiss* habitat is 78 percent of maximum WUA at 200 cfs. This action would be Not Likely to Adversely Affect *O. mykiss* and Not Likely to Adversely Affect CCV critical habitat (i.e., the action would benefit *O mykiss* and the species' habitat).

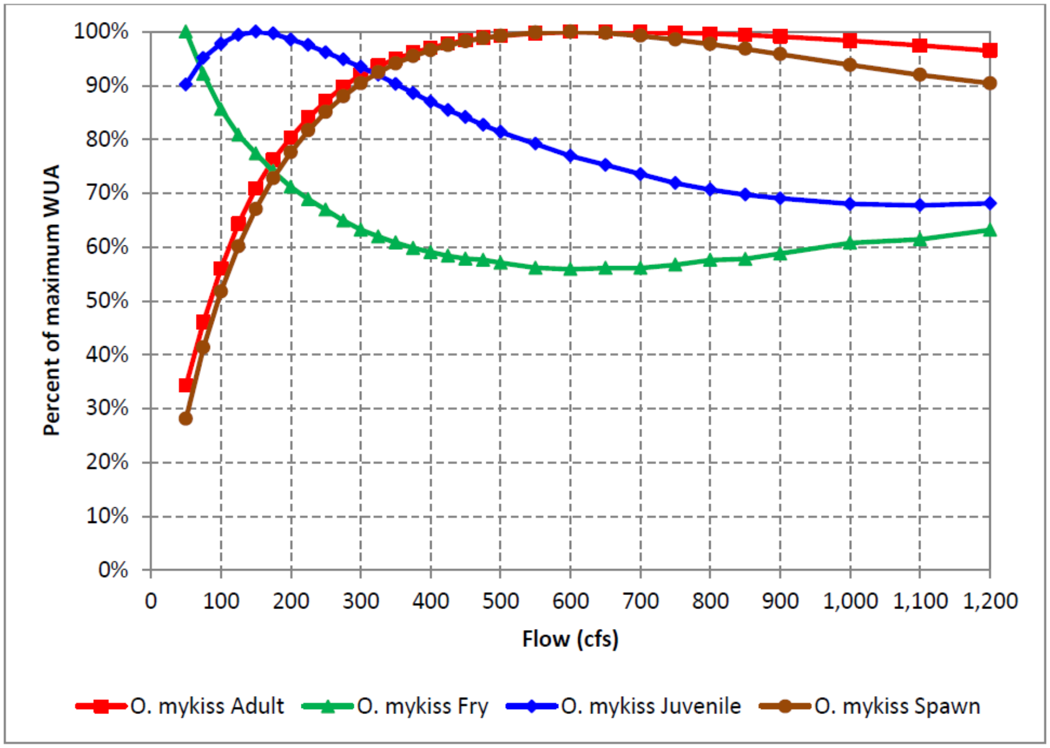

Figure 5.3-1. ***O. mykiss*** **WUA results for the lower Tuolumne River (source: Stillwater Sciences 2013).**

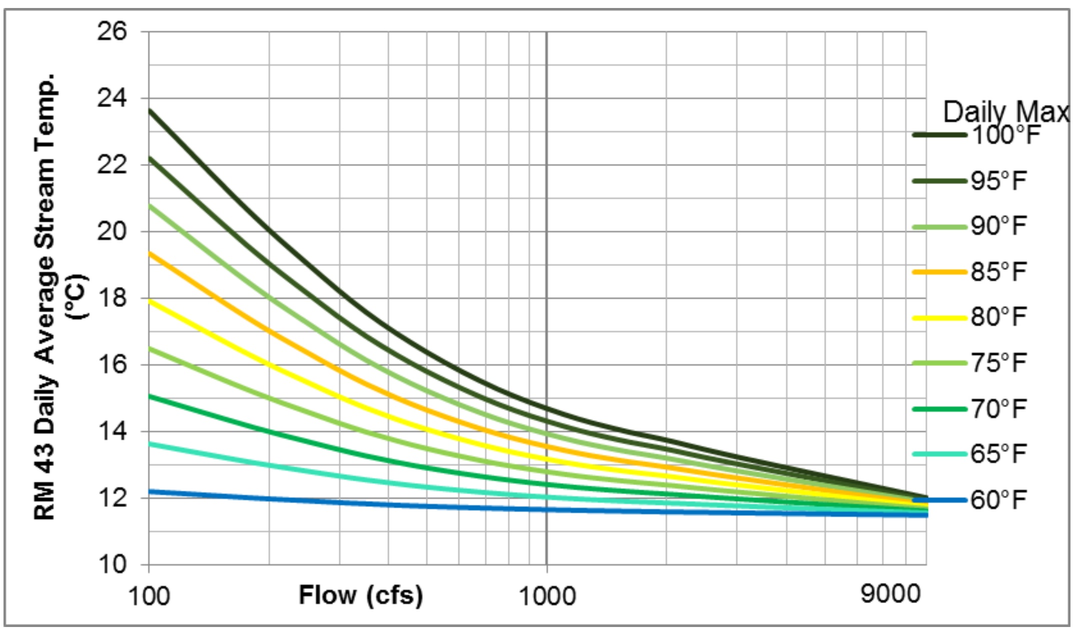

Figure 5.3-2. **RM 43 daily average water temperatures versus flow and maximum air temperatures.**

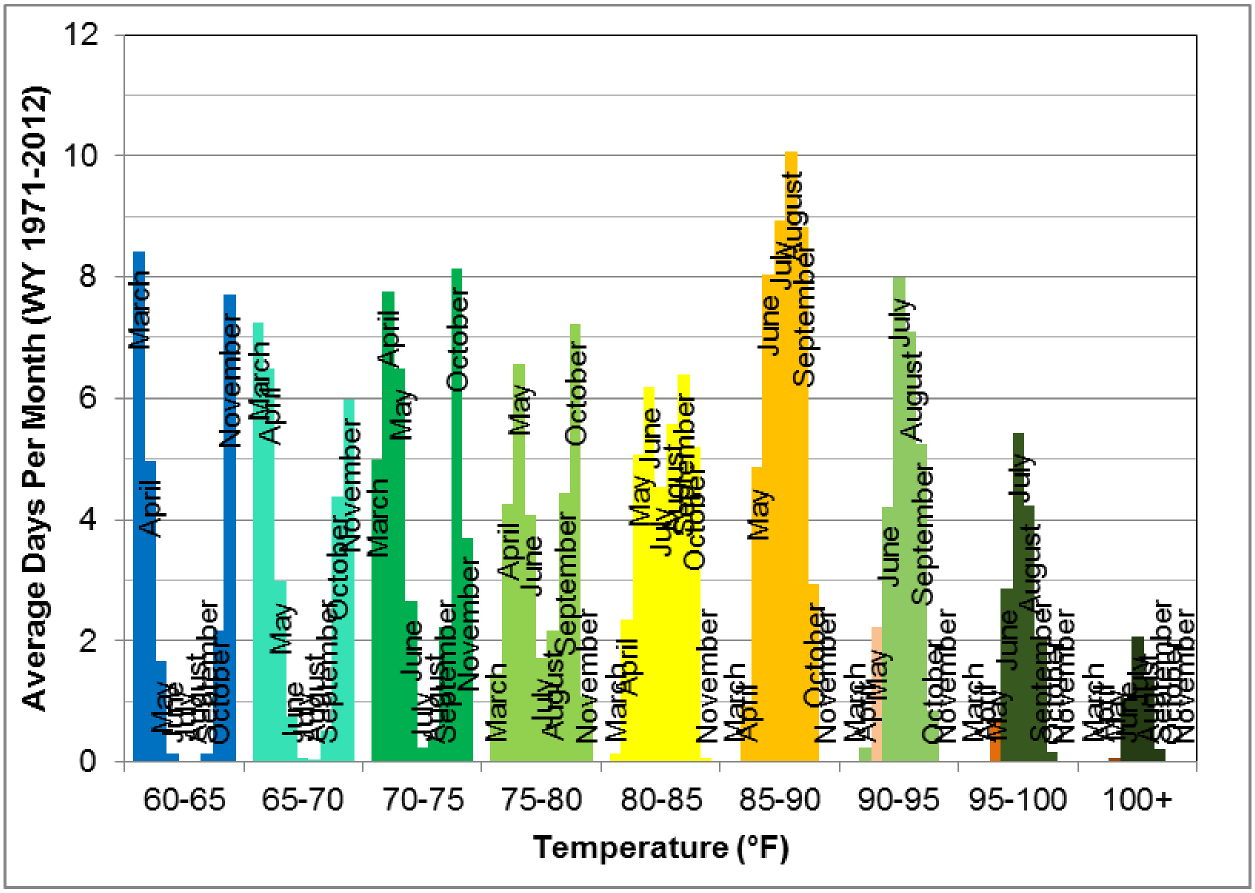

Figure 5.3-3. **Frequency of occurrence of maximum daily air temperatures by month for the lower Tuolumne River (estimated for approximately RM 40).**

5.3.7.3 Late Summer *O. mykiss* Juvenile Rearing (July 1 – October 15)

The Districts are proposing to provide an instream flow of 350 cfs at the La Grange gage from July 1–October 15 of Wet, Above Normal, and Below Normal water-year types to benefit *O. mykiss* juvenile rearing. During Dry and Critical water years, flow at the La Grange gage would be reduced to 300 cfs. Downstream of RM 25.5 (i.e., downstream of the infiltration galleries) instream flows during this period would be 150 cfs during Wet, Above Normal, and Below Normal water years and 75 cfs in Dry and Critical years.

During this period, the Districts would provide a flushing flow to clean gravels of accumulated algae and fines prior to the onset of substantial spawning. The Districts would provide an instream flow of 1,000 cfs (not to exceed 5,950 AF) on October 5, 6, and 7, with appropriate up and down ramps and IGs shut off. These flows would be provided in Wet, Above Normal, and Below Normal water years only. In Dry and Critical years, the flows at La Grange would continue to be 300 cfs, with withdrawals of 225 cfs at the IGs, leaving 75 cfs in the river below RM 25.5.

By July, *O. mykiss* in the lower Tuolumne River consist predominantly of juvenile and adult life-stages. Juveniles are stronger swimmers than fry and can maintain position at higher flows. The primary habitat concern during this period is the maintenance of adequate water temperatures from just downstream of the La Grange Project to approximately RM 42. Wild *O. mykiss* juveniles tested as described in Farrell et al. (2017) had an optimum metabolic capacity between 21 and 22 °C, and maintained 95 percent of peak aerobic capacity over a temperature range of 17.8 °C to 24.6 °C. At a flow of 350 cfs, adult hydraulic habitat for *O. mykiss* in the lower Tuolumne River is 95 of maximum and juvenile hydraulic habitat is 90 percent of maximum (Figure 5.3-3). A flow of 350 cfs would maintain average daily water temperatures below 18 °C at RM 43 until daily maximum air temperatures exceed 105 °F (40.6 °C) (Figure 5.3-2). During Dry and Critical years, flow at the La Grange gage would be reduced to 300 cfs, at which both juvenile and adult habitat is 91 percent of maximum. Under these flows, average daily water temperatures would be maintained below 19 °C at RM 43 until daily maximum air temperatures exceed 100 °F (38 °C) (Figure 5.3-2). This action would be Not Likely to Adversely Affect *O. mykiss* and Not Likely to Adversely Affect CCV critical habitat (i.e., the action would benefit *O mykiss* and the species' habitat).

5.3.7.4 Fall-Run Chinook Spawning Flows (October 16 – December 31)

To provide habitat for fall-run Chinook spawning, the Districts propose to provide the following minimum instream flows for the October 16 – December 31 spawning period: 275 cfs (BN, AN, and W water years), 225 cfs (D water years), and 200 cfs (C water years). At a flow of 275 cfs, adult *O. mykiss* habitat is 90 percent of maximum, and juvenile habitat is 95 percent of maximum (Figure 5.3-1). At a flow of 225 cfs, adult *O. mykiss* habitat is 84 percent of maximum, and juvenile habitat is 98 percent of maximum (Figure 5.3-1). At a flow of 200 cfs, adult *O. mykiss* habitat is 80 percent of maximum, and juvenile habitat is 99 percent of maximum (Figure 5.3-1). At 275 cfs, average daily water temperatures at RM 43 would be less than 14.5°C until daily maximum air temperatures exceed 75°F, which is estimated to occur about one day in November on average (see Figures 5.3-2 and 5.3-3). Average daily water temperatures would generally remain below 14°C in December throughout the entire gravel-bedded reach of the lower Tuolumne River. This action would be Not Likely to Adversely Affect *O. mykiss* and Not Likely to Adversely Affect CCV critical habitat (i.e., the action would benefit *O mykiss* and the species' habitat).

5.3.7.5 Fall-Run Chinook Fry Rearing (January 1 – February 28/29)

To provide habitat for fall-run Chinook fry rearing, the Districts propose to provide the following minimum instream flows for the period of January 1–February 28/29: (1) 225 cfs (BN, AN, and W water years), (2) 200 cfs (D water years), and (3) 175 cfs (C water years). February and March are the periods of peak *O. mykiss* spawning in the lower Tuolumne River. It is important that flows do not decline substantially following the fall-run Chinook spawning period (see previous section), which would result in the dewatering of established redds. The flows identified here represent a balance between protecting Chinook redds while still providing substantial *O. mykiss* habitat. Based on the rating curve for the USGS gage at La Grange, the change in flow from 275 cfs to 225 cfs would result in a 0.4-ft stage change, and from 225 cfs to 200 cfs a 0.2 ft stage change.

At a flow of 225 cfs, *O. mykiss* spawning habitat is 82 percent of maximum, adult *O. mykiss* habitat is 84 of maximum, and juvenile habitat is 98 percent of maximum (Figure 5.3-1). At a flow of 200 cfs, *O. mykiss* spawning habitat is 78 percent of maximum, adult *O. mykiss* habitat is 80 of maximum, and juvenile habitat is 99 percent of maximum (Figure 5.3-1). At a flow of 175 cfs, *O. mykiss* spawning habitat is 73 percent of maximum, adult *O. mykiss* habitat is 77 of maximum, and juvenile habitat is 100 percent of maximum (Figure 5.3-1). This action would be Not Likely to Adversely Affect *O. mykiss* and Not Likely to Adversely Affect CCV critical habitat (i.e., the action would benefit *O mykiss* and the species' habitat).

5.3.7.6 Fall-run Chinook Juvenile Rearing (March 1 – April 15)

To provide habitat for Chinook juvenile rearing, the Districts propose to provide the following minimum instream flows for the period of March 1–April 15: (1) 250 cfs (BN, AN, and W water years), (2) 225 cfs (D water years), and (3) 200 cfs (C water years). As noted above, February and March are the periods of peak *O. mykiss* spawning in the lower Tuolumne River.

At a flow of 250 cfs, *O. mykiss* spawning habitat is 85 percent of maximum, adult *O. mykiss* habitat is 88 of maximum, juvenile habitat is 97 percent of maximum, and fry habitat is 67 percent of maximum (Figure 5.3-1). At a flow of 225 cfs, *O. mykiss* spawning habitat is 82 percent of maximum, adult *O. mykiss* habitat is 84 of maximum, juvenile habitat is 98 percent of maximum, and fry habitat is 69 percent of maximum (Figure 5.3-1). At a flow of 200 cfs, *O. mykiss* spawning habitat is 78 percent of maximum, adult *O. mykiss* habitat is 80 of maximum, juvenile habitat is 99 percent of maximum, and fry habitat is 70 percent of maximum (Figure 5.3-1). At 250 cfs, average daily water temperatures would remain below 18°C at RM 39.5 until maximum daily air temperatures exceed about 80°F (Figure 5.3-4), which occurs on average between three and four days in April (Figure 5.3-3), and would remain below 20°C at RM 39.5 until maximum daily air temperature exceeds 85°F (Figure 5.3-4), which occurs about one day in April on average (Figure 5.3-3). This action would be Not Likely to Adversely Affect *O. mykiss* and Not Likely to Adversely Affect CCV critical habitat (i.e., the action would benefit *O mykiss* and the species' habitat).

5.3.7.7 Fall-run Chinook Outmigration Base flows (April 16 – May 15)

The Districts propose to provide the following outmigration base flows for the period of April 16–May 15: (1) 275 cfs (BN, AN, and W water years), (2) 250 cfs (D water years), and (3) 200 cfs (C water years). Increasing base flows above those in the March 1–April 15 period would maintain favorable water temperatures during the mid-April through mid-May period, which is expected to benefit salmonids. Water temperature modeling shows that at RM 43, a flow of 275 cfs would maintain average daily water temperatures at less than 20 °C, even at maximum daily ambient air temperatures that exceed 100 °F (38 °C) (Figure 5.3-2). At RM 43, a flow of 275 cfs would maintain average daily water temperatures below 15°C until maximum daily air temperatures exceed 80°F (Figure 5.3-2), which, on average, occurs about three to four days in April and 15 in May. At RM 39.5, a flow of 275 cfs would maintain average daily water temperatures below 21 °C until maximum daily air temperatures exceed 100 °F (35 °C) (Figure 5.3-4), which occurs one day on average in May (Figure 5.3-3). At RM 39.5, a flow of 225 cfs would maintain average daily water temperatures below 21°C until maximum air temperatures exceed 95 °F (32 °C) (Figure 5.3-4), which occurs on average about two days in May (Figure 5.3-3). As explained below, these base flows could be augmented by outmigration pulse flows (see below), depending on the timing of pulse flows, which would further reduce water temperatures at a given location and extend the plume of colder water farther downstream.

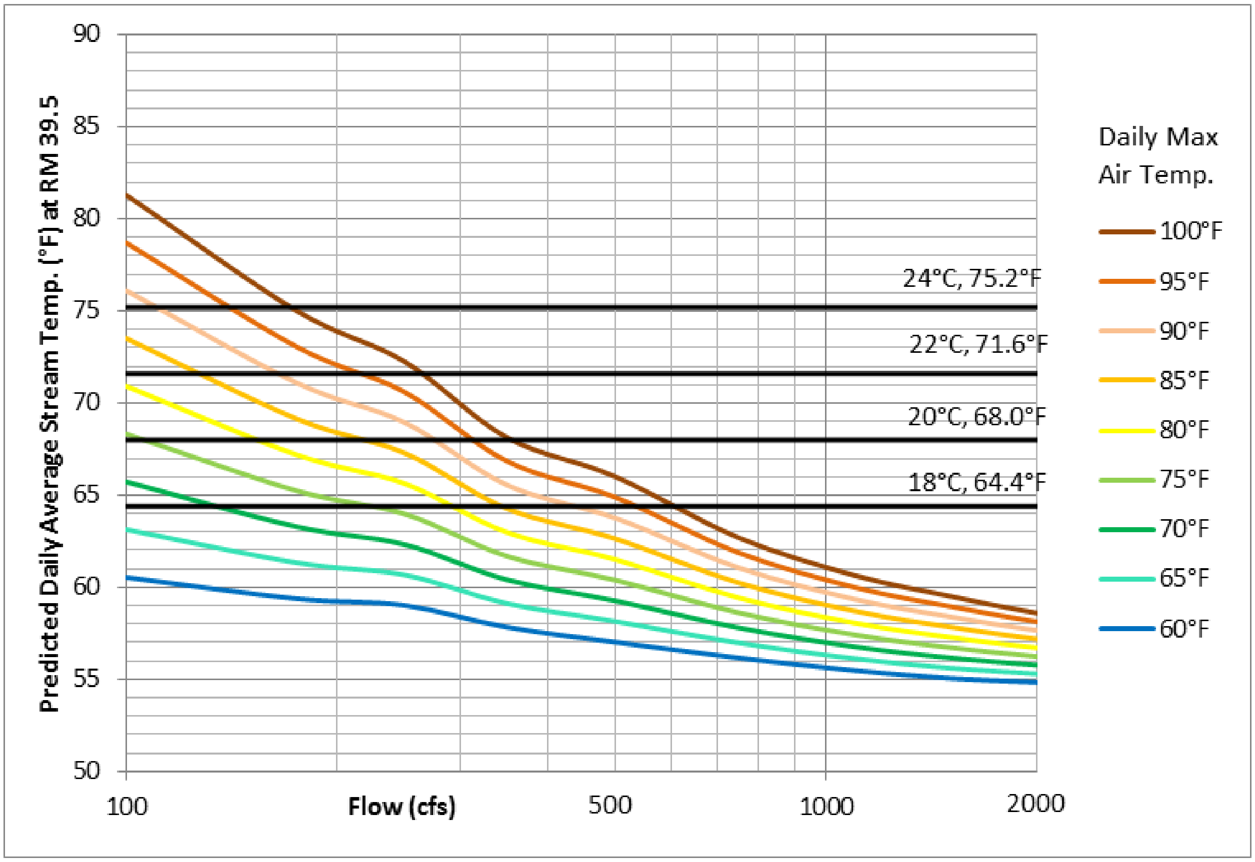

Figure 5.3-4. RM 39.5 daily average water temperatures versus flow and maximum air temperatures.

These flows represent a balance between facilitating fall-run Chinook outmigration, while maintaining adult and juvenile *O. mykiss* habitat at substantial levels and fry habitat at moderate levels. At a flow of 275 cfs, adult *O. mykiss* habitat is 90 percent of maximum, juvenile habitat is 95 percent of maximum, and fry habitat is 65 percent of maximum (Figure 5.3-1). At a flow of 250 cfs, adult *O. mykiss* habitat is 88 of maximum, juvenile habitat is 97 percent of maximum, and fry habitat is 68 percent of maximum (Figure 5.3-1). At a flow of 200 cfs, adult *O. mykiss* habitat is 80 of maximum, juvenile habitat is 99 percent of maximum, and fry habitat is 70 percent of maximum (Figure 5.3-1). This action would be Not Likely to Adversely Affect *O. mykiss* and Not Likely to Adversely Affect CCV critical habitat (i.e., the action would benefit *O mykiss* and the species' habitat).

5.3.7.8 Fall-run Chinook Outmigration Base flows (May 16 – May 31)

To maintain lower water temperatures during the latter half of May, the Districts are proposing the following base flow releases: (1) 300 cfs (BN, AN, and W water years), (2) 275 cfs (D water years), and (3) 225 cfs (C water years). These base flows could be augmented by outmigration pulse flows, as explained below. At a flow of 300 cfs, adult *O. mykiss* habitat is 91 percent of maximum, juvenile habitat is 93 percent of maximum, and fry habitat is 62 percent of maximum (Figure 5.3-1). At a flow of 275 cfs, adult *O. mykiss* habitat is 90 percent of maximum, juvenile habitat is 95 percent of maximum, and fry habitat is 65 percent of maximum (Figure 5.3-1). At a flow of 225 cfs, adult *O. mykiss* habitat is 84 of maximum, juvenile habitat is 98 percent of maximum, and fry habitat is 69 percent of maximum (Figure 5.3-1). This action would be Not Likely to Adversely Affect *O. mykiss* and Not Likely to Adversely Affect CCV critical habitat (i.e., the action would benefit *O mykiss* and the species' habitat).

5.3.7.9 Outmigration Pulse Flows (April 16 – May 31)

To encourage fall-run Chinook smolt outmigration and increase survival, pulse flows would be provided to coincide with periods when large numbers of parr- or smolt-size fish are occurring in the river. The available pulse flow volumes will be substantially increased over baseline levels, except in the second (and subsequent to the second) Dry and Critical water years. The Districts are proposing to allocate the following volumes of water for pulse flow releases: 150,000 ac-ft (AN and W water years), 100,000 ac-ft (BN water years), 75,000 ac-ft (D water years), 45,000 ac-ft (sequential D water years), 35,000 ac-ft (initial C water year), and 11,000 ac-ft (sequential C water years).[15] These pulse flows would augment outmigration base flows (see above), which would further reduce water temperatures at a given location and extend the beneficial plume of colder water farther downstream relative to that provided by the base flows alone. This action would be Not Likely to Adversely Affect *O. mykiss* and Not Likely to Adversely Affect CCV critical habitat (i.e., the action would benefit *O mykiss* and the species' habitat).

5.3.7.10 Flow Hydrograph Shaping

In spill years, the Districts would make reasonable efforts to shape the descending limb of the snowmelt runoff hydrograph to mimic natural conditions. If spill conditions allow, streamflow recession rates would be managed during the cottonwood seed dispersal period to provide soil moisture conditions that allow seeds to take up water, germinate, and form roots. All flows released to promote seed dispersal and germination would also be based on the need to minimize water supply impacts. Riparian recruitment streamflows timed to coincide with cottonwood seed dispersal would also benefit tree willows. Increasing natural recruitment of snowmelt-dependent hardwoods would increase stands of trees that could contribute large wood to the channel over the long-term and provide cover and shade for aquatic species. Benefits to the overall ecosystem could translate into benefits for *O. mykiss* occupying the lower river. This action would be Not Likely to Adversely Affect *O. mykiss* and Not Likely to Adversely Affect CCV critical habitat (i.e., the action would benefit *O mykiss* and the species' habitat).

5.3.8 Flows to Enhance Recreational Boating

The Districts would release the flows described below to enhance conditions for canoeing and kayaking on the lower Tuolumne River. From April 1–May 31 of all water years, a flow of 200 cfs or greater would be provided at the La Grange gauge. Provision of these flows would be a

[15] This reduced pulse flow, while still greater than or equal to Base Case pulse flows, would also occur in a sequence of "D" and "C" years. For example, in a sequence of the years C, D, C, D, C, D, the second and third "critical" years and the second and third "dry" years would each have pulse flows of 11 TAF and 45 TAF, respectively.

byproduct of the flows provided for the benefit of aquatic resources, so no incremental effects would occur beyond those described above.

From June 1 to June 30, a flow of 200 cfs would be provided in all water years at the La Grange gauge. Provision of this flow would be a byproduct of that provided for the benefit of aquatic resources, so no incremental effects would occur beyond those described above. In Wet, Above Normal, and Below Normal water years, withdrawal of water at the infiltration galleries would cease for one pre-scheduled weekend in June to provide an additional 100 cfs (for a total of 200 cfs) at RM 25.5. This short-duration, incremental flow increase in the sand-bedded reach of the lower river would have no significant effects on *O. mykiss*.

From July 1 to October 15, a flow of 350 cfs in Wet, Above Normal, and Below Normal water years and 300 cfs in Dry and Critical water years would be provided at the La Grange gauge. Provision of these flows would be a byproduct of those provided for the benefit of aquatic resources, so no incremental effects would occur beyond those described above. In all but Critical water years, the Districts would provide a flow of 200 cfs at RM 25.5 for the three-day July 4 holiday, the three-day Labor Day holiday, and for two pre-scheduled additional weekends in either July or August. In Wet, Above Normal, and Below Normal water years this would represent an incremental increase of 50 cfs downstream of RM 25.5 (over the background of 150 cfs), and in Dry water years this would represent an incremental increase of 125 cfs (over the background of 75 cfs). In both cases, these short-duration incremental flows in the sand-bedded reach of the lower river would have no significant effects on *O. mykiss*. These actions would be Not Likely to Adversely Affect *O. mykiss* and Not Likely to Adversely Affect CCV critical habitat.

5.4 Cumulative Effects of the Proposed Action

Under the ESA, cumulative effects are the effects of state or private activities not involving federal activities that are reasonably certain to occur within the Action Area of the federal action subject to consultation (i.e., FERC issuance of a new license for the Project) [50 CFR §402.02]. This definition applies only to ESA Section 7 analyses and should not be confused with the broader use of the term in NEPA or other environmental laws. Federal actions that are unrelated to the Project are not considered because they require separate consultation pursuant to Section 7 of the ESA.

O. mykiss in the Action Area may be cumulatively affected by individually minor but collectively significant actions taking place over a period of time. Activities contributing to cumulative effects in the lower Tuolumne River include water storage and diversions for irrigation and M&I water supply, historical and ongoing gravel and gold mining activities, riparian diversions, urbanization, other land and water development activities, the introduction and persistence of non-native species, channel modification by levees, recreation, flood control operations, wastewater treatment plant discharges, climate change, and other potential activities.

There are eight dams and reservoirs on the Tuolumne River and its tributaries, with a combined storage capacity of about 2,777,000 AF. Six of these dams are located upstream of the Don Pedro Project. One mainstem dam, the Districts' non-Project La Grange Diversion Dam, is located approximately 2 miles downstream of the Don Pedro Project. The lower Tuolumne River below La Grange Diversion Dam is directly affected by the operations of La Grange Diversion Dam, which is used to divert water into the Districts two irrigation canals. Therefore, all flow-related effects of the Don Pedro Project downstream of the La Grange Diversion Dam are, by definition, cumulative effects related to a variety of uses but not the result of flow management for hydropower generation associated with the Proposed Action. This includes high flows released to meet flow management targets established by the ACOE to protect the Modesto area. Protection is needed because of floodplain development and encroachment and channel modification that have together created a risk of flood-related effects.

As noted above, the Districts are proposing a suite of enhancement measures for implementation under the new FERC license. These measures would benefit *O. mykiss*, either directly or indirectly, as described in Section 5.3. These enhancements would counteract to some degree adverse effects of non-Project actions described in the following sections of this Draft BA and work in tandem with ongoing mitigation and enhancement measures, also described below, to benefit *O. mykiss* in the Action Area.

5.4.1 Past, Present, and Future Actions Affecting the Action Area

Because the Action Area consists of the lower Tuolumne River from La Grange Diversion Dam to the confluence of the Tuolumne and San Joaquin rivers, the actions described below include only those non-federal actions, other than the Proposed Action, that have taken, are taking, or will take place within the foreseeable future. Clearly, many actions that occur outside the Tuolumne River (including federal actions such as the Central Valley Project) influence any Tuolumne River CCV steelhead when they are completing their life-cycle outside the Action Area. Non-federal actions that would influence steelhead outside of the basin include (1) CCSF's regional water system, (2) the State Water Project, (3) water management in the San Joaquin, Merced, and Stanislaus rivers, (4) the Stockton Deep Water Ship Channel, (5) private diversions in the Delta, (6) increased water demand driven by population growth, (7) construction and maintenance of levees in the San Joaquin River and Delta, (8) mining, particularly in-channel aggregate mining, (9) agriculture and livestock grazing, (10) industrial and residential development, (11) fish hatchery practices, (12) adverse effects associated with introduced species, piscivorous fish species in particular, (13) recreation, and (14) a range of anadromous fish recovery efforts. For a comprehensive description of potential actions influencing steelhead in the San Joaquin River and the Bay Delta, see Section 4 of Exhibit E of the Districts' AFLA.

5.4.1.1 Chronology of In-Basin Actions

In accordance with the requirements of cumulative effects assessments provided under ESA, the initial step of performing the analysis is to identify significant past, present, and foreseeable future actions that contribute to cumulative effects. The Tuolumne River basin has been affected by substantial resource use and land and water management activities over the past 150 years. Table 5.4-1 summarizes a chronology of major in-basin actions that are likely to contribute to cumulative effects on any CCV steelhead occupying the Action Area.

The information available on each of these potential contributors to cumulative effects varies greatly, ranging from very little (e.g., early to mid-1900s commercial and sport fish harvest) to large volumes of study (e.g., effects on flow-habitat relationships in the lower Tuolumne River over the past decade). This section includes operations and maintenance activities associated with the overall Don Pedro Project, i.e., those that are unrelated to the Proposed Action, e.g., providing water for irrigation or managing reservoir storage for flood control.

Table 5.4-1. Chronology of actions in the Tuolumne River Basin contributing to cumulative effects on *O. mykiss*, including any CCV steelhead, in the Action Area.

Action	Date
Dams, Diversions, Flow Regulation	
Wheaton Dam	1871
La Grange Mining Ditch (Indian Bar Diversion)	1871
Phoenix Dam	1880
La Grange Diversion Dam	1893
Irrigation diversion begins	1901
Modesto Reservoir Dam	1911
Turlock Lake Dam	1914
Eleanor Dam	1918
Old Don Pedro Dam	1923
O’Shaughnessy Dam (Hetch Hetchy) (206,000 AF)	1923
Priest Dam	1923
Early Intake	1924
Hetch Hetchy Aqueduct completed; exports to San Francisco begin	1934
O’Shaughnessy Dam raised (360,000 AF)	1938
Cherry Lake	1956
Pine Mountain Dam	1969
New Don Pedro Dam	1971
Riparian water diversions along the lower Tuolumne River	1870s - present
In-Channel and Floodplain Mining	
Placer mining	1848 - 1890
Hydraulic mining (La Grange)	1871 – c.1900
Dredge mining of the lower Tuolumne River (gold)	1908-1942, 1945-1951
Gravel and aggregate mining of the lower Tuolumne River	1940s to present
Non-Native Fish Species	
18 fish species introduced in Tuolumne River basin by state/federal agencies	1874 - 1954
4 additional fish species introduced into the Tuolumne River basin	After 1954
Hatchery Practices	
CDFW begins stocking fish in the inland waters of California	Late 1800s
CDFW begins large-scale supplementation of anadromous fish stocks	1945
California’s hatcheries at times use out-of-basin broodstocks/move fry to other basins	Before 1980s
Salmon from Central Valley hatcheries released in San Francisco Bay	Ongoing
Commercial and Sport Harvest	
Commercial salmon fishing begins in California	Early 1850s
Gill net salmon fisheries well established in lower San Joaquin River basin	1860
Last commercial river salmon fishery closed in Sacramento-San Joaquin basin	1957
Agriculture, Livestock, and Timber Harvest	
Significant timber harvest begins	Mid 1800s
Large-scale agriculture and livestock grazing begins in region	Mid 1800s

5.4.1.2 Don Pedro Project: Actions Independent of the Proposed Action

Project Dam and Reservoir

Don Pedro Dam is a 1,900-ft-long and 580-ft-high, zoned earth and rockfill structure. The top of the dam is at an elevation of 855 ft (NGVD 29). Don Pedro Reservoir extends upstream for approximately 24 miles at its normal maximum water surface elevation of 830 ft. In a typical year, water surface elevation in Don Pedro Reservoir peaks in late June/early July at the end of the snowmelt runoff, and is then steadily drawn down over the summer and fall to serve water supply and lower Tuolumne River fish protection needs. Rainfall and snowmelt runoff resumes in December.

Although operation of the hydroelectric facilities at the Don Pedro Dam is an important function, it is a secondary function of the Project. The primary purposes of the Project are to provide water storage to meet the needs of irrigation and M&I water users and facilitate flood management in accordance with the ACOE flood control manual.

Timing and Magnitude of Flow Releases

Water is released from Don Pedro Reservoir for only three reasons: (1) to provide water needed to meet the Districts' irrigation and M&I demands, (2) for flood management purposes, and (3) to meet the license requirements for fish protection flows in the lower Tuolumne River. The Districts possess senior water rights in the Tuolumne River, but Project operations must consider potential water availability over the course of multiple years, so that even in drier years the reservoir can retain a water supply to meet downstream needs.

Flows released at Don Pedro Dam to meet the Districts' irrigation and M&I water demands are all diverted from the Tuolumne River at La Grange Diversion Dam (the Districts' non-project Diversion Dam) to the TID and MID canal systems. From 1971 to 2012, the average annual water diversion at La Grange Diversion Dam to the Districts canals was approximately 900,000 AF. Diversions for irrigation can occur year round, but generally occur from late February to early November. This water management contributes to cumulative effects on *O. mykiss* in the lower Tuolumne River by storing water that is then scheduled for release into diversion canals. However, these effects due to diversion at La Grange Diversion Dam do not reflect outflow variability at the Don Pedro Project for the purpose of hydropower generation.

Flows released at Don Pedro Dam to comply with the ACOE flood management guidelines consist of both pre-releases to create storage in anticipation of high runoff and releases during periods of high runoff to moderate downstream effects. Both of these release scenarios occur to balance reservoir levels, forecasted runoff, and downstream flows. "High" river flows can be defined as any flows released at Don Pedro Dam that are greater than those needed for irrigation and M&I purposes and aquatic resource protection purposes. The ACOE guidelines call for making 340,000 AF of storage available for management of high-flow conditions. Flow releases for high-flow management purposes from March to July are affected by diversions at La Grange Diversion Dam for water supply purposes. High flows in the Tuolumne River are also affected by the operation of the upstream Hetch Hetchy system.

In addition to flood storage reservation within the reservoir, downstream flow restrictions also affect Project operations from a flood management perspective. The primary downstream flow guideline cited in the 1972 ACOE Flood Control Manual is that flow in the Tuolumne River at Modesto (as measured at the 9th Street Bridge) should generally not exceed 9,000 cfs. Flows in excess of 9,000 cfs have the potential to cause significant property damage in this area of the Tuolumne River basin, while also potentially contributing to flood flows in the San Joaquin River. If a large volume of water is forecasted that could result in flows higher than 9,000 cfs at Modesto, pre-flood releases may be made from Don Pedro Dam to create storage to prevent downstream flows from exceeding 9,000 cfs at a later time.

Between La Grange Diversion Dam and 9th Street in Modesto the single largest contributor of local flow to the Tuolumne River is Dry Creek. The Dry Creek watershed has its headwaters in the foothills just northeast of the Project. It is a “flashy” watershed, and once its soil is saturated any rainfall results in rapid runoff. High flows, on the order of 6,000 cfs or higher, can occur when significant rainfall occurs between Modesto and the upper end of the Dry Creek watershed. Because these flows from Dry Creek come in above the USGS’s Tuolumne River 9th Street river gage, they must be taken into account when making releases from Don Pedro Reservoir to the lower river to avoid exceeding 9,000 cfs.

CCSF participated financially in the construction of the new Don Pedro Dam. In return for its financial contribution, CCSF obtained up to 570,000 AF of water banking privileges in Don Pedro Reservoir, which allows CCSF to improve the reliability of its overall water supply management system for its Bay Area water users. CCSF pre-releases water from its upstream facilities into the water bank in the Don Pedro Reservoir so at other times it can hold back an equivalent amount of water that would otherwise have to be released to satisfy the Districts’ water rights. Once the water enters Don Pedro Reservoir, the water belongs to the Districts, and the Districts have unrestricted entitlement to its use.

Prior to its construction, it was recognized that the new Don Pedro Project was necessary for the protection of Tuolumne River fall-run Chinook salmon because the original Don Pedro reservoir built in the early 1920s, which had no downstream release requirements, would spill less and less water as CCSF increased its exports to the Bay Area. The Federal Power Commission (FPC), the predecessor to FERC, recognized that fisheries releases to the lower Tuolumne River, when combined with rising CCSF diversions, could ultimately undermine the economic feasibility of the new Don Pedro Project. To balance those factors, FPC’s 1964 decision set normal-year releases for fish of 123,210 AF for the first 20 years, and required the Districts to conduct studies that could be used to develop future fisheries requirements.

FERC’s 1996 order (FERC 1996) amending the Don Pedro Project license required the incorporation of the lower Tuolumne River minimum flow provisions contained in the 1995 settlement agreement between the Districts, CCSF, resource agencies, and environmental groups. The revised minimum flows in the lower Tuolumne River vary from 50 to 300 cfs, depending on water year hydrology and time of year. The water year classifications are recalculated each year to maintain an approximately consistent frequency distribution of water year types over time. The settlement agreement and license order also specified certain pulse flows for the benefit of upstream migrating adult salmonids and downstream migrating juveniles, the amount of which also varies with water-year type. The downstream flow schedule provided for by the settlement agreement and subsequent FERC Order is shown in Table 5.4.-2. These flows are a required element of the environmental baseline.

Table 5.4-2. Schedule of flow releases from the Don Pedro Project to the lower Tuolumne River by water year type contained in FERC's 1996 order.

Schedule	Units	# of Days	Critical and Below	Median Critical[1]	Interm. CD	Median Dry	Interm. D-BN	Median Below Normal	Interm. BN-AN[1]	Median Above Normal	Interm. AN-W	Median Wet/Max
Occurrence	%		6.4%	8.0%	6.1%	10.8%	9.1%	10.3%	15.5%	5.1%	15.4%	13.3%
October 1-15	cfs	15	100	100	150	150	180	200	300	300	300	300
	AF		2,975	2,975	4,463	4,463	5,355	5,950	8,926	8,926	8,926	8,926
Attraction Pulse	AF		none	none	None	none	1,676	1,736	5,950	5,950	5,950	5,950
October 16-May 31	cfs	228	150	150	150	150	180	175	300	300	300	300
	AF		67,835	67,835	67,835	67,835	81,402	79,140	135,669	135,669	135,669	135,669
Outmigration Pulse Flow	AF		11,091	20,091	32,619	37,060	35,920	60,027	89,882	89,882	89,882	89,882
June 1-Sept 30	cfs	122	50	50	50	75	75	75	250	250	250	250
	AF		12,099	12,099	12,099	18,149	18,149	18,149	60,496	60,496	60,496	60,496
Volume (total)	AF	365	94,000	103,000	117,016	127,507	142,502	165,003	300,923	300,923	300,923	300,923

[1] Between a Median Critical Water Year and an Intermediate Below Normal-Above Normal Water Year, the precise volume of flow to be released by the Districts each fish flow year is to be determined using accepted methods of interpolation between index values.

Source: FERC 1996.

5.4.1.3 Non-Project Actions

The first dam built on the Tuolumne River, Wheaton Dam, was constructed in 1871 near the current location of the La Grange Diversion Dam at approximately RM 52.2. There are currently a number of dams in the mainstem Tuolumne River and its tributaries, some of which are used for storage and others that are primarily diversion dams. Table 5.4-3 lists the owners of the dams in the Tuolumne River basin and the capacities of their associated impoundments, if known. Dates for completion of construction of select impoundments are also provided in Table 5.4-3. Table 5.4-4 provides information on known hydropower facilities in the Tuolumne River basin, including both small and conventional hydroelectric generation facilities.

Table 5.4-3. Owners and capacities of dams or diversion facilities and their associated reservoirs in the Tuolumne River basin.

Owner	FERC Project No.	Stream	Dam or Diversion Dam	Reservoir or Impoundment Name (date completed)	Capacity (AF)
CCSF	None	Tuolumne River	O'Shaughnessy Dam / diversion to Mountain Tunnel	Hetch Hetchy Reservoir (1923)	360,360 (USGS 1999)
CCSF	None	Eleanor Creek	Eleanor Dam	Lake Eleanor (1918)	26,146 (USGS 1999)
CCSF	None	Cherry Creek	Cherry Dam	Cherry Lake (1956)	274,2520 (USGS 1999)
CCSF	None	Tuolumne River	Early Intake (facility only used by CCSF for infrequent diversion from Cherry watershed)	n/a (1924)	<100
CCSF	None	Off-stream	Priest Dam	Priest Forebay (1923)	1,500
CCSF	None	Off-stream (Moccasin Creek and all local runoff diverted under or around impoundment)	Moccasin Dam	Moccasin Afterbay	Approx. 500
Private	None	Big Creek	Pine Mountain Dam	Pine Mountain Lake (1969)	7,700 (USGS 1999)
Private	None	Sullivan Creek (receives diversion from SF Stanislaus River)	Phoenix Dam	Phoenix Lake (1880)	612 (USGS 1999)
TID/MID	2299	Tuolumne River	Don Pedro Dam	Don Pedro Reservoir	2,030,000
TID/MID	None	Tuolumne River	La Grange Diversion Dam	La Grange Headpond	100
MID	None	Off-stream	Modesto Reservoir Dam	Modesto Reservoir (1911)	28,000
TID	None	Off-stream	Turlock Lake Dam	Turlock Lake (1914)	48,000
TID	None	Off-stream	Dawson Dam	Dawson Lake	< 100

Source: USGS 1999; CCSF 2006.

Table 5.4-4. Hydropower generation facilities in the Tuolumne River watershed.

Owner	FERC Project No.	Powerhouse	Location / Description
CCSF	None	Robert C. Kirkwood Powerplant	124 MW; Completed 1967; water diverted from Hetch Hetchy Reservoir to powerhouse via Canyon Tunnel (CCSF 2006)
CCSF	None	Dion R Holm Powerplant	169 MW; Completed 1960; water diverted from Lake Lloyd via Cherry Power Tunnel (CCSF 2006)
CCSF	None	Moccasin Powerhouse (off-stream)	110 MW; water diverted to powerhouse via CCSF Mountain Tunnel by way of Priest Forebay (CCSF 2006)
TID/ MID	2299	Don Pedro Powerhouse	Immediately downstream of Don Pedro Dam; 4 units, authorized capacity 168 MW.
TID	14581	La Grange Powerhouse	4.5 MW Powerhouse; water source is TID Upper Main Canal.
TID	4450	Dawson Power Plant (off-stream)	5.5 MW; Small hydro located on TID Upper Main Canal between La Grange Diversion Dam and Turlock Lake
TID	3261	Turlock Lake (off-stream)	3.3 MW; Small hydro located at the outflow of the District's Turlock Lake
MID	290	Stone Drop (off stream)	230 kW; small hydro located on the MID main canal just below Modesto Reservoir
TID	1000	Hickman (off stream)	1.1 MW, first built 1979 on the TID Main Canal

Dam and Reservoir Operations Upstream of the Don Pedro Project

CCSF's Hetch Hetchy Water and Power Division maintains and operates several reservoirs in the middle-elevation band of the Tuolumne River watershed upstream of the Don Pedro Project, including CCSF's Cherry Lake (elevation 4,700 ft), Lake Eleanor (elevation 4,660 ft), and Hetch Hetchy Reservoir (elevation 3,800 ft) (CCSF 2006). The primary purposes of these projects are to provide water storage for purposes of water supply and hydropower generation. CCSF stores and diverts water from the upper Tuolumne River for use outside of the Tuolumne River basin. CCSF provides potable water to approximately 2.6 million Bay Area residents and serves much of the Bay Area's commercial, manufacturing, and industrial enterprises. The Hetch Hetchy system includes the San Joaquin Pipeline (SJPL), which transports about 85 percent of CCSF's total water supply. The Hetch Hetchy system is an indispensable component of the welfare and economy of the Bay Area. The Hetch Hetchy system also produces about 1,700,000 MWh of renewable hydroelectric energy in an average year. The maximum rate of diversion from of the upper Tuolumne River to the San Francisco Bay Area is about 465 cfs. The average annual use is about 230,000 AF, or about 12 percent of the average annual runoff.[16]

Another user of water in the upper Tuolumne River is CDFW, which operates the Moccasin Fish Hatchery below CCSF's Moccasin Reservoir, a 505-AF water supply reservoir. Water flow to the hatchery is estimated to be about 15 million gallons per day (23 cfs) or about 11,000 AF per year. Water from the hatchery is discharged into Moccasin Creek. Water from Moccasin Reservoir also feeds CCSF's Foothill Tunnel.

[16] For the period 1987 - 2012.

Dam and Reservoir Operations in the Tuolumne River Downstream of the Don Pedro Project

La Grange Diversion Dam, the Districts' non-Project Diversion Dam, which is located near the border of Stanislaus and Tuolumne counties at RM 52.2, is the most downstream dam on the Tuolumne River. Originally constructed between 1891 and 1893, the purpose of the dam is to raise the level of the Tuolumne River to permit the diversion of water from the Tuolumne River to the Districts' canal systems by means of gravity. TID and MID combined forces to build the dam to divert Tuolumne River flows to which the Districts have water rights. La Grange Diversion Dam has been serving this basic purpose and function for approximately 120 years. When not in spill mode (above elevation 296.5 ft, which occurs about 30 percent of the time), the La Grange headpond operates between elevation 294 ft and 296 ft about 90 percent of the time. The amount of storage in this 2-ft operating band is less than 100 AF of water. Flows in the lower Tuolumne River are recorded at the USGS La Grange gage, located about 0.3 miles below the La Grange Diversion Dam.

Diversions Downstream of the Don Pedro Project

There are an estimated 26 points of water diversion along the lower Tuolumne River between La Grange Diversion Dam and the San Joaquin River, and four known diversions along Dry Creek (Figure 5.4-1). Water diversions along the lower Tuolumne River typically occur during irrigation season.

Accretion Flows

Runoff from Dry Creek, agricultural return flows, groundwater seepage, and operational spills from irrigation canals all enter the lower Tuolumne River. Average monthly accretion flows in the lower Tuolumne River range from 40 cfs to 200 cfs, with an estimated annual average accretion from water years 1970-2010 of 152 cfs (TID/MID 2017f).

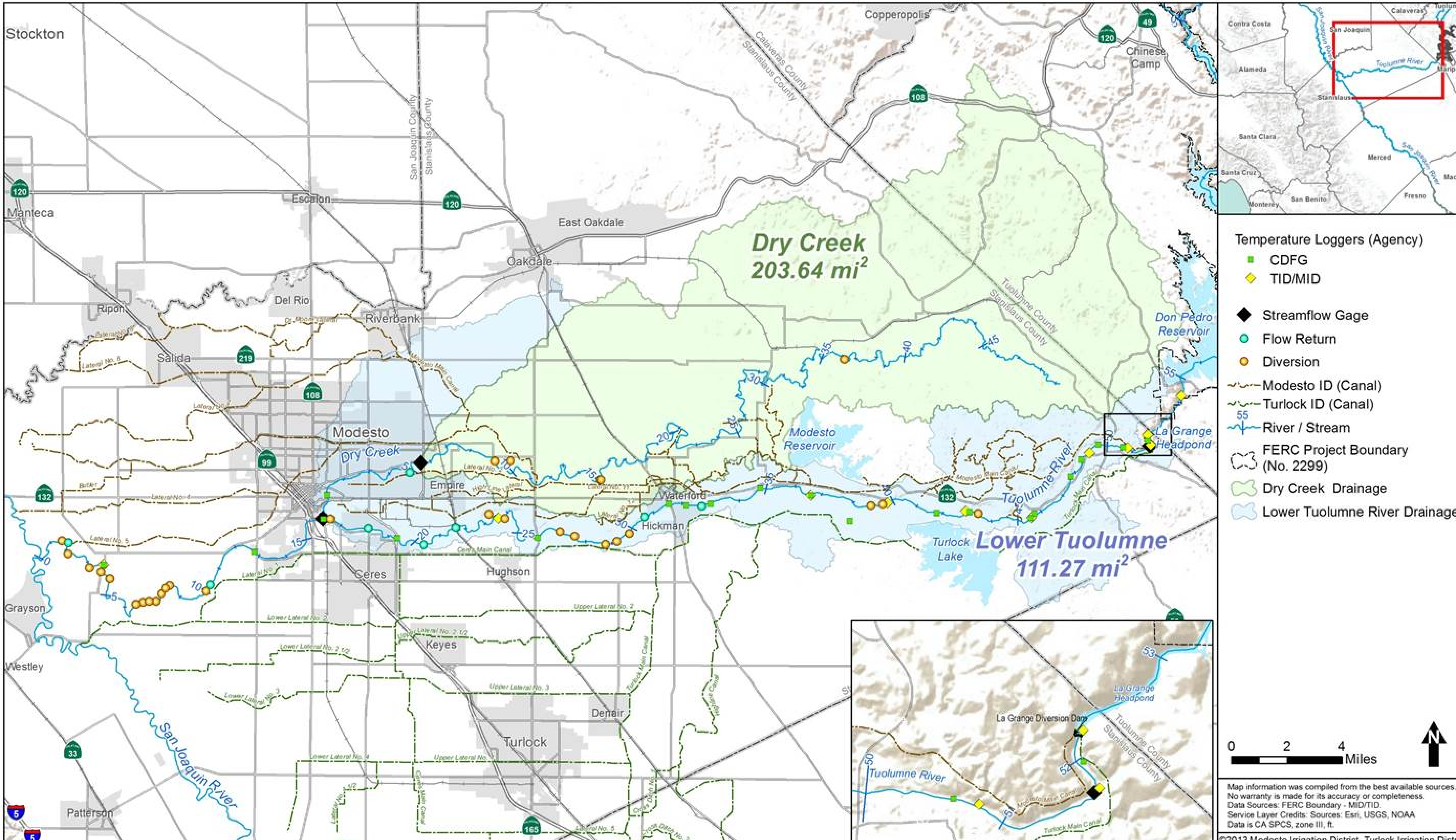

Figure 5.4-1. **Locations of diversions along the lower Tuolumne River and Dry Creek.**

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Resource Extraction, Development, and Land Uses along the Tuolumne River

In-Channel and Floodplain Mining

The chief mining commodities in the vicinity of the Project are gold and aggregate. Mining-related impacts on the mainstem of the Tuolumne River corridor began with the California Gold Rush in 1848. A historical timeline of mining activities in the San Joaquin River's tributaries, including the Tuolumne River, includes placer mining (1848–1880), hydraulic mining in the La Grange vicinity (1871 to about 1900), dredge mining (1908-1942, 1945-1951), and gravel and aggregate mining (1940s to present) (McBain and Trush 2000). Decades of dredge mining in the main channel of the Tuolumne River resulted in the excavation of channel and floodplain sediments and a legacy of significant channel modifications and dredger tailings deposits between RM 50.5 and 38.0. Gravel and aggregate mining, with their attendant floodplain modifications, continue alongside the river corridor today.

The Columbia and Springfield placer mining operations northwest of the Project produced approximately $55 million in gold prior to 1899 (TID/MID 2011). The pocket mines of Sonora and Bald Mountain, as well as others in their vicinity, have been highly productive and long-lived. Marble and limestone products have been second in value to gold. The Columbia marble beds northwest of the Project had a long history of production prior to 1941, and two plants are currently processing stone from these deposits (TID/MID 2011). From the 1860s to the 1940s, roughly 10,000 tons of chromite ore and several hundred tons of crude magnesite ore were mined in the Project vicinity (TID/MID 2011). Most of the chromite came from the McCormick Mine, located northwest of the Project. All magnesite production in Tuolumne County occurred in the 1920s and came from two sites in the northern portion of the Red Hills located northwest of the Project (TID/MID 2011).

Gold mined in Stanislaus County has come predominantly from placers. Quaternary gravels of the lower Tuolumne River channel near Waterford were among the most productive (TID/MID 2011). In the early 1900s, large-scale dredging of Quaternary gravels began in the Tuolumne River between La Grange and Waterford, and most of the gold produced in Stanislaus County from 1932 through 1959, came from this area. In the late 1940s, gold mining declined sharply (Koschmann and Bergendahl 1968).

California leads the United States in aggregate production, and virtually all aggregate is removed from alluvial deposits (Kondolf 1995). As of 1994, sand and gravel mining exceeded the economic importance of gold mining in the state. Large-scale, in-channel aggregate mining began in the Tuolumne River corridor in the 1940s, when aggregate mines extracted sand and gravel directly from large pits excavated in the active river channel. Off-channel and floodplain aggregate mining along the Tuolumne River have also been extensive.

Aggregate in Stanislaus County is currently classified as aggregate resources (potentially useable aggregate that may be mined in the future but for which no mining permit has been granted) and aggregate reserves (aggregate resources for which mining and processing permits have been granted) (Higgins and Dupras 1993). An estimated 540 million tons (338 million yd^3) of aggregate resources are located in six different geographic areas of Stanislaus County (Higgins and Dupras 1993). The lower Tuolumne River corridor is the largest of the six areas and contains an estimated 217 million tons (135 million yd^3) in its channel and terraces (Higgins and Dupras 1993). The Gravel Mining Reach of the lower Tuolumne (RM 34.2 to 40.3) is currently the focus of development by commercial aggregate producers.

Much of the residual dredger tailings upstream of RM 45 were removed from the floodplain downstream of La Grange Diversion Dam as part of the construction of the new Don Pedro Dam in the 1960s. Reaches of the Tuolumne River between RM 47 and 50 that had been affected by gold dredger mining in the early 1900s were reconfigured following removal of the dredger tailings.

Agriculture, Livestock Grazing, and Timber Harvest

After the Gold Rush, there was a substantial increase in crop production and ranching in the Central Valley (TID/MID 2013b). During this period, woody vegetation along the Tuolumne River was cleared to allow for crop production in the rich alluvial soils of the bottomlands. Levees were constructed to protect the new farmlands from flooding in spring, and irrigation canals were constructed to provide water during the growing season (Thompson 1961; Katibah 1984). Of the estimated 4 million acres of wetland that occurred historically in the Central Valley, only about 300,000 ac remained in 1990. The conversion of wetlands to agricultural uses accounts for much of this reduction in wetland area.

Land in the lower Tuolumne River watershed is primarily privately owned, including that used for agriculture and livestock grazing (Stanislaus County 2006). Primary agricultural land uses along the gravel-bedded reach include orchards and row crops (RM 24.0-40) and livestock grazing (RM 40-51) (McBain & Trush 2000).

Timber operations have existed throughout the Sierra Nevada range since the mid-1800s. The Gold Rush of 1849 fueled a human migration into California that resulted in dramatic increases in the demand for timber. The indirect effects of gold mining included steamship transportation along the major rivers of the Central Valley, which was fueled by cordwood harvested from adjacent lands, which likely resulted in the first wave of riparian forest clearing in some areas of the Tuolumne River basin (Rose 2000, as cited in McBain and Trush 2002).

In recent times, timber harvest in the Tuolumne River watershed has typically been limited to lands in the upper basin. The Yosemite Stanislaus Solutions (YSS) collaborative group was formed in December 2010 to assist the Stanislaus National Forest in developing restoration plans across the landscape, regardless of ownership patterns, in the southern part of the Forest. One critical area within the YSS collaborative is Hetch Hetchy Reservoir. Approximately one third of the land within the YSS boundary burned in 1987 and succeeding years. After 1987, the majority of this land was successfully reforested. The 2013 Rim Fire (which burned from August 17, 2013 through September 20, 2013) burned a total of 253,360 acres (USFS 2013). Much of the burn occurred in the Tuolumne River watershed.

Industrial, Urban, and Residential Development

Privately owned land in the lower Tuolumne River watershed is also used for rural residential purposes or for denser residential, municipal, and industrial purposes in communities such as Waterford and Modesto (Stanislaus County 2006). Many miles of river bank have been leveed and stabilized with rip rap by agencies or landowners. Levees and bank revetment extend along portions of the river bank from the area near Modesto (RM 16) downstream to the San Joaquin River. Following the 1997 flood, some subdivisions that had been inundated in the Modesto area were found to have been constructed within the Federal Emergency Management Agency floodplain area designated prior to 1997 (TID/MID 2013b).

Four wastewater treatment plants (WWTPs), i.e., Tuolumne County Water District #1, Jamestown, Sonora, and Tuolumne contribute a little over 19 percent of the total phosphorus to Don Pedro Reservoir. The Sonora WWTP accounts for about 11 percent of the phosphorus input (TID/MID 2011). Urban runoff to the lower Tuolumne River from the Modesto area has been shown to contain pesticides (Dubrovsky et al. 1998). A total of fifteen pesticides were detected, and chlorpyrifos, diazinon, DCPA, metolachlor, and simazine were detected in almost every sample (Dubrovsky et al. 1998).

The Central Valley Regional Water Quality Control Board (CVRWQCB) has issued various Cleanup and Abatement Orders for the Tuolumne River and its tributaries (TID/MID 2011). For example, in 2004, the CVRWQCB issued Order No. R5-2004-0718 for a discharger within the City of Hickman because a water retention pond at a nursery failed and caused 2,000 yd^3 of sediment and rock to enter the Tuolumne River. In 2008, the CVRWQCB issued Order No. R5-2008-0701 because two dischargers graded over 1,000 acres of land and caused significant discharges (11,200 nephelometric turbidity unit [NTU]) of sediment into Peaslee Creek and the Tuolumne River. In 2009, the CVRWQCB issued Order No. R5-2009-0707 because a discharger graded over 76 acres of land and caused significant discharges of sediment into Peaslee Creek and one of its unnamed tributaries.

Fish Hatchery Practices

The Moccasin Creek Hatchery, which was completed in 1954, receives its water from the afterbay of the Moccasin Creek Powerhouse, which is a part of the Hetch Hetchy water supply system (CDFW 2016a). Annual average hatchery production from 2004 through 2008 included approximately 41,000 brook trout (mostly fingerlings), about 88,000 brown trout (fingerlings and sub-catchable), 21,000 Lahontan cutthroat throat (mostly fingerlings), 124,000 Eagle Lake trout (mostly yearlings), and 807,000 rainbow trout (primarily yearlings and fingerlings) (CDFG and USFWS 2010). In the past, the hatchery was also used to rear non-salmonid species.

CDFW manages the Don Pedro Reservoir salmonid fishery as a put-and-grow resource with substantial stocking and associated fishing regulations. Don Pedro Reservoir is also managed by CDFW as a year-round fishery for black bass. CDFW and DPRA have been releasing hatchery fish into Don Pedro Reservoir since 1953, when more than 10,000 kokanee salmon were planted. From 1954-1956 between 49,000 and 57,000 kokanee were planted annually. In 1959, about 222,000 brook trout were planted, and in 1964, about 389,000 rainbow trout were planted. From

1972 onward, stocking of various fish species in Don Pedro Reservoir became more frequent and consistent (Table 5.4-5). Moccasin Creek, a tributary to Don Pedro Reservoir, is stocked with rainbow trout (CDFG 2006).

Chinook salmon planted in Don Pedro Reservoir in the 1980s and 1990s came from the Feather River Hatchery, and Chinook salmon were sourced from the Nimbus and Iron Gate hatcheries on the Klamath River (Perales et al. 2015). Starting in 2014, triploid (sterile) Chinook salmon from the Iron Gate Hatchery/Silverado Fisheries Base have been stocked in Don Pedro Reservoir (Perales et al. 2015). Kokanee planted in Don Pedro Reservoir come from the San Joaquin Hatchery, and all stocked trout have come from the Moccasin Creek Hatchery (CDFW, unpublished data).

No known fish stocking has occurred in the reach of the Tuolumne River between Don Pedro Dam and La Grange Diversion Dam (TID/MID 2013a).

Large numbers of trout have been stocked in the Tuolumne River basin upstream of Don Pedro Reservoir. The reaches of the mainstem Tuolumne River below Yosemite National Park are stocked by CDFW with triploid (sterile) rainbow trout and triploid brown trout raised at the Moccasin Creek Hatchery. CDFW stocks rainbow trout and Eagle Lake trout in the North Fork, Middle, and South Fork Tuolumne River (CDFW 2016b). Eleanor Creek, a tributary to Cherry Creek, is not currently stocked, but a hatchery was operated on one of its tributaries (Frog Creek) until the 1950s. The hatchery raised rainbow trout sourced from Lake Eleanor. Brook trout were historically stocked in the headwaters of Clavey Creek, a tributary to the Clavey River (Carion et al. 2010), and during 1975-1976, more than 100,000 brown trout fingerlings were stocked by CDFW into the Clavey River, although these brown trout did not establish a self-sustaining population (Carion et al. 2010).

The first hatchery in the State of California, the Baird Hatchery on the McCloud River, was owned and operated by the U.S. Fish Commission from 1872-1883 and again from 1888-1935 (Leitritz 1970). During the twentieth century, hatcheries were constructed throughout the state to supplement declining native anadromous fish populations. CDFW is currently the principal agency responsible for managing and conserving fisheries in California. Fish are reared and released for recreational fishing and commercial harvest, conservation and restoration of native fish species, mitigation for habitat losses caused by development, and mitigation for fish lost at pumping facilities in the Delta. Hatchery production, particularly of Sacramento River fall-run Chinook salmon, contributes to major recreational and commercial fisheries in the ocean and inland areas (California HSRG 2012).

CDFW currently operates 21 hatcheries that raise a variety of trout and salmon. There are 11 hatcheries in California that produce Chinook salmon, coho salmon, and/or steelhead, nine of which were constructed to mitigate for the effects of dams (California HSRG 2012). Annual production of salmon and steelhead in California hatcheries approaches 50 million juveniles. During most years, over 32 million fall-run Chinook salmon are produced at five hatcheries in the Central Valley, and nearly 9 million are produced at two hatcheries in the Klamath-Trinity River basin. Initially, CDFW produced Chinook from eggs derived from out-of-state sources, but the practice was terminated due to concern over disease transmission (JHRC 2001), and for many years, California's hatcheries used out-of-basin broodstock or transferred fry among river basins (JHRC 2001).

Table 5.4-5. Fish Stocked in Don Pedro Reservoir (1970-2012).

Year	Kokanee Salmon[1]	Chinook Salmon	Brook Trout	Brown Trout	Rainbow Trout	Eagle Lake Trout	Largemouth Bass	Coho Salmon
1972	0	0	0	0	813,012	0	0	27,584
1973	0	0	0	0	0	0	0	72,800
1974	0	0	0	0	52,500	0	0	111,241
1975	0	0	0	0	40,150	0	0	36,480
1976	0	0	0	0	660,810	10,320	0	102,295
1977	17,184	0	0	0	16,036	15,660	0	111,600
1978	0	0	135,500	0	18,080	0	0	100,208
1979	0	0	228	200	64,800	22,000	0	0
1980	0	0	0	0	25,530	18,150	0	100,000
1981	6,000	0	0	600	36,160	31,260	0	0
1982	25,155	131,510	0	0	1,200	3,600	7,500	0
1983	0	66,920	7,600	0	1,900	20,010	0	0
1984	0	0	0	0	50,500	10,000	0	0
1985	0	61,130	0	0	5,780	10,075	0	0
1986	0	0	0	0	5,029	10,105	0	0
1987	0	0	0	0	62,485	0	0	0
1988	0	54,800	0	0	70,150	0	0	0
1989	0	0	0	0	77,705	0	0	0
1990	0	0	0	0	164,635	0	0	0
1991	0	30,600	0	0	228,905	0	0	0
1992	0	25,500	0	0	112,760	0	0	0
1993	0	0	0	0	170,340	0	15,000	0
1994	0	0	0	0	77,920	0	2,222	0
1995	0	0	190,405	20,124	0	0	2,711	0
1996	0	0	22,450	40,912	0	0	2,222	0
1997	0	0	0	20,400	36,980	0	2,222	0
1998	0	0	0	20,000	101,736	0	2,222	0
1999	0	40,000	35,341	22,925	13,055	0	1,682	0
2000	45,982	0	2,000	20,070	59,100	0	1,980	0
2001	50,103	0	3,520	19,800	65,600	0	2,758	0
2002	10,080	0	0	14,600	52,450	0	1,719	0
2003	10,043	0	0	0	71,675	0	1,825	0
2004	9,984	0	0	26,400	179,263	0	3,621	0
2005	10,143	100,440	118,400	73,687	262,585	3,600	2,000	0
2006	4,061	70,015	0	22,100	388,720	405	1,062	0
2007	6,517	91,000	0	15,860	41,720	72,680	1,667	0
2008	10,080	93,885	18,222	10,050	37,617	31,600	1,680	0
2009	10,050	100,006	5,610	31,320	329,495	93,790	1,367	0
2010	10,032	100,000	0	0	4,800	52,300	1,755	0
2011	10,260	129,980	0	16,000	44,300	55,300	0 [2]	0
2012	10,000	99,997	0	15,400	52,300	37,900	2,000	0

1 Stocked kokanee are primarily reared at San Joaquin Hatchery.
2 No bass planted due to mortalities at hatchery.

CDFW currently stocks trout in high mountain lakes, low elevation reservoirs, and various streams and creeks. Salmon and steelhead have been stocked primarily in rivers, including direct tributaries to the Pacific Ocean. Chinook, coho, and kokanee have also been planted in reservoirs for sport fishing. CDFW currently stocks salmonids in over 500 locations in 25 counties (CDFW 2016b). Significant numbers of salmon from Central Valley hatcheries have been transported by truck to San Francisco Bay and released (JHRC 2001). For example, in 1999 the following releases of fall-run Chinook smolts were made downstream of the Delta: 5.88 million from the Feather River Hatchery; 3.8 million from the Nimbus Hatchery, and 1.72 million from the Mokelumne River Hatchery (JHRC 2001). Also in 1999, the Feather River Hatchery released 2.12 million of its spring Chinook smolts in San Pablo Bay (JHRC 2001). Releasing hatchery salmon downstream of the Delta is aimed at improving their survival and contribution to fisheries and reducing the potential for competition between hatchery smolts and naturally produced fish (JHRC 2001).

CDFW operates four hatcheries in the San Joaquin River basin: (1) the San Joaquin Hatchery in the town of Friant, (2) the Merced River Hatchery in the town of Snelling, (3) the Mokelumne River Hatchery in the town of Clements (see paragraphs below dedicated to individual hatchery programs), and (4) the Moccasin Creek Hatchery on Moccasin Creek (discussed previously), a tributary to Don Pedro Reservoir. Fish species raised at these hatcheries include brook trout, Eagle Lake trout (*O. mykiss aquilarum*), golden trout (*O. aguabonita*), kokanee, rainbow trout/steelhead, Chinook salmon, brown trout, and Lahontan cutthroat trout (*O. clarkii henshawi*). Anadromous salmonids are also released from CDFW facilities in the Sacramento River basin, including fall-run Chinook salmon (the anadromous fish run type that occurs in the Tuolumne River) produced at the Nimbus Hatchery. In addition, the San Joaquin River Restoration Program (SJRRP) operates the Interim Salmon Conservation and Research Facility (Interim Facility), located below Friant Dam on the San Joaquin River.

CDFW first stocked fish in the San Joaquin River basin in the 1930s, although planting locations were not always recorded (SCEC 2004). CDFW records indicate that 82 percent of the fish stocked in the South Fork of the San Joaquin River (above Friant Dam) were rainbow trout (SCEC 2004). Currently, only steelhead and Chinook salmon are released by CDFW into the lower San Joaquin, lower Merced, lower Mokelumne, and lower Tuolumne rivers. As part of the Vernalis Adaptive Management Program (VAMP), Chinook salmon from the Merced River and Feather River hatcheries were released into the San Joaquin River as part of coded-wire tag studies. The SJRRP released juvenile Central Valley spring-run Chinook salmon into the San Joaquin River annually during 2014-2016.

The San Joaquin Hatchery, which began operating in 1954, is currently one of the largest hatcheries in the state (CDFW 2016c). Historical annual production was as high as 3,000,000 fingerlings, 20,000 sub-catchable fish, and 800,000 catchable fish, with a total weight of 165,000 pounds (Leitritz 1970). Currently, the hatchery raises brook trout, cutthroat trout, Eagle Lake trout, golden trout, kokanee, and rainbow trout (CDFW 2016d). Annual average production during 2004-2008 included approximately 6,000 brook trout (mostly fingerlings), 1,700 cutthroat trout (sub-catchable), 171,000 Eagle Lake trout (fingerlings, sub-catchable, and yearlings), 26,000 golden trout (fingerlings), 314,000 kokanee (fingerlings), and 1.2 million rainbow trout (primarily fingerlings and yearlings) (CDFG and USFWS 2010).

The Merced River Fish Hatchery, located just downstream of the Crocker-Huffman Diversion Dam and operated by CDFW, began production in 1970 (Merced Irrigation District 2012). The hatchery rears fall-run Chinook salmon and follows an integrated broodstock strategy. Broodstock consists of unsegregated, natural and hatchery-produced Chinook salmon that volitionally enter the hatchery's facilities. The original annual production targets for the facility were 960,000 fall-run Chinook salmon smolts and 330,000 yearlings. However the yearling program was discontinued due to losses from proliferative kidney disease. The current production target is 1 million smolts by late April to mid-May. Potential release locations include the Merced River at the hatchery, locations along the lower Merced River, and the lower San Joaquin River. A Hatchery Genetic Management Plan (HGMP) has not been prepared for the Merced River Fish Hatchery, and until a HGMP is completed, the hatchery will continue to operate according to the existing hatchery and stocking plan. Chinook salmon produced at the Merced River Fish Hatchery are routinely used for investigations in the San Joaquin River watershed, such as the previously conducted VAMP smolt survival evaluations, and have been stocked in the Stanislaus and Tuolumne rivers. The Merced Irrigation District and others voluntarily fund the coded-wire tagging of smolts produced at the hatchery.

The Mokelumne River Hatchery, constructed in 1963 by the East Bay Municipal District and remodeled in 2002, is currently used to raise Chinook salmon and steelhead (CDFW 2016e). Fish production is used to offset impacts on fisheries due to construction of Camanche Dam (ICF Jones & Stokes 2010). Chinook salmon broodstock used at the hatchery is of Central Valley origin, and steelhead broodstock is from the Feather River Hatchery, the American River, and Battle Creek (CDFW 2012). The annual smolt production target for fall-run Chinook salmon is 5 million, and approximately 2 million additional Chinook are raised to post-smolt size for an ocean enhancement program. The annual production goals for steelhead are 250,000 yearlings and smaller numbers of two-year-olds, which are released in groups of less than 2,000 individuals (California HSRG 2012). The normal Mokelumne River Hatchery release schedule is as follows: (1) fall-run Chinook salmon smolts are released from May through July into San Pablo Bay at 40–60 fish per pound and (2) steelhead yearlings are released from January through February into the lower Mokelumne River at four fish per pound.

Freshwater Salmonid Harvest

In the Central Valley, recreational fishing for steelhead is a popular activity, but harvest is restricted to visibly marked hatchery-origin fish, which reduces the likelihood of anglers retaining naturally spawned fish (NMFS 2014). A combination of gear restrictions, closures, and size limits have been formulated to protect CCV steelhead smolts (NMFS 2014).

It is unclear to what degree historical commercial harvest took place in the Tuolumne River, but based on the scale of harvest within the San Joaquin River basin as a whole, past harvest, especially in the late 1800s and early 1900s, could have been significant.

Non-Native Fish Species

Of the 22 non-native fish species documented in the lower Tuolumne River, 18 were introduced by state or federal agencies (CDFW, NMFS, USFWS, and the State Board of Human Health) between 1874 and 1954, and one was introduced with permission from CDFW in 1967 (Dill and Cordone 1997; Moyle 2002). The remaining three species were introduced by aquarists, catfish farms, or private individuals (Dill and Cordone 1997). Sixteen of the fish species released by state or federal agencies were introduced intentionally for sport or commercial fisheries, as a prey base for sport fish, or for mosquito control; two were introduced incidentally with shipments of sport fish (Dill and Cordone 1997). The most abundant and widespread non-native fish species in the lower Tuolumne River, bluegill, redear sunfish, and green sunfish, were first released in California between 1891 and 1954. Largemouth and smallmouth bass were first released in California by CDFW between 1874 and 1891 (Dill and Cordone 1997; TID/MID 1992b). The other introduced fish species in the lower Tuolumne River include threadfin shad, black and brown bullhead, white and channel catfish, common carp, fathead minnow, red shiner, golden shiner, goldfish, striped bass, black and white crappie, warmouth, bigscale logperch, western mosquitofish, and inland silversides.

Management and Recovery Activities

Native Salmonid Management and Recovery Programs

Steelhead management has been addressed by a number of federal and state initiatives. The Central Valley Steelhead Recovery Plan (NMFS 2014) describes recovery strategies; lists recovery goals, objectives, and criteria; and proposes recovery scenarios and numerous recovery actions for steelhead throughout the Central Valley. The California Advisory Committee on Salmon and Steelhead Trout was established by the California legislature in 1983 to develop a strategy for the conservation and restoration of salmon and steelhead in California.

The Central Valley Salmon and Steelhead Restoration and Enhancement Plan (CDFG 1990) was intended to outline CDFW's restoration and enhancement goals for salmon and steelhead in the Sacramento River and San Joaquin River systems and to provide direction for various CDFW programs and activities.

The Restoring Central Valley Streams (CDFG 1993) plan identifies the following goals to benefit anadromous fish: restore and protect California's aquatic ecosystems that support fish and wildlife, protect threatened and endangered species, and incorporate the state legislature's mandate and policy to double the size of populations of anadromous fish in California. The plan encompasses only Central Valley waters accessible to anadromous fish, excluding the Sacramento-San Joaquin Delta.

The Steelhead Restoration and Management Plan for California (CDFG 1996), which focuses on restoration of native and naturally produced fish stocks, has the following goals: (1) increase natural production, as mandated by The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988, so that steelhead populations are self-sustaining and maintained in good condition and (2) enhance angling opportunities and non-consumptive uses.

The CVPIA established the AFRP in 1992, which directed the Secretary of the Interior to develop and implement a program that made "all reasonable efforts to at least double natural production of anadromous fish in California's Central Valley streams on a long-term, sustainable basis." Approximately $15 million per year of CVPIA restoration funds are to be used to protect, restore, and enhance special-status species and their habitats in areas directly or indirectly affected by the CVP. Through the AFRP, federal funding was allocated for spawning gravel augmentation, instream flow management (i.e., use of 800 thousand acre feet of water from the CVP), and habitat restoration projects, including the Bobcat Flats project on the Tuolumne River. The AFRP also includes elements aimed at obtaining funds for fish screening projects.

To protect wild steelhead in California, all hatchery steelhead receive an adipose fin-clip, although they are not coded-wire tagged, so hatchery of origin and straying rates for particular stocks cannot be discerned (NMFS 2014). The State of California also works closely with NMFS to review and improve inland fishing regulations (NMFS 2014). These include zero bag limits for unmarked steelhead, gear restrictions, closures, and size limits designed to protect smolts.

Habitat Protection, Restoration, and Enhancement Projects

Conditions in the lower Tuolumne River have been improved by the involvement of the TAC, the role of which was formalized in the Districts' 1995 settlement agreement. Since the early 1990s, the TAC has been engaged in developing, reviewing, and participating in activities to improve and protect the fisheries of the Tuolumne River downstream of La Grange Diversion Dam. In addition to the Districts, the TAC includes members from state and federal resource agencies, CCSF, and NGOs.

As directed under the 1995 Settlement Agreement, the TAC developed 10 priority habitat restoration projects aimed at improving geomorphic and biological aspects of the lower Tuolumne River corridor (listed below), which have the potential to benefit *O. mykiss* at one or more times during the species' life cycle.

- Channel and Riparian Restoration Projects (RM 34.3-RM 40.3)
    - Gravel Mining Reach Phase I - 7/11 Gravel Mining Reach Restoration (restored channel and floodplain along 1.5 river miles) (RM 38-39.5) (completed in 2003)
    - Gravel Mining Reach Phase II (not completed)[17]
    - Gravel Mining Reach Phase III (not completed)

[17] By the terms of the 1995 Settlement Agreement, the Districts and CCSF pledged $500,000 and an additional $500,000 in matching funds for Tuolumne River restoration projects. Also by the terms of the agreement, CDFW and USFWS were responsible for actively pursuing state and federal funding. After securing funding and constructing the initial four priority projects identified by the TAC, CDFW, while supporting additional restoration projects at the TAC, actively opposed using CALFED funding for additional projects. Consequently, approved CALFED funding of over $14.75 million for three additional TAC projects, designed to benefit fall-run Chinook and *O. mykiss*, was never able to be used and the projects were never implemented due to factors outside the control of the Districts.

- Gravel Mining Reach Phase IV (not completed)

▪ Predator Isolation Projects
  - Special Run Pool (SRP) 9 Channel and Floodplain Restoration (restored channel and floodplain along 0.2 river miles) (RM 25.7-25.9) (completed in 2001)
  - SRP 10 (RM 25.5) (not completed)

▪ Sediment Management Projects (RM 43.0-RM 51.8)
  - River Mile 43 Channel Restoration (restored channel and floodplain along 0.5 river miles) (completed in 2005)
  - Gasburg Creek Fine Sediment Retention Project (RM 50) (completed in 2008)
  - Gravel Augmentation (coarse sediment) (not completed)
  - Riffle Cleaning (fine sediment) (not completed)

Other restoration efforts have been implemented in the lower Tuolumne River corridor by various groups, including FOT, TRT, NRCS, ESRCD, USFWS, CDFW, Stanislaus County, and the cities of Waterford, Ceres, and Modesto.

To improve salmonid spawning and rearing conditions in the lower Tuolumne River, several coarse sediment augmentation and habitat restoration projects have been completed (TID/MID 2005, from TID/MID 2013e). CDFW placed approximately 27,000 yd^3 of gravel in the river near Old La Grange Bridge (RM 50.5) from 1999 to 2003 (TID/MID 2007, Report 2006-10). Riffle and floodplain reconstruction projects have also been completed at Bobcat Flat (RM 43.5), near the site of 7/11 Materials (RM 40.3–37.7), and at SRPs 9 and 10 (approximately RM 25.7) (TID/MID 2007, Report 2006-8), with designs and preliminary permitting completed for additional gravel augmentation projects at upstream locations.

Riparian restoration projects along the Tuolumne River include Grayson River Ranch, Big Bend, SRP 9, 7/11 Mining Reach Segment #1, and RM 43 at Bobcat Flat. Floodplain restoration was conducted at Grayson River Ranch (located approximately 4 miles upstream of the San Joaquin River confluence) by FOT in 2000. Anecdotal evidence indicates that some recovery of riparian vegetation has occurred on the floodplain and along newly constructed sloughs. The TRT and other partners acquired approximately 250 acres on both sides of the Tuolumne River at Big Bend (RM 5.8 to 7.4). Restoration was completed in 2005, and monitoring results suggest that planting to reestablish native, woody riparian species has been effective. In 2001, restoration of river and floodplain habitat was completed at SRP 9 (RM 25.7 to 25.9). A brief survey conducted in 2002 indicated that tree survival typically exceeded 60 percent for most species one year after planting. In 2003, restoration of river and floodplain habitat was completed at the 7/11 site (RM 40.3 to 34.4). Post-project monitoring has been limited to quantifying survival of planted vegetation and replacing plants as stipulated in the construction contract. The Bobcat Flat restoration site includes 303 acres of riparian and instream habitat owned by FOT. Restoration was conducted in 2005-2006, and anecdotal evidence and site photos indicate some success in restoring riparian vegetation at the site.

The AMF was initiated in 2001 to review designs for restoration projects in Central Valley rivers and assist resource agencies and tributary restoration teams. The AMF panel of technical experts reviewed and made recommendations concerning tributary restoration projects and called for incorporating adaptive management into projects to maximize restoration success.

5.4.2 Assessment of Cumulative Effects on CCV Steelhead

Because continued generation of hydroelectric power would result in no effect on the lower river (see Sections 5.1 and 5.2), it cannot contribute to cumulative effects in the Action Area. The Districts' proposed resource enhancement measures would, however, contribute to cumulative effects, as described below (direct effects of the Districts' resource enhancement measures are provided in Section 5.3). Although there are potential effects on CCV steelhead resulting from unrelated, non-interdependent actions associated with the Don Pedro Project as a whole, these are not part of the Proposed Action. The effects of the actions on *O. mykiss* and their habitat within the Action Area are discussed in the following sections.

Any CCV steelhead occurring in the Action Area are affected by a large number of past, present, and potential future anthropogenic actions and background environmental conditions. Factors that influence any steelhead in the Action Area include water management activities, past and present in-river and floodplain mining, a variety of historical and current land-use practices, non-native species, ongoing fisheries management, and habitat restoration activities.

The cumulative effects of the overall Don Pedro Project–i.e., effects due to aspects of the Project that are not part of the Proposed Action–are attenuated with increasing distance downstream in the Action Area. With increased distance downstream of the Project, the number and complexity of factors affecting the environment grow considerably, and it becomes increasingly difficult to isolate the specific effects of any individual action on the life cycle of CCV steelhead.

The following cumulative effects assessment is organized according to the type of effects produced by the actions described in Section 5.4. Topics include (1) hydrologic and physical habitat alteration, (2) temperature and water quality, (3) connectivity and entrainment, (4) hatchery fish propagation and stocking, (5) introduced fish species and predation, (6) benthic invertebrates and fish food availability, and (7) freshwater harvest. The geographic scope of the assessment, as noted above, pertains to the Action Area, i.e., the Tuolumne River from La Grange Diversion Dam (RM 52.2) downstream to the San Joaquin River.

5.4.2.1 Hydrologic and Physical Habitat Alteration

Prior to widespread settlement, the channel form of the lower Tuolumne River consisted of a combination of single-thread and split channels that migrated and avulsed (McBain & Trush 2000). Variation in hydrologic and geologic controls, primarily valley width and the location and elevation of underlying bedrock, resulted in variable and complex localized channel morphologies (McBain & Trush 2000). The riparian corridor was miles wide in places where the river lacked confinement (McBain & Trush 2000). More than a century of cumulative impacts have transformed the lower Tuolumne River from a dynamic, alluvial system capable of forming its own bed and bank morphology to a river constrained between either man-made dikes or agricultural fields, or constrained by riparian vegetation that has encroached into the low-water channel (McBain & Trush 2000).

Over the past 120 years, each increment of flow regulation (Wheaton, La Grange, O'Shaughnessy, old Don Pedro, and new Don Pedro dams along the mainstem and dams constructed along tributaries above O'Shaughnessy Dam, including Cherry and Eleanor Creeks) has modified the lower Tuolumne River hydrologic regime. Historically, Wheaton Dam and the present day La Grange Diversion Dam lacked the storage capacity needed to affect high flow conveyance to the lower Tuolumne River during winter and spring (McBain and Trush 2000). CCSF's Hetch Hetchy Project, the Districts' Don Pedro Dam, and CCSF's Cherry Lake combined to reduce the magnitude and frequency of flood flows and snowmelt runoff to the Tuolumne River downstream of La Grange Diversion Dam.

Analyses of streamflow records from the USGS gaging station at La Grange (Station 11-289650) reveal the following alterations of hydrologic conditions: (1) the magnitude and variability of summer and winter base flows, fall and winter storm flows, and spring snowmelt runoff have been reduced and (2) the magnitude, duration, and frequency of winter floods have been reduced (McBain & Trush 2000). Following completion of the New Don Pedro Dam in 1971, compliance with ACOE flood control and other flow requirements reduced the estimated average annual flood (based on annual maximum series) from 18,400 cfs to 6,400 cfs.

These changes in hydrology have both immediate impacts on habitat conditions (e.g., effects on depth, velocity, water temperature, etc.) for CCV steelhead and the non-native piscivores that may prey on any steelhead present in the Action Area. Hydrologic alterations have also had longer-term impacts on aquatic habitat characteristics due to changes in flow magnitude and timing, flood frequency, sediment supply and transport, and channel morphology.

The operation of La Grange Diversion Dam has directly affected flows in the lower Tuolumne River since 1893, thereby influencing water resources and, as a result, CCV steelhead habitat in the Action Area. The direct effects resulting from La Grange Diversion Dam operations occur whenever all flows, except FERC-required minimum flows, are diverted to meet the needs of the Districts' water users. During flood management periods that coincide with water diversions, La Grange Diversion Dam operations contribute to cumulative effects in the Action Area, but during flood management periods when there are no such diversions, the La Grange Project does not contribute to either direct or cumulative effects on CCV steelhead habitat in the Action Area, and effects are due to flood management requirements alone.

Gravel and gold mining, as well as other land uses, adversely affected aquatic habitat prior to dam construction on the Tuolumne River (TID/MID 2005) (see Section 5.4.1.1 for a summary of the chronology of current and historic actions within the Tuolumne River basin). The presence of dams, aggregate extraction, agricultural and urban encroachment, and other land uses have resulted in sediment imbalances in the lower Tuolumne River channel (McBain & Trush 2000). Don Pedro Dam and La Grange Diversion Dam, combined with other dams upstream of the Project, trap all coarse sediment and woody debris that would otherwise pass downstream, and excavation of bed material for gold and aggregate to depths below the river thalweg has significantly reduced steelhead spawning habitat availability, eliminated active floodplains and terraces, and created large in- and off-channel pits that provide habitat suitable for non-native predator species. The channel downstream of La Grange Diversion Dam is characterized by downcutting, widening, armoring, and depletion of sediment storage features (e.g., lateral bars and riffles) due to the cumulative effect of sediment trapping by upstream reservoirs, mining, and other land uses (CDWR 1994; McBain & Trush 2004). Sequences of historical photos show that channel corridor width has been progressively reduced by land use (McBain & Trush 2000).

Sediment model simulations indicate that without gravel augmentation, the channel bed from RM 52 to 39.7 would undergo a slow degradation (as opposed to aggradation) and coarsening (armoring) in response to the reduction in sediment supply (TID/MID 2013g). Gravel augmentation, however, has helped to increase coarse sediment storage in this area (TID/MID 2013g). The current rate of gravel transport compared to the stores of gravel in most of the Action Area is low, and little change in overall gravel availability is expected to occur over the next several decades.

As noted above, the large pits formed where aggregate was extracted from the channel created SRPs. Historical deposits of dredger tailings (RM 50.5–38.0) confined the active river channel, preventing sediment recruitment that would otherwise have resulted from the normal process of channel migration (McBain and Trush 2000). Under current conditions, channel migration has been substantially curtailed.

More recent aggregate mining operations have excavated sand and gravel from floodplains and terraces immediately adjacent to the river channel at several locations downstream of Roberts Ferry Bridge (RM 39.5). Floodplain and terrace pits in this reach are typically separated from the channel by narrow berms that can breach during high flows, resulting in capture of the river channel. The January 1997 flood caused extensive damage to dikes separating deep gravel mining pits from the river, breaching or overtopping nearly every dike along a 6-mile-long reach in the lower river (TID/MID 2011).

Most woody debris captured in Don Pedro Reservoir is small, and it appears that the majority of it would pass through the lower Tuolumne River during high flows if it were not trapped in the reservoir (TID/MID 2017d). The lower Tuolumne River between RM 52 and 26 has channel widths averaging 119 feet, and woody debris would have a limited effect on the morphology of such a channel (TID/MID 2017d). It is unknown, however, to what extent smaller pieces of wood might add to existing wood accumulations or initiate small jams in the lower river, thereby increasing habitat complexity.

Historical clearing of riparian forests in the Tuolumne River basin modified vegetation and associated habitat, halting many attendant ecosystem processes (Katibah 1984, Naiman et al. 2005). Urban and agricultural encroachment and mining have resulted in the direct removal of large tracts of riparian vegetation. Livestock selectively graze younger riparian plants, which limits the establishment of vegetation adjacent to the channel (McBain & Trush 2000). The clearing of woody plant cover has also created openings in the riparian corridor where non-native plant species have become established and proliferated (McBain and Trush 2000). Land conversion and levee construction that constrain channel migration, including alteration of meander bends and cutoff/oxbow formations, have reduced riparian complexity (McBain and Trush 2000, Grant et al. 2003).

Mining has also substantially altered riparian conditions along the lower Tuolumne River. Aggregate mining leaves large pits in the floodplain, converting floodplain vegetation to open water. Levees built to isolate mining pits from the river constrain lateral movement of the river (TID/MID 2013f, W&AR-19), which precludes regeneration of riparian vegetation by reducing the amount and diversity of riparian habitat surfaces (TID/MID 2013f, W&AR-19). Dredger tailings of unconsolidated sediments on the floodplain have replaced rich soils with poor ones, resulting in changes to riparian plant species composition and reducing the extent and diversity of riparian vegetation (TID/MID 2013b). The reduced development of riparian vegetation on dredger spoil piles has also diminished riparian habitat connectivity (TID/MID 2013b).

Flow regulation and sediment trapping associated with upstream dams indirectly affected riparian vegetation by modifying the hydrologic and fluvial processes that influence survival and mortality of riparian vegetation. As noted above, each increment of flow regulation (La Grange Diversion Dam, Hetch Hetchy Dam, Old Don Pedro Dam, New Don Pedro Dam) successively reduced the magnitude, duration, and frequency of flood flows, and removed key mortality agents, including scour, channel migration, flood-induced toppling, and inundation (McBain & Trush 2000). Reduced flood scour allowed riparian vegetation to initiate along the low water channel, where historically vegetation would have been absent.

The lateral extent of riparian vegetation along the Tuolumne River remains greatly diminished from what it was prior to large-scale settlement along the river. Currently, less than 15 percent of the historical riparian forests remain along the Tuolumne River (McBain & Trush 2000). However, over the past 15 years the areal extent of lands dominated by native plants has slowly increased (TID/MID 2013b), with a 419-acre increase in the net extent of native vegetation between 1996 and 2012 (an average increase of about 8 acres/mile), brought about primarily through active vegetation restoration projects (TID/MID 2013b).

Anadromous fish abundance in the Tuolumne River has been reduced by habitat degradation and extensive instream and floodplain mining beginning in the mid-1800s (McBain and Trush 2000). Dams and water diversions associated with mining had affected fish migration as early as 1852 (Snyder 1993 unpublished memorandum, as cited in Yoshiyama et al.1996). Access to historical spawning and rearing habitat was significantly restricted beginning in the 1870s, when a number of dams and irrigation diversion projects were constructed. Wheaton Dam, built in 1871–three years before either District was formed–near the site of the present-day La Grange Diversion Dam, was a barrier to anadromous fish migration. In 1884, the California Fish and Game Commission reported that the Tuolumne River was “dammed in such a way to prevent the fish from ascending” (California Fish and Game Commission 1884, as cited in Yoshiyama et al. 1996).

Because no impact of power peaking occurs downstream of La Grange Diversion Dam, the potential risk of juvenile steelhead stranding or entrapment is low. Some stranding may occur during flow reductions following flood control releases. However, the low frequency of these flood events, in combination with ramping rate restrictions required by the current FERC license, likely result in a low overall risk of fish mortality due to stranding and entrapment (TID/MID 2013e). A comprehensive evaluation of stranding surveys was conducted on the lower Tuolumne River (TID/MID 2000, Report 2000-6) and is summarized in the Districts' 2005 Ten-Year Summary Report (TID/MID 2005). This evaluation indicated that the highest potential for stranding occurred at flows between 1,100 and 3,100 cfs, i.e., the range of flows under which the floodplain is inundated in several areas along the gravel-bedded reach.

Although increased structure has been shown to reduce territory size that must be defended (Imre et al. 2002) and to improve steelhead feeding opportunities (Fausch 1993), it is unlikely that the alluvial portions of the Tuolumne River downstream of La Grange Diversion Dam historically supported the large wood or boulder features more typically found in high-gradient streams of the Central Valley and along the coasts of California and Oregon (TID/MID 2013e). Therefore, it is unclear to what degree wood retention by upstream dams has contributed to adverse habitat effects in the lower river.

SRPs, which can be up to 400 ft wide and 35 ft deep and occupy approximately 32 percent of the length of the channel in the gravel-bedded reach (RM 52–24), harbor non-native fish, such as largemouth and smallmouth bass, which prey on juvenile salmonids. Introduced predators have been, and continue to be, most abundant in low-velocity areas prevalent in the middle section of the lower Tuolumne River (Orr 1997), making it likely that the present pattern and degree of predation mortality for any steelhead that occupy the Action Area is to a large extent a result of habitat alterations due to past sand and gravel mining coupled with the introduction of non-native piscivorous fish species (Orr 1997).

Measures have been undertaken to improve conditions for migratory and resident salmonids in the Tuolumne River relative to what they would otherwise be. Since implementation of increased summer flows under the 1996 FERC Order, the abundance of *O. mykiss* has increased (TID/MID 2013e). The habitat protection, restoration, and enhancement projects described in Section 5.4.1 have improved instream habitat (e.g., boulder placement and gravel augmentation) and riparian conditions, which may have benefitted *O. mykiss*.

Continued hydroelectric power generation at the Project as part of the Proposed Action would not contribute to cumulative effects on aquatic resources in the lower Tuolumne River, because the lower river flow regime is dictated by the independent, non-interrelated primary purposes of the Don Pedro Project (i.e., water supply, flood control, CCSF's water bank) and releases to protect aquatic resources. However, some of the Districts' proposed measures for the lower Tuolumne River would contribute positively to cumulative effects on flow regime and physical habitat, which would influence aquatic resources, as described below. Greater detail on the direct effects of these measures can be found in Section 5.3 of this Draft BA.

Coarse Sediment Augmentation

Coarse sediment augmentation at discrete locations from RM 52 to RM 39 would enhance the quality and quantity of *O. mykiss* spawning habitat. Adding coarse sediment (0.125–5.0 inches in diameter) to the river channel at locations selected based on biological and geomorphic needs, would result in the following expected benefits (1) an increase in *O. mykiss* egg-to-emergence ratio, (2) increased benthic macroinvertebrate production, and (3) potentially improved hyporheic flow and cold water habitat downstream of La Grange Diversion Dam.

Gravel Mobilization Flows

Flow releases ranging from 6,000–7,000 cfs would provide the following expected benefits (1) reduced fine sediment storage in the low-flow channel and in spawning gravels, which could increase *O. mykiss* egg-to-emergence success and fry production, and benthic macroinvertebrate production, (2) increased fine sediment storage on floodplains, which could improve regeneration of native riparian plant species during wetter water years, and (3) a net increase in lateral channel migration, bar formation, and large wood introduction, which together could create new floodplains and complex hydraulic environments for improved adult *O. mykiss* holding, spawning, and juvenile rearing.

Experimental Gravel Cleaning Program

Experimental gravel cleaning to flush fine sediments from gravel interstices has the potential to expand the availability of high quality gravel, which could improve spawning success and egg incubation for *O. mykiss*. To minimize potential adverse effects on *O. mykiss* redds, gravel cleaning would occur after April 30.

Boulder Placement

Boulders (approximately 0.07-1.5 yd^3 in size) placed between RM 50 and 42 are expected to provide favorable microhabitats for *O. mykiss* (TID/MID 2017d) by increasing structural and hydraulic complexity, and improve spawning habitat for *O. mykiss* as localized scour displaces fines from gravel beds. This measure could also result in local increases in benthic macroinvertebrate production, through substrate improvements due to the scouring of fines.

Contribute to CDBW’s Efforts to Remove Water Hyacinth

Providing funds to CDBW for the removal of water hyacinth in the lower Tuolumne River would likely benefit aquatic biota in the lower river, although *O. mykiss* are very rare in the lowermost reaches of the river where water hyacinth infestations occur.

Fall-Run Chinook Spawning Improvement Superimposition Reduction Program

A temporary barrier weir would be installed in the lower river channel to reduce rates of fall-run Chinook redd superimposition. Because suitable *O. mykiss* habitat is available both upstream and downstream of the potential placement locations of the weir, i.e., at or upstream of approximately RM 47, seasonal installation of the weir is not expected to affect *O. mykiss* in the river (*O. mykiss* are predominantly found upstream of RM 42).

Flow-Related Measures for Fish and Aquatic Resources in the Lower Tuolumne River

The Districts are proposing to implement the flow regime summarized in Table 5.3.2 (and described in greater detail in Section 5.3) to achieve the following aquatic resource objectives: (1) flows from June 1–June 30 to benefit *O. mykiss* fry rearing (2) flows from July 1–October 15 to benefit *O. mykiss* juvenile rearing, (3) flows from October 15–December 31 to provide habitat for fall-run Chinook spawning, (4) flows from January 1–February 28/29 to provide habitat for fall-run Chinook fry rearing, (5) flows from March 1 – April 15 to provide habitat for fall-run Chinook juvenile rearing, (6) fall-run Chinook outmigration base flows from April 16–May 31, and (7) outmigration pulse flows from April 16–May 31. The benefits of these flows to *O. mykiss* in terms of physical habitat availability are described in detail in Section 5.3.

Flow Hydrograph Shaping

Shaping the descending limb of the snowmelt runoff hydrograph to mimic natural conditions to facilitate cottonwood seed dispersal would increase natural recruitment of snowmelt-dependent hardwoods that could contribute LWD to the channel over the long-term and potentially provide cover and shade for *O. mykiss*.

5.4.2.2 Water Quality

Water quality conditions (primarily temperature and DO) with the potential to adversely affect any CCV steelhead in the Action Area are thought to be limited to late spring through early fall. Temperature modeling conducted to evaluate the reach of the Tuolumne River from La Grange Diversion Dam to the confluence with the San Joaquin River showed that water temperatures in this reach are typically affected more by meteorological conditions than they are by changes in flows.

Because adult resident *O. mykiss* are generally found in upstream habitats of the lower Tuolumne River throughout the year (Stillwater Sciences 2012b), temperature related mortality is unlikely to occur in the lower Tuolumne River. It is unknown, however, whether adverse temperature effects occur during potential smolt emigration occurring late in the spring (TID/MID 2013e). As noted previously, increased summer base flows and stable summer temperatures in the Tuolumne River since 1996 appear to have selected for a largely resident *O. mykiss* life history (TID/MID 2013e).

Water temperatures in the lower Tuolumne River are unlikely to cause mortality, either directly or as the result of increased susceptibility to pathogens, of any upstream migrating adult steelhead that may enter the Tuolumne River (TID/MID 2013e). NMFS (2014, Appendix B) states that because steelhead immigration into the Tuolumne River occurs mainly during winter, water temperatures downstream of La Grange Diversion Dam are probably suitable for adult immigration.

The CCV steelhead spawning period extends from December through April and peaks in February and March, so water temperature would be unlikely to adversely affect spawning success of any steelhead present in the lower Tuolumne River (TID/MID 2013e). NMFS (2014,

Appendix B) states that water temperatures in the lower Tuolumne River during winter are probably suitable for steelhead spawning.

Available information suggests that juvenile *O. mykiss* rearing habitat may at times be limiting in the lower Tuolumne River during summer due to a combination of high water temperatures and potential territorial interactions with *O mykiss* of older age classes (TID/MID 2013e). Increased densities and downstream distribution of juvenile *O. mykiss* have been documented since implementation of increased summer base flows under the 1996 FERC Order, and during years with extended flood control releases (TID/MID 2013e). NMFS (2014, Appendix B) states that high water temperatures during summer months are likely a limiting factor for steelhead rearing in the lower Tuolumne River, especially at low flows. NMFS (2014, Appendix B) states that current FERC-mandated flow schedules appear to provide suitable rearing habitat for the first 15 miles downstream of La Grange Diversion Dam during non-dry years (McBain & Trush 1998), but temperatures may not be low enough (i.e., < 14 °C) to optimize smoltification and increase survival to the ocean. NMFS (2014, Appendix B) states that water quality, other than temperature, is not likely to adversely affect juvenile steelhead in the Tuolumne River.

A study recently conducted by the Districts, i.e., Thermal Performance of Wild Juvenile *Oncorhynchus mykiss* in the Lower Tuolumne River: a Case for Local Adjustment to High River Temperature (TID/MID 2015), calls into question some of the current assertions made about temperature suitability for *O. mykiss* in the lower Tuolumne River. The thermal performance study (i.e., the “swim tunnel” study) (TID/MID 2015) showed that wild *O. mykiss* from the lower Tuolumne River can maintain 95 percent of peak aerobic capacity over a temperature range of 17.8 °C to 24.6 °C, and all fish tested could maintain sufficient aerobic capacity to properly digest a meal at temperatures up to 23 °C. Video analysis of *O. mykiss* swimming activity in the Tuolumne River indicates that fish at ambient water temperatures have an excess aerobic capacity well beyond that needed to swim and maintain station against the river’s current in their usual habitat.

These thermal performance results are consistent with those derived for *O. mykiss* populations known to be high-temperature tolerant, such as the redband strain of rainbow trout (*O. mykiss gairdneri*) that occurs in the high deserts of eastern Oregon and Idaho. Whether the high thermal performance that was demonstrated for the *O. mykiss* of the Tuolumne River downstream of La Grange Diversion Dam arose through genetic selection or physiological acclimatization was beyond the scope of the thermal performance study.

Results of the study (TID/MID 2015) support the hypothesis that the thermal tolerance of wild *O. mykiss* from the Tuolumne River represents an exception to that expected based on the 18 °C 7DADM criterion set out by EPA (2003) for Pacific Northwest *O. mykiss*. Given that lower Tuolumne River *O. mykiss* can maintain 95 percent of peak aerobic capacity at temperatures up to 24.6 °C, a more reasonable upper performance limit is likely to be 22 °C, rather than the established 18 °C.

Results from a CDFW (2014) drought stressor monitoring case study are consistent with the general findings of the thermal performance study (i.e., that *O. mykiss* in California tolerate temperatures greater than 18 °C). From May through October 2014, 453 juvenile steelhead were caught in the lower American River (83 [18 percent] were of natural origin and 370 [82 percent] were of hatchery origin). A portion of these fish were PIT tagged (14 of natural origin and 59 of hatchery origin). Average monthly water temperature from July through September 2014 was 20 °C (68 °F), and the maximum observed temperature during this period was 22.8 °C (73 °F). Growth rates of recaptured fish were high (1.23-1.38 mm/day), but CDFW reports that "there were no visible signs of stress in the captured fish."

Shoreline protection measures at Don Pedro Reservoir, including prohibition of shoreline disturbances and off-road vehicle use on Project lands, benefit reservoir water quality, which could translate into limited downstream water quality benefits. There is no evidence that regulated herbicide and pesticide applications near recreation and operational facilities adjacent to Don Pedro Reservoir have adverse effects on water quality in the Tuolumne River.

The CDPR has documented over 300 herbicides and pesticides that are discharged throughout agricultural regions of the Central Valley and Delta (Werner et al. 2008). Six pesticides were detected in runoff from agricultural and urban areas during a study conducted in the lower Tuolumne River, and chlorpyrifos, DCPA, metolachlor, and simazine were detected in almost every sample (Dubrovsky et al. 1998). Peak diazinon concentrations measured in the lower Tuolumne River have frequently exceeded levels that can be acutely toxic to some aquatic organisms (Dubrovsky et al. 1998).

Section 303(d) of the federal Clean Water Act (CWA) requires each state to submit to the EPA a list of rivers, lakes, and reservoirs for which pollution control and/or requirements have failed to provide adequate water quality. Based on a review of this list, the surface water bodies identified by the State Water Resources Control Board (SWRCB) as CWA § 303(d) State Impaired in and adjacent to the lower Tuolumne are listed in Table 5.4-6.

Table 5.4-6. Clean Water Act Section 303(d) List for the lower Tuolumne River and associated water bodies.

Water Body	Pollutant	Final Listing Decision
Lower Tuolumne River (Don Pedro Reservoir to San Joaquin River)	Chlorpyrifos	List on 303(d) list (TMDL required list)
	Diazinon	Do Not Delist from 303(d) list (TMDL required list)
	Escherichia coli	List on 303(d) list (TMDL required list)
	Mercury	List on 303(d) list (TMDL required list)
	Temperature	List on 303(d) list (TMDL required list)
	Unknown Toxicity	List on 303(d) list (TMDL required list)
Turlock Lake	Mercury	List on 303(d) list (TMDL required list)
Modesto Reservoir	Mercury	List on 303(d) list (TMDL required list)
Dry Creek (tributary to Tuolumne River at Modesto)	Chlorpyrifos	List on 303(d) list (TMDL required list)
	Diazinon	List on 303(d) list (TMDL required list)
	Escherichia coli	List on 303(d) list (TMDL required list)
	Unknown Toxicity	List on 303(d) list (TMDL required list)

Source : http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2012.shtml (accessed June 2016).

Discharge of nutrients such as nitrogen and phosphorus from non-point runoff of agricultural fertilizer and point sources, such as water treatment facilities, stimulates algae growth, with attendant increases in the magnitude of diurnal DO variation. This can cause changes in food webs (Durand 2008) and as a result food availability for fish populations (TID/MID 2013e).

The extent to which CCV steelhead may be affected by pollutants is not well understood, but a range of literature sources suggests that early life history exposure to trace metals, herbicides, and pesticides may impair olfactory capabilities required for homing sensitivity (Hansen et al. 1999, Scholz et al. 2000, Tierney et al. 2010), which could affect arrival of adult steelhead in their natal streams. However, there is no documentation of olfactory impairment of returning adult CCV steelhead in the Action Area (TID/MID 2013e). It is also unknown whether pesticide levels affect rearing or any out-migrating steelhead juveniles (TID/MID 2013e) in the lower Tuolumne River.

Some of the Districts' proposed measures for the lower Tuolumne River would contribute to cumulative effects on water quality, which would influence *O. mykiss*, as described below. Greater detail on the direct effects, including potential short-duration impacts associated with initial implementation of these measures, can be found in Section 5.3 of this Draft BA.

Gravel Mobilization of 6,000 to 7,000 cfs

Flow releases ranging from 6,000–7,000 cfs could result in minor, short-duration pulses of turbidity. However, benefits to *O. mykiss* spawning habitat would outweigh any short-term effects on water quality associated with turbidity increases. Such turbidity increases are not expected to contribute significantly to cumulative effects on water quality in the basin.

Gravel Cleaning

Experimental gravel cleaning undertaken to flush fine sediments from gravel interstices and expand the availability of high quality gravel for *O. mykiss* has the potential to result in short-duration, localized increases in turbidity that might exceed state water quality standards. However, improvements in spawning gravel quality are likely to significantly outweigh any short-term effects of increased turbidity. As noted in Section 5.3, the Districts would coordinate with the SWRCB to secure necessary permits and conduct any required turbidity monitoring. If gravel cleaning is judged to be successful, the program would continue, adjusted as needed to comply with any water-quality related concerns of the SWRCB.

Contribute to CDBW's Efforts to Remove Water Hyacinth

The Districts propose to provide funds to the CDBW for the removal of water hyacinth in the lower Tuolumne River. Partial removal of these introduced invasive plants could improve water quality in the lower river, particularly during summer when plant densities and background water temperatures are higher, thereby resulting in a positive contribution to cumulative effects.

Early Summer Flows (June 1–June 30)

Instream flows provided from June 1–June 30 to benefit *O. mykiss* fry rearing would reduce water temperatures in the lower river relative to baseline conditions (see Section 5.3). Cooler water would benefit *O. mykiss*, thereby resulting in a positive contribution to cumulative effects in the lower Tuolumne River.

Late Summer Flows (July 1–October 15)

Instream flows provided from July 1–October 15 to benefit *O. mykiss* juvenile rearing would also reduce water temperatures in the lower river relative to baseline conditions (see Section 5.3). Cooler water would benefit *O. mykiss*, thereby resulting in a positive contribution to cumulative effects in the lower Tuolumne River.

During this period, the Districts would provide a flushing flow to clean gravels of accumulated algae and fines prior to the onset of substantial spawning. The Districts would provide an instream flow of 1,000 cfs (not to exceed 5,950 AF) on October 5, 6 and 7, with appropriate up and down ramps and IGs turned off. These flows would be provided in Wet, Above Normal, and Below Normal water years only. In Dry and Critical years, the flows at La Grange would continue to be 300 cfs, with withdrawals of 225 cfs at the IGs leaving 75 cfs in the river below RM 25.5. These flushing flows would not be expected to have significant effects on water quality, but would benefit *O. mykiss* spawning habitat.

Outmigration Base Flows (April 16 – May 16)

Instream flows provided from April 16–May 16 to facilitate fall-run Chinook outmigration would maintain favorable lower river water temperatures, which is expected to benefit salmonids (see Section 5.3). Base flows would at times be augmented by outmigration pulse flows, which would further reduce water temperature at a given location and extend the plume of colder water farther downstream. Providing lower water temperatures relative to baseline conditions would contribute positively to cumulative effects in the lower Tuolumne River.

Outmigration Base flows (May 16 – May 31)

To maintain lower water temperatures during this period, the Districts are proposing the following base flow releases: (1) 300 cfs (BN, AN, and W water years), (2) 275 cfs (D water years), and (3) 225 cfs (C water years). These base flows would, depending on environmental conditions, be augmented by outmigration pulse flows, which would further reduce water temperature at a given location and extend the plume of colder water farther downstream, thereby resulting in a positive contribution to cumulative effects in the lower Tuolumne River.

Flow Hydrograph Shaping

In spill years, the Districts would make reasonable efforts to shape the descending limb of the snowmelt runoff hydrograph to mimic natural conditions to promote seed dispersal and germination of cottonwoods and native willows. Increasing natural recruitment of snowmelt-dependent hardwoods would increase stands of trees that would eventually provide shade, which could over the long-term contribute to water temperature reduction, thereby contributing positively to cumulative effects in the lower Tuolumne River.

5.4.2.3 Connectivity and Entrainment

Dams throughout the San Joaquin River and its tributaries are potential barriers to upstream migration of anadromous salmonids and other migratory fish species. Dams and water diversions associated with mining adversely affected fish migration in the Tuolumne River as early as 1852 (Snyder 1993 unpublished memorandum, as cited in Yoshiyama et al.1996). Access to historic spawning and rearing habitat was significantly restricted beginning in the 1870s, when a number of dams and irrigation diversion projects were constructed on the Tuolumne River. Wheaton Dam, built in 1871 at the site of the present-day La Grange Diversion Dam (RM 52.2), was a barrier to salmonid migration.

As noted, there are approximately 26 points of water diversion along the lower Tuolumne River between La Grange Diversion Dam and the San Joaquin River. Diversions at these points typically occur during irrigation season. *O mykiss* in the Action Area might be subject to entrainment in these diversion intakes along the river, although there are no available data that can be used to assess the extent to which these diversions affect *O mykiss*, if they are affected at all.

5.4.2.4 Hatchery Propagation and Stocking

Recent studies have increasingly indicated adverse effects of hatchery-reared fish on co-occurring wild stocks with which they may interact via interbreeding, competition, or predation. Hatchery management was identified as a cause for the ESA listing of CCV steelhead (61 FR 41541; 63 FR 13347). Over the past few decades, the genetic integrity of CCV steelhead has been reduced by increases in the abundance of hatchery fish relative to wild fish, the reliance on out-of-basin stocks for hatchery production, and the straying of hatchery-origin fish (CDFG and NMFS 2001; California Hatchery Scientific Review Group [HSRG] 2012). Genetic introgression of hatchery stocks with “natural” stocks can result in a decrease in the biological fitness of the natural stocks (e.g., ISAB 2003, Berejikian and Ford 2004, Kostow 2004, Araki et al. 2007, Lindley et al. 2007, CDFG and NMFS 2001). In its most recent five-year review for the CCV steelhead DPS, NMFS (2016) states, “It is unclear whether the impacts of hatchery programs have changed in severity since the last review, but new information clearly suggests a loss of genetic diversity and population structure over time. Overall, impacts from hatcheries continue to be an ongoing threat to this DPS.”

Studies indicate that 63 to 92 percent of steelhead smolt production in the Central Valley is of hatchery origin (NMFS 2003), and hatchery fish account for the majority of the CCV steelhead DPS (Lindley et al. 2007). The HSRG (2012) expressed concern related to the predominance of Eel River genetics in the Nimbus Hatchery steelhead program (NMFS 2014), and *O. mykiss* populations downstream of migration barriers are in fact most closely related to populations in far northern California, specifically genetic groups that include the Eel and Klamath rivers (NMFS 2014). Because Eel River broodstock were used for years at the Nimbus Hatchery, it is likely that Eel River genes not only persist there but have also spread to other basins via straying (NMFS 2014).

Although all naturally-spawned *O. mykiss* in Central Valley river basins are to some degree related, (NMFS 2014), lower genetic diversity in *O. mykiss* populations above migration barriers indicates a lack of substantial genetic input from outside (i.e., downstream) sources. The genetic clustering of *O. mykiss* that occur upstream of migration barriers and relationships in California-wide genetics comparisons indicate that the above-barrier fish better represent the ancestral genetic structure of CCV steelhead than fish currently occurring below barriers (Garza and Pearse 2008).

Facilities that produce steelhead whose life histories could overlap temporally or spatially with *O. mykiss* in the Tuolumne River include the Coleman National Fish Hatchery, Feather River Fish Hatchery, Nimbus Hatchery, and the Mokelumne River Hatchery (ICF Jones & Stokes 2010). However, NMFS (2016) considers steelhead from the Coleman, Feather River, and Mokelumne River hatcheries to be part of the CCV DPS.

Although hatchery straying could affect any steelhead spawning in the lower Tuolumne River, the absence of basin-specific data on spawning or straying from out-of-basin hatcheries makes it difficult to determine to what extent hatchery-origin steelhead may attempt to spawn in the Action Area (TID/MID 2013e). However, based on the near absence of steelhead relative to resident *O. mykiss* documented in otolith analyses in the Tuolumne River (Zimmerman et al. 2009), and the low numbers of upmigrating *O. mykiss* observed at the counting weir, it is likely that effects of hatchery-origin fish would be primarily on resident *O. mykiss* (TID/MID 2013e).

No known fish stocking has occurred in the reach of the Tuolumne River between Don Pedro Dam and La Grange Diversion Dam (TID/MID 2013a), so rainbow trout in this reach appear to be displaced fish, likely of hatchery origin, from Don Pedro Reservoir. As noted in Section 4.0, the September 2011 population estimates conducted for larger fish (150–200 mm) downstream of La Grange Diversion Dam showed that *O. mykiss* numbers were substantially higher in 2011 than in 2010 (Stillwater Sciences 2012c). The larger population in 2011 relative to 2010 may be the result of an influx of fish that originated upstream of La Grange Diversion Dam (RM 52.2) during a year with substantial spill, although there is no empirical evidence of this occurrence. The potential interaction of these resident *O. mykiss* with the population downstream of La Grange Diversion Dam is poorly understood and complicates any future monitoring of population response to potential management measures.

Hatchery Genetic Management Plans (HGMPs) are being prepared pursuant to Section 7 of the ESA for hatcheries in California to guide the propagation of steelhead. The goal of the plans is to prevent adverse impacts on the genome of federally-listed fish and any potential effects of stocking on the size, abundance, run-timing, and distribution of wild fish.

In an attempt to encourage more harvest of hatchery-origin steelhead, regulations have been promulgated to incrementally increase the opportunity for harvest of hatchery-origin steelhead in the Central Valley (NMFS 2016). The rationale behind this is that increasing daily bag and possession limits for hatchery steelhead will minimize potential negative behavioral and genetic interactions with natural-origin steelhead.

As part of their suite of measures, the Districts propose to build, in cooperation with CDFW, a fall-run Chinook restoration hatchery to be operated by CDFW (see Section 5.3). The proposed supplementation program, like state and federal programs, would be implemented in accordance with procedures that prevent or minimize adverse impacts on wild fish. Temporary disturbance or displacement of *O. mykiss* could occur during instream installations or construction. No adverse effects on *O. mykiss* are predicted as the result of operating this facility.

5.4.2.5 Introduced Species and Predation

Predation on native salmonids in the lower Tuolumne River is influenced by channel modifications that have created habitats that support non-native piscivores. Reductions in flood frequency resulting from the construction of large upriver reservoirs have increased predator habitat suitability within in-channel pits and SRPs created by mining (Orr 1997; McBain & Trush 2000; Ford and Brown 2001). Inter-annual variations in flows and water temperatures have been associated with variations in river-wide predator distribution (Ford and Brown 2001) and year-class strength in multi-year surveys for the SRP 9 predator isolation project at RM 25.7 (McBain & Trush and Stillwater Sciences 2006).

No data exist to document the degree of piscine or avian predation on juvenile steelhead present in the lower Tuolumne River. Predation risk on resident *O. mykiss* in the lower river is likely low because their distribution during summer is generally restricted to cool water locations upstream of Roberts Ferry Bridge (RM 39.5), and predators are found mostly downstream of this reach (Brown and Ford 2002). In addition to this habitat segregation, the larger body size of adult *O mykiss* limits their risk to predation, so mortality is most likely limited to resident age 0+ fish during water-year types with low flows and warmer temperatures that allow predators to move upstream (TID/MID 2013e).

Predation on juvenile salmonids by piscivores is not the only adverse effect associated with introduced species. The presence of introduced zooplankton species and the overbite clam (*Corbula amurensis*) in the lower Tuolumne River (Brown et al. 2007) may have affected the availability of suitable prey for any rearing steelhead moving through this reach (see also, Benthic Invertebrates and Fish Food Availability, below).

The measures proposed by the Districts for implementation under the new license term, particularly the new counting weir and predator control program, will reduce the risk of predation on *O. mykiss*, as described in Section 5.3.

As explained in greater detail in Section 5.3, the Districts' proposed predator control and suppression program would consist of constructing and operating a barrier weir coupled with active predator control and suppression. The barrier weir, which would be located at RM 25.5, would prevent striped and black bass from moving into upstream habitats used by rearing *O. mykiss*. The weir would also provide a location where striped bass would likely congregate, thereby allowing them to be removed or isolated.

The Districts proposed comprehensive predator suppression and control program would consist of (1) isolating, collecting, and/or relocating striped bass prior to spring pulse-flow releases, (2) sponsorship and promotion of black bass and striped bass fishing derbies and reward-based angling at locations to diminish predator population sizes over time; other removal and/or isolation methods would include, but not be limited to, electrofishing, seining, and fyke netting, and (3) seeking and advocating for changes to fishing regulations for the lower Tuolumne River (e.g., length of season, bag limit, catchable size, requested removal of black bass/striped bass caught, allowing a bounty program) to reduce black and striped bass numbers and educating the public on the adverse effects of predation on *O. mykiss* in the Tuolumne River to encourage participation in the removal program and advocacy of changes to fishing regulations.

The proposed removal of striped and black bass would lead to substantial reductions in the abundance of non-native predators in the lower river, which in turn would lead to increases in the survival of juvenile *O. mykiss*, and as a result a positive contribution to cumulative effects in the lower Tuolumne River. Greater detail on the direct effects of these measures can be found in Section 5.3 of this Draft BA.

5.4.2.6 Benthic Invertebrates and Fish Food Availability

Analysis of long-term Hess sampling data gathered from 1988-2009 at Riffle 4A (RM 48.8) in the lower Tuolumne River indicates that increased summer flows since 1996 have resulted in beneficial shifts in the invertebrate food supply for fishes. Overall invertebrate abundances in Riffle 4A samples have declined slightly from 1996 to the present, but community composition has shifted away from pollution-tolerant invertebrate taxa toward those with higher food value for juvenile *O. mykiss* (TID/MID 2010d, Report 2009-7).

The following resource measures proposed by the Districts for the lower river have the potential to increase benthic macroinvertebrate abundance: gravel augmentation, gravel mobilization flows, experimental gravel cleaning, scour associated with placement of boulder-size stones, and increases in riparian vegetation and associated LWD recruitment resulting from shaping the descending limb of the snowmelt runoff hydrograph to mimic natural conditions. It is not clear, however, that such increases would translate into significant benefits for *O. mykiss*, because population modeling suggests that food availability in the lower Tuolumne River is not limiting *O. mykiss* rearing under current conditions (TID/MID 2017a, 2017e).

5.4.2.7 Steelhead Harvest

There is no commercial steelhead fishery in the rivers of the Central Valley, and ocean harvest of steelhead is an insignificant source of mortality for the CCV steelhead DPS (NMFS 2016). Existing data are unavailable to directly estimate freshwater exploitation rates of CCV steelhead, but rates are considered to be low because it is illegal to keep natural-origin fish. Estimated angler effort based on self-report cards increased significantly over the period of 1993–2005, potentially as the result of regulations allowing anglers to keep hatchery-origin steelhead caught in the Central Valley. Despite the observed increase in angler effort, inadvertent injury resulting from targeting hatchery fish is extremely low in the Tuolumne River, given that steelhead, regardless of origin, are very rare.

To protect wild steelhead in California, all hatchery steelhead receive an adipose fin-clip, and CDFW works closely with NMFS to review and improve inland fishing regulations (NMFS 2014). These include zero bag limits for unmarked steelhead, gear restrictions, closures, and size limits designed to protect smolts. Notwithstanding the benefits of these regulations, McEwan and Jackson (1996) contend that legal harvest in the years prior to the listing of CCV steelhead was not the cause of recent population declines.

Because the Tuolumne River downstream of La Grange Diversion Dam supports a catch-and-release recreational trout fishery from January 1 through October 15, it is possible that *O. mykiss* redds in the Action Area are at times inadvertently disrupted by wading anglers (NMFS 2014). However, annual fishing report cards (Jackson 2007) do not provide data to quantitatively assess hooking mortality or other sport fishing impacts on *O. mykiss*. Illegal harvest of resident *O. mykiss* could occur year-round, but no data are available that address the extent to which *O. mykiss* poaching occurs in the Action Area (TID/MID 2013e).

6.0 CONCLUSIONS

Table 6.1-1 summarizes potential effects of the Districts' Proposed Action. The overall determination for the Proposed Action is "Not Likely to Adversely Affect (NLAA)" *O. mykiss* or CCV steelhead critical habitat. See Section 5.3 of this Draft BA for the effects analysis upon which the summary table is based.

Table 6.1-1. Effects Determinations associated with the Proposed Action, including the Districts' proposed enhancement measures, for any CCV Steelhead DPS in the Action Area and the species' Critical Habitat.

Action	Effect Determination - Species	Effect Determination - Critical Habitat	Effects Description	Estimated Frequency and Duration of Action
Continued generation of hydroelectric power at the existing Don Pedro Powerhouse	NLAA	NLAA	▪ Continued generation of hydroelectric power would have no effect on flows, water quality, or other environmental conditions in the Action Area, and thereby no effect on *O. mykiss* or CCV steelhead critical habitat in the Action Area. Flows in the lower river are driven by the overall Don Pedro Project's primary purposes of water supply and flood protection, as well as background hydrology and other uses in the lower river basin.	▪ Continuous with the exception of short-term power outages.
Augment current gravel quantities through a coarse sediment management program	NLAA	NLAA	▪ Sediment would be placed after fry rearing to minimize smothering of *O. mykiss* fry in substrate interstices. ▪ Use of clean coarse sediment would minimize the release of fines into the water column and resulting potential effects on *O. mykiss*. ▪ BMPs would be implemented to avoid effects on *O. mykiss* due to use and storage of heavy equipment. ▪ Snorkel surveys conducted to assess *O. mykiss* spawning use would result in minimal disturbance of *O. mykiss*, but no injury or mortality is expected. ▪ Long-term increases in the availability of quality coarse sediment would improve *O. mykiss* egg-to-emergence survival, increase benthic macroinvertebrate production, and possibly improve hyporheic flow and cold water habitat.	▪ Coarse sediment placement would take placed from August–October for 10 years. ▪ Snorkel surveys would take place for three to five days per year during summer over a 5-year period (following augmentation).

Action	Effect Determination - Species	Effect Determination - Critical Habitat	Effects Description	Estimated Frequency and Duration of Action
Gravel mobilization flows of 6,000 to 7,000 cfs	NLAA	NLAA	▪ Localized, short-duration pulses in turbidity. ▪ Substrate surveys to assess gravel quality could lead to short-term disturbance of *O. mykiss* juveniles and adults, but no expected injury or mortality. ▪ Flows would reduce fine sediment storage, which could increase *O. mykiss* egg-to-emergence survival and fry production. ▪ Flows could lead to increased benthic macroinvertebrate production. ▪ Flows would increase fine sediment storage on floodplains, which could improve regeneration of native riparian plant species during wetter water years. ▪ There would be a net increase in lateral channel migration, bar formation, and large wood introduction, which could create complex hydraulic environments for improved *O. mykiss* holding, spawning, and juvenile rearing.	▪ Releases would take place at an estimated average frequency of once in five years. During a release year, operational flows would persist for at least two days. ▪ Substrate surveys would be implemented prior to each winter season and following any operational releases.

Action	Effect Determination - Species	Effect Determination - Critical Habitat	Effects Description	Estimated Frequency and Duration of Action
Gravel cleaning	NLAA	NLAA	▪ Gravel cleaning would take place in May, to minimize disturbance of *O. mykiss* redds. ▪ Short-term localized destabilization of substrate. ▪ Localized turbidity pulses. ▪ BMPs to avoid effects on *O. mykiss* due to use and storage of heavy equipment. ▪ Before-and-after substrate surveys to assess gravel quality would result in short-term disturbance of *O. mykiss* juveniles and adults, but no significant injury or mortality is expected. ▪ Reductions in fine material in spawning gravels would increase intragravel flow and DO concentrations, improve *O. mykiss* egg-to-fry survival, and enhance macroinvertebrate habitat.	▪ Gravel cleaning would take place over three weeks during May for a five-year period. ▪ If gravel cleaning is successful, the program would continue beyond five years. ▪ Substrate surveys would occur twice annually over the five-year initial cleaning period. Survey duration is anticipated to be about three days twice per year.
Improve Instream Habitat Complexity (boulder placement)	NLAA	NLAA	▪ Short-duration disturbance on juvenile *O. mykiss* during boulder placement but no injury or mortality. ▪ Boulders would be placed after the *O. mykiss* fry rearing period to avoid disturbance of fry. ▪ Snorkel surveys to document *O. mykiss* use near boulders and assess substrate would result in short-term disturbance of *O. mykiss* juveniles and adults, but no significant injury or mortality. ▪ Boulders would provide microhabitats for *O. mykiss* by increasing structural and hydraulic complexity, and could improve *O. mykiss* spawning habitat as scour displaces fines from gravels.	▪ Boulder placement would take place each summer (after July 15) for four years. ▪ Snorkel surveys to document *O. mykiss* use and assess substrate would occur for several days during fall and spring for four years.

Action	Effect Determination - Species	Effect Determination - Critical Habitat	Effects Description	Estimated Frequency and Duration of Action
Contribute to CDBW's efforts to remove water hyacinth	NLAA	NLAA	▪ Water quality improvements. ▪ Benefits would not accrue to resident *O. mykiss*, because water hyacinth is located downstream of the range of residency.	▪ Ongoing throughout license term, with treatment intensity varying from year to year based on levels of water hyacinth infestation.
Fall-run Chinook spawning improvement superimposition reduction program	NLAA	NLAA	▪ Disturbance of juvenile *O. mykiss* during barrier placement in the channel but no injury or mortality. ▪ Placement timing would be outside the *O. mykiss* fry rearing period and most of the incubation and emergence period, thereby minimizing disturbance of *O. mykiss* eggs, alevins, or fry in substrate interstices. ▪ Resident *O. mykiss* would have access to habitat both above and below the temporary barrier. ▪ Migratory *O. mykiss* are very rare in the Tuolumne River, but any that encounter the barrier would find adequate habitat downstream of the barrier.	▪ Location and timing of installation based on fall-run Chinook counting weir data. Barrier placement would likely occur in October or early November. ▪ After installation, the barrier would likely remain in place for the duration of the Chinook spawning period, i.e., until the end of December.

Action	Effect Determination - Species	Effect Determination - Critical Habitat	Effects Description	Estimated Frequency and Duration of Action
Predator control and suppression program	NLAA	NLAA	▪ The barrier weir would be installed at RM 25.5, well downstream of where most resident *O. mykiss* occur (*O. mykiss* are predominantly found upstream of RM 42). ▪ There are very few migratory *O. mykiss* in the lower Tuolumne River (only 26 upstream migrants have been documented at the counting weir from 2009-2017, and of these only six were >16 inches in length). ▪ Excluding introduced piscivores from the reach that supports resident *O. mykiss* would increase survival rates of *O. mykiss*, especially juveniles. ▪ Electrofishing, seining, or fyke netting could have inadvertent effects on nearby *O. mykiss*, but these would be short-term and spatially limited, and thereby far outweighed by the benefits of predator removal. ▪ Reduced abundance of striped and black bass are expected to increase survival rates of juvenile *O. mykiss*. ▪ Monitoring could temporarily disturb *O. mykiss* but injury or mortality are not expected.	▪ Installation would likely occur during about a two- to three-month period. ▪ Operation would be ongoing throughout the new license term. ▪ Implemented seasonally over the term of the new license, likely in spring to reduce predator numbers prior to Chinook smolt outmigration and summer when low-flow conditions improve capture potential. ▪ Monitoring would occur for short periods (likely in summer) during each year of the new license term.

Action	Effect Determination - Species	Effect Determination - Critical Habitat	Effects Description	Estimated Frequency and Duration of Action
Fall-run Chinook salmon restoration hatchery program (will require a separate ESA Section 7 consultation)	NLAA	NLAA	▪ A separate, individual Section 7 consultation would occur after a design for the facility is finalized. ▪ The program would be implemented in accordance with procedures primarily aimed at preventing or minimizing adverse impacts on wild Chinook; however, potential effects on *O. mykiss*, though not genetic in nature, would also be avoided.	▪ Construction is likely to occur over a two-year period. ▪ Full term of operation to be determined, but at least 20 years.
Infiltration Galleries 1 and 2	NLAA	NLAA	▪ The infiltration galleries would be installed well downstream of where most resident *O. mykiss* occur. *O. mykiss* are predominantly found upstream of RM 42. ▪ There are very few migratory *O. mykiss* in the lower Tuolumne River. Only 26 upstream migrants have been documented at the counting weir from 2009-2017, and of these only six were >16 inches in length. ▪ Benefits would accrue to *O. mykiss* by allowing the Districts to maintain higher flows in the channel upstream of the infiltration galleries.	▪ Construction would take place within in a single year, during the low-flow months. ▪ Infiltration galleries would operate for the full term of the new license.
Flows to enhance habitat for *O. mykiss* fry rearing (June 1–June 30)	NLAA	NLAA	▪ Proposed flow represents a balance between providing physical (hydraulic) habitat and maintaining low water temperature. ▪ Fry *O. mykiss* WUA = 71% max ▪ Adult *O. mykiss* WUA = 78 % max ▪ Flows would maintain suitable water temperatures.	▪ Annually for the term of the new license.
Flows to enhance habitat for *O. mykiss* juvenile rearing (July	NLAA	NLAA	▪ Juvenile *O. mykiss* WUA = 90–93 % max ▪ Adult *O. mykiss* WUA = 91–95 %	▪ Annually for the term of the new license.

Action	Effect Determination - Species	Effect Determination - Critical Habitat	Effects Description	Estimated Frequency and Duration of Action
1–October 15)			max ▪ Flows would maintain suitable water temperatures. ▪ Flushing flow would clean gravels of accumulated algae and fines prior to spawning.	
Flows to enhance habitat for fall-run Chinook spawning (October 16–December 31)	NLAA	NLAA	▪ Adult *O. mykiss* WUA = 80–90 % max ▪ Juvenile *O. mykiss* WUA = 95–99 % max ▪ Flows would maintain suitable water temperatures.	▪ Annually for the term of the new license.
Flows to enhance habitat for fall-run Chinook fry rearing (January 1–February 28/29)	NLAA	NLAA	▪ Balance between protecting Chinook redds from dewatering while providing *O. mykiss* habitat. ▪ Spawning *O. mykiss* WUA = 73–82 % max ▪ Adult *O. mykiss* WUA = 77–84 % max ▪ Juvenile *O. mykiss* WUA = 98–100 % max	▪ Annually for the term of the new license.
Flows to enhance habitat for fall-run Chinook juvenile rearing (March 1–April 15)	NLAA	NLAA	▪ Spawning *O. mykiss* WUA = 78–85 % max ▪ Adult *O. mykiss* WUA = 80–88 % max ▪ Juvenile *O. mykiss* WUA = 97–99 % max ▪ Fry *O. mykiss* WUA = 67–70 % max	▪ Annually for the term of the new license.
Fall-run Chinook outmigration base flows (April 16–May 15)	NLAA	NLAA	▪ Increasing base flows above March 1–April 15 would maintain favorable water temperatures. ▪ Adult *O. mykiss* WUA = 80–91 % max ▪ Juv. *O. mykiss* WUA = 93–99 % max ▪ Fry *O. mykiss* WUA = 62–70 % max	▪ Annually for the term of the new license.
Outmigration pulse flows (May 16–May	NLAA	NLAA	▪ Primarily a short-duration temperature benefit for *O. mykiss*.	▪ Annually for the term of the new license.

Action	Effect Determination - Species	Effect Determination - Critical Habitat	Effects Description	Estimated Frequency and Duration of Action
31)				
Hydrograph shaping	NLAA	NLAA	▪ Diffuse benefits that would accrue over the long-term in the form of increased natural recruitment of snowmelt-dependent hardwoods, which would in turn increase stands of trees that could contribute large wood to the channel and provide cover and shade.	▪ When spill conditions allow.
Flows to enhance recreational boating	NLAA	NLAA	▪ Boatable flows would be an ancillary recreational benefit resulting from flows provided to enhance salmonid habitat.	▪ Annually for the term of the new license.

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