UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

DEC 5 2016

Refer to NMFS No: WCR-2015-3218

Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, D.C. 20426

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and Fish and Wildlife Coordination Act Recommendations for Relicensing the Oroville Facilities Hydroelectric Project, Butte County California (**FERC Project No. 2100-134**)

Dear Secretary Bose:

Thank you for your letter of July 31, 2007, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the Federal Energy Regulatory Commission's (FERC) proposed relicensing of the Oroville Facilities Hydroelectric Project **(FERC Project No. 2100-134).**

NMFS also reviewed the proposed action for potential effects on essential fish habitat (EFH) designated under the Magnuson-Stevens Fishery Conservation and Management Act (MSA). This review was pursuant to Section 305(b) of the MSA, implementing regulations at 50 CFR 600.920, and agency guidance for use of the ESA consultation process to complete EFH consultation. Based on the best available scientific and commercial information, NMFS concludes in the enclosed biological opinion that the proposed action is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, or the Southern distinct population segment of North American green sturgeon or destroy or adversely modify designated critical habitat for these listed species. However, NMFS anticipates that incidental take will occur in the form of death, injury, or temporary changes to the habitat associated with the proposed action. An incidental take statement with non-discretionary terms and conditions is included.

This biological opinion is based on the best scientific and commercial information available. NMFS used information provided by FERC, the applicant (California Department of Water Resources), from literature, and our analysis of the effects of the proposed action. A complete administrative record of this consultation is on file at the NMFS California Central Valley Office in Sacramento, California.

In the enclosed EFH consultation, NMFS concludes that the proposed action will adversely affect the EFH of Pacific Coast Salmon and has included conservation recommendations. FERC has a statutory requirement under section 305(b)(4)(B) of the MSA to provide a written response to this letter within 30 days of its receipt and prior to start of the action. The response must include a description of measures adopted by FERC for avoiding, minimizing, or mitigating the impact of the activity. In the case of a response that is inconsistent with NMFS conservation recommendations, FERC must explain its reasons for not following the conservation recommendations, including the scientific justification for any disagreements at least 10 days prior to final approval of the action (50 CFR 600.920(k)).

Because the proposed action will modify a stream or other body of water, NMFS also provides recommendations and comments for the purpose of conserving fish and wildlife resources under the Fish and Wildlife Coordination Act (16 U.S.C. 662(a)).

Please contact Gary Sprague, NMFS, Central Valley Office, 650 Capitol Mall, Suite 5-100, Sacramento, California, (916) 930-3615, Gary.Sprague@NOAA.gov, if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Barry A. Thom
Regional Administrator

Enclosures

cc: File 151422-WCR-2015-SA00115
Timothy J. Welch FERC
Earl Nelson DWR

Enclosure 1

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

California Department of Water Resources	)	
Oroville Facilities Hydroelectric Project	)	**Project No. 2100**
Feather River	)	

CERTIFICATE OF SERVICE

I hereby certify that I have this day served, by first class mail or electronic mail, a letter to Secretary Bose of the Federal Energy Regulatory Commission from NOAA's National Marine Fisheries Service (NMFS), containing NMFS' biological opinion for the Project and this Certificate of Service, upon each person designated on the official service list compiled by the Commission in the above-captioned proceeding.

Dated this 5th day of December, 2016

Gary R. Sprague
National Marine Fisheries Service

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Enclosure 2

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Response and Fish and Wildlife Coordination Act Recommendations

Oroville Facilities Hydroelectric Project Relicensing **(Project No. 2100-134)**

National Marine Fisheries Service (NMFS) Consultation Number: 151422-WCR2015-SA00115

Action Agency: Federal Energy Regulatory Commission

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to adversely Affect Species or Critical Habitat?	Is Action Likely to Jeopardize the Species?	Is Action Likely to Destroy or Adversely Modify Critical Habitat?
California Central Valley steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	No
Central Valley spring-run Chinook (*O. tshawytscha*)	Threatened	Yes	No	No
Green Sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No
Sacramento River winter-run Chinook (*O. tshawytscha*)	Endangered	Yes	No	No
Southern Resident killer Whales (*Orcinus orca*)	Endangered	No	No	No
Central California Coast steelhead (*O. mykiss*)	Threatened	No	No	No

Fishery Management Plan That Describes EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon Plan	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By: Barry A. Thom

Barry A. Thom
Regional Administrator

Date: DEC 5 2016

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Acronyms

Acronyms used in this document are listed below.

Acronym	Definition
7DADM	Maximum 7-day Average of the Daily Maxima (temperature)
7DMAVG	7-day Moving Average of Maximum Daily Temperatures
ACID	Anderson-Cottonwood Irrigation Dam
ADCP	Acoustic Doppler Current Profiler
af	acre-feet
BA	Biological Assessment
BCSSRP	Battle Creek Salmon and Steelhead Restoration Project
BDCP	Bay Delta Conservation Plan
BKD	Bacterial Kidney Disease
BLM	United States Department of the Interior, Bureau of Land Management
BO	Biological Opinion
BOR	Bureau of Reclamation
BRT	Biological Review Team
CALFED	CALFED Bay-Delta Program
CCC	Central California Coast
CCV	California Central Valley
CCVAO	West Coast Region's California Central Valley Area Office
CCVO	California Central Valley Office
CDEC	California Data Exchange Center
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CO2	Carbon Dioxide
COA	Coordinated Operations Agreement
Coleman	Coleman National Fish Hatchery
Consultees	USFWS, NMFS, CDFW, SWRCB, CVRWQCB
CRR	Cohort Replacement Rate
CV	Central Valley

Acronym	Definition
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CWA	Clean Water Act
CWT	Coded Wire Tag
CWQM	Comprehensive Water Quality Management
CVP/SWP BO	Central Valley Project/State Water Project biological and conference opinion
DAT	Daily Average Temperature
DEIS	Draft Environmental Impact Statement
Delta	Sacramento-San Joaquin Delta
Deputy Director	Deputy Director for Water Rights
DIDSON	Dual Frequency Identification Sonar
DPR	California Department of Parks and Recreation
DPS	distinct population segment
DQA	Data Quality Act
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utilities District
EC	Ecological Committee
EFH	Essential Fish Habitat
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FEIS	Final Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FL	Fork Length
FPA	Federal Power Act
fpp	fish per pound
fps	feet per second
FR	Federal Register
FRFH	Feather River Fish Hatchery

Acronym	Definition
FROG	Feather River Operations Group
FRSA	Feather River Service Area
FRTT	Feather River Technical Team
GCID	Glen Colusa Irrigation District
HEA	Habitat Expansion Agreement
HEP	Habitat Expansion Plan
HEC-DSS	Hydrologic Engineering Center Data Storage System
HEC-RAS	Hydrologic Engineering Center River Analysis System
HFC	High Flow Channel
HGMP	Hatchery and Genetics Management Plan
IHNV	Infectious Hematopoietic Necrosis Virus
ITS	Incidental Take Statement
JPE	Juvenile Production Estimate
KRPH	Kelly Ridge Powerhouse
LFC	Low Flow Channel
LSNFH	Livingston Stone National Fish Hatchery
LWD	Large Woody Debris
LWM	Large Woody Material
MAF	Million Acre Feet
mm	millimeter
MSA	Magnuson-Stevens Fishery Conservation and Management Act
msl	Mean Sea Level
MW	Megawatt
MWAT	Maximum Weekly Average Temperature
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
OCAP	CVP/SWP Operation Criteria and Plan
OEHHA	California Office of Environmental Health Hazard Assessment

Acronym	Definition
OHW	Ordinary High Water
OTMI	Oroville Temperature Management Index
OWA	Oroville Wildlife Area
PAH	Polycyclic Aromatic Hydrocarbons
PBF	Physical and Biological Features
PCB	Polychlorinated Biphenyl
PDEA	Preliminary Draft Environmental Assessment
PG&E	Pacific Gas and Electric
PM&E	Protection, Mitigation, and Enhancement
Program	Comprehensive Water Quality Monitoring Program
PVA	Population Viability Analysis
PVP	polyvinylpyrrolidone
RBDD	Red Bluff Diversion Dam
Reclamation	United States Department of the Interior, Bureau of Reclamation
RK	river Kilometer
RM	river mile
RMP	Recreation Management Plan
RST	Rotary Screw Trap
RVOS	River Valve Outlet System
SA	Settlement Agreement
SDFPF	Skinner Delta Fish Protection Facility
sDPS	Southern Distinct Population Segment
SFFR	South Fork Feather River
SFWPA	South Feather Water & Power Agency
SHSI	Structural Habitat Supplementation and Improvement
SJRRP	San Joaquin River Restoration Project
State Water Board	California State Water Resources Control Board
SWFSC	Southwest Fisheries Science Center
SWP	State Water Project
SWRCB	State Water Resources Control Board

Acronym	Definition
TAO	Thermalito Afterbay Outlet
TCP	Temperature Compliance Point
TFCF	Tracy Fish Collection Facility
TRT	Technical Recovery Team
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USC	United States Code
USFWS	United States Fish and Wildlife Service
UV	Ultraviolet
VSP	Viable Salmonid Populations
WQRRS	WQRRS
WRO	Water Rights Order

1 INTRODUCTION

This *Introduction* section provides information relevant to the other sections of this document and is incorporated by reference into sections *2 Endangered Species Act* and *3 Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation* below.

1.1 Background

NOAA's National Marine Fisheries Service (NMFS) prepared the Biological Opinion (Opinion) and incidental take statement portions of this document in accordance with Section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 *et seq.*) and implementing regulations at 50 CFR 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 *et seq.*) and implementing regulations at 50 CFR 600.

Because the proposed action would modify a stream or other body of water, NMFS also provides recommendations and comments for the purpose of conserving fish and wildlife resources and enabling the Federal agency to give equal consideration with other project purposes, as required under the Fish and Wildlife Coordination Act (16 U.S.C. 661 *et seq.*).

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts. A complete record of this consultation is on file at NMFS California Central Valley Office (CCVO) in Sacramento.

The Oroville Facilities are also known as the Feather River Division of the broader State Water Project (SWP), which is operated under a coordinated agreement between the Bureau of Reclamation (BOR) and California Department of Water Resources (DWR), called the Central Valley Project (CVP) Operations Criteria and Plan (OCAP). The SWP includes several dams in the Sacramento River watershed and conveyance and pumping facilities in the Sacramento-San Joaquin River Delta (Delta). As they relate to conveyance of SWP water through the Sacramento River and the Delta, the Oroville Facilities water management operations are such a large component of the SWP water management operations that they are inextricably linked to the coordinated operation of OCAP. The effects of the broad, coordinated operations of the SWP and the CVP were considered in a separate biological opinion (National Marine Fisheries Service 2009b).

1.2 Consultation History

The DWR owns and operates Oroville Dam and hydropower plant and associated facilities as part of the SWP and filed its final application for a new license for the Oroville Facilities with the Federal Energy Regulatory Commission (FERC) on January 26, 2005.

On March 24, 2006, DWR filed a Settlement Agreement for Licensing of the Oroville Facilities (SA) with FERC, which includes proposed license articles set forth in Appendix A of the SA.[1]

On October 24, 2006, FERC requested that NMFS initiate formal consultation, pursuant to Section 7 of the ESA, regarding a new license for the Oroville Facilities (Oroville Dam, hydropower plant, and associated facilities). In its request, FERC specified that the FERC Draft Environmental Impact Statement (DEIS) be used as the biological assessment (BA) in support of their request for initiation of consultation. On December 19, 2006, NMFS responded to FERC with an insufficiency letter, providing comments on the DEIS/BA and requesting further information be provided before formal consultation could be initiated.

NMFS reserved its authority to prescribe fishways under Section 18 of the Federal Power Act (FPA) for the Oroville Facilities during the term of FERC's proposed license as provided in the Habitat Expansion Agreement. NMFS filed with FERC a modified fishway prescription, dated February 15, 2007, that is consistent with the SA. NMFS also included recommended terms and conditions under Section 10(j) of the FPA that are consistent with Appendix A of the SA.

In August 2007, DWR, NMFS, and other parties entered into a Habitat Expansion Agreement (HEA) for Central Valley spring-run Chinook salmon and California Central Valley steelhead, which is applicable to FERC Project No. 2100 and other hydroelectric projects in the Feather River watershed. The HEA was amended in March 2011.[2]

On August 15, 2007, NMFS received a letter dated July 31, 2007, in which FERC requested initiation of formal consultation again, but this time supported by a Final Environmental Impact Statement (FEIS) issued by FERC on May 18, 2007, and a final BA prepared by DWR, dated June 2007 (received by NMFS on July 17, 2007), which incorporated the additional information requested by NMFS on December 19, 2006. Formal consultation was initiated on September 18, 2007. In addition to the FEIS and BA and other information cited in this biological opinion, NMFS reviewed Feather-River-specific information from the DWR Oroville Facilities relicensing web site.

On October 9, 2009, NMFS designated critical habitat for the Southern distinct population segment (sDPS) of North American green sturgeon (74 FR 52300 October 9, 2009). The Feather River below the Oroville Fish Barrier Dam was included in this designation.

On June 4, 2009, NMFS issued a final *Biological Opinion and Conference Opinion on the Long-term Operations of the Central Valley Project and State Water Project* (CVP/SWP BO) (National Marine Fisheries Service 2009). The Reasonable and Prudent Alternative in the CVP/SWP BO was amended on April 7, 2011 (National Marine Fisheries Service 2011e). That BO evaluated the broad, coordinated operations of the SWP and the CVP. The CVP/SWP BO analyzed the effects related to the conveyance of SWP (including Oroville Facilities) water through the Sacramento River and the Delta to State and Federal water pumping facilities in the

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1 The Settlement Agreement is available on the California Department of Water Resources, Oroville Facilities relicensing web site at: http://www.water.ca.gov/orovillerelicensing/settlement_agreement.cfm

2 The HEA is available on the DWR Oroville Facilities relicensing website at: http://www.water.ca.gov/environmentalservices/hea_home.cfm

south Delta. Therefore, this Opinion does not analyze the effects of Oroville Facilities water management operations on areas downstream of the mouth of the Feather River in section 2.4 *Effects of the Action*; however, those effects are considered in sections *2.2 Rangewide Status of the Species and Critical Habitat* and *2.6 Integration and Synthesis* of this Opinion. This consultation focuses on the effects of the FERC-related components of the Oroville Facilities, which in large part occur within the Feather River, except for effects of the FRFH that extend to areas outside the Feather River as described below in this Opinion.

On July 2, 2009, NMFS issued a draft Biological and Conference Opinion on FERC's proposed action of Oroville Facilities Project Relicensing. On July 9, 2009, DWR requested a comment period extending through August 5, 2009 on the draft Biological and Conference Opinion.

On July 15, 2009, NMFS responded and agreed to the requested comment period. NMFS received comments on the draft Biological and Conference Opinion from the following organizations: California Sportfishing Protection Alliance, dated July 21, 2009; Bob Baiocchi, California Salmon and Steelhead Association, dated July 21, 2009; DWR, dated August 5, 2009; and the State Water Contractors and Metropolitan Water District of Southern California, dated August 6, 2009. In addition, Robert Baiocchi, of the California Salmon and Steelhead Association, filed comments on the draft Biological and Conference Opinion with FERC on August 18, 2009. NMFS considered all these comments and made revisions to the Final Biological and Conference Opinion as appropriate.

On December 15, 2010, the California State Water Resources Control Board (SWRCB) issued the Water Quality Certification (Order WQ 2010-0016) for the new Federal Energy Regulatory Commission license for the Oroville Facilities (FERC Project No. 2100).

On December 24, 2010, DWR provided to NMFS a notice of intent to withdraw from the Habitat Expansion Agreement due to the SWRCB Order WQ 2010-0016 for the Oroville Facilities with terms that DWR insisted were materially inconsistent with the terms of the Habitat Expansion Agreement.

On May 10, 2011, DWR provided to NMFS a letter rescinding its notice of intent to withdraw from the HEA, because the HEA was amended to resolve its concerns. On August 8, 2011, NMFS and other HEA parties filed a letter with FERC regarding how the new license should address a specific condition of the SWRCB Order regarding the SWRCB's review of the Habitat Expansion Plan under the HEA.

On June 12, 2012, the State Water Contractors submitted a letter to NMFS with the subject line "Request for Study of Green Sturgeon". The letter included a January 2012 draft Research, Monitoring & Evaluation Plan, Feather River Green Sturgeon prepared by Ray Beamesderfer of Cramer Fish Sciences (the Research Plan). The Research Plan presented nine research, monitoring, and evaluation strategies for studying green sturgeon in the Feather River that do not include specific flow target measures for green sturgeon for the initial phase of the program. The State Water Contractors asserted in their letter that the approach set forth in the Research Plan will be sufficient to meet the stated goals of describing and quantifying the movements, distribution, abundance, productivity and diversity of green sturgeon in the Feather River and to evaluate the effects of normal variation in river discharge on green sturgeon use of the Feather River.

Beginning in December 2013, NMFS started coordinating with DWR to update the draft biological opinion with updated species and critical habitat information.

On November 14, 2014, NMFS shared revised chapters 1-5 of the draft biological opinion with DWR. These chapters were (I) Consultation History, (II) Analytical Approach, (III) Description of the Proposed Action, (IV) Status of the Species and Critical Habitat, and (V) Environmental Baseline.

On February 13, 2014, in a letter to FERC, NMFS requested clarification of FERC's proposed project description of the Oroville Facilities (Project 2100-134) as modified by SWRCB Order WQ 2010-0016. Specifically, NMFS requested that FERC clarify how Order WQ 20100-0016 would affect the status and scope of the proposed action. NMFS did not receive a response, and in coordination with DWR, NMFS worked to update the description of the proposed action with applicable components of Order WQ 2010-0016 that would affect ESA-listed species under NMFS' jurisdiction because these are mandatory conditions for a new FERC license for the Oroville Facilities.

On March 23, 2015, DWR provided comments to NMFS on chapters 1-5 of the draft biological opinion.

On March 27, 2015, NMFS requested clarification from DWR on project ramping rates, noting conflicting rates present in documents that had been filed by DWR with FERC. Specifically, while multiple relicensing documents stated that there were no changes to proposed project ramping rates from existing ramping rates, various ramping rates appeared in several documents. These included the 1983 DWR/DFG agreement, CVP/SWP 2002, and 2004, biological opinions (two different versions), DWR 2005 License Application, 2005 DWR Preliminary Draft Environmental Document, Draft EIS 2006, Final EIS 2007, and 2009 Draft Oroville Biological Opinion. The request specifically related to what ramping rates DWR is currently using, in that they had identified that they were proposing no changes to the existing ramping rates.

April 22, 2015, DWR responded to NMFS' request for clarification regarding ramping rates noting that the correct proposed ramping rates for the new license are the existing ramping rates that were identified in the CVP/SWP 2004 Biological Opinion for the LFC, and the ramping rates in the 1983 DWR/DFG agreement for the HFC.

On June 15 and 16, 2015, and July 30, 2015, NMFS and DWR met in person to review DWR comments on sections 1-2.3 of the draft Opinion. These sections were 1. Introduction, 1.1 Background, 1.2 Consultation History, 1.3 Proposed Action, 1.4 Action Area, 2. Endangered Species Act, 2.1 Approach to the Analysis, 2.2 Rangewide Status of the Species and Critical Habitat, and 2.3 Environmental Baseline.

On November 9, 2015, NMFS provided DWR with revised versions of sections 1-2.6 of the draft Opinion. In addition to the sections identified above, section 2.6 Effects of the Action on Species and Designated Critical Habitat was provided to DWR.

On January 11, 2016, DWR provided additional comments on the revised draft Opinion.

On January 13, 2016 and February 10 and 24, 2016, NMFS and DWR held in person meetings to resolve final comments and questions on sections 1-2.6.

On November 22 and 28, 2016, NMFS and DWR held in person meetings to review the Reasonable and Prudent Measures, and Terms and Conditions sections.

1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR § 402.02).

The proposed action analyzed in this Opinion is FERC's proposed relicensing of the Oroville Facilities (FERC Project No. 2100-134). The Oroville Facilities were developed as part of the SWP, a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The SWP stores and distributes water to supplement the needs of urban and agricultural water users in Northern California, the San Francisco Bay Area, the San Joaquin Valley, Central Coast, and Southern California. As part of the SWP, the Oroville Facilities are also operated for flood management, power generation, water quality improvement in the Delta, recreation, and fish and wildlife enhancement. The FERC relicensing only applies to the facilities and operations authorized under the Federal Power Act. The operations and features that are only for the delivery of water are not part of the FERC relicensing, and therefore not part of proposed action analyzed in this Opinion.

FERC is authorized to issue licenses for 30 to 50 years for the operation of non-Federal hydroelectric power plants subject to conditions that provide adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat). Relicensing would allow the continued operation and maintenance (O&M) of the Oroville Facilities for electric power generation and enhancement of recreation, fish and wildlife (which includes the continued operation of the Feather River Fish Hatchery (FRFH)).

The Oroville Facilities operations will continue to build upon interim measures implemented by DWR during the relicensing effort, measures continued under the 1983 *Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife* (including operation of the FRFH), and select measures identified during consultation with the U.S. Fish and Wildlife Service (USFWS 2007). The proposed action includes proposed protection, mitigation, and enhancement measures (PM&Es) described in the SA, with proposed license articles in Appendix A of the SA. An interrelated HEA was signed by Pacific Gas and Electric (PG&E), DWR, agencies and interested stakeholders as an alternative to specific fish passage prescriptions or license conditions related to fish passage in the relicensing of the Oroville Facilities and other Feather River hydroelectric projects.

Also, on December 15, 2010, the California SWRCB issued to FERC Order WQ 2010-0016, Water Quality Certification for Federal Permit or License. This order was issued pursuant to Section 401 of the Clean Water Act (CWA) and provides that State certification conditions will become conditions of any Federal license or permit for the project and will become part of FERC's operating license for the Oroville Facilities. This proposed action incorporates applicable components of Order WQ 2010-0016 that would affect ESA-listed species under NMFS' jurisdiction because these are mandatory conditions for a new FERC license for the Oroville Facilities.

1.3.1 Project Location

The Oroville Facilities are located on the Feather River in Butte County, California. The Feather River Watershed emerges from the west slope of the Sierra Nevada and enters the Sacramento Valley approximately 70 miles north of the city of Sacramento. Oroville Dam is approximately 5 miles east of the city of Oroville and about 130 miles northeast of San Francisco. The Feather

River Watershed originates in the Sacramento Valley and has a relatively flat gradient from its confluence with the Sacramento River upstream to Oroville Dam compared to that portion upstream of Lake Oroville with a much steeper topography. Downstream of Oroville Dam, Honcut Creek and the Yuba and Bear Rivers join the Feather River before its confluence with the Sacramento River at Verona.

The FERC license project area includes Lake Oroville and project facilities immediately downstream of Oroville dam along with the Oroville Wildlife Area (OWA). The FERC project boundary extends downstream of Oroville and Thermalito Diversion dams on the Feather River and includes the Fish Barrier Dam along with the FRFH and its components. The FERC project boundary on the Feather River downstream of the Diversion Dam includes both sides of the river, generally following an elevation contour about 100 to 500 feet from the river shoreline, to a point just downstream of the FRFH. In the section where the project boundary encompasses the Oroville Wildlife Area, the project boundary also includes a section of the Feather River and extends between 300 and 8,000 feet from the Feather River. The locations of the Oroville Facilities features are shown in Figure 1-1.

1.3.2 Project Features

Project features encompass 41,100 acres and include the following: Lake Oroville (3.5 million af (MAF) capacity) and Oroville Dam; the Edward Hyatt Powerplant/Edward Hyatt Pumping-Generating Plant; Thermalito Diversion Pool; Thermalito Diversion Dam and Powerplant, Thermalito Power Canal, Thermalito Forebay and the Thermalito Pumping-Generating Plant; and Thermalito Afterbay. Other project features include the FRFH and Fish Barrier Dam along with the OWA. A diagram for the Oroville Facilities is provided in Figure 1-2. Existing dams, power plants, and associated facilities are described below.

No new power facilities or specific modifications of the existing facility are included in the proposed action. However, as part of the SA, DWR is evaluating a number of facilities modifications that could be constructed to improve water temperature conditions in the Feather River down to the southern end of the license boundary. The potential future facilities modifications to be analyzed under SA Article A108.3 and implemented under SA Article A108.4 have the designed intent:

- to improve accessibility to the coldwater pool in Lake Oroville
- to minimize heat gains from the point of release to locations farther downstream in the Feather River
- to reduce cold and warm water mixing in the Thermalito Afterbay

Facilities modifications to improve downstream water temperatures will be constructed by approximately year 10 of the new FERC license, if feasible.

For purposes of this analysis, the period before facilities modification is referred to as the “initial new license period” to distinguish it from the post-facilities modification period. The initial new license period will include non-structural modifications such as augmentation of minimum flow releases (up to 1,500 cfs or the total releases into the High Flow Channel (HFC), whichever is less), shutter manipulation, or adjustments to pump-back operations to meet temperature targets in the Low Flow Channel (LFC) until facilities modifications to provide colder water for coldwater fisheries protection to the LFC and HFC are constructed.

Although not part of the original design intent of the River Valve Outlet System (RVOS) at Oroville Dam, the RVOS had been used for water temperature control in a handful of years over the 48-year operational history of Oroville Dam. This is because the valves provide access to cold water from the bottom of Lake Oroville under essentially any Lake Oroville water surface elevation condition.

The Hyatt Powerplant intake was designed to control water temperatures taken into the plant and released to the Feather River. Through agreements the temperature criteria at the Oroville Facilities have been lowered over time. In some conditions where Lake Oroville is below about 700 feet elevation, the RVOS has been used to blend colder water with the Hyatt Powerplant releases to meet downstream temperature requirements. However, a malfunction and resulting accident that occurred with the RVOS in 2009 resulted in significant restrictions being placed on its operation.

For the purpose of this Opinion, the LFC is defined as the reach of the Lower Feather River from the Fish Barrier Dam downstream to the Thermalito Afterbay Outlet (TAO).The HFC is defined as the reach of the Feather River from the Thermalito Afterbay Outlet downstream to the confluence with the Sacramento River near Verona, California. This may differ from some interpretations that delineate the HFC as the reach from the Thermalito Afterbay Outlet to the downstream project boundary.

1.3.2.1 Lake Oroville, Oroville Dam and Hyatt Powerplant

Oroville dam, along with two small saddle dams, impound Lake Oroville, a 3.5-million-acre-feet (MAF) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level (at elevation 900 feet MSL). Oroville dam is 770 feet high from the base of the dam with a crest length of 6,920 feet. Bidwell Canyon Saddle dam is 47 feet high from the base of the dam with a crest length of 2,270 feet, and Parish Camp Saddle dam is 27 feet high from the base of the dam with a crest length of 280 feet.

The Hyatt Powerplant/Hyatt Pumping-Generating Plant is the largest of the three power plants associated with the Oroville Facilities, with a capacity of 645 megawatts (MW). The intake structure for the Hyatt Powerplant consists of two parallel intake channels, one each for two penstock tunnels. The intake structure has an overflow type shutter system, each shutter being approximately 40 feet square and located at different elevations, thus allowing DWR to control the levels from which water is withdrawn from Lake Oroville. This shutter system allows DWR to adjust the temperature of the water flowing through the power plant to assist in meeting temperature management goals to optimize conditions for fish. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels to the Feather River just downstream of Oroville dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively.

The source of Figure 1-1 is http://www.water.ca.gov.

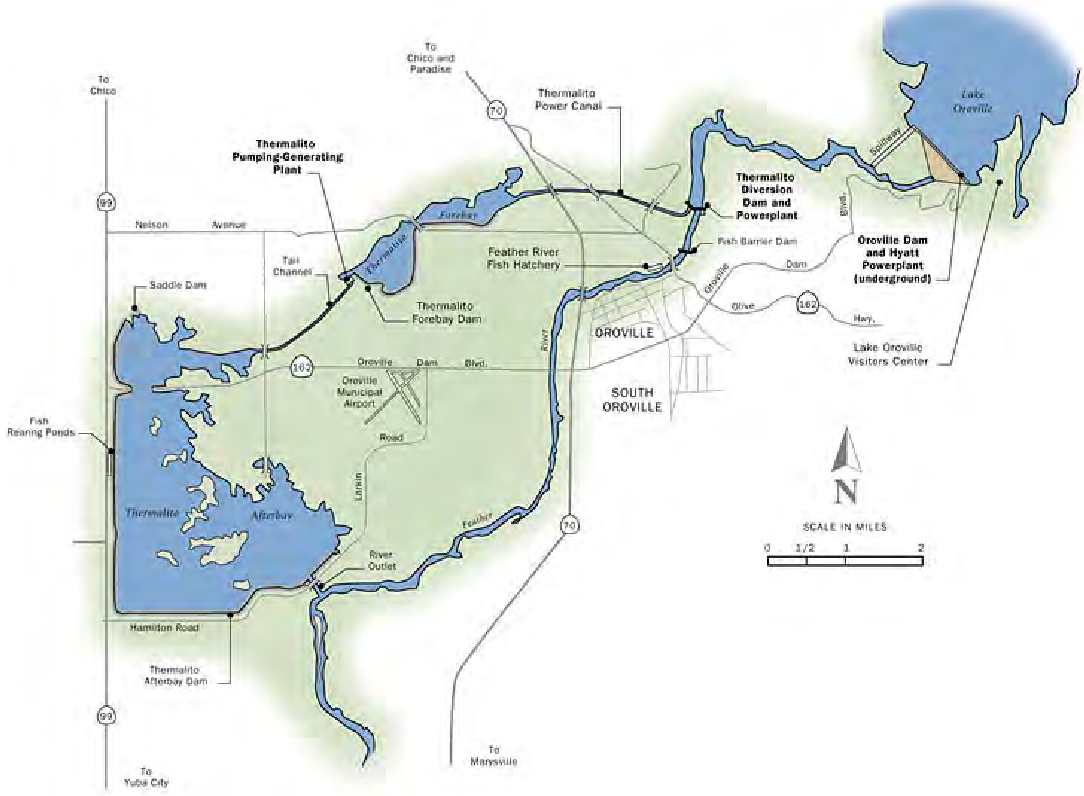


Figure 1-1. Oroville Facilities Locations and Features

1.3.2.2 Thermalito Diversion Dam and Powerplant and Fish Barrier Dam

Approximately four miles downstream of the Oroville Dam/Hyatt Powerplant is the Thermalito Diversion Dam and Powerplant. The Thermalito Diversion Dam is 143 feet high from the base of the dam with a crest length of 1,300 feet. The crest of the dam is at 233 feet above MSL. The Thermalito Diversion Dam creates the Thermalito Diversion Pool, which acts as a water diversion point and includes diversions to the Thermalito Power Canal to the west and to the historical Feather River channel known as the LFC on the south side. The Thermalito Diversion Pool has a storage capacity of 13,350 acre-feet (af) with a maximum water surface area of 320 acres at the maximum water surface elevation of 225 feet MSL. The Thermalito Diversion Dam power plant is a 3-MW power plant located below the left abutment of the diversion dam. The power plant releases a maximum of 615 cfs of water through a single turbine into the Fish Barrier Dam pool.

The Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the FRFH. The Fish Barrier Dam is at the upstream end of the LFC and is an impassable barrier to fish that diverts fish into a ladder for use by the FRFH. The pool formed by the Fish Barrier Dam has a storage capacity of 560 af and covers 50 acres. Flow over the Fish Barrier Dam maintains fish habitat in the eight-mile LFC section of the Feather River, except when flood control releases occur from Lake Oroville, and provides attraction flow for the hatchery fish ladder.

1.3.2.3 Thermalito Power Canal, Thermalito Forebay, Thermalito Pumping-Generating Plant, and Thermalito Afterbay

The Thermalito Power Canal is a 10,000-foot-long channel designed to convey generating flows up to 16,900 cfs to the Thermalito Forebay for use in the Thermalito Pumping-Generating Plant. It also conveys pump-back flows of up to 9,000 cfs from the Thermalito Forebay to the Thermalito Diversion Pool, which in turn acts as a forebay to provide flow to the Hyatt Pumping-Generating Plant when operating in a pump mode.

The Thermalito Forebay is an off-stream regulating reservoir for the Thermalito Pumping-Generating Plant.

The Thermalito Forebay Dam is 91 feet high from the base of the dam with a crest length of 15,900 feet. The crest of the dam is at 231 feet MSL. The dam impounds the Thermalito Forebay, which has a storage capacity of 11,768 af with a maximum water surface area of 630 acres at the maximum water surface elevation of 225 feet mean sea level (MSL).

The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in a generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay.

The Thermalito Afterbay is impounded by the Thermalito Afterbay Dam, a 42,000-foot-long earth-filled dam, which is 39 feet high from the base to the crest. The Thermalito Afterbay is used to release water into the Feather River downstream of the Oroville Facilities. The Thermalito Afterbay helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. The Thermalito Afterbay has a storage capacity of 57,040 af with a maximum water surface elevation area of 4,300 acres at the maximum water surface elevation of 136.5 feet MSL. Several local irrigation districts receive water from the Thermalito Afterbay. Water delivery from the Thermalito Afterbay is not part of the proposed action analyzed in this Opinion.

The Thermalito Afterbay is the location from which diversions are made to meet the Feather River service area irrigation entitlements. The Thermalito Afterbay is operated to meet these requirements, along with regulating inflow from the Thermalito Pumping-Generating Plant , providing water for withdrawal during pump-back operation, and releasing water through the Thermalito Afterbay Outlet back into the Feather River approximately 8 miles downstream of the Fish Barrier Dam. The reach of the Feather River from the Thermalito Afterbay Outlet to the Sacramento River is termed the High Flow Channel (HFC).

Natural hydrologic conditions do not affect the Thermalito Afterbay operation; it is primarily affected by operations. Generally, the Thermalito Afterbay does not have seasonal differences in its water elevation, and the water surface elevation varies from about 124 to 136 feet MSL throughout the year. When peaking or pump-back power operations occur, the Thermalito Afterbay tends to operate on a weekly cycle, causing weekly fluctuations that are higher than those that occur daily. The weekly fluctuations usually range from 2 to 6 feet, although there are times during the year when the elevation is allowed to be higher or lower as a response to system-wide operations or energy prices. Fluctuations of about 9 to 11 feet sometimes occur during a several week period and are most likely to occur in the winter.

Potential future facilities modifications could include one or more of the actions described below in sections *1.3.2.4* through *1.3.2.10* to improve water temperature management in the Feather River.

1.3.2.4 Palermo Canal Improvements

The Palermo Canal currently draws water from Lake Oroville at approximately 549 feet above MSL and delivers approximately 50 cfs (cfs) to the South Feather Power and Water Agency. Improvements will include increasing the volume of water passed through the Palermo Outlet Works to deliver the 50 cfs to the canal and to provide, via a pipeline, approximately 500 cfs to cool Feather River water temperatures at one or more points within the FERC Project boundary. These points could be the FRFH, the LFC downstream of Thermalito Diversion Dam, and the HFC near Thermalito Afterbay Outlet.

1.3.2.5 Hyatt Intake Extension

Currently, the lowest elevation for Hyatt Powerplant intake from Lake Oroville is at 613 feet MSL. An extension of the intake structure to approximately 500 feet MSL would allow access to an increased volume of cold water for release through the Hyatt Powerplant and downstream into the LFC. The extension would connect to the existing intake structure and existing shutters could continue to be used to mix flow from the deeper intake with flows from the upper water column. The inability of the turbines to withstand the low pressures created by operation below the 640–foot dead pool may eliminate this alternative from further consideration.

1.3.2.6 River Valve Improvements

The existing RVOS is a low-level outlet required for all dams in California pursuant to dam safety regulations. It was designed to serve as a bypass around Hyatt Powerplant in the event of a Plant outage and was also designed to serve as a low-level outlet in case emergency evacuation of Lake Oroville was required. Both these operating scenarios are extreme events that are not expected to occur (especially the emergency evacuation scenario).

The RVOS was initially used in 1967 and 1968 to permit continued flow downstream in the Feather River to the Delta while Lake Oroville was filling behind Oroville Dam. It was not used again until the historic drought in 1977, and it was used at that time to meet temperature requirements at the FRFH while the reservoir storage was too low to draw sufficiently cold water through Hyatt Pumping-Generating Plant for downstream release. The RVOS has been used infrequently (1977, 2001, 2002, 2008, and 2014 totaling about 850,000 af) for water temperature control because it provides access to cold water for blending with Hyatt Powerhouse releases.

A malfunction and resulting accident occurred with the RVOS in 2009, however, which resulted in significant restrictions being placed on its operation. At this time, through agreement with the California Division of Occupational Safety and Health and others, the RVOS is approved for limited operations during the current (2015-2016) drought emergency. DWR is working with dam safety regulatory agencies and others toward a long-term solution for using the RVOS, which is intended to restore the full original design capacity of 4,000 cfs at lake elevation 640’ for the RVOS.

1.3.2.7 Canal Around Thermalito Afterbay

A canal would be constructed to route water from the Thermalito Pumping-Generating Plant tailrace directly to the LFC upstream of Thermalito Afterbay Outlet. This would reduce residence time for Oroville water releases within Thermalito Afterbay. Reducing residence time in Thermalito Afterbay could reduce water temperatures released into the HFC.

1.3.2.8 Canal Through Thermalito Afterbay

A system of dikes, channels, and gated structures would be constructed within Thermalito Afterbay to route water more directly from the Thermalito Pumping-Generating Plant tailrace to the existing Thermalito Afterbay Outlet. This would reduce the travel time for flows from the Thermalito Pumping-Generating Plant through Thermalito Afterbay to the Feather River, resulting in decreased water temperature releases to the HFC.

1.3.2.9 Alternate Afterbay Outlet and Channel

An alternate outlet and channel would be constructed to deliver water 4–8 miles downstream of the existing Thermalito Afterbay Outlet. It would work in concert with the existing outlet to provide additional temperature benefits for that portion of the HFC between the existing outlet and the alternate outlet. Minimum flow requirements for the HFC would be maintained through releases from the existing Thermalito Afterbay Outlet, while the remaining flows returning to the Feather River (up to 4,000 cfs) would be redirected for release at the new outlet. Releases in excess of 4,000 cfs would continue to be made through the existing Thermalito Afterbay Outlet.

1.3.2.10 Thermalito Afterbay Temperature Curtain

This measure would employ a temperature curtain installed within Thermalito Afterbay near the western and southern embankment. The goal of this option is to cause water released for irrigation to travel through the entire length of Thermalito Afterbay, by redirecting the flows, thereby increasing residence time and thus likely increasing water temperatures, before release through the irrigation diversion outlets. This will leave cooler water to be released into the Feather River.

1.3.2.11 Feather River Fish Hatchery (FRFH)

The FRFH was built in 1967 by DWR as mitigation for the loss of Chinook salmon and steelhead spawning habitat due to the construction of Oroville Dam. The FRFH is located on the Feather River in the town of Oroville, California (Figure 1-2). The FRFH complex includes the Fish Barrier Dam, fish ladder, collection and holding tanks, enclosed spawning facility and early incubation facilities, grow-out ponds, aeration tower and settling ponds, and fish transport vehicles. The main hatchery building houses the spawning operation and incubators.

The Thermalito Annex Fish Facility (Thermalito Annex) is a FRFH satellite facility located about 10 miles from the FRFH along the Thermalito Afterbay, and it provides additional fish-rearing capacity.

The FRFH is operated by the California Department of Fish and Wildlife (CDFW) under contract with DWR. DWR is responsible for maintaining the hatchery infrastructure and funding hatchery operations. There is also a contract between CDFW and the Commercial Salmon Trollers Advisory Committee that funds the enhancement component of FRFH operations.

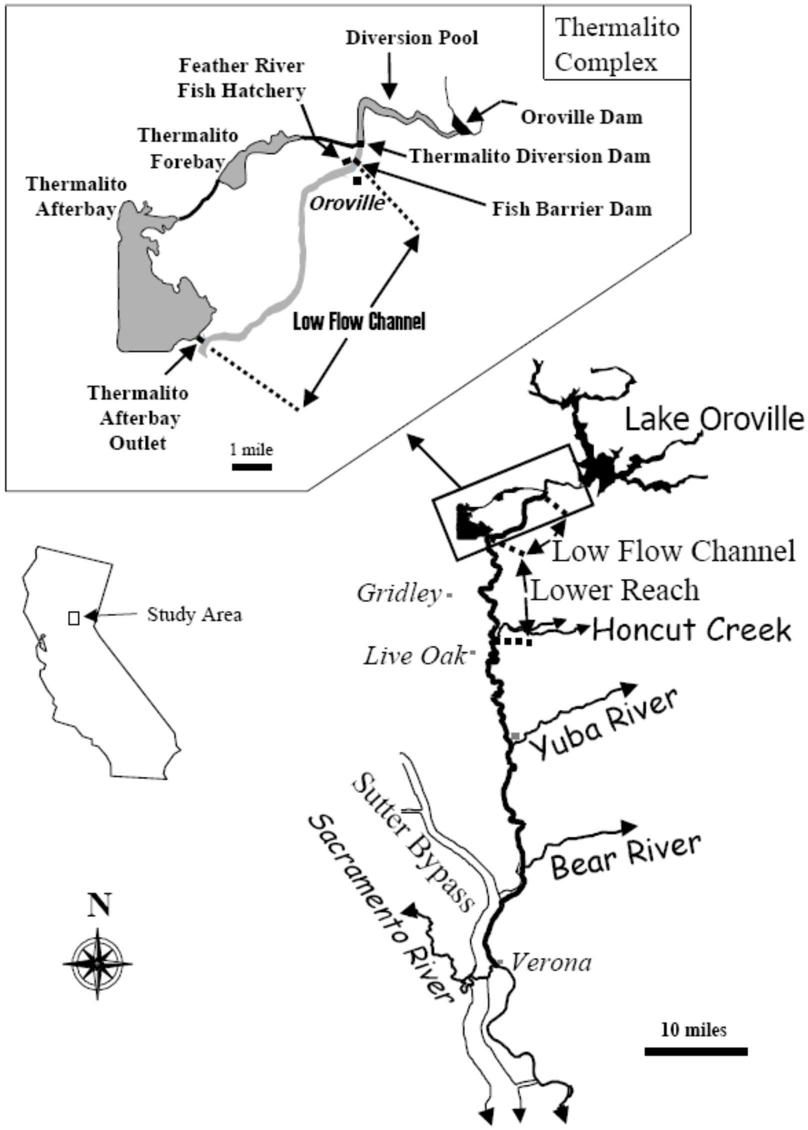


Figure 1-2. Feather River Hatchery and Vicinity [from Sommer et al. (2001a)]

The FRFH produces Central Valley (CV) spring-run Chinook salmon (*Oncorhynchus tshawytscha*) and fall-run Chinook salmon (*O. tshawytscha*), and California Central Valley (CCV) steelhead (*O. mykiss*) for mitigation and recreation fishery enhancement purposes. The FRFH now raises 120,000 juvenile fall-run Chinook salmon for various studies and off-site release, including releases into Lake Oroville. CCV steelhead have been stocked in Thermalito Afterbay when CCV steelhead are available. CCV steelhead stocking started in 2007 to enhance the recreational fishery, and has occurred in 2013, 2014, and 2015, as surplus CCV steelhead eggs were available.

1.3.2.11.1 FRFH Programs and Activities

FRFH mitigation goals are based on salmon and steelhead run abundance recorded prior to the construction of Oroville Dam, from 1954 through 1959 (Brown et al. 2004). Production goals have been adjusted over the years to meet mitigation and enhancement goals; the current production goals are shown in Table 1-1. Hatchery and Genetics Management Plans (HGMPs) are being developed and will direct future hatchery management and will be subject to future ESA consultations.

1.3.2.11.2 Fall-run Chinook Salmon Program

The FRFH fall-run Chinook salmon program produces fish to mitigate for construction of the Oroville Dam and associated facilities, and supports harvest opportunities for commercial and recreational fisheries. Exclusive to the mitigation program, an enhancement program generally produces an additional one to two million smolts for harvest. The program is intended to be integrated with the natural Feather River fall-run Chinook salmon population. The program annual production mitigation goal is 6 million CV fall-run Chinook salmon smolts; another 1 to 2 million juveniles may be produced for the Salmon Stamp Program and additional ocean enhancement. Approximately 25 percent of the fall-run Chinook salmon are currently tagged and marked. Fall-run Chinook salmon are also released into Lake Oroville (Table 1-1).

Table 1-1. DWR Lake Oroville Chinook Salmon Stocking

Year	Fingerlings	Yearlings	Total
2013	91,788		91,788
2014	139,700		139,700

1.3.2.11.3 Spring-run Chinook Salmon Program

The original purpose of the spring-run Chinook salmon program was solely to mitigate for construction of the Oroville Dam and associated facilities. While this remains a goal of the program, the primary purpose of the program has shifted toward aiding in the recovery and conservation of the state and Federal ESA listed Central Valley spring-run Chinook salmon ESU. FRFH spring-run Chinook salmon are intended to be integrated with the naturally spawning spring-run Chinook salmon population. The annual production mitigation goal is 2 million spring-run Chinook salmon smolts. Currently, the goal is to tag and mark all spring-run Chinook salmon that are released but tagging strategies change as needed to meet program objectives. The tagging program is currently a voluntary program done by DWR in cooperation with CDFW, and is subject to funding availability. The FRFH population of Feather River spring-run Chinook salmon is within the CV spring-run Chinook salmon ESU, which is listed as threatened (70 FR 37160; June 28, 2005).

1.3.2.11.4 Steelhead Program

The FRFH CCV steelhead program produces CCV steelhead to mitigate for the construction of Oroville Dam and associated facilities and supports recreational fishing opportunities. The CCV steelhead program also strives to aid in the recovery and conservation of the Federal ESA listed CCV steelhead distinct population segment (DPS). Beginning in 1967, CCV steelhead adults were trapped in the Feather River to establish the hatchery broodstock. CCV steelhead releases are 100 percent marked with an adipose clip. The annual production goal is 400,000 CCV steelhead yearlings, with an additional 50,000 juveniles produced as additional mitigation (for the 4-Pumps Agreement regarding the effects of pumping in the Delta). The hatchery population of

Feather River steelhead is within the CCV steelhead DPS, which is listed as threatened (71 FR 834; January 5, 2006).

1.3.2.11.5 Commercial Fishing Salmon Stamp Program

The Salmon Stamp program is mandated by California Fish and Game Code Sections 7860-7863. Operators of commercial vessels are required to purchase a commercial fishing salmon stamp within the California State licensing requirements for commercial salmon fishing. Salmon Stamp funds are placed in an account administered by CDFW to support salmon restoration and enhancement programs that will serve to increase ocean salmon landings. The program is funded by the Commercial Salmon Trollers Advisory Committee (50 percent) and CDFW (50 percent) to raise up to two million fall-run Chinook salmon to yearling size. The FRFH has raised between one and two million fall-run Chinook salmon smolts for this program annually, although the amount varies from year to year. Currently the FRFH is raising one million fall-run Chinook salmon smolts for this program. These fish are typically raised at the Thermalito Annex Fish Facility and are trucked to San Pablo Bay where they are placed in net pens to acclimate for a short period of time prior to release.

1.3.2.11.6 CDFW Cooperative Program

CDFW began its Cooperative Fish Rearing Program in 1973 with the goal of increasing salmon and steelhead populations, in partnership with nonprofit groups and corporations, service clubs, counties, Indian tribes, and private citizens. Some of the projects receive Salmon Stamp Funding, but cooperatives may also raise their own funds. CDFW provides fish for broodstock or culture, and all of the projects are required to operate with a current 5-year plan approved by a CDFW district biologist.

1.3.2.11.7 Four-Pumps Agreement (Delta Fish Agreement)

In 1986, DWR entered into an agreement with California Department of Fish and Game (CDFG) to offset direct losses of striped bass, Chinook salmon, and steelhead caused by DWR water diversions in the Sacramento-San Joaquin Delta (DWR 1986). DWR provides up to 50,000 FRFH CCV steelhead for planting into the Feather River each year. The fish are marked with an adipose fin-clip and released in February of each year. The Four-Pumps Agreement is not part of the Oroville Facilities.

1.3.2.11.8 Chinook Salmon Sport Fishery Production

Approximately 120,000 fall-run Chinook salmon are released into Lake Oroville for the recreational fishery on an annual basis. From 2002 to 2012, (inclusive, Table 1-2), the FRFH stocked imported Coho salmon (*O. kisutch*), Domsea® Coho, for the recreational fishery, but this program was discontinued in 2012.

Table 1-2. Coho Stocking Summary (Mitigation Stocking) 2002 to 2012

Coho Stocking				
Year	**Fingerlings**	**Yearlings**	**Adults**	**Total**
2002	50,249	128,280	-	178,529
2003	39,222	133,570	-	172,792
2004	-	-	-	0
2005	-	58,802	-	58,802
2006	-	249,827	1,299	251,126
2007	-	133,758	-	133,758
2008	363,800	-	-	363,800
2009		256,542		256,542
2010		184,415		184,415
2011		229,400		
2012	79,600	211,600		291,200

1.3.2.11.9 Feather River Fish Hatchery Water System

The FRFH receives its water from the Feather River at the Thermalito Diversion Dam and distributes it to the hatchery buildings and fish rearing areas. River water (110 cfs) is drawn and gravity fed to an aeration tower and piped through the facility; up to 69 cfs is discharged directly back into the river through the aeration overflow pipe. The current maximum water flow through the facility is 74 cfs. The Thermalito Annex uses 12 cfs of well water that have percolated through Thermalito Afterbay soils (CFS 2009). In case of water system failure or in response to flooding, FRFH fish may be transferred to the Thermalito Annex. Also, the fish screen can be removed, the gate opened at the bottom of the rearing channel and dam boards removed, releasing fish production and water directly to the Feather River (CFS 2009).

1.3.2.11.10Feather River Fish Hatchery Water Treatment

The FRFH upgraded the incubation facilities in 2000 to include equipment for ultraviolet (UV) sterilization of a portion of the incoming water supply to reduce the potential infection of eggs and juvenile fish. A water disinfection system for the FRFH water supply would also be installed in the event that anadromous fish are passed upstream of the FRFH, consistent with Article A107.4 of the SA.

1.3.2.11.11Hatchery Discharge

Most of the spawning building water, 10 rearing raceways and the rearing channel all drain into two settling ponds, 300-feet long by 30-feet wide and 2-3 feet deep (water depth), located on the southern edge of the FRFH grounds, on a terrace above Feather River. This water percolates through the cobble bottom of the settling ponds and provides the flow to the Hatchery Side Channel. A main sump collects wastewater, which is then pumped into the settling basins. Should the pumps fail or reach over-capacity, the wastewater will discharge to the Feather River via the sump overflow pipe. Likewise, wastewater from holding tanks adjacent to the main hatchery building will discharge to the sump overflow pipe, and two newer raceways discharge directly to a settling basin. When the fish ladder is in use, raw water from the ladder, gathering tank, and the four holding tanks discharge directly to the Feather River. No chemicals or fish food are present in direct wastewater discharge, and the hatchery is responsible for meeting discharge criteria in its NPDES permit issued by the Central Valley Regional Water Quality Control Board.

1.3.2.11.12FRFH Production Protocols

1.3.2.11.12.1 Hatchery Ladder Operations

Salmon and CCV steelhead that gather at the Fish Barrier Dam follow a 0.4-mile-long fish ladder into the FRFH. As fish reach the end of the ladder, they swim into the gathering tank, and hatchery personnel can operate a mechanical sweep to move the fish into the spawning building when necessary. The springtime ladder operations allow early entry and tagging of spring-run Chinook salmon from April through June. The ladder is generally open from mid-September through June 30. Any fish still in the ladder after spring-run Chinook salmon tagging is completed are discharged back to the river and the ladder is cleaned.

1.3.2.11.12.2 Fish Sorting

Fish entering the spawning building may be subject to carbon dioxide (CO_2) anesthesia and handling. Unripe fish selected for broodstock are moved to one of four circular holding tanks until they are ready for spawning. Since 2004, hatchery staff has been adaptively managing the spring-run and fall-run Chinook salmon broodstock collection concurrently, rather than following the previous protocol of a cut-off date transition from the spring-run Chinook salmon program to the fall-run Chinook salmon program. Phenotypic spring-run Chinook salmon enter the FRFH from April through June and are counted and given a Hallprint tag regardless of their mark status. Each Hallprint tag is coded with a unique numerical sequence enabling the recording of the date, location, and spawning condition for each fish recovered. The fish are then released back to the river to hold over while the fish ladder is closed from July to mid-September, then reopened in mid-September. The tagged fish serve as broodstock for the FRFH spring-run Chinook program. Unmarked Chinook salmon concurrently entering FRFH in September and up to October 7 are culled to eliminate the spring-fall hybrids. Non-tagged salmon collected after October 7 (or thereabout) are currently retained as fall-run Chinook salmon broodstock.

1.3.2.11.12.3 Broodstock Collection

FRFH collects Chinook salmon and CCV steelhead broodstock in a manner that approximates the distribution in timing, age, and size of fish returning to the Feather River. Jacks are used as needed. Data from the past several years show that jack composition (a salmon less than or equal to 24 inches) ranges from 2 to 10 percent. Tags are used to identify phenotypic spring-run Chinook salmon (see section *1.3.2.11.12.2 Fish Sorting*).

1.3.2.11.12.4 Fish Spawning

FRFH salmon and CCV steelhead are spawned in a manner representative of natural run-timing; fewer fish are spawned at the tail ends of the spawning distribution than the middle of the fish run. Adults are held in circular tanks until they are ready to be spawned. Fall-run Chinook salmon are spawned in a matrix using the gametes from 2-3 males and 2-3 females. Spring-run Chinook salmon and CCV steelhead broodstock are spawned at a 1:1 ratio. Once the CCV steelhead are spawned, they are put into a fresh water tank to recuperate from the anesthetic. They are then either returned to the river or held for reconditioning. Chinook salmon in excess of broodstock needs are excised without being spawned.

No chemicals or therapeutics are used during the spawning process. All equipment used during spawning activities is routinely washed with clean water. Once eggs have been fertilized and washed, they are immersed for 20 minutes in a 100-parts-per-million polyvinylpyrrolidone (PVP) iodine solution to help eliminate a broad spectrum of disease-causing microorganisms, and the PVP solution is also used to kill on contact a wide variety of bacteria, viruses, fungi, protozoa, and yeasts (CFS 2009).

Currently, fall-run Chinook salmon eggs are collected based on a spawning curve developed to collect eggs so that early and late spawners are not over represented in the broodstock. Following this spawning curve, fish are culled and not spawned based on the target number of eggs to be collected on a given spawn day. Further egg culling may also be required to meet production goals and is conducted to maintain the spawning curve. Spring-run Chinook salmon are spawned until an egg take goal of 3 million eggs is reached, then all spring-run Chinook salmon are culled, except those needed for experimental programs such as the San Joaquin Reintroduction Program. If there are eyed eggs in excess of what is needed to meet the production goal they are culled similarly to fall-run Chinook salmon. CCV steelhead returns to the hatchery are relatively low, eggs are collected from all females, and there are generally no subsequent reductions at the eyed stage, except when necessary to meet production goals.

1.3.2.11.12.5 Carcass Disposal

The heads of all adipose clipped salmon are removed from the carcasses, recorded, and stored for coded-wire tag (CWT) processing. The heads are periodically transferred to the CDFW tag recovery and decoding laboratory in Santa Rosa. Carcasses with food value are donated to nonprofit organizations, as determined by the hatchery manager. Carcasses not donated to nonprofit organizations are disposed of at a rendering plant or other appropriate refuse disposal site. Since 1996, as a fish health management precaution, no FRFH salmon carcasses have been returned to the Feather River.

1.3.2.11.12.6 Incubation

Newly fertilized eggs are loaded into one of 128 vertical flow incubators. For CCV steelhead, hatchery staff may use either the vertical flow incubators or hatching jars. The eggs are not disturbed until at the eyed stage, when they are checked daily and dead eggs removed at least every third day (Brown et al. 2004). Once the yolk sac is absorbed (approximately 75 to 90 days), fry are stocked into the raceways at the loading density of 1.5 million fish per raceway. The stocking density is later reduced to 800,000 to 900,000 fish per raceway. When the fry reach about 300 per pound, some of them are moved into the hatchery channel (Brown et al. 2004).

1.3.2.11.12.7 Fish Rearing

Salmon and CCV steelhead fry are transferred to a series of concrete lined raceways, which are covered with a wire mesh enclosure to limit avian depredation. Nominal flow and water velocity are 5 cfs and 0.1 foot per second (fps) respectively in each raceway. The raceways can be blocked at various intervals to provide holding space for special studies or for holding individual groups of marked and tagged fish. Fish destined for the enhancement program are transported to the Thermalito Annex for rearing in additional concrete raceways. Due to temperature differences in the water supplies for the hatchery and the Thermalito Annex (Thermalito Annex water is generally warmer during the rearing season), in the past fish were occasionally moved to the Thermalito Annex for faster growth or to control diseases (infectious hematopoietic necrosis virus in particular). After growth had been achieved, or disease problems eliminated, the fish could be returned to the main hatchery. As of 1993, this practice of moving fish back and forth has been discontinued (except as noted below), and the Thermalito Annex is being used for enhancement fish, although some mitigation fish may be reared there. Once every five years juvenile CCV steelhead are temporarily reared at the Annex to allow routine hatchery water supply inspections.

1.3.2.11.12.8 Fish Marking

All adipose fin-clipped Chinook salmon are given a coded wire tag (CWT). Spring-run Chinook salmon are 100 percent marked; fall-run Chinook salmon are marked at a 25 percent constant fractional rate. All hatchery CCV steelhead are adipose fin-clipped. Pre-release quality checks on tagged spring-run Chinook salmon indicate a 99.9 percent mark rate and a greater than 95 percent tag retention rate 21 days or more after tagging. Fish marking may change over time and will be guided in part by the HGMP. The fall-run Chinook salmon marking program is currently carried out by CDFW and is not part of the proposed action.

1.3.2.11.12.9 Fish Releases

FRFH Chinook salmon are released as young-of-the-year smolts and CCV steelhead are released as yearlings. Chinook salmon may be trucked to San Pablo Bay in water chilled to around 49 degrees-Fahrenheit (ºF) and at a loading density of one pound of fish per gallon of water. Currently half of the CV spring-run Chinook salmon are released at the Boyd’s Pump Boat Ramp at river mile (RM) 22, in the Feather River, except for experimental releases at other in-river locations. At this time, all FRFH CCV steelhead are released at Boyd’s Pump Boat Ramp, or other river locations as needed.

1.3.2.11.12.10 Study Fish

FRFH provides fall-run Chinook salmon on request for monitoring studies on the effects of water management operations, restoration projects, and technical improvements, salmonid out-migration behavior and survival in the Feather River, Sacramento River, and Delta. The project permit holder is responsible for risk assessments and oversight on monitoring and reporting the ecological effects associated with the study. Study fish are not typically reared separately from mitigation fish.

1.3.2.11.12.11 Fish Health Management

CDFW pathologists perform routine health assessments, using a modification of the organosomatic analysis system to check and report on the condition of the fish, as infected fish may not show clinical signs of disease. A random sampling of fish is assessed for general health prior to release. Transferring fish to saltwater is also a control measure for any freshwater parasites that may remain when the fish are released. CDFW policy does not allow the release of diseased fish. If clinical signs of specific diseases are detected, the pathologist may recommend treatment or, in rare cases, disposal or release of the diseased fish on the understanding that the chances of the disease spreading to wild fish are minimal, such as the case of freshwater parasites that do not survive after the fish are released in the lower estuary.

1.3.2.11.13Hatchery Monitoring and Evaluation

The FRFH collects information on fish counts, species identification, average stock fecundity and egg size, and fish length. Additional information is collected specific to adaptive management of the spring-run Chinook salmon program, including maintaining records on Hallprint tags and CWT. Data on FRFH fish is also acquired through salmon and CCV steelhead monitoring activities in the CV and ocean harvest and are important in providing feedback for evaluating FRFH programs.

1.3.2.12 Oroville Wildlife Area

The OWA comprises approximately 11,000 acres west of Oroville and is managed for wildlife habitat and recreational activities. It includes Thermalito Afterbay and surrounding lands (approximately 6,000 acres), along with 5,000 acres adjoining the Feather River. The 5,000-acre area straddles 12 miles of the Feather River, which includes willow and cottonwood-bordered ponds, islands, and channels. Recreation opportunities in the OWA include dispersed recreation (hunting, fishing, and bird watching) and recreation at developed sites, including Monument Hill Day Use Area, model aircraft grounds, three boat launches on Thermalito Afterbay and two on the river, and a primitive camping area. A CDFW habitat enhancement program includes a wood duck/wildlife nest box program and dry land farming for nesting cover and improved wildlife forage.

Permitted gravel mining currently occurs within a portion of the OWA that straddles the Feather River. Piles of barren, gravel/cobble dredger piles are remnants of hydraulic mining during the 1800s and provide a large source of gravel. The mining operations resulted in large amounts of discarded dredger piles that were bought and used by DWR to help construct Oroville Dam. With management assistance from CDFW, DWR then converted the area into a wildlife area that became a feature of the initial project license. These remaining dredger piles cover approximately 615 acres within the OWA. These areas are all located within the Feather River floodplain and provide significant gravel resources for projects throughout the surrounding area.

1.3.2.13 South Feather Hydroelectric Project Description

The following paragraphs describe the basics of the South Feather Power Project. The South Feather Water & Power Agency (SFWPA) is in the process of relicensing its power facilities on the South Fork of the Feather River. The terminal powerhouse for the South Feather Power Project, the Kelly Ridge Powerhouse (KRPH), discharges South Fork Feather River (SFFR) water into DWR's Oroville Facilities Thermalito Diversion Pool, which lies below DWR's Oroville Dam. This discharge can have an effect on DWR's ability to meet temperature criteria at Robinson's Riffle and the FRFH.

One component of the South Feather Power Project that can potentially have an influence on DWR's temperature requirements for its Oroville Facilities (as described in their relicensing SA) is the KRPH discharge. Historically the Project discharged water from the KRPH directly into the Feather River. However, since the construction of the Oroville Facilities, the point of discharge for the KRPH has become the Thermalito Diversion Pool.

The South Feather Hydroelectric Project is not part of the proposed action analyzed in this Opinion. It is included here because the South Feather Hydroelectric Project affects Oroville Facilities operations. The relicensing of the South Feather Hydroelectric Project by the FERC underwent a separate ESA consultation (NMFS letter dated May 11, 2016).

1.3.2.14 South Feather Power Project Operations Related to Oroville Facilities

The KRPH tailrace discharge is located in the upper portions of the Thermalito Diversion Pool which extends between the DWR's Oroville Dam and the Thermalito Diversion Dam (Figure 1-2). Water temperatures in the Thermalito Diversion Pool are controlled by the temperatures of the water released by DWR from Oroville Dam, as well as water released through the KRPH.

During most of the year, up to 97.5 percent of the water in the Thermalito Diversion Pool is from DWR's releases from Lake Oroville. Depending on both the South Feather Power Project's and the Oroville Facilities' generation modes, water in the Thermalito Diversion Pool consists of a combination of waters from Lake Oroville (water from Oroville Dam's upper intake shutters and the dam's bottom River Outlet); the South Feather Power Project's KRPH; and, if pump-back operations resume, water from Oroville's Thermalito Complex. There are times when KRPH discharges into the Thermalito Diversion Pool cause incremental warming in the Thermalito Diversion Pool.

On October 23, 2012, SFWPA, DWR, and the Soil and Water Conservation Society entered into a SA over management of SFWPA's deliveries of Kelly Ridge water to the Thermalito Diversion Pool. The SA allows temporary suspension of water deliveries directly to the Thermalito Diversion Pool by stopping all deliveries to the Miner's Ranch Reservoir (including deliveries to replenish the Reservoir for withdrawals to its water treatment plant and irrigation system) and, instead, releasing water into Lake Oroville. Such suspensions, however, are restricted to a minimum and maximum number of days that the water deliveries can be suspended. However, by doing so the South Feather Power Project is unable to generate hydroelectricity at the KRPH, resulting in lost revenue and can be subject to other costs, fees, and possible penalties. DWR agreed to reimburse SFWPA for these costs.

1.3.2.15 Oroville Facilities Operations

The descriptions of operations in this document represent typical operations of the Oroville Facilities. Sometimes, DWR operates the Oroville Facilities differently due to a variety of factors, such as unusual hydrologic conditions or unanticipated mechanical issues. However, at no time will DWR operate outside of the flow and temperature requirements established for the Oroville Facilities.

1.3.2.16 Overall Oroville Facilities Operations

DWR currently operates and maintains the Oroville Facilities under the terms and conditions of a FERC License (effective February 1, 1957 and issued on February 11, 1957), which expired on January 31, 2007. Based on FPA section 15(a)(1) (16 U.S.C. 808(a)(1)) and FERC regulations (18 CFR 16.18(c)), FERC issued an annual license effective February 1, 2007 with the terms and conditions of the prior license, and the annual license is automatically renewed from each year until a new license is issued. FERC is authorized to issue licenses for 30 to 50 years for the operation of non-Federal hydroelectric power plants subject to conditions that provide adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat).

DWR proposes to operate the project to meet the needs of the SWP (*i.e.* water delivery to irrigation districts, flood control, power generation, recreation, California Water Board decision (D-1641) for flow and water quality standards for the Sacramento-San Joaquin Delta, and fish and wildlife protection). Flows are released from Lake Oroville, primarily through the Hyatt Powerplant where most flows are diverted either through the Thermalito Power Canal and Thermalito Power Plant or the LFC. This eight-mile reach of the Feather River from the Fish Barrier Dam to the Thermalito Afterbay Outlet contains the majority of remaining spawning habitat for CV spring-run Chinook salmon and CCV steelhead in the Feather River.

Winter and spring runoff is stored in Lake Oroville for release to the Feather River to meet downstream water demands and minimum instream flow requirements. Annual planning for operations assumes that the reservoir will retain some water above the minimum pool carried over from prior years to be made available for water releases in subsequent years. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Water can also be stored in Lake Oroville and the other project impoundments over a shorter time-frame (over days or hours) to meet power objectives. The project offers flexibility with respect to energy generation and flow release. Specific technical information about flow, storage, and generating capacity is provided for each project facility in the following sections (1.3.2.17–1.3.2.17.8.1).

Water can be released from Lake Oroville through the Hyatt Pumping-Generating Plant during peak hours. That water can either be: (1) temporarily stored in the Thermalito Diversion Pool for pumping back to Lake Oroville during off-peak hours, (2) released through the Thermalito Diversion Dam and Powerplant to produce electricity and provide instream flow to the LFC; or (3) passed down the Thermalito Power Canal to the Thermalito Forebay. Water passed through the Thermalito Power Canal can be stored in the Thermalito Forebay or passed through the Thermalito Pumping-Generating Plant to produce electricity and then either stored in the Thermalito Afterbay, passed into irrigation diversions, or passed through the Thermalito Afterbay Outlet to the HFC. Water stored in the Thermalito Afterbay can also be temporarily stored and later pumped upstream during off-peak hours to the Thermalito Forebay. Once back in the Thermalito Forebay, water can be sent in either direction, providing the hydraulics that would permit open channel flow back to the Thermalito Diversion Pool.

1.3.2.17 Lake Oroville Operations

DWR stores winter and spring runoff in Lake Oroville for release to the Feather River to meet downstream demands later in the year. The U.S. Army Corps of Engineers (USACE) requires Lake Oroville to reserve 750,000 acre-feet (af) of storage space for flood control. The annual operations plan is developed in late November of the previous year and is updated monthly to reflect changes in hydrology and downstream operations in the current year. Lake Oroville's storage is targeted to fill to near a maximum annual level of 900 feet above MSL. Typically maximum storage, which in drier years may be below 900 feet above MSL, is reached in late spring. After the maximum storage is reached in late spring, Lake Oroville releases stored water to meet downstream requirements, lowering to a minimum annual level in December or January. During and following dry years, the demands increase on the system such that the reservoir may be drawn down more and may not fill to desired levels the following spring.

1.3.2.17.1 Annual Water Operations Planning

Operations planning requires coordination with other Federal, State, and local agencies and must consider a number of factors. The annual water operations plan considers actual and forecast water supply, actual and projected operations of the CVP, contractor demands, Federal and state regulatory requirements (including flood management, instream requirements, and Sacramento Valley in-basin requirements such as Delta water quality and outflow standards, and protection for species of concern) and contractual obligations. The first official plan for the next year is completed in November as part of the water allocation process and is a significant component in determining the amount of forecasted deliveries by the SWP. This monthly time-step plan includes projected releases to the Feather River, forecasts of Oroville inflow, Lake Oroville end-of-month storage levels, local demands, and any scheduled outages. The water operations plan for the allocation process is updated monthly beginning in December to reflect changes in hydrology and downstream operations. The Oroville Facilities power generation plants operate within the constraints established by the water operations plan.

1.3.2.17.2 Weekly Water Operations Planning

Following the guidance of annual water operations planning, a general plan is developed for reservoir releases each week. This plan considers how much water will be needed downstream for local water supply demands, Delta water quality and outflow requirements, instream flow requirements, contractor deliveries, and minimum flood management storage space. The weekly plan is revised as needed to meet changing operational conditions both upstream and downstream.

1.3.2.17.3 Daily Water Operations Scheduling

Water releases through the power plants are scheduled daily. The operation of the power plants is planned to maximize the amount of energy that may be produced during periods when electrical demand is highest. Oroville Facilities operations are scheduled to maximize power benefits as long as the operations fit within the scheduled water operations.

1.3.2.17.4 Flow Releases

Flow releases from Lake Oroville and Thermalito Afterbay are planned weekly to accommodate water deliveries; Sacramento Valley in-basin demands such as Delta requirements; instream flow requirements in the Feather River; and minimum flood management space requirements. Weekly operational plans are updated as needed to respond to changing conditions. The Diversion Pool, Thermalito Forebay, and Thermalito Afterbay are too small for seasonal storage, so they are used only in weekly and daily operations planning. Releases through the Hyatt Powerplant and Thermalito Pumping-Generating Plant are scheduled to maximize the amount of energy produced when power values are highest. Operational decisions are affected by the following considerations:

- Afterbay water demand and available storage
- Environmental requirements including water temperature and Thermalito Afterbay storage levels for water fowl and migratory birds
- Supplemental energy market activities
- Voltage regulation requirements

Storage in Thermalito Forebay and Thermalito Afterbay is used to generate power and maintain uniform flows in the Feather River downstream of the Oroville Facilities. Thermalito Afterbay also provides storage for pump-back operations. Pump-back operations have not been performed since 2004, however, because the process increases the temperature of the water as it passes through the Facilities. The pump-back operations are designed to use water that is in excess of what is required for downstream flow requirements for pumping back into Thermalito Forebay and then into Lake Oroville during off-peak hours. This water is then released again during on-peak hours when power values increase. Generation provided by this pump-back activity contributes on average only about 6 or 7 percent to the total annual Oroville Facilities generation. Because the two main power plants are operated to take advantage of weekday generation when power values are highest, there is usually higher storage in Thermalito Afterbay by the end of the week. During the weekend, water from the Thermalito Afterbay continues to be released to the Feather River, generation at the Hyatt Powerplant and Thermalito Pumping-Generating Plant is decreased, and pump-back operations into Lake Oroville can occur, if desired. By the end of the weekend, the elevation of Thermalito Afterbay is lowered to prepare for a similar operation the following week.

1.3.2.17.5 Releases for Delta Requirements

Flows through the Delta are maintained to meet the SWRCB's D1641 (Bay-Delta standards) arising from DWR's and the USBR's joint water rights permits. These standards are designed to meet several water quality and outflow requirements for municipal, industrial and agricultural users, and fish and wildlife. In particular, they protect a wide range of fish and wildlife including Chinook salmon, delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2.17.6 Feather River Service Area Water Supply Deliveries

DWR has SAs with six local agencies along the Feather River (including the Thermalito Afterbay) from Lake Oroville to the confluence with the Sacramento River. They receive water according to the terms of settlement stemming from the original construction of the Oroville Facilities. These settlements recognized the senior water rights of those agencies and that DWR would provide them certain quantities of water from storage in Lake Oroville in accordance with those senior water rights. Four of these agencies are allowed to divert up to 955,000 af during the irrigation season (April 1 through October 31), subject to provisions for reduction in supply under certain specific low-inflow conditions. The agreements with these agencies also indicate that an unspecified amount of water may be diverted for beneficial use outside of the contract irrigation season (November 1 through March 31). The remaining two agencies are allowed to divert up to 19,000 af annually, also subject to provisions for reduction in supply under certain specific low-inflow conditions. The actual amount diverted varies from year to year depending on the local hydrology. These diversions are made at one location in Lake Oroville, one location in the Thermalito Power Canal, four locations in Thermalito Afterbay, and five locations on the Feather River below Thermalito Afterbay. The agencies that divert directly from the Thermalito Afterbay are collectively referred to as the Feather River Service Area (FRSA) water users and are responsible for most of the local diversions.

DWR has also executed a number of contracts with riparian landowners along the Feather River downstream of Oroville Dam. Riparian owners are entitled to divert unimpaired flow for use on riparian land, but are not entitled to augmented flow made available as a result of project storage. Although the quantities of water are relatively small and do not ordinarily influence SWP operations, in certain years riparian diversions can affect Oroville releases.

1.3.2.17.7 Water Supply for the State Water Project Contractors

As SWP facilities, the Oroville Facilities provide water supply for municipal, industrial, and irrigation purposes after meeting its regulatory requirements.

1.3.2.17.8 Releases for Water Quality in the Delta

1.3.2.17.8.1 Flood Management

The Oroville Facilities are an integral component of the Sacramento River Flood Control Project, the flood management system for the areas along the Feather and Sacramento Rivers downstream of Oroville Dam. The primary objectives of flood control operations are to minimize flood damages downstream and to avoid causing damage, insofar as practicable, that would not have occurred under conditions without Oroville. Section *4.10, Flood Control*, of the Settlement Agreement states that the parties agree that the licensee pursuant to the proposed SA Article A 130 will comply with the rules and regulations prescribed by the USACE.

From September to June, the Oroville Facilities are operated under flood control requirements specified by USACE. Under these requirements, Lake Oroville reserves 750,000 af of storage space for flood control. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with USACE.

During times when flood management space is not required to accomplish flood management objectives (Table 1-3), the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made to ensure adequate space in Lake Oroville to handle flood flows) varies from about 2.8 to 3.2 million acre feet. Actual flood storage requirements are partially based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (*i.e.*, high potential runoff from the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through May and June, the maximum allowable storage limit increases incrementally as the flooding potential decreases. This allows capture of the higher spring flows for use as water supply later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, and in consultation with

USACE, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

Table 1-3. Flood Control Requirements for the Oroville Facilities

Period	Flood Control Requirement Based on Date	Flood Control Requirement Based on Wetness Index[a]	Comment
June 15-September 15	No	No	No flood control requirements
September 16-October 14	Yes	Yes	
October 15-April 1	Yes	Yes	Full flood control reservation space is required
April 2-June 15[b]	Yes	Yes	

a The Wetness Index is a weighted accumulation of season basin mean precipitation and is computed by multiplying the previous day's parameter by 0.97 and adding the current day's new precipitation, thus it is based on accumulated precipitation. A value of 11.0 or greater corresponds to wet conditions within the basin and corresponds to the provision of the full 750 thousand af of flood control space, while a value of 3.5 or less corresponds to dry conditions and to the minimum flood control space requirement of 375 thousand af (Bratovich et al. 2004a).

b The flood control season can end as early as May 8, or as late as June 15, depending on the wetness of the basin.

1.3.2.18 Environmental Facilities and Operations

The Oroville Facilities include facilities and operations to help protect and enhance fish and wildlife species and their habitat. Many of the environmental programs implemented within the FERC Project boundary are cooperatively managed or are based on agreements with other agencies such as CDFW and USFWS. This includes operation and maintenance of facilities such as the FRFH and the Oroville Wildlife Area and implementation of measures developed in consultation to protect Endangered Species Act (ESA)–listed terrestrial species within the FERC Project boundary. In addition, under the SA for the Oroville Facilities, DWR agreed to protection, mitigation, and enhancement measures, which are discussed below in section *1.3.3. Proposed Conservation Measures*.

1.3.3 Proposed Conservation Measures

Besides the proposed operations described above, DWR proposes to implement environmental measures following issuance of the new FERC License (Appendix A of the SA) to protect and enhance resources affected by the project. The measures are proposed to be conditions of the new license. The SA includes a commitment by DWR to develop, in consultation with stakeholders, a number of plans and programs to enhance, protect, mitigate, restore, or create habitat within the

FERC Project boundary. It also requires that DWR complete a number of studies and conduct monitoring to guide future decisions and activities. These plans, programs, studies, and monitoring activities will likely lead to future actions, and thus are described here programmatically.

The SWRCB reviewed the measures and determined that certain measures are not enforceable, will not protect the beneficial uses under their jurisdiction, or will not meet water quality standards in a timely manner. Order WQ 2010-0016 found that beneficial uses impacted by the project may not be reasonably protected if the proposed measures have a management plan with unclear or unenforceable standards, excessively long period prior to implementation, or unspecified implementation dates. The SWRCB modified each measure to provide assurance that the beneficial uses will be reasonable protected. Any water quality certification condition that requires the development of a plan will require the plan to be reviewed, modified if necessary, and approved by the Deputy Director for Water Rights (Deputy Director). Some of the conditions include reservations of authority or adaptive management provisions to address uncertainties.

Of the proposed conservation measures for FERC relicensing, the following 12 programs may affect ESA listed anadromous fish species:

- Ecological Committee (A100). See section *1.3.3.1*.
- Lower Feather River Habitat Improvement Plan (A101). See section *1.3.3.2*.
- Gravel Supplementation and Improvement Program (A102). See section *1.3.3.3*.
- Channel Improvement Program (A103). See section *1.3.3.4*.
- Structural Habitat Supplementation and Improvement (SHSI) Program (A104). See section *1.3.3.5*.
- Fish Weir Program (A105). See *1.3.3.6 Fish Weir Program (A105)*.
- Riparian and Floodplain Improvement Program (A106). See section *1.3.3.7*.
- Feather River Fish Hatchery Improvement Program (A107). See section *1.3.3.8*.
- Instream Flow and Water Temperature Requirements for Anadromous Fish (A108). See section *1.3.3.9*.
- Lake Oroville Cold Water Fishery Habitat Improvement Program (A111). See section *1.3.3.10*.
- Comprehensive Water Quality Monitoring Program (A112). See section *1.3.3.11 Comprehensive Water Quality Monitoring Program (A112)*.
- Oroville Wildlife Area Management Plan (A115). See section *1.3.3.12*.

The 13 programs mentioned above are included as conservation measures in the proposed action and are described in more detail below (section *1.3.3.1*). SWRCB findings and conditions are also included.

1.3.3.1 Ecological Committee (A100)

Within three months of issuance of the new FERC license, DWR will establish an Ecological Committee (EC) to advise DWR on ecological issues related to implementing the new license.

Membership will be comprised of representatives of the signatories to the SA including USFWS, NMFS, and CDFW, U.S. Bureau of Land Management (BLM), California Department of Parks and Recreation (DPR), local governmental entities, Native American tribes, and other interested signatories (*e.g.*, State Water Contractors and American Rivers). The membership will also include representatives of the SWRCB and Central Valley Regional Water Quality Control Board, which are not signatories to the SA.

The SWRCB water quality certification supports consultation with agencies when developing plans or making decisions affecting resources over which agencies may have jurisdiction or expertise, but finds that only certain governmental entities are formally vested with the authority and responsibility to protect such uses and resources and are publicly accountable for these duties. As such, each of the water quality certification conditions that includes consultation with agencies lists the specific agencies and alternatively allows consultation with the EC as long as those agencies are members of the EC.

1.3.3.2 Lower Feather River Habitat Improvement Plan (A101)

Within three years following license issuance, DWR will develop a comprehensive Lower Feather River Habitat Improvement Plan, which includes the following nine components that are intended to improve the lower Feather River habitat for Chinook salmon, CCV steelhead, and other aquatic biota:

- Gravel Supplementation and Improvement Program (A102). See section *1.3.3.3*.
- Channel Improvement Program (A103). See section *1.3.3.4*.
- Structural Habitat Supplementation and Improvement (SHSI) Program (A104). See section *1.3.3.5*.
- Fish Weir Program (A105). See section *1.3.3.6*.
- Riparian and Floodplain Habitat Restoration Program (A106). See section *1.3.3.7*.
- Feather River Fish Hatchery Improvement Program (A107). See section *1.3.3.8*.
- Instream Flow and Water Temperature Requirements for Anadromous Fish (A108). See section *1.3.3.9*.
- Comprehensive Water Quality Monitoring Program (A112). See section *1.3.3.11*.
- Oroville Wildlife Area Management Plan (A115). See section *1.3.3.12*.

The overall strategy is to coordinate various habitat improvement activities to maximize benefits to fish and wildlife species and to assess and correct potential predation problems created or exacerbated by any DWR-sponsored or implemented project modifications. For the first five years, DWR will annually report monitoring results and activities to the EC and after the fifth year of license issuance, DWR will consolidate the reports into a single, comprehensive monitoring and adaptive management summary report to be prepared every five years thereafter for the remainder of the FERC license term. Annual reporting to the EC, if appropriate, will continue for the remainder of the FERC license term. The summary report will include the results of each of the various components of the Lower Feather River Habitat Improvement Plan and will provide a summary of actions taken, management decisions, and proposed modifications to the various program components. Additional details on each component of the Lower Feather River Habitat Improvement Plan are included in Appendix A of the SA.

The SWRCB included the following condition (S1) in the water quality certification for the Lower Feather River Habitat Improvement Plan.

a) *Within three years of license issuance, the Licensee shall develop a comprehensive Lower Feather River Habitat Improvement Plan. The Plan shall provide an overall strategy for managing the various environmental measures developed for implementation within the areas integrated in the Plan, including the implementation schedules, monitoring, and reporting. The Plan shall be developed in consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and Wildlife, California State Water Resources Control Board (State Water Board), and Central Valley Regional Water Quality Control Board (consultees). Consultation with the Ecological Committee complies with the consultation requirement, as long as the agencies listed are part of the Ecological Committee. The Licensee shall submit the Plan to the Deputy Director for Water Rights (Deputy Director) for approval. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the plan shall be deemed approved.*

b) *The Licensee shall individually evaluate each of the programs and components of the Lower Feather River Habitat Improvement Plan to assess the overall effectiveness of each action within it. Each program or component may be updated or modified as appropriate to continue to best meet Habitat Improvement Plan goals.*

c) *The following programs and plans shall be included in the comprehensive Lower Feather River Habitat Improvement Plan: [the condition lists the 9 components listed above].*

d) *The Plan shall provide for and include:*

   1. *Coordination of implementation and monitoring activities agreed to in the individual components included in the comprehensive Plan;*
   2. *Coordination with any project-specific biological opinions and Operational Criteria and Plan findings or recommendations;*
   3. *Annual reporting of monitoring results and activities, if appropriate, for the individual components to the consultees throughout the term of the license;*
   4. *The integration of the programs and plans listed in subdivision (c) above, including an evaluation of synergistic effects and an evaluation and consideration of predation management; and*
   5. *Development of a single, comprehensive monitoring and adaptive management summary report by the Licensee as set forth in (e) below.*

e) *During the sixth year following license issuance and at five-year intervals for the duration of the license, the Licensee shall develop and submit a single, comprehensive monitoring and adaptive management summary report. The Lower*

Feather River Habitat Improvement Plan report shall be submitted to the consultees listed in S1(a) above for review and comment at least 60 days prior to filing the report with the Deputy Director. The comprehensive report shall include the results of each of the various components of each program during the implementation period. The report shall also include information on any proposed changes or updates to the individual plans or programs within the Lower Feather River Habitat Improvement Plan.

1.3.3.3 Gravel Supplementation and Improvement Program (A102)

The Gravel Supplementation and Improvement Program is designed to address the deterioration of current spawning habitat in the LFC due to the blockage by Oroville Dam of suitable spawning gravel movement from upstream sources into the LFC. Because sediments, including gravels, will likely continue to be trapped behind Oroville Dam, DWR will develop a Gravel Supplementation and Improvement Program to mitigate the cumulative impacts of the project on the quantity and quality of spawning gravels available for Chinook salmon and CCV steelhead.

DWR would immediately initiate planning, developing, and implementing a program to supplement up to 15 locations in the Lower Feather River with at least 8,300 cubic yards of spawning gravels suitable for CV spring-run Chinook salmon and CCV steelhead. This initial gravel supplementation would be completed within five years following FERC license issuance.

Within two years of license issuance, DWR will also develop a Gravel Management Plan to address ongoing and future gravel management for the Lower Feather River. The Gravel Management Plan will provide for (1) a physical assessment of the spawning riffles from RM 54.2 to RM 67.2 of the Feather River, (2) a gravel budget for the LFC and, if necessary, portions of the HFC within the FERC Project Boundary, (3) a strategy to augment existing gravel recruitment in the LFC and HFC with gravel injections, placements, or other methods developed through site-specific investigations, (4) plans to monitor and evaluate the effectiveness of gravel augmentation and biological response of fish species, (5) annual summary of activities, (6) definition of high flow events, and (7) coordination with other components of the Lower Feather River Habitat Improvement Program. Specific measures, criteria and timelines are included in Article A102 of the Settlement Agreement.

All work conducted under this program that would occur within the ordinary high water (OHW) of the Lower Feather River would take place during the summer months (June and July) or at other times as allowed by permit conditions to produce minimal impact to CV spring-run Chinook salmon and CCV steelhead and to other river attributes (*i.e.,* water quality).

Gravel placement or riffle rehabilitation would, where feasible, cover the extent of naturally observed spawning, or within an area extending between river banks, of at least 50 feet extending upstream and downstream, and to a depth of at least 1 foot. The replenished or rehabilitated gravel at each site would be monitored every 5 years, as needed, for the term of the License. After the initial supplementation period, the licensee would monitor and maintain a minimum of 10 riffle complexes in the LFC so that approximately 80 percent of the gravels randomly sampled in riffle complexes would be in the median range preferred by Chinook salmon or CCV steelhead. Additional gravel supplementation in the HFC within the Project Boundary would be determined. If needed (but no sooner than 10 years from the issuance of the New FERC License), a gravel budget for supplementation activities would be prepared for activities in the HFC. Chinook salmon and CCV steelhead gravel use would be monitored to determine the effectiveness of the gravel supplementation or riffle rehabilitation, and to determine if spawning gravels are a primarily limiting factor for the natural reproduction of Chinook salmon or CCV steelhead. If monitoring results show suitable spawning areas are primarily limiting for natural reproduction, additional gravel supplementation would be initiated.

The SWRCB included the following condition (S2) in the water quality certification for the Gravel Supplementation and Improvement Program.

a) *Within two years of license issuance, the Licensee shall develop a Gravel Supplementation and Improvement Program Plan to address gravel management for the lower Feather River throughout the term of the license. The Plan shall be developed in consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, the California Department of Fish and [Wildlife], and the State Water Board (consultees). Consultation with the Ecological Committee complies with the consultation requirement, as long as the agencies listed are part of the Ecological Committee. The Licensee shall include with the Plan copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why any such comment was not adopted. The Licensee shall submit the Gravel Management Plan to the Deputy Director for approval. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the Gravel Management Plan shall be deemed approved. Upon Deputy Director approval, and after obtaining all necessary permits, the Licensee shall implement the Plan, including any changes required by the Deputy Director.*

b) *The Licensee, in consultation with the consultees listed in S2(a) above, shall coordinate the gravel supplementation activities with the measures conducted within the Lower Feather River Habitat Improvement Plan.*

c) *The Plan shall include a schedule to complete, within five years of license issuance, the supplementation of at least 8,300 cubic yards over the December 31, 2006 baseline of spawning gravels suitable for spring-run Chinook salmon or steelhead, which shall be distributed over up to 15 locations in the LFC or HFC of the Feather River.*

d) *The Plan shall provide for: (1) a physical assessment of the spawning riffles from RM 54.2 up to RM 67.2 of the Feather River; (2) a gravel budget for the LFC and, if necessary, portions of the HFC within the project boundary; (3) a strategy to augment existing gravel recruitment beyond the 8300 cubic yards referenced in subdivision (c) above in the LFC and HFC with gravel injections, placements, or other methods developed through site-specific investigations; (4) plans to monitor and evaluate the effectiveness of gravel augmentation, particularly the biological response of fish species to the gravel supplementation and enhancement activities; (5) an annual summary account of the activities conducted; and (6) coordination with other components of the license and the Lower Feather River Habitat Improvement Plan to enhance natural reproduction of steelhead and Chinook salmon.*

e) The Gravel Supplementation and Improvement Program Plan shall also include the following measures, criteria and timelines.

1. *All work within the Ordinary High Water mark of the Lower Feather River shall take place during the months of June and July, or at other times as allowed by permit conditions to produce minimal impact to the target species (CCV steelhead and Chinook salmon) and other river attributes (i.e., water quality).*
2. *Gravel placement or riffle rehabilitation at the treated riffles shall, where feasible, cover the extent of naturally observed spawning areas, be within an area extending between river banks, and extend at least 50 feet upstream and 50 feet downstream of the riffle, and be a depth of at least one foot.*
3. *Licensee shall monitor and replenish or rehabilitate gravel at individual sites every five years, as needed, for the term of the license. At five-year intervals after the initial supplementation period, the Licensee shall monitor and maintain a minimum of 10 riffle complexes in the LFC so that approximately 80 percent of the spawning gravels randomly sampled in riffle complexes shall be in the median size range preferred by Chinook salmon or steelhead. All work will be done in consultation with the consultees listed in S2(a) above. High flow events shall be defined in the Gravel Supplementation and Improvement Plan.*
4. *The Licensee, in consultation with the consultees listed in S2(a) above, shall conduct a study on the need for additional gravel supplementation in the HFC of the Feather River (within the Project Boundary). The study shall be submitted to the Deputy Director for modification and approval within eight years of license issuance. If gravel supplementation will benefit spawning and rearing, it will begin within 10 years of license issuance. Gravel supplementation, if provided, shall include the staging of spawning gravel stockpiles, of up to 2,000 cubic yards, of a size distribution determined by study, below the Thermalito Afterbay Outlet.*

f. The Licensee shall prepare an annual summary report describing the activities completed pursuant to the Program and submit the report to the consultees listed in S2(a) above. Throughout the term of the license, the Licensee shall compile these annual reports at least once every five years in the Lower Feather River Habitat Improvement Plan Report.

g. The Licensee, in consultation with the consultees listed in S2(a) above, shall reevaluate the Gravel Supplementation and Improvement Program Plan every five years after initial implementation. Every five years the Licensee shall submit for the Deputy Director's information a Lower Feather River Habitat Improvement Plan report that includes any Plan updates. If any changes are recommended beyond the objectives, activities, or schedules identified in this article or the Gravel Supplementation and Improvement Program Plan, the Licensee shall submit final recommendations in a revised plan to the Deputy Director for approval. The Licensee shall include with the filing copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why any such comment was not adopted. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director *either does not act on the request for approval or identify the need for additional information or actions, the revised plan shall be deemed approved.*

1.3.3.4 Channel Improvement Program (A103)

The Channel Improvement Program includes habitat improvement measures to increase the quality and complexity of salmonid spawning and rearing habitat in two existing side channels, Moe's Ditch and Hatchery Ditch. Additionally, the proposed action includes development of five additional side channel riffle/glide complexes over a 5-year period, which would provide a minimum of 2,460 feet in length of new spawning and rearing habitat for Chinook salmon and CCV steelhead. The EC and agencies would be instrumental in recommending the locations and habitat components of the five additional projects. All side channels created would be adjacent to existing riffle complexes and would, as feasible, approximate historic habitat with respect to base flow ranges and other environmental conditions. Side channel flows would probably range between 10 and 75 cfs and will be designed to provide appropriate depth, velocity, substrate, and instream and riparian cover. To the extent possible, side channel development will coincide with gravel supplementation activities or other habitat improvement measures occurring in the vicinity. The projects would be monitored annually to determine the effectiveness of the program.

The SWRCB included the following condition (S3) in the water quality certification for the Channel Improvement Program.

a) *Within one year of license issuance, the Licensee shall develop and file for Commission approval a Moe Ditch and Hatchery Ditch Plan to improve two existing side channels at the upstream end of the LFC, Moe's Ditch, and Hatchery Ditch, by modifying these channels to provide suitable discharge, velocity, depth, substrate, cover and riparian vegetation to support salmonid spawning and rearing. The Plan shall be developed in consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, State Water Board, and the California Department of Fish and [Wildlife] (consultees). Consultation with the Ecological Committee complies with the consultation requirement, as long as the agencies listed are part of the Ecological Committee. The Licensee shall include with the filing of the Moe and Hatchery Ditch Plan copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why any such comment was not adopted. The Plan shall include a schedule to complete the improvements to Moe's Ditch and Hatchery Ditch within three years of license issuance. The Licensee shall submit the Plan to the Deputy Director for approval. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the Plan shall be deemed approved.*

b) *Within four years of license issuance, the Licensee shall develop and file for Commission approval a Channel Construction Plan to identify and construct, within 10 years of license issuance, five additional side channel riffle/glide complexes of not less than a cumulative total of 2,460 feet in length of new habitat. These side channels shall be located and designed to maximize quantity/quality of suitable salmonid attributes (depth, velocity, substrate, cover, and vegetation) while minimizing the potential for warming, stranding, and predation problems.*

The Plan shall be developed in consultation with the consultees listed in S3(a) above. The Licensee shall include with the filing of the Channel Construction Plan copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why any such comment was not adopted. The Licensee shall submit the Plan to the Deputy Director for approval. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the Plan shall be deemed approved. Upon Commission approval, and after obtaining all necessary permits, the Licensee shall implement the Plan, including any changes required by the Commission.

c) *Maintenance activities shall be developed by the Licensee in consultation with the consultees listed in S3(a) above. Maintenance activities shall occur at least once every five years, or as often as necessary to maintain channel functions. High flow events shall be defined in the Channel Construction Plan.*

d) *Licensee shall annually collect data appropriate for evaluating the effectiveness of the Channel Improvement Program and the achievement of the Channel Improvement Program objectives. The Licensee shall prepare an annual summary report describing monitoring and implementation activities completed pursuant to the Program and submit the report to the consultees listed in S3(a) above for review on an annual basis. Throughout the term of the License, the Licensee shall compile these annual reports every five years in the Lower Feather River Habitat Improvement Plan Report that is submitted to the Commission.*

e) *The Licensee, in consultation with the consultees listed in 4a above shall reevaluate the Channel Construction Plan every five years after initial implementation. If any changes are recommended beyond the objectives, activities, or schedules identified in this article or the Plan, the Licensee shall submit final recommendations in a revised plan to the Deputy Director for approval. The Licensee shall include with the filing copies of the comments, including recommendations made in the course of such consultation, and an explanation why any comment was not adopted. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the revised plan shall be deemed approved. Upon Deputy Director approval, the Licensee shall implement the Plan, including any changes required by the Deputy Director. The Licensee shall include any Deputy Director approved revisions to the Plan into any updates to the Lower Feather River Habitat Improvement Plan set forth in Condition S1.*

1.3.3.5 Structural Habitat Supplementation and Improvement (SHSI) Program (A104)

The proposed action will create additional cover, edge, and channel complexity through the addition of large woody material (LWM), boulders, and other native objects. LWM includes multi-branched trees at least 12 inches in diameter at chest height and a minimum of 10 feet in length with approximately 50 percent of the structures containing intact root wads.

As part of this program, DWR will develop an Instream Structural Habitat Placement Plan in consultation with the EC, and will include proposed locations within the action area for structural placements; a strategy to map existing LWM, riparian habitat, and sources of riparian and LWM recruitment; and completion of a safety analysis. LWM or other native materials will be placed within the river at the lowest stipulated base flow with the root wad (if attached) oriented upstream. A monitoring plan that will occur after high flow events, or at least once every five years in the absence of a high flow event, will evaluate the effectiveness of the program and its objectives, establish maintenance criteria, such as the interval for replacement of LWM or other structures, and include the submittal of an annual report describing the monitoring and implementation of the plan's activities.

The SWRCB included the following condition (S4) in the water quality certification for the Structural Habitat Supplementation and Improvement Program.

a) *Within two years of license issuance, the Licensee shall develop and file for Commission approval a Structural Habitat Supplementation and Improvement Program Plan to provide additional salmonid rearing habitat in the Lower Feather River by creating additional cover, edge, and channel complexity through the addition of structural habitat, including large woody debris, boulders, and other objects. The Plan shall be developed in consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, State Water Board, and California Department of Fish and [Wildlife] (consultees). Consultation with the Ecological Committee complies with the consultation requirement, as long as the agencies listed are part of the Ecological Committee. The Licensee shall include with the filing of the Plan copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why any such comment was not adopted. The Licensee shall submit the Plan to the Deputy Director for approval. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the Plan shall be deemed approved. Within two years following Deputy Director approval of the Plan, and after obtaining all necessary permits, the Licensee shall implement the Plan, including any changes required by the Deputy Director.*

b) *The Plan shall contain the following elements.*

   1. *Proposed locations for structural placements, including large woody debris, boulders, or other material. Large woody debris for this Program is defined as multi-branched trees at least 12 inches in diameter at chest height, and a minimum of 10 feet in length (with a preference for approximately 20 feet or longer), with approximately 50 percent of the structures containing intact root wads. Large woody debris or other native materials shall be located within the river to maximize the instream benefit at the lowest minimum flow specified in Condition S8 with the root wad (if attached) oriented upstream.*
   2. *Development and implementation of a strategy to map existing large woody debris, riparian habitat, and sources of riparian and large woody debris recruitment.*
   3. *Placement of a minimum of two pieces of large woody debris, boulders, or other appropriate material per riffle in the LFC and HFC from RM 54.2 to*

RM 67.2 of the Feather River for a total of between 50 and 500 pieces in locations that maximize benefits for salmonids. Additional large woody debris, boulders, or other material may be placed in glide, riffle or pool habitat where appropriate.

4. *Completion of a safety analysis, and any resulting necessary modifications to the Plan, prior to program implementation to ensure that issues relating to human safety are adequately addressed.*
5. *Monitoring the structural placements after major high flow events, or at least once every five years in the absence of a high flow event, to collect data appropriate for evaluating the effectiveness of the Program and its objectives. High flow events shall be defined in the Structural Habitat Supplementation Improvement Program Plan.*
6. *Inclusion of specific maintenance criteria, including the interval for replacement of large woody debris or other structures. Replacement shall occur at a minimum of every five years.*

c) *The Licensee shall annually collect data appropriate for evaluating the effectiveness of the Program and the achievement of Program objectives. The Licensee shall prepare an annual summary report describing monitoring and implementation activities completed pursuant to the Program and submit the report to the consultees listed in S4(a) above for review on an annual basis. Throughout the term of the license, the Licensee shall compile these annual reports every five years in the Lower Feather River Habitat Improvement Plan Report that is submitted to the Commission.*

d) *The Licensee, in consultation with the consultees listed in (a) above, shall reevaluate the Plan every five years after initial implementation. If any changes are recommended beyond the objectives, activities, or schedules identified in this article or the Plan, the Licensee shall submit final recommendations in a revised plan to the Deputy Director for approval. The Licensee shall include with the filing copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why the comment was not adopted. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the revised plan shall be deemed approved. Upon Commission approval, the Licensee shall implement the Plan, including any changes required by the Commission. The Licensee shall include any Commission and Deputy Director approved revisions to the Plan into any updates to the Lower Feather River Habitat Improvement Plan set forth in Condition S1.*

1.3.3.6 Fish Weir Program (A105)

Feather River dams and associated facilities block the passage of migratory fish and cause CV spring-run and fall-run Chinook salmon to share spawning habitat in the Lower Feather River. The reduced amount of spawning habitat available in the Lower Feather River results in an increased rate of redd superimposition (subsequent spawning on top of an existing redd) that causes increased rates of egg and alevin mortality.

The proposed action includes a Fish Weir Program whereby two fish barrier weirs will be installed in two phases. The first phase weir will be used to determine the abundance of early returning adult life history behavior of Chinook salmon (phenotypic CV spring-run) and CCV steelhead in the LFC. The second weir will then be installed to spatially separate phenotypic CV spring-run and fall-run Chinook salmon in the LFC to create a dedicated spawning preserve to protect the CV spring-run Chinook salmon, and if necessary, provide collection of fall-run Chinook salmon eggs for use at the FRFH.

Within 1 year after license issuance, DWR will develop a Phase 1 weir construction and operations Plan consistent with the Project biological opinion(s). The Phase 1 Plan will be designed to document run timing for Chinook salmon and steelhead, and include design and safety analysis including boating compatibility, detailed engineering design, and a permitting process schedule. Within three years of license issuance, Phase 1 will be implemented. Phase 1 includes monitoring and data collection over a period of time sufficient to allow for collecting adequate baseline information on migration timing and abundance of Chinook salmon and CCV steelhead adults in the LFC necessary to develop the segregation weir plan.

The location selected for implementation of Phase 2, fish segregation weir, will be designed to isolate and dedicate an amount of spawning habitat adequate to meet the phenotypic CV spring-run Chinook salmon population quantified in Phase 1. DWR will compile annual reports into the 5-year Lower Feather River Habitat Improvement Plan Report.

By the end of the eighth year of the new FERC License, DWR will develop a Phase 2 Anadromous Segregation Weir Plan (Phase 2 Segregation Weir Plan). This phase will also consider installation of an egg-taking station, if appropriate, to collect fall-run Chinook salmon eggs for transport to the FRFH. The weir will be installed within 12 years of license issuance. Data appropriate for monitoring and evaluating the effectiveness of the weirs and egg-taking station will be collected annually, and annual reports summarizing the monitoring results will be provided.

This program will be coordinated with other additional improvements for anadromous salmonids in the Lower Feather River. The monitoring weir will be operated upstream of the Thermalito Afterbay Outlet. The Phase 2 Segregation Weir Plan will include a weir operations protocol, safety analysis including boating compatibility, detailed engineering design, and a permitting process description.

The SWRCB included the following condition (S5) in the water quality certification for the Fish Weir Program.

a) *Within one year of license issuance, the Licensee shall develop and file for Deputy Director approval a Phase 1 Weir Construction and Operations Plan consistent with the Project biological opinion(s). The Plan shall be developed in consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, State Water Board, and California Department of Fish and [Wildlife] (consultees). Consultation with the Ecological Committee complies with the consultation requirement, as long as the agencies listed are part of the Ecological Committee. The Licensee shall include with the filing of the Phase 1 Plan copies of the comments, including recommendations, made in the course of such consultation and an explanation for why any such comment was not adopted. The Licensee shall submit the Plan to the Deputy Director for approval. The Deputy*

Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the Plan shall be deemed approved.

Upon Commission and Deputy Director approval, and after obtaining all necessary permits, the Licensee shall implement the Plan, including any changes required by the Commission and Deputy Director.

b) *The Phase 1 Plan shall include a schedule to install and operate a monitoring weir in the vicinity upstream of the Thermalito Afterbay Outlet within three years of license issuance.*

c) *The Phase 1 Plan shall be designed to document run timing for spring-run and fall-run Chinook salmon and steelhead. It will include design and safety analysis, including boating compatibility, detailed engineering design, and a permitting process schedule. The Plan will include using the monitoring weir, or an additional separate interim weir, to provide interim spatial or temporal segregation of Chinook salmon runs. It will include a timeline and study plan to implement such segregation within five years of license issuance. After issuance of a final biological opinion by the National Marine Fisheries Service, and upon the request of the Licensee, the Deputy Director may approve a different time frame for implementation of the weir. The time for implementation may not exceed the time required in the final biological opinion issued by the National Marine Fisheries Service. The Plan shall be part of the Lower Feather River Habitat Improvement Plan.*

d) *Licensee shall correlate data from the monitoring weir to carcass surveys or other existing population counts. The Licensee, in consultation with the consultees listed in S5(a) above, shall use the data collected in Phase 1 to develop recommendations to the Deputy Director and the Commission regarding Phase 2 as set forth below.*

e) *Within eight years of license issuance, the Licensee shall develop and file for Commission approval a Phase 2 Anadromous Fish Segregation Weir Plan for the purpose of providing spatial separation for the spawning of spring-run and fall-run Chinook salmon. The Plan shall be developed in consultation with the consultees listed in S5(a) above. The Licensee shall include with the filing of the Phase 2 Plan copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why any such comment was not adopted. The Licensee shall submit the Plan to the Deputy Director for approval. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the Plan shall be deemed approved. Upon Commission and Deputy Director approval, and after obtaining all necessary permits, the Licensee shall implement the Plan, including any changes required by the Commission and Deputy Director.*

f) *The Phase 2 Plan shall include a weir operations protocol, safety analysis including boating compatibility, detailed engineering design, and identification of the required permitting process. The Phase 2 Plan shall also evaluate the* *installation of an egg- taking station, if appropriate, to collect fall-run Chinook salmon eggs for transport to the Feather River Fish Hatchery.*

g) *The Phase 2 Plan shall include a schedule to install and operate a Phase 2 anadromous fish segregation weir in the Lower Feather River upstream of the Thermalito Afterbay Outlet within 12 years of license issuance.*

h) *The Licensee shall annually collect data appropriate for evaluating the effectiveness of the Fish Weir(s) and Egg-Taking Station, and correlate this data to carcass surveys or other existing population counts. The Licensee shall prepare annual summary reports for Phase 1 and Phase 2 describing the monitoring results and provide these reports to the consultees listed in S5(a) above for review. Every five years the annual reports shall be compiled in the Lower Feather River Habitat Improvement Plan Report.*

i) *The Licensee, in consultation with the consultees listed in S5(a) above, shall reevaluate the program every five years after initial implementation. The Licensee shall provide all Plan updates to the Deputy Director for information. If any changes are recommended beyond the objectives, activities, or schedules identified in this article or the Plan, the Licensee shall submit final recommendations in a revised plan to the Deputy Director for approval. The Licensee shall include with the filing copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why any such comment was not adopted. The Licensee shall submit the revised plan to the Deputy Director for approval. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the revised plan shall be deemed approved. Upon Commission and Deputy Director approval, the Licensee shall implement the Plan, including any changes required by the Commission and the Deputy Director. The Licensee shall include any Commission and Deputy Director approved revisions to the Plan into any updates to the Lower Feather River Habitat Improvement Plan set forth in Condition S1.*

1.3.3.7 Riparian and Floodplain Improvement Program (A106)

Under the proposed action, DWR will investigate and implement projects to improve riparian habitat and habitat for associated terrestrial and aquatic species, and to connect portions of the Feather River to its floodplain within the OWA.

The Riparian and Floodplain Improvement Program will be implemented in four phases by DWR in consultation with the EC and resource agencies.

Phase 1 will occur within one year of license issuance and consists of a screening level analysis of potential projects and identification of the recommended alternative. In the screening level analysis, higher priority will be given to those projects that maximize benefits for all species and habitats, including restoring riparian vegetation and the riparian corridor, restoring habitat for terrestrial species, reconnecting the river to its floodplain, and restoring and enhancing riparian and channel habitat for fish and other aquatic species.

Phase 2 will occur within 15 years of license issuance and consists of implementing the Phase 1 recommended alternative.

Phase 3 will occur within 15 years of license issuance and will reevaluate other potential feasible projects, including those considered under Phase 1, and will identify a Phase 3 alternative.

Phase 4 will occur within 25 years of license issuance and consists of implementing the Phase 3 alternative. Implementation will include a full scope and cost analysis of the recommended alternative as well as design, project level environmental documentation, permitting, and construction.

The SWRCB included the following condition (S6) in the water quality certification for the Riparian and Floodplain Improvement Program.

a) *Within six months of license issuance the Licensee shall develop and file for Deputy Director approval of a Plan for a phased program to enhance riparian and other floodplain habitats for associated terrestrial and aquatic species. The Plan shall address the connection of portions of the floodplain habitat with the Feather River within the Oroville Wildlife Area and shall include a description of areas in which gravel extraction may take place, in anticipation of improving fish and wildlife benefits. The Plan shall also include a definition of high flow events. The Plan shall be developed in consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, State Water Board, and California Department of Fish and [Wildlife] (consultees). Consultation with the Ecological Committee complies with the consultation requirement, as long as the agencies listed are part of the Ecological Committee. The Licensee shall include with the filing of the Plan copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why such comment was not adopted. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the Plan shall be deemed approved. Upon Commission and Deputy Director approval, and after obtaining all necessary permits, the Licensee shall implement the Plan, including any changes required by the Commission and Deputy Director.*

b) *The Program set forth in the Plan shall be implemented in the following four phases:*

   Phase 1 - Within one year of license issuance and in consultation with the consultees listed in S6(a) above, the Licensee shall develop and submit to the Deputy Director a screening level analysis of proposed riparian/floodplain improvement projects, including how flood/pulse flows may contribute to floodplain values and benefit fish and wildlife species. This phase shall include the identification of a Phase 1 recommended alternative. This phase shall also include an assessment of the gravel value and potential extraction processes in order to provide guidance on the scope, timing, and magnitude of the Program.

   Phase 2- Within four years of license issuance and in consultation with the consultees listed in S6(a) above, the Licensee shall initiate Phase 2 of the Program. Phase 2 shall begin with conducting a full scope and feasibility *evaluation and development of an implementation schedule of the Phase 1 recommended alternative. Within six years of license issuance, the Licensee shall submit the Phase 1 recommended alternative and implementation schedule to the Deputy Director for approval. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the Phase 1 recommended alternative and implementation schedule shall be deemed approved. Within eight years of license issuance, the Licensee shall complete the final design and commence construction and implementation of the approved alternative. Within 15 years of license issuance the Licensee shall fully implement this approved alternative.*

Phase 3 - Within 15 years of license issuance and in consultation with the consultees listed in S6(a) above, the Licensee shall complete an evaluation of other potentially feasible projects and the identification of a Phase 3 recommended alternative. This phase shall include a reevaluation of how flood or pulse flows may contribute to floodplain values and benefit fish and wildlife species and shall include an assessment of the gravel value and potential extraction processes similar to the one completed in Phase 1.

Phase 4 - Upon Deputy Director approval, and within 25 years of license issuance, the Licensee shall complete construction of the Phase 3 recommended alternative.

c) The Licensee shall annually collect data appropriate for evaluating the effectiveness of the Program and the achievement of program objectives. The Licensee shall prepare an annual summary report describing monitoring and implementation activities completed pursuant to the Program and submit the report to the consultees listed in S6(a) above, for annual review. Throughout the term of the license, the Licensee shall compile these annual reports every five years in the Lower Feather River Habitat Improvement Plan Report that is submitted to the Commission.

d) The Licensee, in consultation with the consultees listed in S6(a) above, shall reevaluate the Plan every five years after initial implementation. If any changes are recommended beyond the objectives, activities, or schedules identified in this article or the Plan, the Licensee shall submit final recommendations in a revised plan to the Deputy Director for approval. The Licensee shall include with the filing copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why any comment was not adopted. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the revised plan shall be deemed approved. Upon Commission and Deputy Director approval, the Licensee shall implement the Plan, including any changes required by the Commission and Deputy Director.

1.3.3.8 Feather River Fish Hatchery Improvement Program (A107)

At this time, no facilities modifications to the FRFH are included in the proposed action. A proposed Feather River Fish Hatchery Improvement Program will provide a framework for continued operation of the FRFH in cooperation with CDFW for the production of anadromous salmonids and will provide for ongoing evaluation of and improvements to hatchery operations.

Under the proposed action, DWR, in cooperation with CDFW, will ensure the continued operation of the FRFH for the production of anadromous salmonids. The Feather River Fish Hatchery Improvement Program includes a Feather River Hatchery Management Program, an approach to facility assessment for O&M activities, and a strategy to evaluate facility or operational modifications to achieve FRFH water temperature targets in coordination with the Instream Flow and Temperature Improvement for Anadromous Fish (A108). See section *1.3.3.9*.

1.3.3.8.1 Feather River Fish Hatchery Fish Management Program

Under the proposed action, DWR will prepare a comprehensive Feather River Fish Hatchery Management Plan (FRFH Management Plan) within two years of license issuance. The plan will include production goals for the FRFH and the protocols that will be used to meet these goals. The FRFH Management Plan will include (per SA A107.3):

1) *Hatchery and Genetic Management Plans for each anadromous species managed by the hatchery.*
2) *Adaptive management protocols for hatchery production including egg taking, spawning, incubation, hatching, rearing, and stocking of fish.*
3) *A methodology to implement appropriate form(s) of tagging or marking of the Feather River Fish Hatchery artificial propagation programs, along with recovery of these tags/marks.*
4) *A methodology to study Feather River Fish Hatchery management effects on salmonids, and the interaction between in-river and hatchery-produced salmonids.*
5) *A methodology to study the phenotypic or genotypic traits that may be lost due to management actions or the adverse effects of the facilities if existing literature on these subjects is insufficient.*
6) *Development of a disease management methodology to reduce the incidence of disease outbreaks with the Feather River Fish Hatchery facilities and a plan to implement the methodology, as well as a requirement that the Licensee monitor and report to the EC on disease and water quality issues. This component of the Plan shall include investigation of the mechanisms to control disease, including water supply disinfection, temperature control devices (e.g., chillers, shade screens, well water), chemical treatments, fish stress reduction methods (fish density manipulation, flow increases aeration) and standards for acceptable loss.*
7) *A methodology to work with other Central Valley hatcheries to improve methods of integrating operations, marking and tag recovery, and data management.*
8) *A methodology to minimize straying of salmonids produced at the Feather River Fish Hatchery.*

9) *A methodology for the release of fish that evaluates full in-river release for the spring-run production, and in-river fall-run releases starting with 25% of the hatchery fall-run production, or other suitable amount to be determined by Licensee, in consultation with the Ecological Committee, and specifically the California Department of Fish and Game.*

10) *A methodology to utilize the results of studies, monitoring, and other information, in order to make changes to the operations of the Feather River Fish Hatchery.*

The Plan will include a full description of the hatchery operations and issues, including egg-taking, hatching, rearing, tagging, straying, and release methods and locations. Anadromous fish current production goals, (such as number of fish, size of fish, and release location-including in-river releases) and future program changes (such as the current spring-run Chinook salmon (phenotypic) program) will be determined by the Licensee and CDFW, in consultation with the Feather River Technical Team (FRTT), the resource agencies, and the EC, as a component of the FRFH Adaptive Management Program. The Plan will include Hatchery and Genetic Management Plans (HGMPs) for each anadromous fish species managed by the FRFH. The HGMPs will identify the effects of the hatchery program on federally listed salmonids and identify methods to reduce negative impacts on federally listed salmonids. The HGMPs will be submitted to NMFS and approved through the ESA section 4(d) process, which is separate from this Opinion.

The Plan will include a methodology to study FRFH management effects on salmonids, a description of the interaction between in-river and hatchery-produced salmonids, and the approach for integrating the operation of FRFH management with the operation of the fish segregation weir and egg-taking station.

Annual summary reports will be prepared, and a comprehensive report on the Feather River Fish Hatchery Management Program will be prepared every five years for public and EC review. Elements of the annual report are identified in the SA. In addition, the FRFH program will be reevaluated every five years.

DWR will prepare annual hatchery reports that will include, but not be limited to, the following information:

1) Number of each species or run of fish taken, along with the number of adults, grilse, steelhead, and half-pounders.
2) Estimate of the number of eggs taken for each species or run.
3) Number, size, and species or run of all fish reared at the FRFH.
4) Number, size, release location, and date of each species stocked or transferred.
5) Annual summary of disease management activities, including the diseases detected, species infected, the number of losses, and treatment methods.
6) Egg-take and stocking goal used that year.
7) Description of any significant operational changes that may have occurred as a result of the adaptive management process.

Details of the Feather River Fish Hatchery Management Program are provided in SA Article A107.3, and the SWRCB included text related to this program within condition S7 (Feather River Fish Hatchery) of the water quality certification under the heading of Feather River Fish Hatchery Management Program.

1.3.3.8.2 Feather River Fish Hatchery Water Supply Disinfection System

If anadromous salmonids are passed upstream of the FRFH, the proposed action will also include installing a water disinfection system for the FRFH water supply before such passage is implemented. Details of the Feather River Fish Hatchery Water Supply Disinfection System are provided in SA Article A107.4, and the SWRCB included text related to this system within condition S7 (Feather River Fish Hatchery) of the water quality certification under the heading of Hatchery Water Supply Disinfection System.

1.3.3.8.3 Feather River Fish Hatchery Annual Operation and Maintenance

The SA requires DWR to provide O&M funding to support the FRFH programs identified in the SA (SA Article B104). This will include a comprehensive inspection of the FRFH facilities at least once every five years to identify maintenance and repair needs, as well as possible facility improvements. The inspection reports will be a component of the Lower Feather River Habitat Improvement Plan. SA Article A107.5 describes these requirements, and the SWRCB included text related to these requirements within condition S7 (Feather River Fish Hatchery) of the water quality certification under the heading of Hatchery Annual Operation and Maintenance.

1.3.3.8.4 Feather River Fish Hatchery Water Temperature

This action is intended to provide water temperatures in the FRFH suitable for all life stages needed to achieve the production goals identified in the FRFH production program. This includes holding, spawning, incubating, hatching, and rearing life stages necessary for project operations and mitigation. Project operations or facilities will be modified to meet temperature objectives.

The temperatures in the first column of Table 1-4 are the interim maximum daily mean temperature targets, which will take effect upon issuance of the new FERC license and be followed until facilities modifications are completed. (See section *1.3.3.9 Instream Flow and Water Temperature Requirements for Anadromous Fish (A108)* below).

DWR shall initially use certain operational measures to seek not to exceed these temperature targets. After facilities modifications are complete, but no later than 10 years after license issuance, the daily mean temperature targets listed in the first column of Table 1-4 will become requirements for the remaining term of the new license.

The hourly maximum temperatures listed in the second column of Table 1-4 are a temperature requirement that DWR agrees not to exceed in any circumstance during the term of the license. There will be no minimum temperature requirement except between April 1, and June 1, during which time the temperatures must not fall below 51°F.

During conference years as defined in SA Article A108.6, after the maximum daily mean temperatures become requirements, DWR and the resource agencies will conference to determine proper temperature and disease management goals.

Table 1-4. Proposed Water Temperature Objectives and Requirements for the FRFH

Water Temperature Objectives and Requirements for the FRFH		
Time Period	**Interim Daily Mean Maximum (°F)**	**Hourly Mean Maximum (°F)**
September	56	56
October–November	55	55
December–March	55	55
April–May 15	55	55
May 16–May 31	55	59
June 1–June 15	60	60
June 16–August 15	60	64
August 16–August 31	60	62

Source: DWR 2007

The SWRCB included within condition S7 (Feather River Fish Hatchery) of the water quality certification the following text under the heading of Water Temperature.

Upon license issuance, the Licensee shall not exceed the water temperatures in Table S7. From April 1 through May 31 the water temperature shall not fall below 51 Fahrenheit.

Table S7

September 1-September 30	*56 °F*
October 1 – May 15	*55 °F*
May 16 – May 31	*59 °F*
June 1 – June 15	*60 °F*
June 16 – August 15	*64 °F*
August 16 – August 31	*62 °F*

The temperatures in Table S7 shall be measured hourly year-round at the Feather River Fish Hatchery intake/aeration tower.

Upon facility modification as described in S7b, or after the first 10 years of operation under the License, whichever comes first, the Licensee shall not *exceed the water temperatures in Table S7A. From April 1 through May 31 the water temperature shall not fall below 51 degrees Fahrenheit.*

Table S7A

September 1-September	*56°F*
October 1 – May 31	*55°F*
June 1 – August 31	*60°F*

For the purposes of this Opinion, it is assumed that section "S7b" in the Water Quality Certification is referring to the potential facilities modifications identified in sections *1.3.2.4* to *1.3.2.10* above and in Article A108 of the Settlement Agreement. The SWRCB continues:

The temperatures in Table S7A are Maximum Mean Daily Temperatures and shall be calculated by adding the hourly temperatures achieved each day and dividing by 24. Water temperatures in Table S7A shall be measured year-round at the FRFH intake/aeration tower.

During conference years, as defined in Condition S8, the Licensee shall confer with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and Wildlife, and State Water Board to determine proper temperature and disease management goals.

a) Within six months of license issuance, the Licensee shall submit a status report describing any progress towards repairing or refurbishing the river valve and a list of temperature control actions being used or contemplated to meet the Table S7 water temperatures. Within one year of license issuance, the Licensee shall submit a schedule for repair or refurbishment of the river valve or for implementation of a proposed alternative method for meeting water temperature requirements in Table S7 to the Deputy Director for approval. The schedule shall include the steps and time necessary to evaluate, design, and complete the repair or refurbishment of the river valve. If the Licensee proposes an alternative method for meeting temperature requirements, evidence must be submitted that the alternative method will provide equivalent water temperature control as the river valve. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the schedule shall be deemed approved.

b) If the Licensee cannot meet the water temperature requirements in Table S7A without facility modification(s), it shall within three years of license issuance, submit a long-term facility modification(s) and operations plan to the Deputy Director for approval. The Deputy Director may require modifications as part of the approval. If, within 90 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the plan shall be deemed approved.

1.3.3.9 Instream Flow and Water Temperature Requirements for Anadromous Fish (A108)

Under the proposed action, the following key steps will be taken to provide suitable flows and temperatures to support anadromous fish.

1.3.3.9.1 River Outlet Valves

The river valves provide an alternate method to release water when Hyatt Powerplant is out of service. The valves were not usable for a period but now have been refurbished and returned to operational status. Although not intended nor designed for regular use, under very limited circumstances the river valves may be used for meeting the FRFH temperature requirements outlined in the 1983 Agreement until a physical modification for providing colder water to the LFC and HFC is constructed.

1.3.3.9.2 Facilities Modifications

Within three years after license issuance, DWR will prepare and submit for FERC's approval a Feasibility and Implementation Plan for one or more project facilities modifications to protect and improve temperature conditions for the benefit of anadromous fish holding, spawning, egg incubation, and rearing habitat in the LFC and HFC in the least costly manner. The plan will clearly identify resource issues and goals; identify and describe an array of alternatives to address these issues and goals; and identify potential concerns, benefits, impacts, and likely costs of the identified alternatives. The plan will recommend a specific alternative for implementation. Upon approval by FERC, DWR will implement the facilities modifications according to the plan.

1.3.3.9.3 Conference Years

A Conference Year is defined in SA Article A108.6 as any year in which the Oroville Temperature Management Index (OTMI) is equal or less than 1.35 million acre-feet. OTMI is calculated by multiplying the total volume of stored water in Lake Oroville on May 1 by one half and adding to that the projected May-through-September unimpaired Feather River flow at Oroville. The unimpaired Feather River flow at Oroville means the runoff that would be in the Feather River at Oroville if there were no human development on the Feather River. The amount of Feather River unimpaired flows used for calculating the OTMI will be the median value (with an exceedance probability of 50 percent) of May 1 forecast published in DWR Bulletin 120. As the actual amount of unimpaired flow after May 1 becomes available, the OTMI will be recomputed in the beginning of June, July, and August to account for the potential errors of the May 1 prediction. The OTMI will not be updated after the August 1 update.

The SWRCB included within condition S8 (Flow/Temperature to Support Anadromous Fish) of the water quality certification the following text related to the definition of a Conference Year under the heading Conference Year Actions:

c) A Conference Year is defined as any year in which the Oroville Temperature Management Index (OTMI) is equal or less than 1.35 million acre-feet. OTMI is calculated by multiplying the total volume of stored water in Lake Oroville on May 1 by one half and adding to that calculation the projected May-through-September unimpaired Feather River flow at Oroville. The unimpaired Feather River flow at Oroville means the runoff that would be in the Feather River at

Oroville if there were no human development on the Feather River. The amount of Feather River unimpaired flows used for calculating the OTMI will be the median value (with an exceedance probability of 50 percent) of May 1 forecast published in DWR Bulletin 120. As the actual amount of unimpaired flow after May 1 becomes available, the OTMI will be recomputed in the beginning of June, July, and August to account for the potential errors of the May 1 prediction. The OTMI will not be updated after the August 1 update.

1.3.3.9.4 Conference Year Actions

After completion of the Facilities Modification(s), by May 1 of a Conference Year as defined in SA Article A108.6 (see the preceding subsection), and in consultation with the EC, DWR will prepare a strategic plan that states the specific actions that it will take to manage the coldwater pool to minimize exceedances of water temperatures in applicable tables consistent with its water supply and other legal obligations.

The SWRCB included within condition S8 (Flow/Temperature to Support Anadromous Fish) of the water quality certification the following text under the heading Conference Year Actions (in addition to the text related to the definition of Conference Year discussed in the preceding subsection):

a) *By May 1 of a Conference Year, the Licensee shall consult with the National Marine Fisheries Service, U.S. Fish and Wildlife Service, California Department of Fish and [Wildlife], and State Water Board (consultees) and prepare a strategic plan that states the specific actions that it will take to manage the coldwater pool to minimize exceedances of Table S8 and applicable water temperature requirements at the lower project boundary, consistent with its water supply and other legal obligations. After consultation, the Licensee shall submit the strategic plan to the Deputy Director for approval and to the Commission for information. The Deputy Director may require modifications as part of the approval. If, within 30 days, the Deputy Director does not either act on the request for approval or identify the need for additional information or actions, the plan shall be deemed approved. The Licensee shall implement the approved strategic plan. As part of any strategic plan, the minimum flows shall be maintained.*
b) *The Licensee shall inform the U.S. Fish and Wildlife Service, National Marine Fisheries Service, State Water Board, and California Department of Fish and [Wildlife] within 10 days of the initial determination of a Conference Year and subsequent updates of the year-type classification.*

1.3.3.9.5 Minimum Flows and Temperature Requirements in the Low Flow Channel

The new minimum flow in the LFC will be increased to 700 cfs and will be increased to 800 cfs from September 9 to March 31 of each year to accommodate spawning, unless NMFS, USFWS, and CDFW provide a written notice that a flow between 700 and 800 cfs will substantially meet the needs of anadromous fish (in which event, DWR may release that lower flow). If the increase in minimum flow does not result in achievement of the temperature targets identified in Table 1-5. DWR will (i) curtail pump-back operations, (ii) remove shutters on the Hyatt intake to draw the flow release from lower reservoir elevation, or (iii) increase flow releases up to a maximum of

1,500 cfs or no more than the actual flow in the HFC, whichever is less, until facility modifications for providing colder water to the LFC are constructed. The temperature targets in Table 1-5 will be implemented on license issuance.

Table 1-5. Water Temperature Targets (Maximum Mean Daily Value) for the LFC as Measured at Robinson Riffle

Water Temperature Targets at Robinson Riffle	
Month	**Water Temperature Target (°F)**
January	56
February	56
March	56
April	56
May 1–15	56–63*
May 16–31	63
June 1–15	63
June 16–30	63
July	63
August	63
September 1–8	63–58*
September 9–30	58
October	56
November	56
December	56

*Indicates a period of transition from the first temperature to the second temperature.

The SWRCB included within condition S8 (Flow/Temperature to Support Anadromous Fish) of the water quality certification the following text under the heading Minimum Flows and Temperature Requirements in the Low Flow Channel.

a) *Upon license issuance, the Licensee shall release a minimum flow of 700 cfs into the LFC. The minimum flow shall be 800 cfs from September 9 to March 31 of* *each year to accommodate spawning of anadromous fish, unless another minimum flow, recommended by the resource agencies as envisioned under the Settlement Agreement A108.1(a), is approved by the Deputy Director. The Deputy Director's evaluation of the impact of reduced flow will include its impact on anadromous fish as well as on other beneficial uses. If the Licensee receives such approval, it may operate consistent with the revised minimum flow. Within 30 days of receipt, the Licensee shall file such notice with the Commission for information.*

b) *Licensee shall operate the project to not exceed the water temperatures in Table S8 as measured at Robinson Riffle. If the Licensee demonstrates to the satisfaction of the Deputy Director that it cannot feasibly meet these water temperature requirements using current facilities, it shall within one year of license issuance submit for Deputy Director approval an interim operations plan that includes measures to reduce water temperatures. While documentation is pending to demonstrate that the Licensee cannot meet Table S8 requirements, the Licensee shall not be considered in violation of this subsection if the Deputy Director determines that exceedance of Table S8 temperatures is due to limitations of existing facilities. Similarly, if the Deputy Director determines that the Licensee cannot feasibly meet Table S8 requirements using current facilities, exceedances of Table S8 temperatures that the Deputy Director determines to be due to the limits of the current facilities will not be considered violations of this subsection during the time period in which DWR is preparing, and the Deputy Director is reviewing, the interim operations plan. The Deputy Director may require modifications of the interim operations plan as part of the approval. If, within 90 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the plan shall be deemed approved.*

c) *If the Licensee cannot meet the water temperature requirements in Table S8 without facility modification(s), it shall within three years of license issuance, submit a long-term facility modification(s) and operations plan to the Deputy Director for approval. The plan must demonstrate compliance with Table S8 temperatures within 10 years of license issuance. The Deputy Director may require modifications as part of approval. If, within 90 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the plan shall be deemed approved. If after facility modification(s) the Licensee demonstrates to the satisfaction of the Deputy Director that it cannot feasibly meet water temperatures in Table S8, it shall submit to the Deputy Director proposed alternative temperature requirements that provide reasonable protection of the COLD beneficial use. The Deputy Director may require modifications as part of the approval. If, within 90 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the proposed requirements shall be deemed approved. Upon approval of the Deputy Director, the Licensee shall comply with the alternate temperature requirements.*

Table S8. LFC Measured at Robinson Riffle [all temperatures are in daily mean value (degrees F)]

MONTH	Temperature
January	56
February	56
March	56
April	56
May 1-15	*56-63**
May 16-31	63
June 1–15	*63*
June 16–30	*63*
July	*63*
August	*63*
September 1-8	*63-58**
September 9–30	*58*
October	*56*
November	*56*
December	*56*

** Indicates a period of transition from the first temperature to the second temperature.*

Note: Table S7 in the above quotation is the same as Table 1-5 in this document.

1.3.3.9.6 Minimum Flow and Temperature Requirements in the High Flow Channel

Minimum instream flow requirements in the HFC, downstream of the Thermalito Afterbay Outlet, will remain as they are in the current license and per the 1983 Agreement (ranging between 1,000 and 1,700 cfs). The minimum instream flows are based on annual runoff (Table 1-6). Per SA Article A108.2(b), if the April 1 runoff forecast in a given water year indicates that, under normal operation of the project, Oroville Reservoir will be drawn to 733 feet in elevation, minimum flows in the HFC may be diminished on a monthly average basis, in the same proportion as the respective monthly deficiencies imposed upon deliveries for agricultural use from the project; however, in no case shall the minimum flows be reduced by more than 25 percent.

Table 1-6. HFC Minimum Flow Schedule

Preceding April through July Unimpaired Runoff	Minimum Flow in HFC October–February	Minimum Flow in HFC March	Minimum Flow in HFC April–September
Percent of Normal			
55% or greater	1,700 cfs	1,700 cfs	1,000 cfs
Less than 55%	1,200 cfs	1,000 cfs	1,000 cfs

The SWRCB included within condition S8 (Flow/Temperature to Support Anadromous Fish) of the water quality certification the following text under the heading Minimum Flow and Temperature Requirements in the High Flow Channel:

d) Upon license issuance, the Licensee shall, based upon the April through July unimpaired runoff of the Feather River near Oroville of the preceding water-year (October 1 through September 30), maintain a minimum flow in the HFC in accordance with the following schedule, provided that such releases will not cause Oroville Reservoir to be drawn down below elevation 733 feet (approximately 1,500,000 af).

Table S8. HFC Minimum Flow Schedule

Preceding April through July Unimpaired Runoff	Minimum Flow in HFC October–February	Minimum Flow in HFC March	Minimum Flow in HFC April–September
Percent of Normal			
55% or greater	1,700 cfs	1,700 cfs	1,000 cfs
Less than 55%	1,200 cfs	1,000 cfs	1,000 cfs

The preceding water-year's unimpaired runoff shall be reported in Licensee's Bulletin 120, "Water Conditions in California-Fall Report." The term "normal" is defined as the April through July 1911-1960 mean unimpaired runoff near Oroville of 1,942,000 acre-feet.

e) If the April 1 runoff forecast in a given water-year indicates that Oroville Reservoir will be drawn to elevation 733 feet (approximately 1,500,000 acre-feet) under normal operation of the Project, then the minimum flows in the HFC may be reduced on a monthly average basis, in the same proportion as the respective monthly deficiencies imposed upon State Water Project deliveries to the State Water Contractors for agricultural use; however, in no case shall minimum flow releases be reduced by more than 25 percent. If, between October 15 and November 30, the highest total 1-hour flow exceeds 2500 cfs, Licensee shall maintain a minimum flow within 500 cfs of that peak flow, unless such flows are caused by flood flows, an inadvertent equipment failure or malfunction.

f) Upon license issuance, Licensee shall operate the project to protect the COLD beneficial use in the HFC, as measured in the Feather River at the downstream Project Boundary, to the extent reasonably achievable. Within one year of license issuance, Licensee shall submit a plan for project operations to reasonably protect COLD beneficial uses before facility modification to the Deputy Director for approval. This interim plan must include a table of

> *proposed interim temperature requirements, as well as interim measures to reduce water temperatures. The Deputy Director may require modifications as part of the approval. If, within 90 days, the Deputy Director does not either act on the request for approval or identify the need for additional information or actions, the plan shall be deemed approved. Within three years of license issuance, Licensee shall submit a long- term facility modification and operations plan to the Deputy Director for approval, which shall include a table of proposed temperature requirements to protect the COLD beneficial use within 10 years after license issuance. When submitting the plan to the Deputy Director, the Licensee shall also submit the plan to parties on the FERC service list (#2100) and post the plan on its web site. The Deputy Director may require modifications as part of the approval. If, within 120 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the plan shall be deemed approved.*

Water temperature objectives for the HFC are also proposed (Table 1-7). Upon issuance of the new FERC license, DWR will try to meet the Maximum Daily Mean Water Temperature for the HFC listed in Table 1-6 by modifying operations including the specific operations listed in Article A108.1(b) of the SA. Proposed Article A108.1(b) states, in relevant part:

> *Prior to the Facilities Modification(s) described in Article A108.4, if the Licensee does not achieve the applicable Table 1 temperature upon release of the specified minimum flow, the Licensee shall singularly, or in combination (i) curtail pump-back operation, (ii) remove shutters on Hyatt Intake, and (iii) increase flow releases in the LFC up to a maximum of 1500 cfs; provided however these flows need not exceed the actual flows in the HFC, but in no event would HFC flows be less than those specified in A108.2 to meet Table 1 temperatures or minimize exceedances thereof.*

After facilities modifications are completed, the ability of the modifications to meet the temperatures depicted in Table 1-7 will be tested for five years. After the testing period, the ability of the project to meet these temperatures will be reviewed and, subject to that review, these temperatures will become temperature requirements for the HFC for the remaining term of the license.

Table 1-7. Temperature Objectives (°F) in the HFC of the Lower Feather River.

Temperature Objectives (°F)	
Maximum Daily Mean Water Temperature for the HFC (measured at the downstream project boundary[1])	
Period	**Temperature**
January 1–March 31	56
April 1–30	61
May 1–15	64

Temperature Objectives (ºF)	
Maximum Daily Mean Water Temperature for the HFC (measured at the downstream project boundary[1])	
Period	**Temperature**
May 16–31	64
June 1–August 31	64
September 1–8	61
September 9–30	61
October 1–31	60
November 1–December 31	56

[1]The project boundary ends approximately 5 RM downstream of the Thermalito Afterbay Outlet to the Feather River (see FERC FEIS, Figure 2).

1.3.3.9.7 Ramping Rates

Maximum allowable down ramping release requirements are intended to prevent rapid reductions in water levels that could potentially cause stranding juvenile salmonids and other aquatic organisms. Proposed project operations incorporate down ramping release requirements to the Feather River during periods outside of flood management operations, and to the extent controllable, during flood management operations. Planned down ramping rates are provided in Table 1-8 (based on documents and clarifications provided by DWR). There has been some confusion about LFC down ramping rates. Different tables have been included in various documents (DEIS, FEIS, BA, SA). DWR has identified that their current ramping rates and those in the proposed action (no change) are as identified in Table 1-8. Other ramping rates were included in some modeling and were inadvertently included in some of the relicensing documents.

Table 1-8. LFC and HFC Ramping Rates

LFC Down Ramping Rates	
Feather River LFC Releases (cfs)	**Rate of Decrease (cfs)**
3,500–5,000	1,000 per 24 hours
2,500–3,500	500 per 24 hours
< 2,500	300 per 24 hours

HFC Down Ramping Rates	
Feather River LFC Releases (cfs)	**Rate of Decrease (cfs)**
< 2,500	200 per 24 hours

Exceptions to these down ramping rates may occur when increases in flows occur due to flood control releases, accident, mechanical or electrical failure and outages due to major or unusual maintenance. When it is mutually agreeable to the parties, deviations from these conditions may be made (1983 Agreement between DWR and CDFG).

1.3.3.9.8 Inability to Meet Temperature Requirements Due to Uncontrollable Forces

SA Article A108.7 provides that if the Licensee is unable to meet the temperature requirements in other SA articles described above due to an event or circumstances beyond its reasonable control, the Licensee will file a notice with the Commission within ten days describing the event or circumstances and provide a copy of the notice to the Ecological Committee, including listed agency consultees, for comment and an opportunity for dispute resolution. The notice will include a statement of specific actions that the Licensee will take to address the event or circumstance and how it will manage the coldwater pool to minimize exceedances of water temperatures in applicable tables described above. If the Commission finds that there is a pattern of exceedances that could result in adverse impacts to fishery resources, it may require the Licensee to file a plan developed in consultation with the consultees identifying any feasible measures that the Licensee may undertake, or modifications to other license requirements, to address the exceedances.

The SWRCB included within condition S8 (Flow/Temperature to Support Anadromous Fish) of the water quality certification the following text under the heading Inability to Meet Temperature Requirements Due to Uncontrollable Forces:

> *If the Licensee is unable to meet the temperature requirements in sections S7 and S8 of this certification due to an event or circumstance beyond its reasonable control, the Licensee shall file a notice within 10 days of such event or circumstance with the Deputy Director describing the event or circumstance causing the inability to meet those temperature requirements. Such notice shall include a statement of specific actions that the Licensee will take to address the event or circumstance and how it will manage the coldwater pool to minimize exceedances of Table S8 or of applicable temperature requirements at the lower project boundary, consistent with its water supply and other legal obligations. If the Deputy Director finds that there is a pattern of exceedances that could result in adverse impacts to fishery resources, it may require the Licensee to file a plan identifying any feasible measures that the Licensee may undertake, or modifications to other license requirements, to address the exceedances.*

1.3.3.10 Lake Oroville Coldwater Improvement Program (A111)

Under the proposed action, DWR will develop and implement a Lake Oroville Coldwater Fishery Improvement Program, similar to an existing fish stocking program designed to support a coldwater sport fishery at a level that is desirable to Lake Oroville anglers. Through the Lake Oroville Coldwater Fishery Improvement Program, DWR will stock coldwater fish in Lake

Oroville to improve the sport fishery, which may increase recreational opportunities and tourism at the reservoir.

Within one year of license issuance, DWR will develop a Coldwater Fisheries Management Plan for Lake Oroville in consultation with the EC. The plan will provide for stocking, managing, and monitoring salmonids at approximately the same level of stocking as under the existing FERC License, which is 170,000 (+/- 10 percent) yearlings (or their equivalent) per year. The plan will focus on the first 10 years of coldwater fish stocking, and will be revised every 10 years thereafter. Before filing the report with FERC, DWR will submit a monitoring report to the EC for review and recommendations every two years.

The SWRCB included the following condition (S11) in the water quality certification for the Lake Oroville Coldwater Fishery Improvement Program.

a) *Within one year following license issuance, the Licensee shall develop and file with the Deputy Director for approval a Plan to provide a cold water fishery primarily for the purpose of recreational fishing. The Licensee shall consult with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, State Water Board, and California Department of Fish and [Wildlife] (consultees) in developing this Plan. Consultation with the Ecological Committee complies with the consultation requirement, as long as the agencies listed are part of the Ecological Committee. The Licensee shall include with the filing the plan copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why any such comment was not adopted. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the Plan shall be deemed approved.*

b) *Any modification to the implementation measures not within the scope of the approved Plan must be filed with the Deputy Director for modification and approval.*

c) *The Plan shall provide for: (1) the stocking of 170,000 yearling salmon or equivalents per year, plus or minus 10 percent; (2) identification of a primary source of salmonids for stocking in the lake; (3) addressing disease issues associated with the source or handling of salmonids; (4) identification of alternative sources of salmonids for stocking in the lake; (5) analyzing the feasibility of providing a disinfection system for hatchery water resources; and (6) a monitoring program.*

d) *The Plan shall be reviewed and updated by the Licensee every 10 years. The Licensee shall consult with the consultees listed in S11(a) above, and then file the updated Plan with the Deputy Director for modification and approval. The Licensee shall include with the filing any comments, including recommendations made in the course of such consultation, and an explanation as to why any such comment was not adopted.*

e) *The Licensee shall submit a monitoring report every two years with the Deputy Director and shall include with filing copies of the comments, including* *recommendations, made by the consultees, and an explanation for why any such comment was not adopted.*

1.3.3.11 Comprehensive Water Quality Monitoring Program (A112)

The proposed action includes development of a Comprehensive Water Quality Monitoring Program that is intended to expand the existing program of data collection to document water quality conditions in project-affected waters, including contributions from upstream sources, limnologic changes occurring within the project impoundments, pathogen levels at recreation sites, effects of project operations on the Feather River thermal regime, and long-term effects of the project on water quality from present and future operations.

Within six months following FERC license issuance, DWR, in consultation with the EC, SWRCB, Central Valley Regional Water Quality Control Board (CVRWQCB), and Butte County Health Department, will begin preparing a draft initial Comprehensive Water Quality Monitoring Program designed to track potential changes to water quality associated with the project and to collect data necessary to develop a water quality trend assessment through the life of the new FERC license. The draft initial Comprehensive Water Quality Monitoring Program will focus on identifying those organic and inorganic constituent and physical parameter levels that may affect beneficial uses for surface waters. Following the consultation, and within nine months of FERC license issuance, DWR will submit the draft initial Comprehensive Water Quality Monitoring Program to the SWRCB for review and approval. Upon approval from the Deputy Director of the Division of Water Rights (SWRCB), DWR will file the program with FERC for approval. Upon FERC approval, DWR will implement the initial Comprehensive Water Quality Monitoring Program, including any changes required by FERC. In each of the first five years of the initial program, DWR will collect, analyze, and compile the water quality data into annual reports that will be provided to the EC and Butte County Health Department.

Following completion of all data collected for the fifth year, DWR will compile a summary report of the initial program, which will be provided to FERC, the EC, and Butte County Health Department, and any other entity upon request. A 45-day notice will accompany the report, inviting all recipients to attend a water quality meeting scheduled by DWR to discuss the findings of the 5-year data set. After consultation, DWR will submit recommendations for a final Comprehensive Water Quality Monitoring Program to the SWRCB for review and approval. Upon approval from the Chief of the Division of Water Rights, SWRCB, DWR will file the final Comprehensive Water Quality Monitoring Program with FERC for approval. Upon FERC approval, DWR will implement the final Comprehensive Water Quality Monitoring Program, including any changes required by FERC.

The SWRCB included the following condition (S12) in the water quality certification for the Comprehensive Water Quality Monitoring Program.

a) *Within six months of license issuance, Licensee shall begin preparation of a Comprehensive Water Quality Monitoring Program (Program) to monitor water quality associated with the Project, and collect data necessary to develop a water quality trend assessment through the life of the Commission license. This Program shall be developed in consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, California Department of Fish and [Wildlife], State Water Board, the Central Valley Regional Water Quality*

Control Board, as well as Butte County Health Department (consultees). Consultation with the Ecological Committee complies with the consultation requirement, as long as the agencies listed are part of the Ecological Committee. The Program will include components to sample water chemistry, fish tissue bioaccumulation, recreation site pathogens and petroleum product concentrations, water temperatures, bioassays, cyanobacteria/cyanotoxins, and aquatic macroinvertebrate monitoring. The Program shall use accepted methodologies for field sampling and laboratory analysis and shall be consistent with State of California's Surface Water Ambient Monitoring Program Quality Assurance Program Plan.

b) Within nine months of license issuance, and following the consultation set forth in S12(a), the Program shall be submitted to the Deputy Director for approval. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director does not either act on the request for approval or identify the need for additional information or actions, the Plan shall be deemed approved. Upon approval by the Deputy Director, the Licensee shall implement the Program. The Licensee may at any time, after consultation with consultees in S12(a), submit to the Deputy for approval changes to the Program. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director does not either act on the request for approval or identify the need for additional information or actions, the Plan shall be deemed approved.

c) In each of the first five years of the Program, Licensee shall collect, analyze and compile the water quality data into annual reports. The annual reports shall be provided to the Deputy Director and the consultees listed in S12(a) above, and any other entity upon request, by May 30th of the following year. Following completion of all data collected for year five, the Licensee shall compile a summary report of the initial Program, which shall be provided to the Deputy Director, the consultees listed in S12(a) above, and any other entity upon request. A 45-day notice shall accompany the report, inviting all recipients to attend a water quality meeting, scheduled by the Licensee, to discuss the findings of the five-year data set. After consultation, the Licensee shall submit recommendations for a final Program to the Deputy Director for approval prior to the Licensee's filing of the Program with the Commission. The Licensee shall include with the filing copies of the comments, including recommendations, made in the course of consultation with the consultees, and an explanation as to why any such comment was not adopted. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director does not either act on the request for approval or identify the need for additional information or actions, the Program shall be deemed approved. Upon Deputy Director approval, the Licensee shall implement the Program. Water quality data shall be analyzed and compiled by the Licensee into five-year reports and distributed to the consultees listed in S12(a) above, and any other entity upon request.

d) Within six months of Deputy Director approval of the final Comprehensive Water Quality Monitoring Program, Licensee shall begin implementation of the

Water Chemistry Monitoring Plan component of the Program, including the following:

1. *In-situ Physical Parameters: The Licensee shall monitor between 15 and 20 locations four times each year (seasonally) for in-situ physical parameters necessary for determining water quality. In-situ data collected at each sampling location shall include water temperature, dissolved oxygen (DO), pH, specific conductivity, oxidation/reduction, and turbidity. Monitoring at Lake Oroville, the Diversion Pool at Oroville Dam, and one site within the Thermalito Afterbay shall include vertical profiles for temperature, DO, pH, oxidation/reduction, and specific conductivity collected at the Diversion Pool and Thermalito Afterbay at one meter intervals from surface to substrate and at Lake Oroville as follows: at one meter intervals from surface to 30 meters depth, at three meter intervals from 33 to 60 meters depth, at five meter intervals from 65 to 100 meter depth, and at ten meter intervals from 110 meters to substrate.*
2. *Nutrients: The Licensee shall monitor between 15 and 20 locations two times each year (spring and fall), for nutrients necessary for determining water quality. Nutrient data collected at each sampling location shall include nitrate plus nitrite, ammonia, organic nitrogen, dissolved orthophosphate, and total phosphorus.*
3. *Metals: The Licensee shall monitor between 18 and 22 locations four times each year (seasonally), for metals necessary for determining water quality. The developed marinas (Bidwell and Lime Saddle) shall be included in the locations, along with sites to be specified in Lake Oroville, the Diversion Pool, Thermalito Forebay, Thermalito Afterbay, the LFC, Mile Long Pond, and the Feather River at the southern boundary of the Project. Additional monitoring shall occur at both marinas one time each month during the recreation season (June-September). Metals shall be analyzed and reported as total concentrations and dissolved fractions for aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, selenium, silver, zinc, and mercury; in addition, total hardness shall be analyzed for each sampling location.*
4. *Minerals and Alkalinity: The Licensee shall monitor between 15 and 20 locations two times each year (spring and fall), for minerals and alkalinity necessary for determining water quality. Minerals data collected at each sampling location shall include calcium, sodium, potassium, magnesium, sulfate, chloride, boron, and alkalinity.*
5. *Plankton: The Licensee shall monitor two locations, two times each year, for phytoplankton and zooplankton as part of the water quality assessment. The monitoring sites are Lake Oroville and Thermalito Afterbay.*

e) Within three years of Deputy Director approval of the final Program, Licensee shall begin implementation of the Fish Tissue Bioaccumulation Monitoring Plan component of the Program. The Licensee shall collect resident fish species from seven locations within project waters, one time every five years, beginning five *years after license issuance, and analyze tissue for metals and organic compounds. Sampling strategy for target species, numbers of individuals, sampling locations, and analytical methods used shall be determined through Licensee consultation with the State Water Board, California Office of Environmental Health Hazard Assessment, Central Valley Regional Water Quality Control Board during development of the Comprehensive Water Quality Monitoring Program. Constituents to be analyzed include metals (arsenic, cadmium, chromium, copper, iron, lead, nickel, selenium, silver, zinc, and mercury), and organic compounds (chlordane, chlorpyrifos, DDT isomers, dieldrin, hexachlorobenzene, and polychlorinated biphenyls).*

f) *Within six months of Deputy Director approval of the Program, Licensee shall begin implementation of the Recreation Site Water Quality Monitoring Plan component of the Program, including the following:*

1. *Pathogens - The Licensee shall collect and analyze water samples for pathogens at 10 to 14 locations within project waters each summer season. Near-shore water samples shall be collected five times within a 30-day period at each location, and one time between June 15 and September 15. Potential sampling locations shall include developed beach areas, marinas, and boat launch areas along with high-use dispersed beach and shoreline locations in all waters affected by project operations. Prior to April 30th each year, the Licensee, in consultation with the State Water Board, Central Valley Regional Water Quality Control Board, Butte County Health Department, and California Department of Parks and Recreation shall select the locations to be included in the upcoming seasonal sampling program. In addition, the Licensee shall collect and analyze water samples for pathogens from June 1 through September 30 at North Forebay recreation area, South Forebay recreation area, Loafer Creek recreation area, Monument Hill recreation area, Lime Saddle recreation area, Foreman Creek boat launch area, Stringtown boat launch area, and Mile Long Pond. Additionally, at the North Forebay recreation area, individual screening samples shall be collected monthly between June 1 and September 30. Laboratory analyses for pathogens shall include: total coliform, fecal coliform, e-coli, enterococcus, and streptococcus, or other pathogens of concern for public health protection identified during annual consultation.*

2. *Petroleum Products - The Licensee shall monitor six locations for petroleum products in project waters (Bidwell Marina, Lime Saddle Marina, Foreman Creek Boat-in Campground, Spillway Boat Ramp/Day Use Area, Oroville Dam, and Monument Hill). Water column samples shall be collected one time each month from June through September. Field sampling methods shall include both surface and bottom samples at each location. Samples shall be analyzed for Total Petroleum Hydrocarbons, and benzene.*

3. *Soil Erosion - The Licensee shall inspect trails between May 1 and May 15 and following the summer recreation season to identify soil erosion and potential subsidence into reservoirs or flowing waterways.*

g) Within three months of Deputy Director approval of the Program, Licensee shall begin implementation of the Water Temperature Monitoring Plan to provide information that demonstrates compliance with the water temperature requirements in this certification. The Licensee shall site four permanent continuous temperature monitoring devices, one each at the following locations: (1) Feather River Hatchery aeration tower, (2) Robinson's Riffle, (3) Thermalito Afterbay Outlet, and (4) the Feather River adjacent to the most southern Project 2100 boundary. The permanent temperature gages shall be capable of providing real-time data to the hatchery operators and to the public via an internet-based medium such as the Department of Water Resources' California Data Exchange Center (CDEC). The four permanent gages shall remain operational throughout the life of the license.

h) The Water Temperature Monitoring Plan shall be designed and implemented to provide data necessary for additional modeling or study associated with facility modification(s). The Licensee shall install and collect temperature data from temporary continuous recording devices at appropriate locations to provide data necessary for additional modeling or study associated with facility modification(s).

i) The Water Temperature Monitoring Plan shall be reviewed after five years, to determine if modifications to the Comprehensive Water Quality Monitoring Program are necessary for consistency with measures that may be implemented following decisions on water temperature management in the LFC and High Flow Channel. Continuous temperature monitoring will include both stream stations and reservoir stations, including vertical profile data collection adequate to evaluate changes in cold water pool and stratification in other deep water bodies within the Project boundary.

j) Within three years of Deputy Director approval of the Program, Licensee shall implement the Water Quality Bioassay Monitoring Plan component of the Program. The Licensee shall collect water column samples from two locations in the LFC, four times in a single year (seasonally), every five years, beginning five years after license issuance, to conduct bioassay tests on aquatic organisms. Aquatic organisms to be used in bioassays will be Ceriodaphnia and Fathead minnow (Pimephales promelas).

k) Within one year of Deputy Director approval of the Program, Licensee shall implement the Aquatic Macroinvertebrate Monitoring Plan component of the Program. The Licensee shall collect benthic macroinvertebrate samples from a minimum of seven stream locations during the fall index period one time every three years, beginning three years after license issuance. Field sampling, laboratory identification, and statistical analysis shall be consistent with the California Stream Bioassessment Procedures (California Department of Fish and [Wildlife]) or Surface Water Ambient Monitoring Program (or successor program). A minimum of four sites shall be located in the LFC and one site in the High Flow Channel at the southern-most project boundary. Following construction of any side channel habitat created as part of the Lower Feather River Habitat Improvement Program, sampling sites representative of each channel shall be added to the monitoring program.

l) *Within six months of license issuance, the Licensee shall submit a plan to the Deputy Director for modification and approval to protect the public from harmful cyanobacteria. The plan shall include sampling locations, sampling methodology, and laboratory procedures to monitor for the presence of harmful cyanobacteria and cyantoxins within Project waters. The plan shall include procedures for protecting the public from harmful levels of cyanotoxins. The plan shall be consistent with the Statewide Guidance for Blue-Green Algae.*

m) *The Licensee, in consultation with the consultees listed in (a) above shall reevaluate the Program every five years after initial implementation. Any recommendations acceptable to the Licensee for changes to the Program shall be submitted to the Deputy Director for modification and approval. The Licensee shall include with the filing copies of the comments, including recommendations, made in the course of such consultation, and an explanation for why any such comment was not adopted. Upon Deputy Director approval, the Licensee shall implement the Program, including any changes required by the Deputy Director.*

n) *The State Water Board reserves the authority to require Licensee to conduct studies and, if appropriate, develop a methyl mercury management plan. If ongoing or future research and monitoring data indicate that the reservoirs or other aspects of power operations increase mercury methylation rates, the Deputy Director may require Licensee to prepare and submit for approval a study plan, including studies, to identify: (1) DWR's contribution to the methyl mercury problem; (2) potential measures to reduce the amount of methylated mercury in the waters affected by Licensee's operations, as well as to protect human health; and (3) an evaluation of the feasibility of those measures. The Deputy Director may require modifications as part of the approval, and the Licensee shall implement the study plan as approved. If, based on the results of the study plan or other information, the Deputy Director determines that that DWR has contributed to the problem and there are appropriate and feasible measures that DWR could implement to reduce methyl mercury, Licensee shall develop an implementation plan for measures to reduce mercury and submit it to the Deputy Director for approval. The Deputy Director may require modifications as part of the approval. If, within 90 days, the Deputy Director does not either act on the request for approval or identify the need for additional information or actions, the plan shall be deemed approved. Upon approval by the Deputy Director, the Licensee shall implement the mercury management plan.*

o) *The Deputy Director reserves jurisdiction to require a plan to address any Basin Plan violations identified in this monitoring which the Deputy Director finds the project causes or to which it significantly contributes.*

1.3.3.11.1 Water Chemistry Monitoring

Within six months of FERC approval of the final Comprehensive Water Quality Monitoring Program, DWR will begin implementing the Water Chemistry Monitoring Plan component of the program, including monitoring at 15 to 20 locations four times (seasonally) each year for in-situ physical parameters such as water temperature, dissolved oxygen, pH, specific conductivity, and turbidity. Twice a year monitoring will be conducted at the same 15 to 20 sites to evaluate nutrients, such as nitrate plus nitrite, ammonia, organic nitrogen, dissolved orthophosphate, and total phosphorus, as well as minerals, including calcium, sodium, potassium, magnesium, sulfate, chloride, boron, and alkalinity. DWR will monitor between 18 to 22 locations four times (seasonally) each year for metals, including aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Locations for metal sampling will include developed marinas and other sites within Lake Oroville, the diversion pool, Thermalito Forebay, Thermalito Afterbay, the LFC, Mile Long Pond, and the Feather River at the southern portion of the action area. DWR will also monitor two locations, twice a year, for phytoplankton and zooplankton as part of the water quality assessment in Lake Oroville and Thermalito Afterbay.

1.3.3.11.2 Fish Tissue Bioaccumulation Monitoring

Within three years of FERC approval of the final Comprehensive Water Quality Monitoring Program, DWR will begin implementation of the Fish Tissue Bioaccumulation Monitoring Plan. DWR will collect resident fish species from seven locations within project waters of the action area, once every five years, and analyze tissue for metals and organic compounds. The sampling strategy for target species, sampling locations, and analytical methods will be consistent with SWRCB Surface Water Ambient Monitoring Program needs and will be determined through consultation with SWRCB, California Office of Environmental Health Hazard Assessment (OEHHA), CVRWQCB, USFWS, NFMS, CDFW, and the EC before each sampling year. Constituents to be analyzed include metals and organic compounds.

1.3.3.11.3 Water Temperature Monitoring

Within three months of FERC approval of the final Comprehensive Water Quality Monitoring Program, DWR will begin implementation of the Water Temperature Monitoring Plan to provide information that demonstrates compliance with the FRFH water temperature requirements, CVP/SWP BO, and Water Quality Control Plan for the Central Valley-Sacramento and San Joaquin River Basins (Basin Plan) water quality standards. DWR will install four permanent continuous temperature monitoring devices at the following locations: (1) FRFH aeration tower, (2) Robinson Riffle, (3) Thermalito Afterbay Outlet, and (4) the Feather River adjacent to the most southern point of the project area. These monitoring devices will be capable of providing real-time temperature data to the FRFH operators and to the public via an Internet-based medium and will remain operational throughout the life of the new License.

The Water Temperature Monitoring Plan will be reviewed after five years to determine if modifications to the Comprehensive Water Quality Monitoring Program are necessary for consistency with measures that may be implemented following decisions on water temperature management in the LFC and the HFC. DWR will also install and collect temperature data from temporary continuous recording devices at appropriate locations to provide additional data necessary for modeling or studies associated with potential facility modifications under consideration during the flow/temperature reconnaissance effort.

1.3.3.11.4 Water Quality Bioassay Monitoring

Within three years of FERC approval of the final Comprehensive Water Quality Monitoring Program, DWR will begin implementation of the Water Quality Bioassay Monitoring Plan. DWR will collect water column samples from two locations in the LFC, four times (seasonally) in a single year, every five years, to conduct bioassay tests on aquatic organisms. Field sampling and laboratory analysis will be consistent with methods recognized by the SWRCB Surface Water Ambient Monitoring Program and will include the aquatic organisms *Ceriodaphnia* and fathead minnow.

1.3.3.11.5 Aquatic Macroinvertebrate Monitoring

Within one year of FERC approval of the final Comprehensive Water Quality Monitoring Program, DWR will begin implementation of the Aquatic Macroinvertebrate Monitoring Plan. DWR will collect benthic macroinvertebrate samples from a minimum of seven stream locations during the fall index period once every three years. Field sampling, laboratory identification, and statistical analysis will be consistent with the California Stream Bioassessment Procedures used by CDFW or subsequent methodologies acceptable to the SWRCB's Surface Water Ambient Monitoring Program and CDFW. A minimum of four sites will be located in the LFC, and one site will be located in the HFC at the most southern point of the action area. After construction of side channel habitat as part of the Lower Feather River Habitat Improvement Program, sampling sites representative of each channel will be added to the Aquatic Macroinvertebrate Monitoring Plan.

1.3.3.12 Oroville Wildlife Area Management Plan (A115)

Within two years of license issuance, DWR shall develop a management plan for the Oroville Wildlife Area, which will include, among other things, conservation measures required by final Federal biological opinions, certain elements of the Lower Feather River Habitat Improvement Program (SA Article A101, described above in section *1.3.3.2*), and actions designed to improve conditions for special status species and their habitats. After initial implementation, this Oroville Wildlife Area Management Plan will be reevaluated every five years. The approved plan, and revisions, shall be included in any updates to the Lower Feather River Habitat Improvement Plan (SA Article A101).

The SWRCB included the following condition (S15) in the water quality certification for the Oroville Wildlife Area Management Plan.

a) *Within two years of license issuance the Licensee shall develop and file for Deputy Director approval a management plan for the Oroville Wildlife Area (OWA), including the Thermalito Afterbay. The Plan shall be developed in conjunction with the California Department of Fish and [Wildlife] and the California Department of Parks and Recreation, and in consultation with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, State Water Board, and Central Valley Regional Water Quality Control Board (consultees). Consultation with the Ecological Committee complies with the consultation requirement, as long as the agencies listed are part of the Ecological Committee. The Licensee shall include with the filing of the Plan copies of the comments, including recommendations, made in the course of such consultation, and an explanation as to why any such comment was not adopted. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the Plan shall be deemed* *approved. Upon Commission and Deputy Director approval, and after obtaining all necessary permits, the Licensee shall implement the Plan, including any changes required by the Commission and Deputy Director.*

b) The Plan shall contain the following elements:

1. *Conservation measures required by Final Federal Biological Opinions.*
2. *Resource actions included in this license that may affect the OWA.*
3. *Strategies to minimize current and future conflicts between wildlife and recreation.*
4. *Wildlife management goals and objectives.*
5. *Recreation management goals and objectives (consistent with the recreation measures outlined in the Recreation Management Plan, the Recreation Advisory Committee shall have an opportunity to provide input.).*
6. *Other best management practices, including fuel load management for the reduction of fire risk to nearby properties and human life.*
7. *Common elements of the Lower Feather River Habitat Improvement Plan.*
8. *Actions designed to improve conditions for special status species and their habitats.*
9. *An implementation schedule.*
10. *Monitoring and reporting requirements.*
11. *A provision for periodic updates to the Plan as needed.*
12. *Agency management and funding responsibilities.*

c) The Licensee, in consultation with the California Department of Fish and [Wildlife] and the consultees listed in S15(a) above, shall reevaluate the Plan every five years after initial implementation. Consistent with the recreation measures outlined in the Recreation Management Plan, the Recreation Advisory Committee shall have an opportunity to provide input. The Licensee shall provide all Plan updates to the Deputy Director for information. If any changes are recommended beyond the objectives, activities, or schedules identified in the Plan, the Licensee shall submit final recommendations in a revised plan to the Deputy Director for approval. The Licensee shall include with the filing copies of the comments, including recommendations, made in the course of such consultation, and an explanation as to why any such comment was not adopted. The Deputy Director may require modifications as part of the approval. If, within 60 days, the Deputy Director either does not act on the request for approval or identify the need for additional information or actions, the revised plan shall be deemed approved. Upon Commission and Deputy Director approval, the Licensee shall implement the Plan, including any changes required by the Commission and Deputy Director.

1.4 Interrelated and Interdependent Actions

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR § 402.02).

1.4.1 Habitat Expansion Agreement

The National Marine Fisheries Service and the U.S. Department of the Interior agreed in the SA to reserve their authority to prescribe fishways pursuant to Section 18 of the FPA as provided in the Habitat Expansion Agreement (HEA), and the SA includes a proposed license article to that effect (SA Article A109).

The SWRCB included the following condition (S9) in the water quality certification for Habitat Expansion:

> *The Licensee shall implement the Habitat Expansion Agreement ("HEA"), in cooperation with PG&E, as provided in the HEA. The Licensee shall submit the habitat expansion plan to the Deputy Director at the same time it submits the plan to NMFS; and the State Water Board delegates to the Deputy Director the authority to review, modify as appropriate, and approve the plan. State Water Board staff will participate in the procedures under the HEA. The plan shall include a specific description of the circumstances when the plan will be deemed to be implemented.*
>
> *This condition does not change the respective obligations which the HEA assigns to the Licensee and PG&E, the procedures, or the schedule for implementation. This condition does not establish regulatory jurisdiction over any entity other than Licensee. This condition shall extinguish if the HEA terminates, or if State Water Board on recommendation from NMFS determines that the HEA has been implemented. If the HEA terminates before implementation under its terms, the State Water Board reserves its authority to require mitigation for the Project's impacts on fish passage; and the State Water Board will undertake to exercise its reserved authority in coordination with NMFS.*

The HEA was finalized in August 2007 and amended in March 2011. The HEA addresses the blockage by several hydroelectric projects on the Feather River, including the Oroville Facilities, of fish passage to historical habitat. The HEA is not part of FERC's proposed action for purposes of this Opinion, but is interrelated to the proposed action. Therefore, the HEA is described in this section of the Opinion, and the effects of the HEA will be analyzed in section 2.4 *Effects of the Action* of this Opinion. The specific goal of the HEA is to expand spawning, rearing, and adult holding habitat within the Sacramento River basin sufficiently to accommodate an increase of approximately 2,000 to 3,000 spawning CV spring-run Chinook salmon (which is also expected to accommodate some amount of habitat for spawning CCV steelhead). Potential actions include, but are not limited to, dam removal, dam reoperation, creation or enhancement of fishways, flow and water temperature improvements, or other physical habitat improvements. Based on requirements of the HEA, DWR and PG&E prepared and distributed a draft Habitat Expansion Plan (HEP) in November 2009. In November 2010, DWR and PG&E submitted a final HEP to NMFS. In January 2014, NMFS responded to DWR and PG&E with a determination that the habitat expansion actions recommended in the final HEP did not meet several of the NMFS Approval Criteria in the Amended HEA (2011). However, NMFS noted that its determination was subject to additional procedures described in the Amended HEA. NMFS, DWR, and PGE are continuing discussions about measures needed to implement the HEA.

1.5 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02).

In this Opinion, the Federal action is FERC's relicensing of the Oroville Facilities project (Oroville Dam, hydropower plants and associated facilities), owned and operated by DWR. The Action Area is not the same as FERC's defined project boundary because the action area must delineate all areas that may be affected by the project's actions, which include the Feather River downstream from the project boundary, the Sacramento River, the Delta, and other tributaries where hatchery fish may stray and interact with other listed populations of salmon and CCV steelhead.

Water captured and stored in Lake Oroville, which is formed by Oroville Dam, is released downstream. Some water from Lake Oroville is released for users in the Feather River, but most of the water flows into the Sacramento River and down into the Sacramento River–San Joaquin River Delta (Delta). When it reaches the Delta, some SWP water is pumped through the Harvey G. Banks Pumping Plant to the North Bay and South Bay Aqueducts to Napa, Solano, Santa Clara, and Alameda counties. Some is also used for salinity control in the Delta and fish and wildlife protection. After leaving the Banks Pumping Plant, however, most water flows into the California Aqueduct and continues south to the San Joaquin Valley, Central California coast, and Southern California. While operations of Oroville Facilities do influence flows downstream of the confluence of the Feather River and the Sacramento River, through the Delta, San Pablo and San Francisco Bays to the ocean, these flows are mixed with natural flows and those related to the operation of the CVP, so that the effects are not easily segregated. The broader effects of the Oroville Facilities as part of the coordinated operations of the CVP and SWP are analyzed in the CVP/SWP BO. These include the effects of the co-mingled flows of the CVP and SWP in the lower Sacramento River, downstream from the confluence of the Feather River with the Sacramento River, through the Sacramento-San Joaquin River Delta, Suisun Bay, San Pablo Bay, San Francisco Bay, and westward to the Pacific Ocean. Therefore, in section *2.4 Effects of the Action* of this Opinion, we do not consider the downstream effects of the proposed action in terms of how the Feather River flows influence the Sacramento River and fish downstream of the Feather River. The effects analyzed in the CVP/SWP BO, however, are considered in sections *2.2 Rangewide Status of Species and Critical Habitat in the Action Area and 2.6 Integration and Synthesis* of this Opinion.

In the past, the FRFH, one of the Oroville facilities, has released a significant portion of its fall-run and spring-run Chinook salmon production into San Pablo Bay, a practice which may increase the chances of these fish straying into rivers and streams tributary to San Pablo Bay, Suisun Bay, the Delta and other Central Valley streams when they return as adults to spawn.

The HEA proposes to increase the abundance and distribution of independent populations of CV spring-run Chinook salmon. Although the exact location has not been identified, it is expected to affect one or more of the anadromous-fish-producing watersheds in the Sacramento River Basin.

Considering the geographic extent of the direct and indirect effects combined with the interrelated and interdependent activities of the proposed action, the action area associated with the Oroville Facilities project encompasses much of the anadromous fish habitat in the Central Valley of California, including the Feather River, the Sacramento River and its major tributaries, the Delta, along with Suisun Bay, San Pablo Bay and San Francisco Bay watersheds to the Pacific Ocean.

Therefore, for purposes of this Opinion, the action area is described as follows.

The Upper Feather River (upstream of Lake Oroville) and its historic salmon- and CCV-steelhead- producing tributaries were included to characterize the action's effects on fish passage and habitat loss.

Areas within the project boundary (including Lake Oroville) and the lower Feather River (from the Fish Barrier Dam to the confluence with the Sacramento River) were included to evaluate the potential effects of changes in instream flow, water temperature, and habitat restoration included in the proposed action.

Tributaries to the lower Feather River (*e.g.,* Yuba River, Bear River, and many salmonid streams) were included to evaluate the potential effects of changes in instream flow, water temperature, and effects related to the FRFH, and implementation of the HEA.

The Sacramento River (and tributaries that support anadromous fishes) from Keswick Dam downstream to the Pacific Ocean, and the San Joaquin River (and tributaries that support anadromous fishes) were included to evaluate potential effects related to the FRFH (*e.g.*, straying of hatchery-released fish) and implementation of the HEA.

The primary focus area for our analyses will be on effects of Oroville Facilities operations within the Feather River basin (Figure 1-3). An exception is that effects of FRFH operations extend to a broader area described above. The focus area for this Opinion includes the historically accessible portions of the mainstem Feather River from its confluence with the Sacramento River to the historical upper limits of anadromous access, including Lake Oroville, Oroville Dam, and associated facilities in the Feather River. The focus area is where we analyze water storage and release operations in detail.

Within the primary focus area of this Opinion, the lower Feather River (downstream of Oroville Dam) is further partitioned into three reaches: (1) the Diversion Reach from Oroville Dam downstream to the Fish Barrier Dam (RM 67); (2) the LFC from the Fish Barrier Dam to the Thermalito Afterbay Outlet (RM 59); (3) the HFC from the Thermalito Afterbay Outlet to Verona (RM 0). These reaches of the lower Feather River will be referenced throughout this Opinion. Figure 1-4 and Figure 1-5 delineate river miles in the Feather River progressing upstream from the confluence with the Sacramento River at Verona, CA.

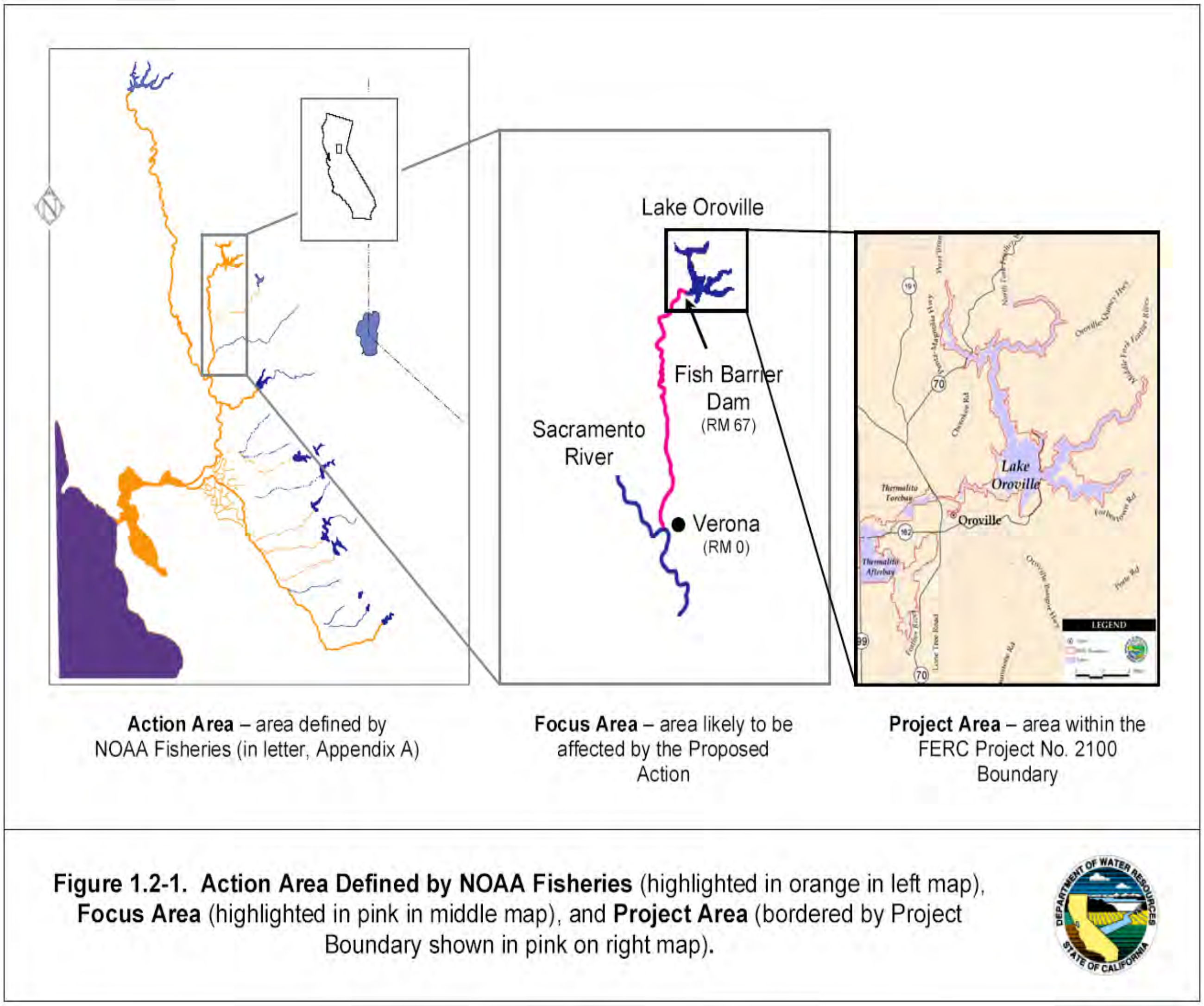


Figure 1.2-1. Action Area Defined by NOAA Fisheries (highlighted in orange in left map), **Focus Area** (highlighted in pink in middle map), and **Project Area** (bordered by Project Boundary shown in pink on right map).

Figure 1-3. Map of the Action Area, the Focus Area, and the Project Area

Figure 1-4 is a map of the Feather River showing river miles in terms of miles upstream from the confluence with the Sacramento River. The reach depicted as the HFC is for illustrational purposes.

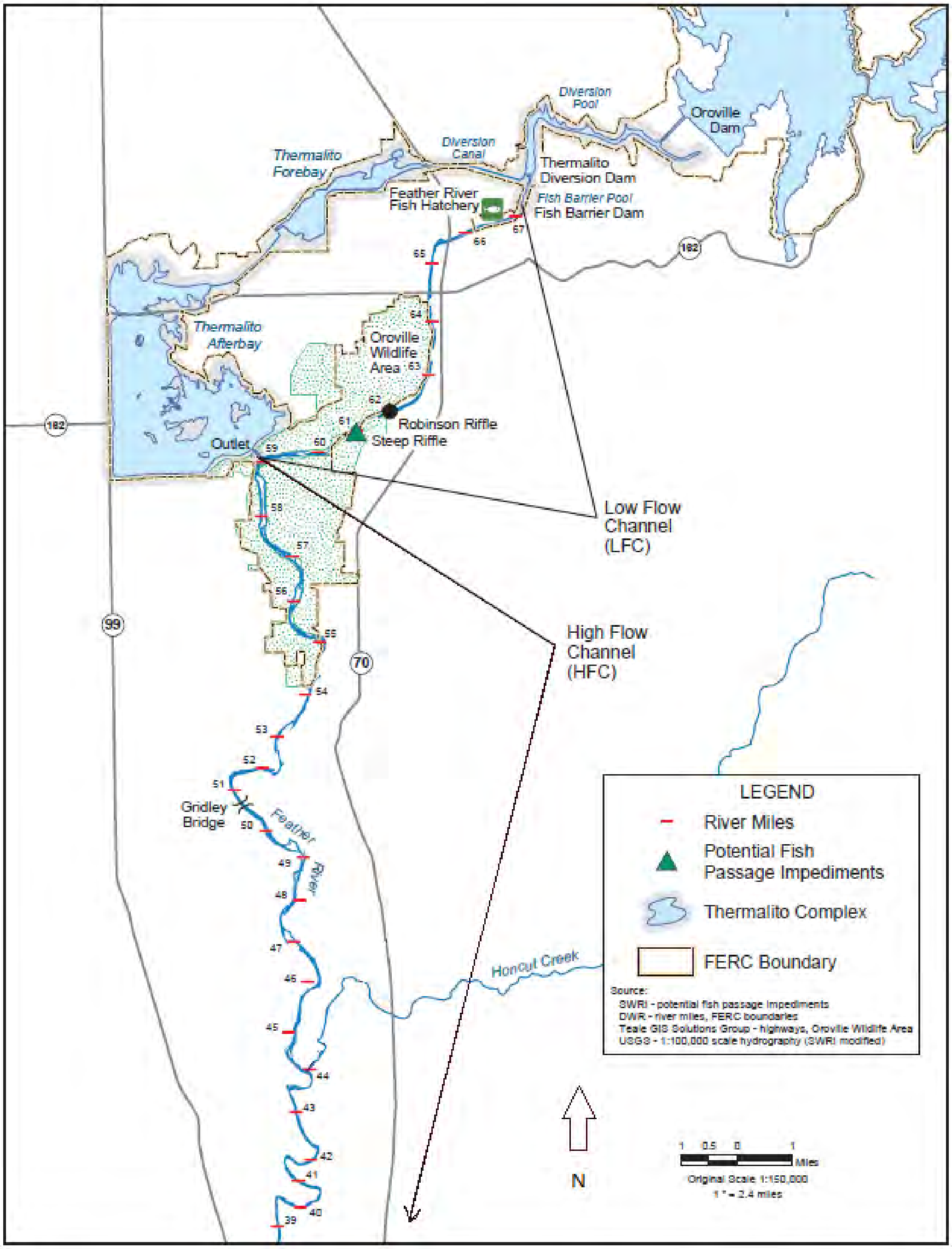


Figure 1-4. Map of the Feather River Upstream from the Yuba River Confluence

Figure 1-5 is a map of the Feather River showing river miles in terms of miles upstream from the confluence with the Sacramento River at Verona, California.

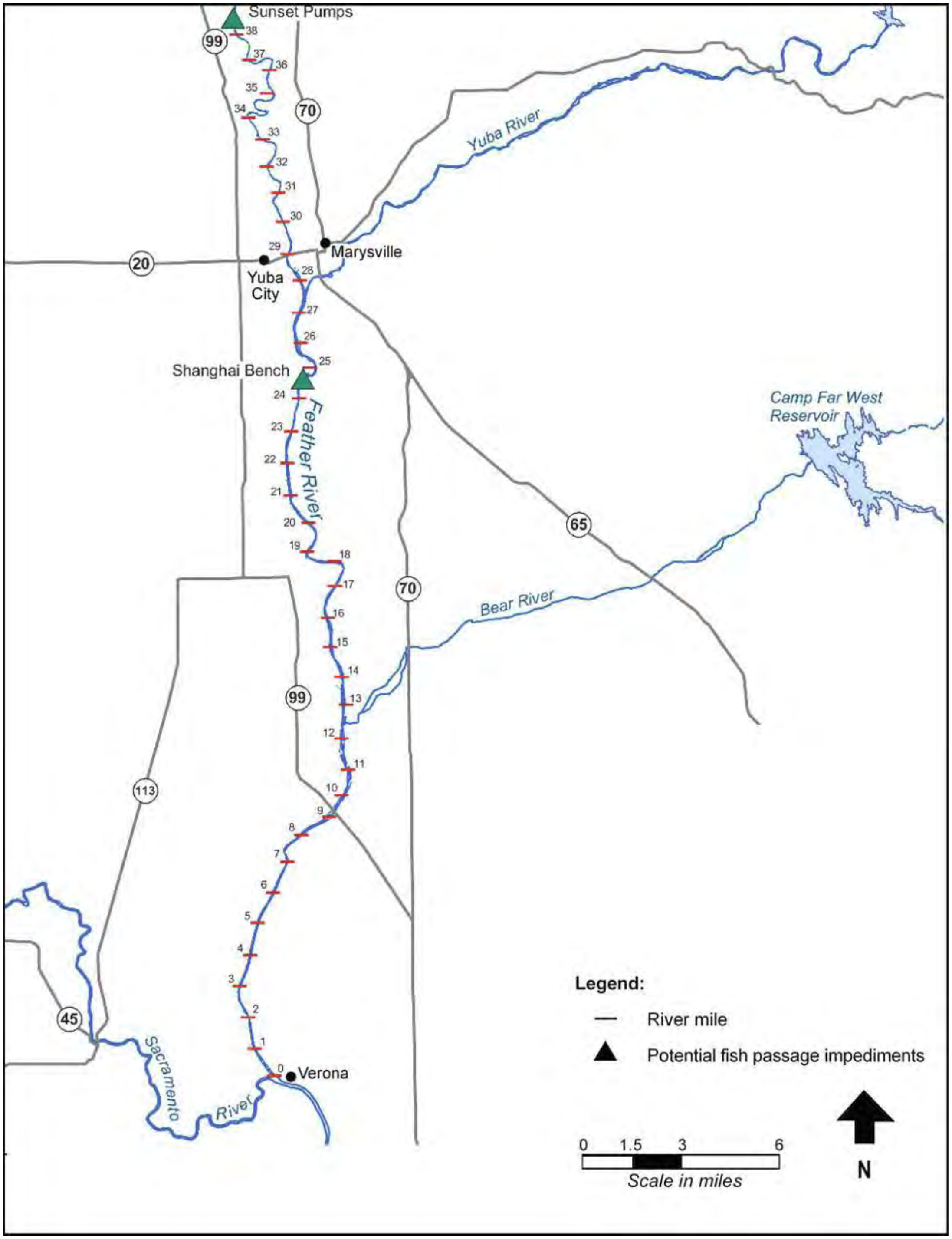


Figure 1-5. Map of the Feather River Upstream from the Sacramento River Verona Confluence

2 ENDANGERED SPECIES ACT BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by Section 7(a)(2) of the ESA, Federal agencies must ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and Section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical habitat. If incidental take is expected, Section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures and terms and conditions to minimize such impacts.

2.1 Analytical Approach

This Opinion includes both a jeopardy analysis and an adverse modification analysis.

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR § 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion relies on the regulatory definition of "destruction or adverse modification", which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214; February 11, 2014).

The designations of critical habitat for CV spring-run Chinook salmon, CCV steelhead and sDPS of North American green sturgeon use the term primary constituent elements (PCE) or essential features. The recently revised critical habitat regulations (81 FR 7414 February 11, 2016) replace this term with physical or biological features (PBFs). 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 essential features. In this Opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.

- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a RPA to the proposed action.

2.1.1 Introduction

This section describes the analytical approach used by NMFS to evaluate the effects of the proposed action on listed species under NMFS jurisdiction. The approach is intended to ensure that NMFS comports with the requirements of statute and regulations when conducting and presenting the analysis. This includes using the best available scientific and commercial information relating to the status of the species and critical habitat and the effects of the action.

The following subsections outline the conceptual framework and key steps and assumptions used in the critical habitat destruction or adverse modification risk assessment and the listed species jeopardy risk assessment. Wherever possible, these sections were written to apply to all the listed species and associated designated critical habitats considered in this Opinion.

The following discussion of our analytical approach is organized into several subsections, with the first subsection describing the legal framework provided by the ESA and case law and policy guidance related to Section 7 consultations. Second, a general overview of how NMFS conducts its Section 7 analysis is described, including various conceptual models of the overall approach and specific features of the approach are discussed. This includes information on tools used in the analysis specific to this consultation. We describe our critical habitat analysis using the primary effects to the species and habitat that are related to the physical, chemical, and biotic changes to the ecosystem caused by the proposed action. Our listed species analysis follows on the critical habitat analysis as we use the effects on habitat to determine effects on the listed species.

2.1.2 Legal and Policy Framework

The purposes of the ESA are to:

> *…provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in subsection (a) of this section.* (16 U.S.C. 1531(b)).

To help achieve these purposes, ESA Section 7(a)(2) requires that:

> *Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency… is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse*

> *modification of habitat of such species which is determined by the Secretary… to be critical….* (16 U.S.C. 1536(a)(2).

2.1.2.1 Jeopardy Standard

The "jeopardy" standard has been defined in regulation.

> Jeopardize the continued existence of *means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.* (50 CFR § 402.02).

It is important to note that the purpose of the analysis is to determine whether or not appreciable reductions are reasonably expected, but not necessarily to precisely quantify the amount of those reductions. As a result, our assessment often focuses on whether a reduction is expected or not, but not on detailed analyses designed to quantify the absolute amount of reduction or the resulting population characteristics (abundance, for example) that could occur as a result of proposed action implementation.

NMFS relates a listed species' probability or risk of extinction with the likelihood of both the survival and recovery of the species in the wild for purposes of conducting jeopardy analyses under Section 7(a)(2) of the ESA. In the case of listed salmonids and green sturgeon, NMFS uses the Viable Salmonid Population (VSP) framework to inform the jeopardy analysis (McElhany et al. 2000). A designation of a high risk of extinction or low likelihood of viability indicates that the species faces significant risks from internal and external processes that can drive a species to extinction. The status assessment considers and diagnoses both the internal and external processes affecting a species' extinction risk.

The VSP parameters are important to consider because they are predictors of extinction risk and reflect general biological and ecological processes that are critical to the survival and recovery of the listed salmonid species (McElhany et al. 2000). The analysis of this Opinion applies the basic viability framework to green sturgeon because, from the perspective of conservation biology, they represent general parameters of species status and risk that can be applied to many species, not just salmonids. The VSP parameters of productivity, abundance, and population spatial structure are consistent with the "reproduction, numbers, or distribution" criteria found within the regulatory definition of "jeopardize the continued existence of" (50 CFR § 402.02) and are used as surrogates for "reproduction, numbers, or distribution." The VSP parameter of diversity relates to all three jeopardy criteria. For example, numbers, reproduction, and distribution are all affected when genetic or life history variability is lost or constrained, resulting in reduced population resilience to environmental variation at local or landscape-level scales.

NMFS has developed a recovery plan for the listed Central Valley salmon and CCV steelhead species. A technical recovery team (TRT) was established to assist in the effort. One of the TRT products, provides a "*Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin*" (Lindley et al. 2007). Along with assessing the current viability of the listed Central Valley salmon and CCV steelhead species, Lindley et al. (2007) provided recommendations for recovering those species. In addition, we relied on the recovery plan for listed salmonids that are the subject of this Opinion (National Marine Fisheries Service 2014a), the latest species status reports, and current scientific information to determine the current status of ESA listed anadromous species that are the subject of this Opinion.

2.1.2.2 Destruction or Adverse Modification Standard

As described above, this Opinion relies on the regulatory definition of "destruction or adverse modification" (81 FR 7214; February 11, 2014).

Additional requirements on the analysis of the effects of an action are described in regulation (50 CFR Part 402) and our conclusions related to “jeopardy” and “destruction or adverse modification” generally require an expansive evaluation of the direct and indirect consequences of the proposed action, related actions, and the overall context of the impacts to the species and habitat from past, present, and future actions as well as the condition of the affected species and critical habitat. For example, see the definitions of “cumulative effects,” “effects of the action,” and the requirements of 50 CFR § 402.14(g).

Past court cases have reinforced the requirements provided in Section 7 regulations that NMFS must evaluate the effects of a proposed action within the context of the current condition of the species and critical habitat, including other factors affecting the survival and recovery of the species and the functions and value of critical habitat. In addition, courts have directed that our risk assessments consider the effects of climate change on the species and critical habitat and our prediction of the impacts of a proposed action.

Consultations designed to allow Federal agencies to fulfill these purposes and requirements are concluded with the issuance of a biological opinion or a concurrence letter. Section 7 of the ESA and the implementing regulations (50 CFR Part 402) and associated guidance documents (*e.g.,* (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998) require biological opinions to present: (1) a description of the proposed Federal action; (2) a summary of the status of the affected species and its critical habitat; (3) a summary of the environmental baseline within the action area; (4) a detailed analysis of the effects of the proposed action on the affected species and critical habitat; (5) a description of cumulative effects; and (6) a conclusion as to whether it is reasonable to expect the proposed action is not likely to appreciably reduce the species’ likelihood of both surviving and recovering in the wild by reducing its reproduction, numbers, or distribution or result in the destruction or adverse modification of the species’ critical habitat.

2.1.3 General Overview of the Approach and Models Used

NMFS uses a series of sequential analyses to assess the effects of Federal actions on endangered and threatened species and designated critical habitat. These sequential analyses are illustrated in Figure 2-3.

The first step in the approach is to identify the action and deconstruct it into its component parts that create stressors that act on federally listed species and their designated critical habitat. The next step is to identify and analyze those physical, chemical, or biotic aspects of proposed actions that are likely to have individual, interactive, or cumulative direct and indirect effect on the environment (we use the term “stressors” for these aspects of an action). As part of this step, we identify the spatial extent of any potential stressors and recognize that the spatial extent of those stressors may change with time or environmental conditions (the combined spatial extent of these stressors is the “action area” for a consultation).

The analysis identifies the endangered species, threatened species, and critical habitat that are likely to occur in the same space and at the same time as these potential stressors. Then we try to estimate the nature of that co-occurrence (these represent our "exposure analyses"). In this step of our analyses, we try to identify the number and age (or life stage) of the individuals that are likely to be exposed to an action's effects, and the populations or subpopulations those individuals represent, or the specific areas and physical or biological features (PBFs) of critical habitat that are likely to be exposed.

Once we identify which listed resources (endangered and threatened species and critical habitat) are likely to be exposed to potential stressors associated with an action and the nature of that exposure, in the third step of our analyses we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our "response analyses"). The final steps of our analyses—establishing the risks those responses pose to listed resources—are different for listed species and designated critical habitat and are further discussed in the following subsections (these represent our "risk analyses").

2.1.3.1 Application of the Exposure Analyses

The first steps in evaluating the potential impacts a project may have on an individual fish entail: (1) identifying the seasonal periodicity and life history traits and biological requirements of listed fish within the action area. Understanding the spatial and temporal occurrence of these fish is a key step in evaluating how they are affected by current human activities and natural phenomena; (2) identifying the main variables that define riverine characteristics that may change as the result of project implementation; (3) determining the extent of change in each variable in terms of time, space, magnitude, duration, and frequency; (4) determining if individual listed species will be exposed to potential changes in these variables; and (5) then evaluating how the changed characteristic would affect the individual fish in terms of the fish's growth, survival, or reproductive success.

Riverine characteristics may include: flow, water quality, vegetation, channel morphology, hydrology, neighboring channel hydrodynamics, and connectivity among upstream and downstream processes. Each of these main habitat characteristics is defined by several attributes (*e.g.,* water quality includes water temperature, dissolved oxygen, ammonia concentrations, turbidity, *etc.*). The degree to which the proposed action may change attributes of each habitat characteristic will be evaluated quantitatively or qualitatively, in the context of its spatial and temporal relevance. Not all riverine characteristics and associated attributes identified above may be affected by proposed action implementation to a degree where meaningful qualitative or quantitative evaluations can be conducted. That is, if differences in flow with and without the proposed action implementation are not sufficient to influence neighboring channel hydrodynamics, then these hydrodynamics will not be evaluated in detail, either quantitatively or qualitatively. The changed nature of each attribute will then be compared to the known or estimated habitat requirements for each fish species and life stage.

NMFS then evaluates the likely response of listed fish species to such stressors based on the best scientific and commercial information available, including observations of how similar exposures have affected these species. NMFS assesses whether the conditions that result from the proposed action, in combination with conditions influenced by other past and ongoing activities and natural phenomena as described by the factors responsible for the current status of the listed species, will affect growth, survival, or reproductive success (*i.e.,* fitness) of individual listed salmonids and sturgeon at the life stage scale.

NMFS will then evaluate how the proposed action's effects on riverine characteristics may affect the growth, survival, and reproductive success of individual fish. For example, growth and survival and reproductive success of individual fish may all be affected if the proposed action results in increased water temperatures during multiple life stages. Individual fish growth also may be affected by reduced availability, quantity, and quality of habitats (*e.g.*, floodplains, channel margins, intertidal marshes, *etc*.). Survival of an individual fish may be affected by suboptimal water quality, increased predation risk associated with non-native predatory habitats and physical structures (such as gates, weirs), impeded passage, and susceptibility to disease.

Reproductive success of individual fish may be affected by impeded or delayed passage to natal streams, suboptimal water quality (*e.g.*, temperature), which can increase susceptibility to disease for example, and reduced quantity and quality of spawning habitats. Instream flow studies (*e.g.*, instream flow incremental methodology studies) available in the literature, which describe the relationship between spawning habitat availability and flow, will be used to assess proposed action-related effects on reproductive success. All factors associated with the proposed action that affect individual fish growth, survival, or reproductive success will be identified during the exposure analyses.

2.1.3.2 Application of the Approach to Listed Species Analyses

Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the probability of extinction or probability of persistence of listed species depends on the probabilities of extinction and persistence of the populations that comprise the species. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce.

Our analyses reflect these relationships between listed species and the populations that comprise them and the individuals that comprise those populations. We identify the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those risks to individuals to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individual's "fitness," which are changes in an individual's growth, survival, annual reproductive success, or lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable response to an action's effects on the environment are likely to have consequences for the individual's fitness.

When individual listed animals are expected to experience reductions in fitness, we would expect those reductions to also reduce the abundance, reproduction rates, or growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (Stearns 1992). If we conclude that listed animals are likely to experience reductions in their fitness, our assessment tries to determine if those fitness reductions are likely to be sufficient to increase the probability of extinction of the populations those individuals represent (measured using changes in the populations' abundance, reproduction, diversity, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's extinction risks). In this step of our analyses, we use the population's base condition (established in the *2.2 Rangewide Status of the Species and Critical Habitat* section of this Opinion) as our point of reference. Generally, this condition is a measure of how near to or far from a species is to extinction or recovery.

An important tool we use in this step of the assessment is a consideration of the life cycle of the species. The consequences on a population's probability of extinction as a result of impacts to different life stages are assessed within the framework of this life cycle and our current knowledge of the transition rates (essentially, survival and reproductive output rates) between stages, the sensitivity of population growth to changes in those rates, and the uncertainty in the available estimates or information.

Various sets of data and modeling efforts are useful to consider when evaluating the transition rates between life stages and consequences on population growth as a result of variations in those rates. These data are not available for each Evolutionary Significant Unit (ESU) or DPS considered in this opinion; however, data from surrogate populations may be available for inference. Where available, information on transition rates, sensitivity of population growth rate to changes in these rates, and the relative importance of impacts to different life stages will be used to inform the translation of individual effects to population level effects. Generally, however, we assume that the consequences of impacts to older reproductive and pre-reproductive life stages are more likely to affect population growth rates than impacts to early life stages. But it is not always the adult transition rates that have the largest effect on population growth rate. For example, the absolute changes in the number of smolts that survive their migration to the ocean have the largest impact on Chinook salmon population growth rate (Wilson 2003) followed by the number of alevins that survive to fry stage.

We also recognize that populations may be vulnerable to small changes in transition rates. Particularly at low abundances, small reductions across multiple life stages can have significant consequences and can even be sufficient to cause the extirpation of a population through the reduction of future abundance and reproduction of the species. See, for example, Figure 9 in Naiman and Turner (2000).

Finally, our assessment tries to determine if changes in population viability are likely to be sufficient to reduce the viability of the species those populations comprise. In this step of our analyses, we use the species' status (established in the *2.2 Rangewide Status of the Species and Critical Habitat* section of this Opinion) as our point of reference. We also use our knowledge of the population structure of the species to assess the consequences of the increase in extinction risk to one or more of those populations. Our section *2.2 Rangewide Status of the Species and Critical Habitat* will discuss the available information on the structure and diversity of the populations that comprise the listed species and any available guidance on the role of those populations in the recovery of the species.

An example conceptual model of the population structure of CV spring-run Chinook salmon is provided in Figure 2-1. This model illustrates the historic structure of the species and notes those populations that have been extirpated to provide a sense of existing and lost diversity and structure within the species. Both existing and lost diversity and structure are important considerations when evaluating the consequences of increases in the extinction risk of an existing population or effects to areas that historically had populations.

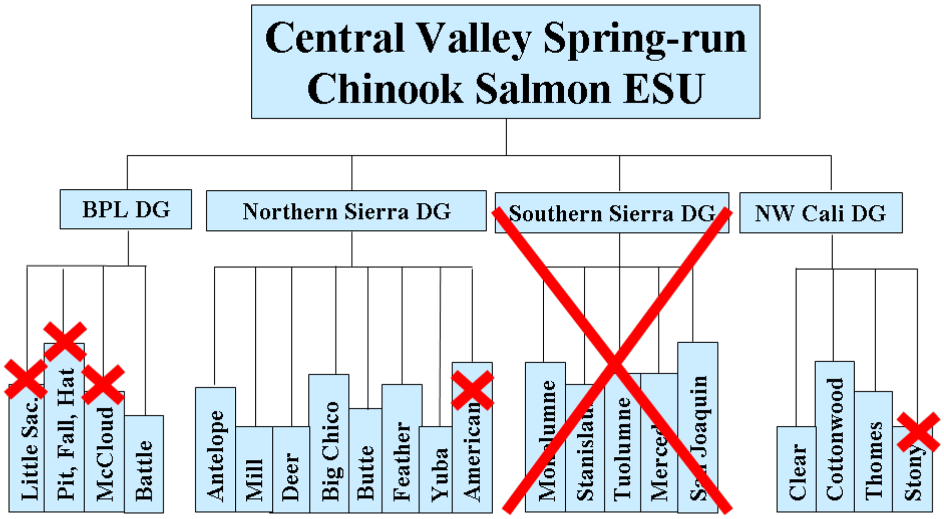


Figure 2-1. Population structure of the Central Valley spring-run Chinook salmon. Red crosses indicate populations and diversity groups that are currently extirpated.

Figure 2-2 is a conceptual model of the hierarchical structure that is used to organize the jeopardy risk assessment.

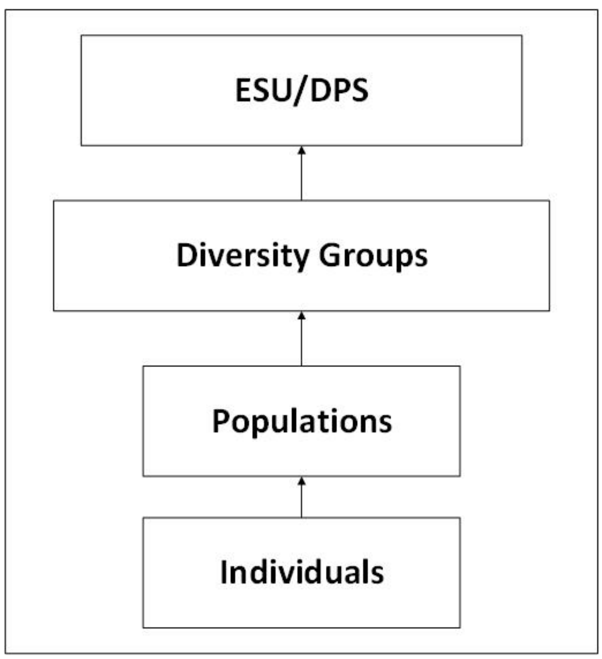


Figure 2-2. Hierarchical Structure Used to Organize the Jeopardy Risk Assessment

For example, the Central Valley Domain Technical Recovery Team (TRT) recommended that for winter-run, CV spring-run Chinook salmon, and CCV steelhead, all extant populations should be secured and that, "…*every extant population be viewed as necessary for the recovery of the ESU.*" (Lindley et al. 2007). Based on this recommendation, it was assumed that if appreciable reductions in any population's viability are expected to result from implementation of the proposed action, then this would be expected to appreciably reduce the likelihood of both the survival and recovery of the diversity group the population belongs to as well as the listed ESU/DPS.

2.1.3.3 The Viable Salmonid Populations Framework in Listed Salmonid Analyses

In order to assess the survival and recovery of any species, a guiding framework that includes the most appropriate biological and demographic parameters is required. This has been generally defined above. For Pacific salmon, (McElhany et al. 2000) defines a viable salmonid population (VSP) as an independent population that has a negligible probability of extinction over a 100-year time frame. The VSP concept provides specific guidance for estimating the viability of populations and larger-scale groupings of Pacific salmonids such as ESU or DPS. Four VSP parameters form the key to evaluating population and ESU/DPS viability: (1) abundance; (2) productivity (*i.e*., population growth rate); (3) population spatial structure; and (4) diversity.

Abundance—A population should be large enough to survive and be resilient to environmental variations and catastrophes such as fluctuations in ocean conditions, local contaminant spills or landslides. Population size must be sufficient to maintain genetic diversity.

Productivity—Natural productivity should be sufficient to reproduce the population at a level of abundance that is viable. Productivity should be sufficient throughout freshwater, estuarine, and nearshore life stages to maintain viable abundance levels, even during poor ocean conditions. A viable salmon population that includes naturally spawning hatchery-origin fish should exhibit sufficient productivity from spawners of natural origin to maintain the population without hatchery subsidy. A viable salmon population should not exhibit sustained declines that span multiple generations.

Spatial Structure—Habitat patches should not be destroyed faster than they are naturally created**.** Human activities should not increase or decrease natural rates of straying among salmon sub-populations. Habitat patches should be close enough to allow the appropriate exchange of spawners and the expansion of population into underused patches. Some habitat patches may operate as highly productive sources for population production and should be maintained. Due to the time lag between the appearance of empty habitat and its colonization by fish, some habitat patches should be maintained that appear to be suitable, or marginally suitable, even if they currently contain no fish.

Diversity—Human-caused factors such as habitat changes, harvest pressures, artificial propagation, and exotic species introduction should not substantially alter variation in traits such as run timing, age structure, size, fecundity (birth rate), morphology, behavior, and genetic characteristics. The rate of gene flow among populations should not be altered by human-caused factors. Natural processes that cause ecological variation should be maintained.

As presented in Good et al. (2005)_ENREF_114, criteria for VSP are based upon measures of the VSP parameters that reasonably predict extinction risk and reflect processes important to populations. Abundance is critical because small populations are generally at greater risk of extinction than large populations. Stage-specific or lifetime productivity (*i.e.*, population growth rate) provides information on important demographic processes. Genotypic and phenotypic diversity are important in that they allow species to use a wide array of environments, respond to short-term changes in the environment, and adapt to long-term environmental change. Spatial structure reflects how abundance is distributed among available or potentially available habitats, and can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change.

The VSP concept also identifies guidelines describing a viable ESU/DPS. The viability of an ESU or DPS depends on the number of populations within the ESU or DPS, their individual status, their spatial arrangement with respect to each other and to sources of catastrophes, and diversity of the populations and their habitat (Lindley et al. 2007). Guidelines describing what constitutes a viable ESU are presented in detail in (McElhany et al. 2000). More specific recommendations of the characteristics describing a viable Central Valley salmon population are found in Table 1 of Lindley et al. (2007).

Along with the VSP concept, NMFS uses a conceptual model of the species to evaluate the potential impact of proposed actions. For the species, the conceptual model is based on a bottom-up hierarchical organization of individual fish at the life stage scale, population, diversity group, and ESU/DPS (Figure 2-4). The guiding principle behind this conceptual model is that the viability of a species (*e.g.*, ESU) is dependent on the viability of the diversity groups that compose that species and the spatial distribution of those groups; the viability of a diversity group is dependent on the viability of the populations that compose that group and the spatial distribution of those populations; and the viability of the population is dependent on the four VSP parameters and on the fitness and survival of individuals at the life stage scale. The anadromous salmonid life cycle includes the following life stages and behaviors, which will be evaluated for potential effects resulting from the proposed action: adult immigration and holding, spawning, embryo incubation, juvenile rearing and downstream movement, and smolt outmigration.

2.1.3.4 Application of the Approach to Critical Habitat Analyses

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214; February 11, 2016).

The basis of the "destruction or adverse modification" analysis is to evaluate whether the proposed action results in negative changes in the function and role of the critical habitat in the conservation of the species. Our evaluation of conservation value entails an assessment of whether the physical or biological features are functioning to meet the biological requirements of a recovered species, or how far the features are from this condition. As a result, NMFS bases the critical habitat analysis on the affected areas and functions of critical habitat essential to the conservation of the species, and not on how individuals of the species will respond to changes in habitat quantity and quality. If an area encompassed in a critical habitat designation is likely to be exposed to the direct or indirect consequences of the proposed action on the natural environment, we ask if PBFs included in the designation (if there are any) or physical, chemical, or biotic phenomena that give the designated area value for the conservation of the listed species are likely to respond to that exposure. In particular we are concerned about responses that are sufficient to reduce the quantity, quality, or availability of those PBFs or physical, chemical, or biotic phenomena.

To conduct this analysis, NMFS follows the basic exposure-response-risk analytical steps described in Figure 2-3 and applies a set of reasoning and decision-making questions designed to aid in our determination. These questions apply a logic path for evaluating the effects of the action and follow a basic hierarchical organization of the elements and areas within a critical habitat designation. Figure 2-4 contains the basic hierarchical organization of critical habitat.

To aid our analysis, NMFS developed a set of tables Table 2-20, Table 2-26, and Table 2-29 in section *2.4 Effects of the Action*) that are designed to track and combine the stressors, exposure, response, and risk related to the various elements of the proposed action. These tables allow us to determine the expected consequences of the action on elements and areas of critical habitat, sort or rank through those consequences, and determine whether areas of critical habitat are exposed to additive effects of the proposed action and the environmental baseline. We rank the effects to critical habitat on the basis of the severity of the predicted response of the element or area within the functions provided by various areas of critical habitat (effects ranked within spawning habitat or migratory corridors, for example). In the absence of information regarding the relative importance or vulnerability of different habitat types, we did not find it appropriate to attempt to rank effects across habitat types or functions. We recognize that the value of critical habitat for the conservation a listed species has a dynamic property that changes over time in response to changes in land use patterns, climate (at several spatial scales), ecological processes, changes in the dynamics of biotic components of the habitat, etc. For these reasons, some areas of critical habitat might respond to an exposure when others do not. We also considered how areas and functions of critical habitat are likely to respond to any interactions and synergisms between or cumulative effects of pre-existing stressors and proposed stressors.

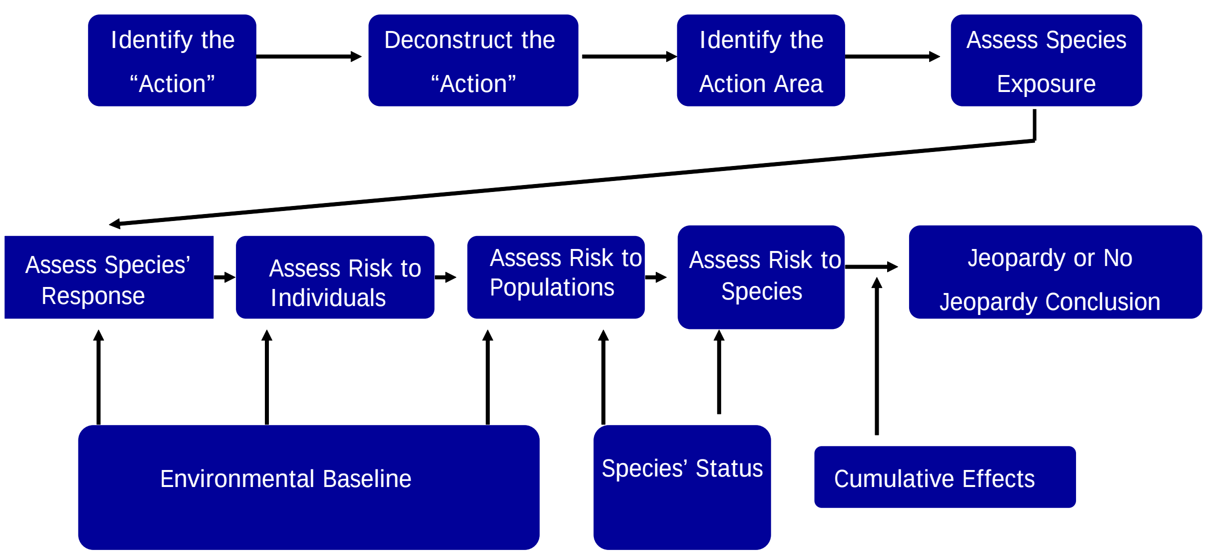


Figure 2-3. General Conceptual Model for Conducting Section 7 Applied to Analyses for Listed Species

Figure 2-4 is a conceptual model of the hierarchical structure that is used to organize the destruction or adverse modification assessment for critical habitat. This structure is sometimes collapsed for actions with very large action areas that encompass more than one specific area or feature.

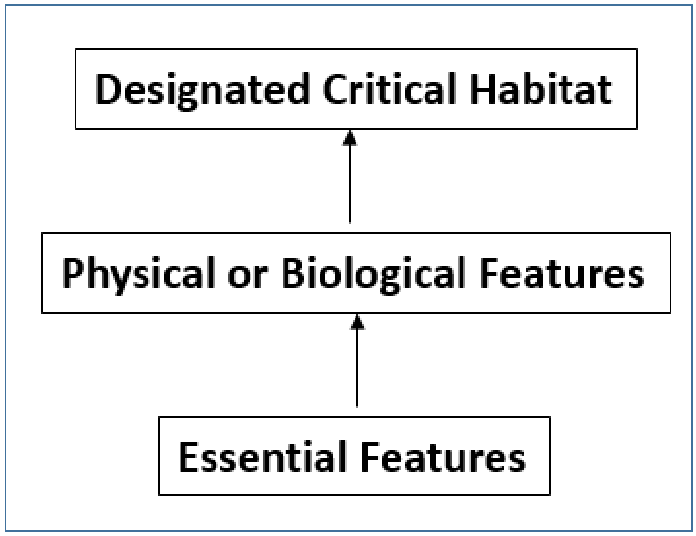


Figure 2-4. Conceptual Model of the Hierarchical Structure

Central to the analysis is the basic premise that the value of critical habitat for the conservation of a listed species the sum of the values of the components that comprise the habitat. For example, the value of critical habitat for the conservation of a listed species of listed salmonid critical habitat is determined by the value of critical habitat for the conservation of a listed species of the watersheds that make up the designated area. In turn, the value of critical habitat for the conservation of a listed species is the sum of the value of the PBFs that make up the area. PBFs are specific areas or functions, such as spawning or rearing habitat, that support different life history stages or requirements of the species. The value of critical habitat for the conservation of a listed species of the PBFs is the sum of the quantity, quality, and availability of the physical or biological features of those PBFs. Physical or biological features are the specific processes, variables, or elements that comprise a PBF. Thus, an example of a PBF would be spawning habitat and the physical or biological features of that PBF are conditions such as clean spawning gravels, appropriate timing and duration of certain water temperatures, and water quality free of pollutants.

Therefore, reductions in the quantity, quality, or availability of one or more physical or biological feature reduce the value of the PBF, which in turn reduces the function of the sub-area (*e.g.*, watersheds), which in turn reduces the function of the overall designation. In the strictest interpretation, reductions to any one physical or biological feature would equate to a reduction in the value of the whole. There are, however, other considerations. We look to various factors to determine if the reduction in the value of a physical or biological feature would affect higher levels of organization. For example:

- The timing, duration and magnitude of the reduction
- The permanent or temporary nature of the reduction

- Whether the PBF is limiting (in the action area or across the designation) to the recovery of the species or supports a critical life stage in the recovery needs of the species (*e.g.*, juvenile survival is a limiting factor in recovery of the species and the habitat element supports juvenile survival).

In our assessment, we combine information about the contribution of PBFs of critical habitat (or of the physical, chemical, or biotic phenomena that give the designated area value for the conservation of listed species) to the value of critical habitat for the conservation of a listed species of those areas of critical habitat that occur in the action area, given the physical, chemical, biotic, and ecological processes that produce and maintain those PBFs in the action area. We use the value of critical habitat for the conservation of a listed species of those areas of critical habitat that occur in the action area as our point of reference for this comparison. For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species that limited value is our point of reference for our assessment of the consequences of the added effects of the proposed action on that conservation value.

2.1.4 Information Used for the Analysis

In order to conduct this analysis, NMFS examined multiple sources of information available through published and unpublished material. The primary source of initial information was the Oroville Facilities BA, produced for this consultation, FERC's *Final Environmental Impact Statement for the Oroville Facilities* (Federal Energy Regulatory Commission 2007), and an extensive compilation of fishery, geomorphic, engineering, and operations study plan reports that were prepared during the study period for the license proceeding. Included within the Oroville Facilities BA was an extensive bibliography that served as a valuable resource for identifying key unpublished reports available from state and Federal agencies, as well as private consulting firms. It also provided a robust set of key background papers and reports in the published literature on which to base further literature searches.

We examined the literature that was cited in documents and any articles we collected through electronic and physical file searches. Most references were available as electronic copies.

The following provides a list of some of the additional resources that we considered in the development of our analysis:

- Final rules listing the Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS of North American green sturgeon, as threatened or endangered;
- Final rules designating critical habitat for the Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead species, and sDPS of North American green sturgeon (sDPS green sturgeon);
- Previously issued NMFS biological opinions;
- NMFS-Southwest Fisheries Science Center reviews (*e.g.*, ocean productivity, declarations, climate change);
- NMFS' *Recovery Plan for the Evolutionary 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*;

- CDEC data;
- CDFG's Grand Tab (2008) database for adult escapement estimates and indices.

The following operation, temperature, and sediment models were used to perform environmental analysis of the various alternatives included in the Preliminary Draft Environmental Assessment (PDEA) and the FEIS. Modeling results were reviewed in preparing this Opinion. NMFS also reviewed CALSIM II runs to evaluate river flows, especially the Bay Delta Conservation Plan (BDCP) No Action Alternative because it represents the baseline condition for water operations.

CALSIM II: Modeled SWP and CVP flows and temperatures using a monthly time step over an 82-year period (1922 to 2003). Water Quality for River-Reservoir System (WQRRS) modeled temperatures in the Oroville and Thermalito Complex and in the Feather River, from the base of Oroville Dam extending downstream to its confluence with the Sacramento River. Electronic files of numerous modeling results were provided to NMFS during the study period and used to review exceedance probabilities at numerous locations on the Feather River from the vicinity of the FRFH, downstream to the confluence with the Sacramento River at Verona. The different modeling results that we reviewed include "Existing and Future Benchmark" conditions; modeling comparisons from "Appendix E" of DWR's *Final Environmental Impact Report*; and Feather River temperature modeling conducted for the CVP/SWP BA (U.S. Bureau of Reclamation 2008b, a).

Local Operations (HYDROPS™): Modeling Oroville Facilities operations at an hourly time step with the goal of maximizing hydroelectric power production given input constraints.

HYDROPS™ simulated the operation of the Oroville Facilities to optimize power production for each week within the operational constraints from the CALSIM modeling. The result was an hourly disaggregation of the CALSIM result. This was used as an input to the temperature model.

Reservoir–River Temperature (WQRRS): Modeled temperatures in the Oroville–Thermalito Complex and in the Feather River, from the base of Oroville Dam extending downstream to its confluence with the Sacramento River.

WQRRS is a one-dimensional, deterministic model that performs water balance and heat budget calculations to determine water temperatures. In lakes or reservoirs the model assumes vertical temperature stratification and provides vertical temperature profiles without spatial distribution of water temperature conditions. In river networks the model assumes vertical mixing and provides longitudinal temperatures in branching channels or around islands.

The Feather River temperature models are an hourly temperature simulation of the Oroville Facilities and the Feather River downstream to the confluence with the Sacramento River. The model accepts all water operations as inputs and computes the resulting temperature profiles in the reservoirs, reservoir release temperatures, diversion temperatures, and temperatures in the Feather River.

The Feather River Temperature Model is a system of five individual temperature models of the various reservoir and river portions of the system. The specific temperature models include the Oroville Reservoir Temperature Model, Thermalito Diversion Pool Temperature Model, Thermalito Forebay Temperature Model, Thermalito Afterbay Temperature Model, and the Feather River Hydraulic Model.

These individual models and utility programs are linked via a central database system used to manage the data flow between the models. This database system uses the USACE Hydrologic Engineering Center Data Storage System (HEC-DSS) (http://www.hec.usace.army.mil).

Flow-Stage (HEC-RAS): Modeled channel geometry and flow resistance to develop flow-stage relationships along the Feather River from the base of Oroville Dam extending downstream to its confluence with the Sacramento River.

FLUVIAL-12: Modeled sediment movement in the Feather River to provide input to the analysis of scour and erosion within the river.

2.1.5 Integrating the Effects

The preceding discussions describe the various quantitative and qualitative models, decision frameworks, and ecological foundations for the analysis presented in this Opinion. The purpose of these various methods and tools is to provide a transparent and repeatable mechanism for conducting analyses to determine whether the proposed action is not likely to jeopardize the continued existence of the listed species and not likely to result in the destruction or adverse modification of designated critical habitat.

Many of the methods described above focus the analysis on particular aspects of the action or affected species. Key to the overall assessment, however, is an integration of the effects of the proposed action both with each other and with all other stressors to which the species and critical habitat are also exposed. In addition, the final analysis steps require a consideration of the effects of the action within the context of the status of the species as listed and the entire critical habitat as designated or proposed. That is, following the hierarchical approaches outlined above, NMFS aggregates the effects of the proposed action, the environmental baseline condition of the species and habitat, and the cumulative effects of future actions, taking into account the status of the species and critical habitat, to determine whether or not the action is likely to appreciably reduce the likelihood of both the survival and recovery of the species or is likely to result in the destruction or adverse modification of critical habitat.

2.1.6 Presentation of the Analysis in This Biological Opinion

Biological opinions are constructed around several basic sections that represent specific requirements placed on the analysis by the ESA and implementing regulations. These sections contain different portions of the overall analytical approach described here. This section is intended as a basic guide to the reader of the other sections of this Opinion and the analyses that can be found in each section. Every step of the analytical approach described above will be presented in this opinion in either detail or summary form.

2.1.6.1 Description of the Proposed Action

This section contains a basic summary of the proposed Federal action and any interrelated or interdependent actions. This description forms the basis of the first step in the analysis where we consider the various elements of the action and determine the stressors expected to result from those elements. The nature, timing, duration, and location of those stressors define the action area and provide the basis for our exposure analyses. See section *2.2*.

2.1.6.2 Rangewide Status of the Species and Critical Habitat

This section provides the reference condition for the species and critical habitat at the listing and designation scale. For example, NMFS will evaluate the viability of each salmonid ESU/DPS given its exposure to human activities and natural phenomena such as variations in climate and ocean conditions, throughout its geographic distribution. These reference conditions form a basis for the determinations of whether the proposed action is not likely to jeopardize the species or result in the destruction or adverse modification of critical habitat. Other key analyses presented in this section include critical information on the biological and ecological requirements of the species and critical habitat and the impacts to species and critical habitat from existing stressors.

2.1.6.3 Environmental Baseline

This section provides the reference condition for the species and critical habitat within the action area. By regulation, the baseline includes "the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process." (50 CFR § 402.02, definition of "effects of the action").

2.1.6.4 Effects of the Proposed Action

This section details the results of the exposure, response, and risk analyses NMFS conducted for individuals of the listed species and features, functions, and areas of critical habitat.

2.1.6.5 Cumulative Effects

This section summarizes the impacts of future non-Federal actions reasonably certain to occur within the action area, as required by regulation. Similar to the rest of the analysis, if cumulative effects are expected, NMFS determines the exposure, response, and risk posed to individuals of the species and features of critical habitat.

2.1.6.6 Integration and Synthesis

In this section of the Opinion, NMFS presents the summary of the effects identified in the preceding sections and then details the consequences of the risks posed to individuals and features of critical habitat to the higher levels of organization. These are the response and risk analyses for the population, diversity group, species, and designated critical habitat. This section is organized around the species and designated critical habitat and includes integration of the analyses from each section described above.

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR § 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the value for the conservation of the listed species of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that value of the critical habitat for the conservation of the listed species.

One major factor affecting the rangewide status of the threatened and endangered anadromous fish in the Central Valley, and aquatic habitat at large, is climate change.

Warmer temperatures associated with climate change reduce snowpack and alter the seasonality and volume of seasonal hydrograph patterns (Cohen et al. 2000). Central California has shown trends toward warmer winters since the 1940s (Dettinger and Cayan 1995). An altered seasonality results in runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (Roos 1991, Dettinger et al. 2004). Specifically, the Sacramento River basin annual runoff amount for April-July has been decreasing since about 1950 (Roos 1987, Roos 1991). Increased temperatures influence the timing and magnitude patterns of the hydrograph.

The magnitude of snowpack reductions is subject to annual variability in precipitation and air temperature. The large spring snow water equivalent (SWE) percentage changes, late in the snow season, are due to a variety of factors including reduction in winter precipitation and temperature increases that rapidly melt spring snowpack (Vanrheenen et al. 2004). Factors modeled by Vanrheenen et al. (2004) show that the melt season shifts to earlier in the year, leading to a large percent reduction of spring SWE (up to 100 percent in shallow snowpack areas). Additionally, an air temperature increase of 2.1°C (3.8°F) is expected to result in a loss of about half of the average April snowpack storage (Vanrheenen et al. 2004). The decrease in spring SWE (as a percentage) would be greatest in the region of the Sacramento River watershed, at the north end of the Central Valley, where snowpack is shallower than in the San Joaquin River watersheds to the south.

Projected warming is expected to affect Central Valley Chinook salmon. Because the runs are restricted to low elevations as a result of impassable rim dams, if climate warms by 5°C (9°F), it is questionable whether any Central Valley Chinook salmon populations can persist (Williams 2006). Based on an analysis of an ensemble of climate models and emission scenarios and a reference temperature from 1951-1980, the most plausible projection for warming over Northern California is 2.5°C (4.5°F) by 2050 and 5°C (9.0°F) by 2100, with a modest decrease in precipitation (Dettinger 2005). Chinook salmon in the Central Valley are at the southern limit of their range, and warming will shorten the period in which the low elevation habitats used by naturally producing fall-run Chinook salmon are thermally acceptable. This would particularly affect fish that emigrate as fingerlings, mainly in May and June, and especially those in the San Joaquin River and its tributaries.

For winter-run Chinook salmon, the embryonic and larval life stages that are most vulnerable to warmer water temperatures occur during the summer, so this run is particularly at risk from climate warming. The only remaining population of winter-run Chinook salmon relies on the cold water pool in Shasta Reservoir, which buffers the effects of warm temperatures in most years. The exception occurs during drought years, which are predicted to occur more often with climate change (Yates et al. 2008). The long-term projection of operations of the CVP/SWP expects to include the effects of climate change in one of three possible forms: less total precipitation; a shift to more precipitation in the form of rain rather than snow; or earlier spring snow melt (U.S. Bureau of Reclamation 2008c).

Additionally, air temperature appears to be increasing at a greater rate than what was previously analyzed (Lindley 2008, Beechie et al. 2012, Dimacali 2013). These factors will compromise the quantity or quality of winter-run Chinook salmon habitat available downstream of Keswick Dam. It is imperative for additional populations of winter-run Chinook salmon to be re-established into historical habitat in Battle Creek and above Shasta Dam for long-term viability of the ESU (National Marine Fisheries Service 2014a).

CV spring-run Chinook salmon adults are vulnerable to climate change because they over-summer in freshwater streams before spawning in autumn (Thompson et al. 2011). CV spring-run Chinook salmon spawn primarily in the tributaries to the Sacramento River, and those tributaries without cold water refugia (usually input from springs) will be more susceptible to impacts of climate change. Even in tributaries with cool water springs, in years of extended drought and warming water temperatures, unsuitable conditions may occur. Additionally, juveniles often rear in the natal stream for one to two summers prior to emigrating, and would be susceptible to warming water temperatures. In Butte Creek, fish are limited to low elevation habitat that is currently thermally marginal, as demonstrated by high summer mortality of adults in 2002 and 2003, and will become intolerable within decades if the climate warms as expected. Ceasing water diversion for power production from the summer holding reach in Butte Creek resulted in cooler water temperatures, more adults surviving to spawn, and extended population survival time (Mosser et al. 2013).

Although CCV steelhead will experience similar effects of climate change as Chinook salmon, as they are also blocked from the vast majority of their historic spawning and rearing habitat, the effects may be even greater in some cases, as juvenile CCV steelhead need to rear in the stream for one to two summers prior to emigrating as smolts. In the Central Valley, summer and fall temperatures below the dams in many streams already exceed the recommended temperatures for optimal growth of juvenile CCV steelhead, which range from 14°C to 19°C (57°F to 66°F). Several studies have found that steelhead require colder water temperatures for spawning and embryo incubation than salmon (McCullough et al. 2001). In fact, McCullough et al. (2001) recommended an optimal incubation temperature at or below 11°C to 13°C (52°F to 55°F). Successful smoltification in steelhead may be impaired by temperatures above 12°C (54°F), as reported in Richter and Kolmes (2005)_ENREF_259. As stream temperatures warm due to climate change, the growth rates of juvenile steelhead could increase in some systems that are currently relatively cold, but potentially at the expense of decreased survival due to higher metabolic demands and greater presence and activity of predators. Stream temperatures that are currently marginal for spawning and rearing may become too warm to support wild CCV steelhead populations.

Southern DPS green sturgeon spawn primarily in the Sacramento River in the spring and summer. Anderson-Cottonwood Irrigation District (ACID) Diversion Dam is considered the upriver extent of sDPS green sturgeon passage in the Sacramento River. The upriver extent of sDPS green sturgeon spawning, however, is approximately 30 kilometers downriver of ACID where water temperature is higher than ACID during late spring and summer. Thus, if water temperatures increase with climate change, temperatures adjacent to ACID may remain within tolerable levels for the embryonic and larval life stages of sDPS green sturgeon, but temperatures at spawning locations lower in the river may be more affected. It is uncertain, however, if sDPS green sturgeon spawning habitat exists closer to ACID, which could allow spawning to shift upstream in response to climate change effects. Successful spawning of sDPS green sturgeon in other accessible habitats in the Central Valley (*i.e*., the Feather River) is limited, in part, by late spring and summer water temperatures. Similar to salmonids in the Central Valley, sDPS green sturgeon spawning in tributaries to the Sacramento River is likely to be further limited if water temperatures increase and higher elevation habitats remain inaccessible.

In summary, observed and predicted climate change effects are generally detrimental to the species (Ford et al. 2011) (Wade et al. 2013), so unless offset by improvements in other factors, the status of the species and critical habitat is likely to decline over time. The climate change projections referenced above cover the time period between the present and approximately 2100. While there is uncertainty associated with projections, which increase over time, the direction of change is relatively certain (McClure et al. 2013). The proposed action is FERC's relicensing of the Oroville Facilities. The Federal Power Act authorizes the FERC to license hydropower projects for 30 to 50 years. As identified above, climate change is projected result to in warming over Northern California of 2.5°C (4.5°F) by 2050 and 5°C (9.0°F) by 2100, with a modest decrease in precipitation. Therefore, over the term of the license temperatures are projected to increase by about 2.5°C (4.5°F) within 30 years. If a 50 year license is issued (through about 2070) we would expect at the end of the license warming over Northern California to exceed 2.5°C (4.5°F), but increase by less than 5°C (9.0°F). Due to the high variability in weather from year to year, there is significant variability in the results of climate modeling. Climate modeling provides the best projections of predicted decadal trends.

The following federally listed anadromous species evolutionarily significant units (ESU) or DPSs and designated and proposed critical habitat occur in the action area and may be affected by the proposed relicensing of the Oroville Facilities (FERC Project No. 2100):

- Southern Resident killer whale DPS (*Orcinus orca*), endangered (70 FR 69903; November 18, 2005)
- CCC steelhead DPS (*O. mykiss*), threatened (71 FR 834; January 5, 2006)
- CCC steelhead designated critical habitat (70 FR 52488; September 2, 2005)
- Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*), endangered (70 FR 37160; June 28, 2005)
- Sacramento River winter-run Chinook salmon designated critical habitat (58 FR 33212; June 16, 1993)
- CV spring-run Chinook salmon ESU (*O. tshawytscha*), threatened (70 FR 37160; June 28, 2005)
- CV spring-run Chinook salmon designated critical habitat (70 FR 52488; September 2, 2005)
- CCV steelhead (*O. mykiss*), threatened (71 FR 834; January 5, 2006)
- CCV steelhead designated critical habitat (70 FR 52488; September 2, 2005)
- Southern DPS of North American green sturgeon (*Acipenser medirostris*), threatened (71 FR 17757; April 7, 2006)
- Southern DPS of North American green sturgeon critical habitat (74 FR 52300 October 9, 2009)

2.2.1 Species and Critical Habitat Likely to be Adversely Affected by the Proposed Action

2.2.1.1 Central Valley Spring-run Chinook Salmon

- Central Valley spring-run Chinook salmon ESU (*O. tshawytscha*) was first listed as threatened on September 16, 1999 (64 FR 50394 September 16, 1999, 64 FR 50394) and reaffirmed as threatened on June 28, 2005 (70 FR 37160).
- Central Valley spring-run Chinook salmon critical habitat was designated on September 2, 2005 (70 FR 52488).

2.2.1.1.1 Species Listing and Critical Habitat Listing History

CV spring-run Chinook salmon were originally listed as threatened on September 16, 1999 (64 FR 50394). This ESU consists of naturally spawned spring-run Chinook salmon originating from the Sacramento River basin. The FRFH spring-run Chinook salmon population has been included as part of the CV spring-run Chinook salmon ESU in the most recent CV spring-run Chinook salmon listing decision (70 FR 37160, June 28, 2005). Although FRFH spring-run Chinook salmon production is included in the ESU, because all the FRFH spring-run Chinook salmon are adipose fin clipped, the take prohibitions in the regulation for threatened anadromous fish (50 CFR 223.203) promulgated under ESA section 4(d) do not apply to these fish. Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488).

In the 2011 status review of the CV spring-run Chinook salmon ESU, the authors concluded that

> *The ESU status had likely deteriorated on balance since the 2005 status review and the Lindley et al. (2007) assessment, with two of the three extant independent populations (Deer and Mill creeks) of spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk. Additionally, Butte Creek remained at low risk, although it was on the verge of moving towards high risk, due to the rate of population decline. In contrast, spring-run Chinook salmon in Battle and Clear creeks had increased in abundance since 1998, reaching levels of abundance that place these populations at moderate extinction risk. Both of these populations have likely increased at least in part due to extensive habitat restoration. The Southwest Fisheries Science Center concluded in their viability report (Williams et al. 2011) that the status of CV spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review and that its extinction risk has increased. The degradation in status of the three formerly low- or moderate-risk independent populations is cause for concern.*

In the 2016 status review of the CV spring-run Chinook salmon ESU, the authors concluded:

> *In the 2016 status review, the authors found, with a few exceptions, CV spring-run Chinook salmon populations have increased through 2014 returns since the last status review (2010/2011), which has moved the Mill and Deer creek populations from the high extinction risk category, to moderate, and Butte Creek has remained in the low risk of extinction category. Additionally, the Battle Creek and Clear Creek populations have continued to show stable or increasing numbers the last five years, putting them at moderate risk of*

> *extinction based on abundance. Overall, the SWFSC concluded in their viability report that the status of CV spring-run Chinook salmon (through 2014) has probably improved since the 2010/2011 status review and that the ESU's extinction risk may have decreased, however the ESU is still facing significant extinction risk, and that risk is likely to increase over at least the next few years as the full effects of the recent drought are realized (Williams et al. 2016).*
>
> *The 2015 adult CV spring-run Chinook salmon returns were very low. Those that did return experienced high pre-spawn mortality. Juvenile survival during the 2012 to 2015 drought has likely been impacted, and will be fully realized over the next several years.*

2.2.1.1.2 Central Valley Spring-run Chinook Salmon Life History

2.2.1.1.2.1 Adult Migration and Holding

Chinook salmon runs are designated on the basis of adult migration timing. Adult CV spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (California Department of Fish and Game 1998) and enter the Sacramento River beginning in March (Yoshiyama et al. 1998). CV spring-run Chinook salmon move into tributaries of the Sacramento River (*e.g.*, Butte, Mill, Deer creeks) beginning as early as February in Butte Creek and typically mid-March in Mill and Deer creeks (Lindley et al. 2004). Adult migration peaks around mid-April in Butte Creek, and mid- to end of May in Mill and Deer creeks, and is complete by the end of July in all three tributaries (Lindley et al. 2004); see Table 2-1 in text). In the Feather River, adult CV spring-run Chinook salmon arrive at the FRFH between late April and June, typically peaking in mid-June. Typically, CV spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama et al. 1998).

During their upstream migration, adult Chinook salmon require stream flows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate stream flows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 3ºC (38ºF) to 13ºC (56ºF)

Bell (Bell, 1991), CDFG (California Department of Fish and Game, 1998), and Boles (Boles, 1988) recommend water temperatures below 18ºC (65ºF) for adult Chinook salmon migration, and Lindley *et al.* (Lindley et al. 2004)_ENREF_165 report that adult migration is blocked when temperatures reach 21ºC (70ºF), and that fish can become stressed as temperatures approach 21ºC (70ºF). Reclamation reports that CV spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 15.6 ºC (60ºF); although salmon can tolerate temperatures up to 18 ºC (65ºF) before they experience an increased susceptibility to disease (Williams 2006).

2.2.1.1.2.2 Adult Spawning

CV spring-run Chinook salmon spawning occurs in September and October (Moyle 2002). Chinook salmon typically mature between 2 and 6 years of age (Myers et al. 1998), but primarily at age 3 (Fisher 1994). Between 56 and 87 percent of adult CV spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Fisher 1994, Kormos et al. 2012). CV spring-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months.

CV spring-run Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (Payne and Allen 2004, National Marine Fisheries Service 2007). Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. Velocity typically ranging from 1.2 feet/second to 3.5 feet/second, and water depths greater than 0.5 feet (Yuba County Water Agency et al. 2007). The upper preferred water temperature for spawning Chinook salmon is 13 ºC to 14 ºC (55ºF to 57ºF) (Chambers 1955, Smith 1973, Bjornn and Reiser 1991, Snider et al. 2001). Chinook salmon are semelparous (die after spawning).

2.2.1.1.2.3 Eggs and Fry Incubation to Emergence

The CV spring-run Chinook salmon embryo incubation period encompasses the time period from egg deposition through hatching, as well as the additional time while alevins remain in the gravel while absorbing their yolk sac prior to emergence. The length of time for CV spring-run Chinook salmon embryos to develop depends largely on water temperatures. In well-oxygenated intergravel environs where water temperatures range from about 5 to 13ºC (41 to 55.4ºF) embryos hatch in 40 to 60 days and remain in the gravel as alevins for another 4 to 6 weeks, usually after the yolk sac is fully absorbed (National Marine Fisheries Service 2014a). In Butte and Big Chico creeks, emergence occurs from November through January, and in the colder waters of Mill and Deer creeks, emergence typically occurs from January through as late as May (Moyle 2002). Similar to other low elevation CV streams with CV spring-run Chinook salmon, fry typically emerge in the Feather River in November and December (Department of Water Resources 2007, Bilski and Kindopp 2009).

Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel permeability, and poor water quality. Studies of Chinook salmon egg survival to emergence conducted by Shelton (1955)_ENREF_276 indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The optimal water temperature for egg incubation ranges from 5ºC to 14ºC (41ºF to 56ºF) (National Marine Fisheries Service 1997, Rich 1997, Moyle 2002).

A significant reduction in egg viability occurs at water temperatures above 14ºC (57.5ºF) and total embryo mortality can occur at temperatures above 17ºC (62ºF) (National Marine Fisheries Service 1997). Alderdice and Velsen (1978)_ENREF_8 found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 16ºC and 3ºC (61ºF and 37ºF), respectively, when the incubation temperature was held constant. As water temperatures increase, the rate of embryo malformations also increases, as well as the susceptibility to fungus and bacterial infestations. The length of development for Chinook salmon embryos depends on the ambient water temperature surrounding the egg pocket in the redd. Colder water necessitates longer development times as metabolic processes are slowed. Within the appropriate water temperature range for embryo incubation, embryos hatch in 40 to 60 days, and the alevins remain in the gravel for an additional 4 to 6 weeks before emerging from the gravel.

During the 4- to 6-week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. The newly emerged fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and small invertebrates. As they switch from endogenous nourishment to exogenous feeding, the fry's yolk-sac is reabsorbed, and the belly suture closes over the former location of the yolk-sac (button-up fry). Fry typically range from 25 mm to 40 mm during this stage. Some fry may take up residence in their natal stream for several weeks to a year or more, while others migrate downstream to suitable habitat. Once started downstream, fry may continue downstream to the estuary and rear or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991).

2.2.1.1.2.4 Juvenile Rearing and Outmigration

Once juveniles emerge from the gravel, they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac and transition to exogenous feeding (Moyle 2002). Many also will disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow larger. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002).

When juvenile Chinook salmon reach a length of 50 mm to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 feet to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Migrational cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams may spur outmigration of juveniles when they have reached the appropriate stage of development (Kjelson et al. 1982, Brandes and McLain 2001).

As fish begin their emigration, they are displaced by the river's current downstream of their natal reaches. Similar to adult movement, juvenile salmonid downstream movement is primarily crepuscular. The daily migration of juveniles passing RBDD is highest in the four-hour period before sunrise (Martin et al. 2001)_ENREF_169. Juvenile Chinook salmon migration rates vary considerably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson et al. (1982) found fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River. As Chinook salmon begin the smolt stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1981).

CV spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the-year, or as juveniles, or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer creeks reflects a prolonged emergence of fry from the gravel (Lindley et al. 2004). Studies in Butte Creek (Ward et al. 2003, McReynolds et al. 2007) found the majority of CV spring-run Chinook salmon migrants to be fry, which emigrated primarily during December, January, and February; and that these movements appeared to be influenced by increased flow. Small numbers of CV spring-run Chinook salmon were observed to remain in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer Creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley et al. 2004). The CDFG (California Department of Fish and Game 1998) observed the emigration period for CV spring-run Chinook salmon extending from November to early May, with up to 69 percent of the young-of-the-year fish out migrating through the lower Sacramento River and Delta during this period. Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000). In the Feather River, CV spring-run Chinook salmon migration is similar to that observed in Butte Creek, with most fry moving downstream soon after emergence, between November and January (Department of Water Resources 2004b, 2007, Chappell 2009).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, CV spring-run Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin et al. 1997, California Department of Fish and Game 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of Diptera, as well as small arachnids and ants are common prey items (Kjelson et al. 1982, Sommer et al. 2001b, MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer et al. 2001b). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 12ºC to 14 ºC (54ºF to 57ºF) (Brett 1952).

2.2.1.1.2.5 Estuarine Rearing

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels and returning to the main channels when the tide recedes (Levy and Northcote 1981, Levings 1982, Levings et al. 1986, Healey 1991).

As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle et al. (1989)_ENREF_193 reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson et al. (1982)_ENREF_149 reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column.

2.2.1.1.2.6 Ocean Rearing

Once in the ocean, juvenile Chinook salmon tend to stay along the California Coast (Moyle 2002). This is likely due to the high productivity caused by the upwelling of the California current. These food-rich waters are important to ocean survival, as indicated by a decline in survival during years when the current does not flow as strongly and upwelling decreases (Moyle 2002, Lindley et al. 2009). After entering the ocean, juveniles become voracious predators on small fish and crustaceans and invertebrates such as crab larvae and amphipods. As they grow larger, fish increasingly dominate their diet. They typically feed on whatever pelagic planktivore is most abundant, usually herring, anchovies, juvenile rockfish, and sardines. The ocean stage of the Chinook life cycle lasts one to five years. Information on salmon abundance and distribution in the ocean is based upon CWT recoveries from ocean fisheries. For over 30 years, the marine distribution and relative abundance of specific stocks, including ESA-listed ESUs, has been estimated using a representative CWT hatchery stock (or stocks) to serve as proxies for the natural and hatchery-origin fish within ESUs. One extremely important assumption of this approach is that hatchery and natural stock components are assumed to be similar in their life histories and ocean migration patterns.

Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement (adult spawner populations that have "escaped" the ocean fisheries and made it into the rivers to spawn). CWT returns indicate that Sacramento River Chinook salmon congregate off the California coast between Point Arena and Morro Bay.

In Table 2-1, darker shades indicate months of greatest relative abundance.

Table 2-1. The Temporal Occurrence of Adult (a) and Juvenile (b) CV Spring-run Chinook Salmon in the Sacramento River

(a) Adult migration												
Location	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Sac. River Basin[a,b]												
Sac. River Mainstem[b,c]												
Mill Creek[d]												
Deer Creek[d]												
Butte Creek[d,g]												
(b) Adult Holding[a,b]												
(c) Adult Spawning[a,b,c]												

(d) Juvenile migration

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River Tribs[e]	Medium	Medium	Medium							Medium	High	High
Upper Butte Creek[f,g]	High	High	Medium	Medium	Medium	Low				Low	Low	High
Mill, Deer, Butte Creeks[d,g]	High	High	Medium	Medium	Medium	Low				Low	Low	Low
Sac. River at RBDD[c]	High	Low	Low	Low	Low, –						High	High
Sac. River at KL[h]	Medium	Medium	High	High	Medium						Medium	High

Relative Abundance: ■ = High ■ = Medium ■ = Low

_ENREF_219Sources: [a]Yoshiyama et al. (1998); [b]Moyle (2002); [c] Myers et al. (1998); [d]Lindley et al. (2004); [e](California Department of Fish and Game 1998); [f]McReynolds et al. (2007); [g]Ward et al. (2003); [h]Snider and Titus (2000)

Note: Yearling CV spring-run Chinook salmon reared in their natal streams through the first summer following their birth. Downstream emigration generally occurs the following fall and winter. Most young-of-the-year CV spring-run Chinook salmon emigrate during the first spring after they hatch.

2.2.1.1.3 Description of Viable Salmonid Population (VSP) Parameters

As an approach to evaluate the likelihood of viability of the CV spring-run Chinook salmon ESU, and determine the extinction risk of the ESU, NMFS uses the VSP concept. In this section, we evaluate the VSP parameters of abundance, productivity, spatial structure, and diversity. These specific parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of salmon (McElhany et al. 2000).

2.2.1.1.3.1 Abundance

Historically, CV spring-run Chinook salmon were the second most abundant salmon run in the Central Valley and one of the largest on the west coast (California Department of Fish and Game 1990). These fish occupied the upper and middle elevation reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1872, Rutter 1904, Clark 1929).

The Central Valley drainage as a whole is estimated to have supported CV spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (California Department of Fish and Game 1998). The San Joaquin River historically supported a large run of CV spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000–500,000 adults returning annually (California Department of Fish and Game 1990). Construction of Friant Dam on the San Joaquin River began in 1939, and when completed in 1942, blocked access to all upstream habitat.

As shown in Figure 1 (National Marine Fisheries Service 2016b), overall, most CV spring-run Chinook salmon escapement have increased slightly in recent years (2012-2014), however, as shown in Figure 2, abundance dropped dramatically in 2015. Abundance and trend statistics for this ESU related to the viability criteria are presented in Table 7. Until 2015, Mill Creek and Deer Creek populations both improved from high extinction risk in 2010 to moderate extinction risk due to recent increases in abundance. Butte Creek continued to satisfy the criteria for low extinction risk. Additionally, since 1996, partly due to increased flows provided in upper Battle Creek, the CV spring-run Chinook salmon population began and is continuing to naturally repopulate Battle Creek, home to a historical independent population in the Basalt and Porous Lava diversity group that was extirpated for many decades. This population has increased in abundance to levels that would qualify it for a moderate extinction risk score. Similarly, the CV spring-run Chinook salmon population in Clear Creek has been increasing, and currently meets the moderate extinction risk score. Returns in 2015, were much lower than the increases observed in 2012 to 2014, and are described further below.

In contrast, since 2007, the dependent (Core 2) populations of Cottonwood, Antelope, and Big Chico creeks, have continued to remain very low, with often zero or near zero returns in recent years. New data for the lower Yuba River suggests that the population's size, based on VAKI counts, meets the low extinction risk criteria for abundance, ranging from a few hundred to a few thousand; however, the population is likely at high extinction risk due to hatchery influence. The Feather River population continues to have high returns (1,000-20,000), but is heavily influenced by the FRFH. The population spawning in-river is difficult to determine because they are not counted when entering, and monitoring during spawning results in difficulties distinguishing between races. The returns to the FRFH collected for propagation have remained fairly consistent, generally between 1,000 to 4,000 fish.

The Sacramento River aerial redd surveys continue to indicate that a small population of CV spring-run Chinook salmon, spawning in September, may exist. Although the origin of these spawners is unknown, redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the Red Bluff Diversion Dam (RBDD), ranging from 3 to 105 redds; zero redds were observed in 2012, and 57 redds were observed in September 2013.

For many decades, CV spring-run Chinook salmon were considered extirpated from the Southern Sierra Nevada diversity group in the San Joaquin River Basin, despite their historical numerical dominance in the Basin (Fry 1961, Fisher 1994). More recently, there have been reports of adult Chinook salmon returning in February through June to San Joaquin River tributaries, including the Mokelumne, Stanislaus, and Tuolumne rivers (Workman 2003, Franks 2014, FISHBIO 2015).

These spring-running adults have been observed in several years and exhibit typical spring-run life history characteristics, such as returning to tributaries during the springtime, over-summering in deep pools, and spawning in early fall (Workman 2003, Franks 2014, FISHBIO 2015).

For example, 114 adult were counted on the video weir on the Stanislaus River between February and June in 2013 with only 7 individuals without adipose fins (FISHBIO 2015).

Additionally, in 2014, implementation of the spring-run Chinook salmon reintroduction plan into the San Joaquin River began, which if successful will benefit the spatial structure, and genetic diversity of the ESU. These reintroduced fish have been designated as a nonessential experimental population under ESA section 10(j) when within the defined boundary in the San Joaquin River (78 FR 79622; December 31, 2013). Furthermore, while the SJRRP is managed to imprint CV spring-run Chinook salmon to the mainstem San Joaquin River, we do anticipate that the reintroduced spring-run Chinook salmon are likely to stray into the San Joaquin tributaries at some level, which will increase the likelihood for CV spring-run Chinook salmon to repopulate other Southern Sierra Nevada diversity group rivers where suitable conditions exist.

Figure 2-5 shows escapement for CV spring-run Chinook salmon over time in thousands of fish (1970 to 2014). Note: Beginning in 2009, Red Bluff Diversion Dam estimates of CV spring-run Chinook salmon in the Upper Sacramento River were no longer available.

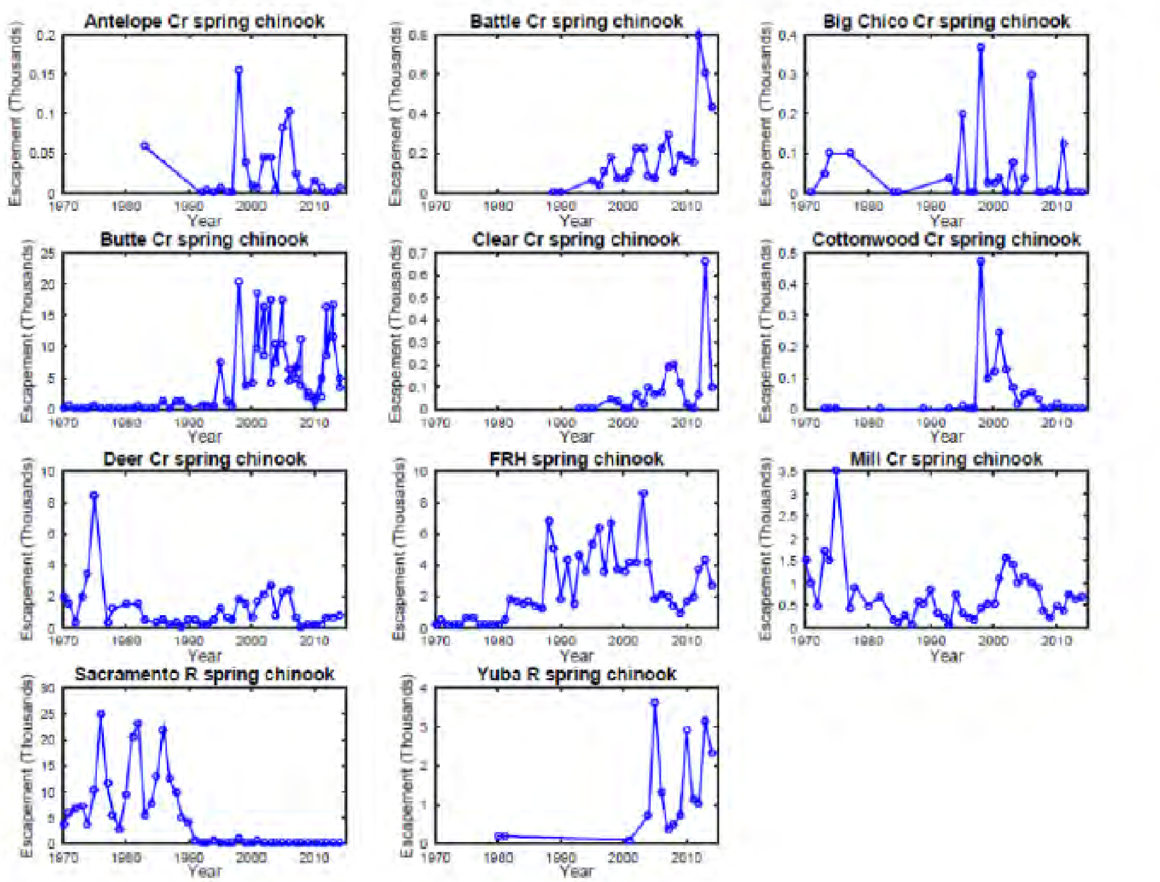


Figure 2-5. Escapement for CV spring-run Chinook salmon over time

Figure 2-6 shows combined escapement for Central Valley spring-run Chinook salmon tributary populations (Butte, Mill, Deer, Battle, Clear creeks) since 2001. Butte Creek numbers drive the curve and are taken from carcass survey counts.

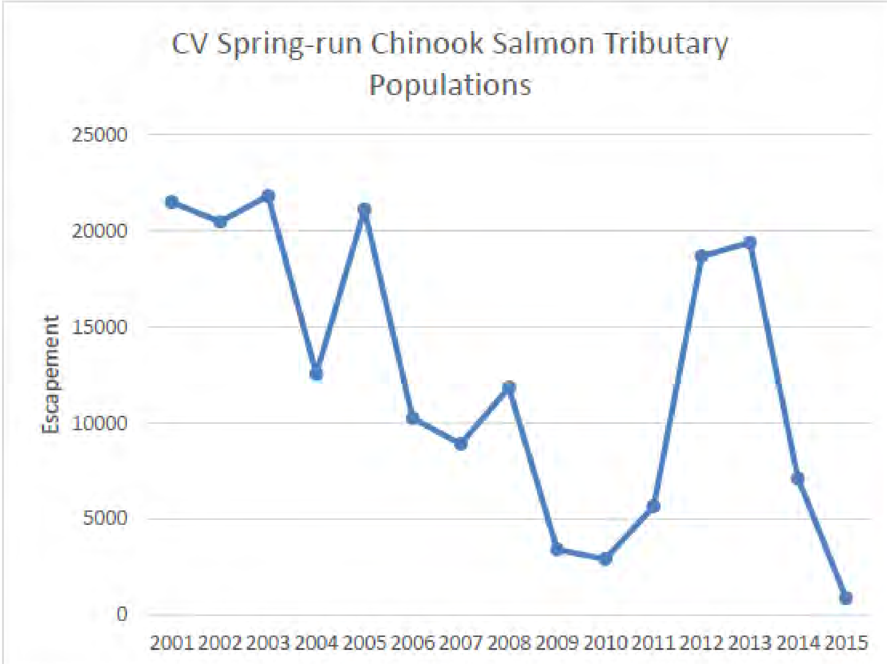


Figure 2-6. Combined Escapement for Central Valley Spring-run Chinook Salmon Tributary Populations

The total population size (N) is estimated as the sum of estimated run sizes over the most recent three years for Core 1 populations (bold) and Core 2 populations. The mean population size ($\hat{S}$) is the average of the estimated run sizes for the most recent 3 years (2012 to 2014). The population growth/decline rate (10 year trend) is estimated from the slope of log-transformed estimated run size. The catastrophic metric (recent decline) is the largest year-to-year decline in total population size (N) over the most recent 10 such ratios.

Table 2-2. Viability Metrics for Central Valley Spring-run Chinook Salmon ESU Populations

Population	N	$\hat{S}$	10-year trend (95% CI)	Recent Decline (%)
Antelope Creek	8.0	2.7	-0.375 (-0.706, -0.045)	87.8
Battle Creek	1836	612	0.176 (0.033, 0.319)	9.0
Big Chico Creek	0.0	0.0	-0.358 (-0.880, 0.165)	60.7
Butte Creek	20169	6723	0.353 (-0.061, 0.768)	15.7
Clear Creek	822	274	0.010 (-0.311, 0.330)	63.3
Cottonwood Creek	4	1.3	-0.343 (-0.672, -0.013)	87.5
Deer Creek	2272	757.3	-0.089 (-0.337, 0.159)	83.8
Feather River Fish Hatchery	10808	3602.7	0.082 (-0.015, 0.179)	17.1
Mill Creek	2091.0	697.0	-0.049 (-0.183, 0.086)	58.0
Sacramento River[a]	-	-	-	-
Yuba River	6515	2170.7	0.67 (-0.138, 0.272)	9.0

[a] Beginning in 2009, estimates of spawning escapement of Upper Sacramento River spring chinook were no longer monitored. Historically, this estimate was derived by the total Red Bluff Diversion Dam (RBDD) counts minus the spring run numbers in the upper Sacramento tributaries. Beginning in 2009, RBDD gates were partially operated in the up position and in 2012 they were entirely removed and thus spring run estimates no longer available.

The FRFH spring-run Chinook salmon population has been included in the ESU based on its genetic linkage to the natural population and the potential development of a conservation strategy for the hatchery program. On the Feather River, significant numbers of CV spring-run Chinook salmon, as identified by run timing, return to the FRFH.

Since 1954, spawning escapement has been estimated using combinations of in-river estimates and hatchery counts, with estimates ranging from 2,908 in 1964 to 202 fish in 1978 (Department of Water Resources 2001).

However, after 1983, CDFG (now CDFW) ceased to estimate in-river spawning CV spring-run Chinook salmon because spatial and temporal overlap with fall-run Chinook salmon spawners made it impossible to distinguish between the two races.

FRFH CV spring-run Chinook salmon estimates after 1981 have been based solely on salmon entering the hatchery during the month of September. The 5-year moving averages from 1997 to 2006 had been more than 4,000 fish, but from 2007 to 2011, the 5-year moving averages declined each year to a low of 1,599 fish in 2011 (Califonia Department of Fish and Wildlife 2015). Since 2011, the 5-year moving average has rebounded slightly, reaching 2,888 CV spring-run Chinook in 2014. In 2015, the 5 year moving average was 2,872.

Using this metric for spring run abundance is misleading, however, because this count is a mix of fall-run Chinook salmon and CV spring-run Chinook salmon that enter the hatchery in September. The September mixing is so prevalent that current practice is to cull all salmon that do not have a Hallprint tag until October 8th, to avoid spawning CV spring-run and fall-run Chinook salmon together. Hallprint tags are made by the Hallprint company and are an external tag that is attached to the dorsal area of a salmon. These tags are also known as spaghetti tags, because they are long thin pieces of colored plastic, similar to a piece of spaghetti. The tags can be numbered.

A better metric of abundance is the unique number of CV spring-run Chinook salmon adults that enter the hatchery in the spring, those that are Hallprint tagged between April and June 30. Since 2005 this program has collected consistent data on CV spring-run Chinook salmon abundance at the FRFH and the average return has been 2,276 adults (CDFW 2016). Although there are CV spring-run Chinook salmon adults that choose not to enter the FRFH in the spring and thus go uncounted, this number is still a better metric for abundance than those reported elsewhere.

Genetic testing has indicated that substantial introgression has occurred between fall-run and CV spring-run Chinook salmon populations within the Feather River system due to temporal overlap and hatchery practices (Department of Water Resources 2001). Because Chinook salmon have not always been spatially separated in the FRFH, CV spring-run and fall-run Chinook salmon have been spawned together, thus compromising the genetic integrity of the CV spring-run Chinook salmon stock (Good et al. 2005, California Department of Fish and Game and California Department of Water Resources 2012).

In addition, CWT information from these hatchery returns has indicated that fall-run and CV spring-run Chinook salmon have overlapped (Department of Water Resources 2001). For the reasons discussed above, the FRFH CV spring-run Chinook salmon numbers are not included in the following discussion of ESU abundance trends.

Monitoring the Sacramento River mainstem during CV spring-run Chinook salmon spawning timing indicates some spawning occurs in the river. Here, the lack of physical separation of spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon has made identification of spring-run Chinook salmon in the mainstem very difficult to determine, and there is speculation as to whether a true spring-run Chinook salmon population still exists in the Sacramento River downstream of Keswick Dam.

Although the physical habitat conditions downstream of Keswick Dam are capable of supporting CV spring-run Chinook salmon, higher than normal water temperatures in some years have led to substantial levels of egg mortality. Less than 15 Chinook salmon redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts (U.S. Fish and Wildlife Service 2003). Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the Red Bluff Diversion Dam (RBDD), ranging from 3 to 105 redds; zero redds were observed in 2012, and 57 redds were observed in September 2013. This is typically when spring-run spawn, however, these redds also could be early spawning fall-run Chinook salmon.

Therefore, even though physical habitat conditions may be suitable for spawning and incubation, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely extensive introgression between the populations has occurred (California Department of Fish and Game 1998). For these reasons, Sacramento River mainstem CV spring-run Chinook salmon are not included in the following discussion of ESU abundance trends.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU as a whole because these streams contain the majority of the abundance and are the only independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998 (Table 2-3).

Table 2-3. CV Spring-run Chinook Salmon Population Estimates From CDFW Grand Tab (2015) with Corresponding Cohort Replacement Rates (CRR) for Years Since 1986

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average Tributary Population Estimate	Trib CRR[b]	5-Year Moving Average of Trib CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR
1986	3,638	1,433	2,205						
1987	1,517	1,213	304						
1988	9,066	6,833	2,233						
1989	7,032	5,078	1,954		0.89			1.93	
1990	3,485	1,893	1,592	1,658	5.24		4,948	2.30	
1991	5,101	4,303	798	1,376	0.36		5,240	0.56	
1992	2,673	1,497	1,176	1,551	0.60		5,471	0.38	
1993	5,685	4,672	1,013	1,307	0.64	1.55	4,795	1.63	1.22
1994	5,325	3,641	1,684	1,253	2.11	1.79	4,454	1.04	1.18
1995	14,812	5,414	9,398	2,814	7.99	2.34	6,719	5.54	1.83
1996	8,705	6,381	2,324	3,119	2.29	2.73	7,440	1.53	2.03
1997	5,065	3,653	1,412	3,166	0.84	2.77	7,918	0.95	2.14
1998	30,533	6,746	23,787	7,721	2.53	3.15	12,888	2.06	2.23
1999	9,838	3,731	6,107	8,606	2.63	3.26	13,791	1.13	2.24
2000	9,201	3,657	5,544	7,835	3.93	2.44	12,669	1.82	1.50
2001	16,865	4,135	12,730	9,916	0.54	2.09	14,300	0.55	1.30
2002	17,212	4,189	13,023	12,238	2.13	2.35	16,730	1.75	1.46
2003	17,691	8,662	9,029	9,287	1.63	2.17	14,161	1.92	1.43
2004	13,612	4,212	9,400	9,945	0.74	1.79	14,916	0.81	1.37
2005	16,096	1,774	14,322	11,701	1.10	1.23	16,295	0.94	1.19
2006	10,828	2,061	8,767	10,908	0.97	1.31	15,088	0.61	1.21
2007	9,726	2,674	7,052	9,714	0.75	1.04	13,591	0.71	1.00
2008	6,162	1,418	4,744	8,857	0.33	0.78	11,285	0.38	0.69
2009	3,801	989	2,812	7,539	0.32	0.69	9,323	0.35	0.60
2010	3,792	1,661	2,131	5,101	0.30	0.53	6,862	0.39	0.49
2011	5,033	1,969	3,064	3,961	0.65	0.47	5,703	0.82	0.53
2012	14,724	3,738	10,986	4,747	3.91	1.10	6,702	3.87	1.16
2013	18,384	4,294	14,090	6,617	6.61	2.36	9,147	4.85	2.06
2014	8,434	2,776	5,658	7,186	1.85	2.66	10,073	1.68	2.32
2015	3,074	1,586	1,488	7,057	0.14	2.63	9,930	0.21	2.28
Median	9,775	3,616	6,159	6,541	1.97	1.89	10,220	1.00	1.46

[a] NMFS is only including the escapement numbers from the FRFH and the Sacramento River tributaries in this table. Sacramento River Basin run size is the sum of the escapement numbers from the FRFH and the tributaries.

[b] The FRFH population column in this table contains three different data sets: (1) Prior to 2004 everything that came into the hatchery before Oct 1 was called a spring-run Chinook salmon. (2) The number of FRFH fish in 2004 represented a transition in methods. (3) The 2005-2011 data is data from the “Hallprint Era” where spring-run Chinook salmon were tagged in the spring, put back in the river and then collected again in the fall at the FRFH. The data reported is the number that returned in the fall. (4) The 2012-2013 data is also “Hallprint Era” but the number reported is the total number of spring run tagged during the spring at the FRFH.

[c] Abbreviations: CRR = Cohort Replacement Rate, Trib = tributary

Escapement numbers are dominated by Butte Creek returns, which averaged over 7,000 fish from 1995 to 2005, but then declined in years 2006 through 2011 with an average of just over 3,000. During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish and just over 1,000 fish, respectively. From 2001 to 2005, the CV spring-run Chinook salmon ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good et al. 2005). Although trends were generally positive during this time, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remained well below estimates of historic abundance.

Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21°C for 10 or more days in July (Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of Columnaris (*Flexibacter columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) diseases in the adult CV spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to a pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult CV spring-run Chinook salmon in Butte Creek due to the diseases.

From 2005 through 2012, abundance numbers in most of the tributaries declined. Adult returns from 2006 to 2011 indicate that population abundance for the entire Sacramento River basin was declining from the peaks seen in the five years before 2006. Declines in abundance from 2005 to 2011 placed the Mill Creek and Deer Creek populations in the high extinction risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (National Marine Fisheries Service 2011a). With increases in CV spring-run populations through 2014, the Mill and Deer creek populations have moved from the high extinction risk category, to moderate, and Butte Creek has remained in the low risk of extinction category. Based on the severity of the drought and the low escapements as well as increased pre-spawn mortality in Butte, Mill, and Deer creeks in 2015, there is concern that these CV spring-run Chinook salmon strongholds will deteriorate into high extinction risk in the coming years based on the population size or rate of decline criteria (National Marine Fisheries Service 2016b).

The Mill Creek and Deer Creek populations increased in abundance in 2012 through 2014, to a range of 644 to 830 CV spring-run Chinook salmon in each stream in each year. While this increase is encouraging, the numbers in all but one year (Deer Creek, 2014: 830) remain at a level of abundance that put these populations at high risk of extinction.

Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2011 is nearly sufficient to classify it as a high extinction risk based on this criteria. The Butte Creek CV spring-run Chinook population increased to over 16,000 fish in 2012 and 2013, but dropped to just over 5,000 fish in 2014.

Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extinction include, Butte, Deer and Mill creeks (National Marine Fisheries Service 2011c). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek, have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers increased in most tributary populations, which resulted in the second highest number of CV spring-run Chinook salmon returning to the tributaries since 1960. The 2014 data indicate an overall large decline in CV spring-run Chinook salmon populations in the Sacramento River basin in comparison to 2012 and 2013, possibly as a result of the current drought. All effects of the drought (2010-2016) have yet to be seen in the returning CV spring-run Chinook salmon.

2.2.1.1.3.2 Productivity

The productivity of a population (i.e., production over the entire life cycle) can reflect conditions (e.g., environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany et al. 2000). In general, declining productivity equates to declining population abundance. McElhany et al. (2000)_ENREF_178 suggested criteria for a population's natural productivity should be sufficient to maintain its abundance above the viable level (a stable or increasing population growth rate). In the absence of numeric abundance targets, this guideline is used. Cohort replacement rates (CRR) are indications of whether a cohort is replacing itself in the next generation. The majority of CV spring-run Chinook salmon are found to return as three-year olds, therefore looking at returns every three years is used as an estimate of the CRR. In the past the CRR has fluctuated between just over 1.0 to just under 0.5, and in the recent years with high returns (2012 and 2013), CRR jumped to 3.87 and 4.85 respectively. CRR for 2014 was 1.68, and the CRR for 2015 with very low returns was a record low of 0.21. Low returns in 2015 decreased due to high temperatures and most of the CV spring-run Chinook salmon tributaries experienced some pre-spawn mortality. Butte Creek experienced the highest prespawn mortality in 2015, resulting in a carcass survey CRR of only 0.02. The productivity of the Feather River and Yuba River populations and contribution to the CV spring-run Chinook salmon ESU currently is unknown; however, the FRFH currently produces 2,000,000 juveniles each year.

2.2.1.1.3.3 Spatial Structure

The extirpation of CV spring-run Chinook salmon from three of the four historically utilized diversity groups has greatly decreased the ESU's spatial structure. The Northern Sierra Nevada diversity group populations (Mill, Deer, and Butte creeks) have been the only wild CV spring-run Chinook salmon populations to persist from prior to 1990. Restoration and more recently consistent returns in Battle Creek (basalt and porous lava diversity group) and Clear Creek (northwestern California diversity group), have begun to improve the spatial structure of the ESU. Additionally, the reintroduction efforts into the San Joaquin, and the spring-running Chinook salmon returning to the San Joaquin tributaries is promising for even further improvement to spatial structure.

The Central Valley Technical Recovery Team (TRT) estimated that historically there were 18 or 19 independent populations of CV spring-run Chinook salmon (Figure 2-7), along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Figure 2-7) (Lindley et al. 2004). Of these 18 populations, only three extant populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River) and they represent only the Northern Sierra Nevada diversity group. Additionally, smaller populations are currently persisting in Antelope and Big Chico creeks and the Feather and Yuba Rivers in the Northern Sierra Nevada diversity group .

All historical populations in the basalt and porous lava diversity group and the Southern Sierra Nevada diversity group had been extirpated. Since 1995, a small persistent population has been present in Battle Creek and the upper Sacramento River may have a small persisting population spawning in the mainstem river as well. The northwestern California diversity group did not historically contain independent populations, and currently contains two small persisting populations, in Clear Creek and Beegum Creek (tributary to Cottonwood Creek), that are likely dependent on the Northern Sierra Nevada diversity group populations for their continued existence.

Construction of low elevation dams in the foothills of the Sierras on the Mokelumne, Stanislaus, Tuolumne, and Merced rivers has been thought to have extirpated CV spring-run Chinook salmon from these watersheds of the San Joaquin River, as well as on the American River of the Sacramento River basin. However, observations in the last decade suggest that perhaps naturally occurring populations may currently persist in the Stanislaus and Tuolumne rivers (U.S. Army Corps of Engineers 2013, Franks 2015).

Figure 2-7 shows the population structure of the Central Valley spring-run Chinook salmon. Red crosses indicate populations and diversity groups that are currently extirpated.

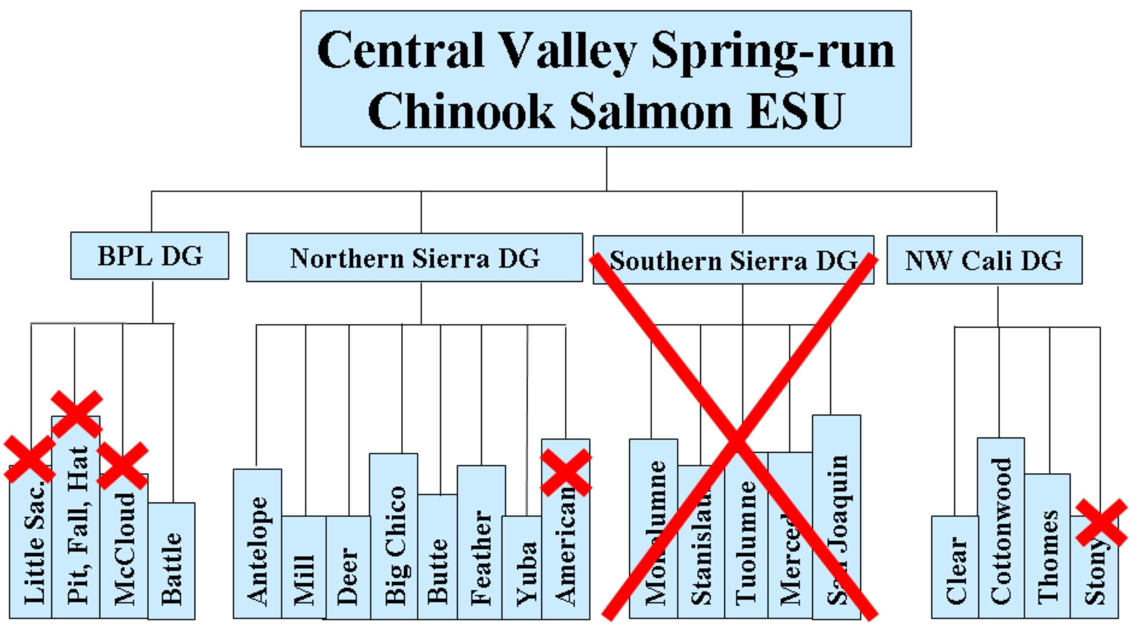


Figure 2-7. Population Structure of the Central Valley Spring-run Chinook Salmon

Spatial structure refers to the arrangement of populations across the landscape, the distribution of spawners within a population, and the processes that produce these patterns. Species with a restricted spatial distribution and few spawning areas are at a higher risk of extinction from catastrophic environmental events (*e.g.*, a single landslide) than are species with more widespread and complex spatial structure. Species or population diversity concerns the phenotypic (morphology, behavior, and life-history traits) and genotypic (DNA) characteristics of populations. Phenotypic diversity allows more populations to use a wider array of environments and protects populations against short-term temporal and spatial environmental changes. Genotypic diversity, on the other hand, provides populations with the ability to survive long-term changes in the environment. To meet the objective of representation and redundancy, diversity groups need to contain multiple populations to survive in a dynamic ecosystem subject to unpredictable stochastic events, such as pyroclastic events or wild fires.

With only one of four diversity groups currently containing viable independent populations, the spatial structure of CV spring-run Chinook salmon is severely reduced. Butte Creek spring-run Chinook salmon adult returns are currently utilizing all available habitat in the creek; and it is unknown if individuals have opportunistically migrated to other systems. The persistent populations in Clear Creek and Battle Creek, with habitat restoration projects completed and more underway, are anticipated to add to the spatial structure of the CV spring-run Chinook salmon ESU if they can reach viable status in the basalt and porous lava and northwestern California diversity group areas. The spatial structure of the CV spring-run Chinook salmon ESU would still be lacking due to the extirpation of all San Joaquin River basin CV spring-run Chinook salmon populations; however, recent information suggests that perhaps a self-sustaining (capable of reproducing without hatchery influence) population of CV spring-run Chinook is occurring in some of the San Joaquin River tributaries, most notably the Stanislaus and the Tuolumne Rivers.

Snorkel surveys (Kennedy and Cannon 2005) conducted between October 2002 to October 2004 on the Stanislaus River identified adults in June 2003 and 2004, as well as observed Chinook fry in December of 2003, which would indicate CV spring-run Chinook salmon spawning timing. In addition, monitoring on the Stanislaus since 2003 and on the Tuolumne since 2009 has indicated upstream migration of adult CV spring-run Chinook salmon (Anderson et al. 2007).

Genetic testing is needed to confirm that these fish are CV spring-run Chinook salmon and to determine whether they are spring-run Chinook salmon. Finally, rotary screw trap (RST) data provided by Stockton USFWS corroborates the CV spring-run Chinook salmon adult timing by indicating that there are a small number of fry migrating out of the Stanislaus and Tuolumne at a period that would coincide with CV spring-run juvenile emigration (Franks 2015, unpub). Plans are underway to re-establish a CV spring-run Chinook salmon population in the San Joaquin River downstream of Friant Dam as part of the San Joaquin River Restoration Program. Interim flows for this began, and juvenile CV spring-run Chinook salmon were released into the San Joaquin River in 2014, 2015, and 2016. The San Joaquin River Restoration Program's future long-term contribution to the CV spring-run Chinook salmon ESU is uncertain.

Lindley et al. (2007) described a general criteria for "representation and redundancy" of spatial structure, which was for each diversity group to have at least two viable populations.

More specific recovery criteria for the spatial structure of each diversity group have been laid out in the NMFS Central Valley Salmon and Steelhead Recovery Plan (National Marine Fisheries Service 2014a). According to the criteria, one viable population in the Northwestern California diversity group, two viable populations in the basalt and porous lava diversity group, four viable populations in the Northern Sierra Nevada diversity group, and two viable populations in the Southern Sierra Nevada diversity group are needed for recovery.

It is clear that further efforts must involve more than restoration of currently accessible watersheds to make the ESU viable. The NMFS Central Valley Salmon and Steelhead Recovery Plan calls for reestablishing populations into historical habitats currently blocked by large dams, such as the reintroduction of a population upstream of Shasta Dam, and to facilitate passage of fish upstream of Englebright Dam on the Yuba River (National Marine Fisheries Service 2014a).

Figure 2-8 shows diversity groups for the Central Valley Spring-run Chinook salmon ESU.

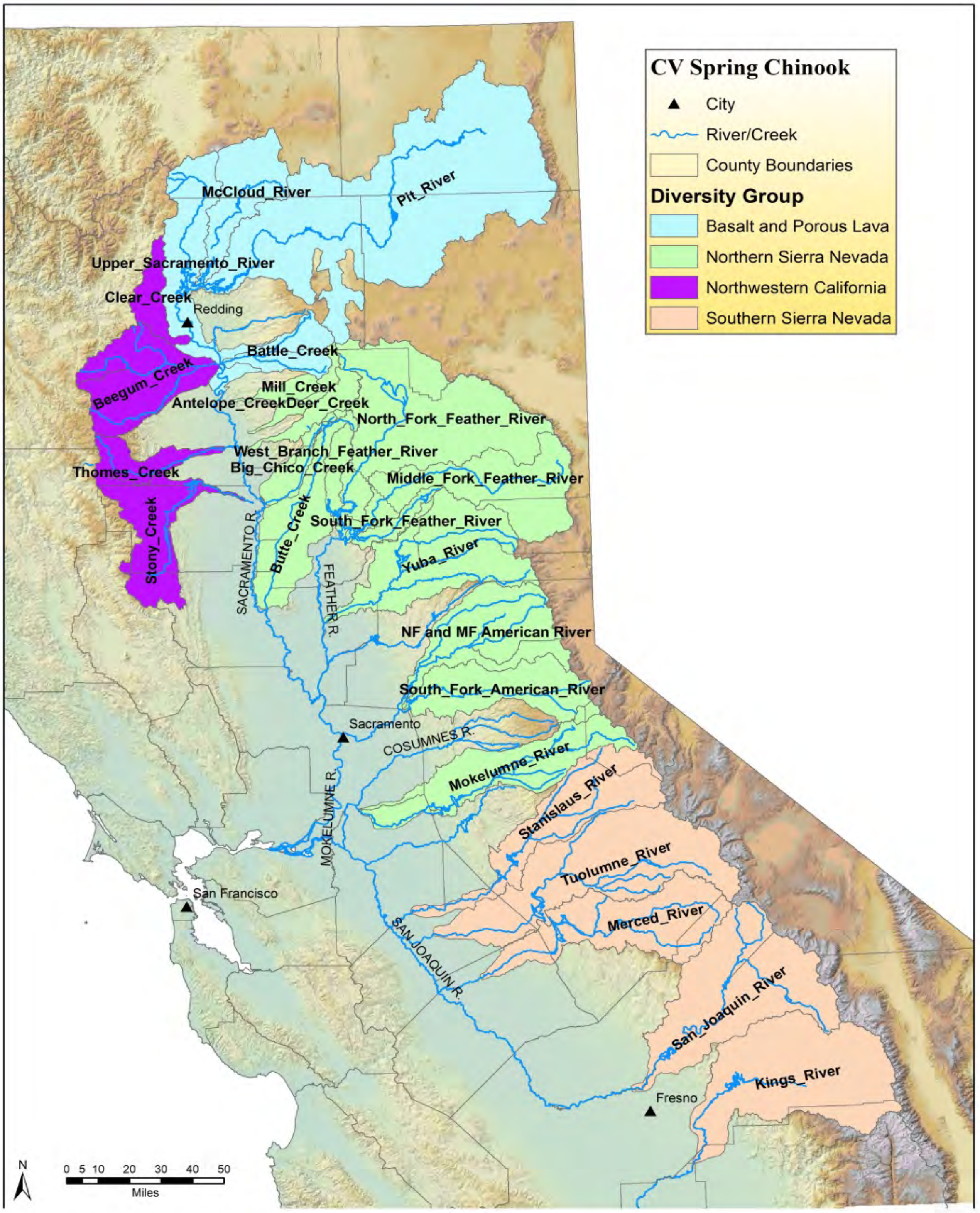


Figure 2-8. Diversity Groups for the Central Valley Spring-run Chinook Salmon ESU

2.2.1.1.3.4 Diversity

Diversity, both genetic and behavioral, is critical to success in a changing environment. Salmonids express variation in a suite of traits, such as anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, and physiology and molecular genetic characteristics (including rate of gene-flow among populations). Criteria for the diversity parameter are that human-caused factors should not alter variation of traits. The more diverse these traits (or the more these traits are not restricted), the more adaptable a population is, and the more likely that individuals, and therefore the species, would survive and reproduce in the face of environmental variation (McElhany et al. 2000). However, when this diversity is reduced due to loss of entire life history strategies or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

The CV spring-run Chinook salmon ESU is comprised of two known genetic complexes. Analysis of natural and hatchery spring-run Chinook salmon stocks in the Central Valley indicates that the Northern Sierra Nevada diversity group CV spring-run Chinook salmon populations in Mill, Deer, and Butte creeks retain genetic integrity as opposed to the genetic integrity of the Feather River population, which has been somewhat compromised. The Feather River CV spring-run Chinook salmon have introgressed with the Feather River fall-run Chinook salmon. It appears that the Yuba River CV spring-run Chinook salmon population may have been impacted by FRFH fish straying into the Yuba River (and likely introgression with wild Yuba River fall-run has occurred). Additionally, the diversity of the CV spring-run Chinook salmon ESU has been further reduced with the loss of the majority, if not all, of the San Joaquin River basin CV spring-run Chinook salmon populations. Efforts underway like the San Joaquin River Restoration Project (SJRRP) (to reintroduce a CV spring-run Chinook salmon population below Friant Dam) are needed to improve the diversity of CV spring-run Chinook salmon.

Because the majority of CV spring-run Chinook salmon returns have been in one diversity group, genetic and behavioral diversity has been decreased compared to historical levels. Populations continuing to return to the other three diversity groups have the potential to increase the diversity of the ESU (National Marine Fisheries Service 2016b).

Some concerns remain with the spring-run Chinook salmon hatchery that is part of the ESU, as there has been and continues to be some introgression with other CV spring-run Chinook salmon populations as well as fall-run Chinook salmon. The majority of the FRFH spring-run Chinook salmon broodstock and in-river spawning population on the Feather River are first generation hatchery-produced fish (Kormos et al., 2012, Palmer-Zwahlen and Kormos 2013). The proportion of natural-origin fish in the broodstock is estimated to be 18 percent and 6 percent in 2010 and 2011 respectively (Kormos et al., 2012, Palmer-Zwahlen and Kormos 2013). Thus, the minimum criteria of greater than 10 percent of natural-origin fish in the broodstock is not being met annually(California Hatchery Scientific Review Group 2012b). The proportion of hatchery-origin spring- or fall-run Chinook salmon contributing to the natural spawning spring-run Chinook salmon population on the Feather River remains unknown due to overlap in the spawn timing of spring-run and fall-run Chinook salmon, and lack of physical separation. However, the hatchery component is likely to be high. For example, 78 percent and 90 percent of spawners in the 2010/2011 spring-/fall- run Chinook salmon carcass survey were estimated to be from the FRFH respectively (Kormos et al., 2012, Palmer-Zwahlen and Kormos 2013).

FRFH-origin spring-run Chinook salmon adults have been recovered in other CV spring-run and fall-run Chinook salmon populations outside of the Feather River. Up until 2015, at least half of the FRFH spring-run Chinook salmon production has been trucked to release sites such as the San Francisco Bay, which leads to the returns straying to other watersheds at a relatively high rate, posing genetic risk to those other Central Valley salmon populations (Kormos et al., 2012, Palmer-Zwahlen and Kormos 2013). The annual spawning run size of CV spring-run Chinook salmon on the Yuba River follows the annual abundance trend of the FRFH spring-run Chinook salmon population. On Battle Creek, as high as 29 percent of CV spring-run Chinook salmon in 2010 were estimated to have originated from the FRFH (USFWS 2014). On Clear Creek, up to five percent of CV spring-run Chinook salmon carcasses above the segregation weir in 2010 to 2013 were from the FRFH. A significant number of FRFH spring-run Chinook salmon strays have been observed in the Keswick Dam fish trap, with a high in 2015 of 114 fish. This indicates a likelihood that they could be interbreeding with natural-origin CV spring- or fall-run Chinook salmon in the Sacramento River (Rueth 2015). A prolonged influx of FRFH spring-run Chinook salmon strays to other CV spring-run Chinook salmon populations even at levels of less than one percent is undesirable and can cause the receiving population to shift to a moderate risk after four generations of such impact (Lindley et al. 2007). More information on the incidence of FRFH spring-run straying is desirable to more accurately estimate the extent to which spawning and introgression is occurring between fall-run and spring-run Chinook salmon populations outside of the Feather River.

2.2.1.1.3.5 Summary of ESU Viability

Because the populations in Butte, Deer and Mill creeks are the best trend indicators for ESU viability, we can evaluate risk of extinction based on VSP parameters in these watersheds. Lindley et al. (2007)_ENREF_166 indicated that the CV spring-run Chinook salmon populations in the Central Valley had a low risk of extinction in Butte and Deer creeks, according to their population viability analysis (PVA) model and other population viability criteria (*i.e.*, population size, population decline, catastrophic events, and hatchery influence, which correlate with VSP parameters abundance, productivity, spatial structure, and diversity). The Mill Creek population of CV spring-run Chinook salmon was at moderate extinction risk according to the PVA model, but appeared to satisfy the other viability criteria for low-risk status. However, the CV spring-run Chinook salmon ESU failed to meet the “representation and redundancy rule” because there are only demonstrably viable populations in one diversity group (northern Sierra Nevada) out of the three diversity groups that historically contained them or out of the four diversity groups as described in the *NMFS Central Valley Salmon and Steelhead Recovery Plan*. Over the long term, these three remaining populations are considered to be vulnerable to catastrophic events, such as volcanic eruptions from Mount Lassen or large forest fires due to the close proximity of their headwaters to each other. Drought is also considered to pose a significant threat to the viability of the CV spring-run Chinook salmon populations in these three watersheds due to their close proximity to each other. One large event could eliminate all three populations.

Until 2012, the status of CV spring-run Chinook salmon ESU had deteriorated on balance since the 2005 status review and Lindley et al.’s (2007) assessment, with two of the three extant independent populations (Deer and Mill creeks) of CV spring-run Chinook salmon slipping from low or moderate extinction risk to high extinction risk. Additionally, Butte Creek remained at low risk, although it was on the verge of moving towards high risk, due to rate of population decline. In contrast, CV spring-run Chinook salmon in Battle and Clear creeks had increased in abundance since 1998, reaching levels of abundance that place these populations at moderate extinction risk. Both these populations have likely increased at least in part due to extensive habitat restoration. The Southwest Fisheries Science Center concluded in their viability report that the status of CV spring-run Chinook salmon ESU has probably deteriorated since the 2005 status review and that its extinction risk has increased (Williams et al. 2011). The degradation in status of the three formerly low- or moderate-risk independent populations is cause for concern.

The most recent viability assessment of CV spring-run Chinook salmon was conducted during NMFS's 2016 status review (National Marine Fisheries Service 2016b). This review found that the status of the CV spring-run Chinook salmon ESU has probably improved on balance since the 2010 status review, through 2014, with two of the three extant independent populations improving from high extinction risks to moderate extinction risks. The third, Butte Creek, has remained at low risk, and all viability metrics had been trending in a positive direction, up, until 2015. The Butte Creek spring-run Chinook salmon population has increased in part due to extensive habitat restoration and the accessibility of floodplain habitat in the Sutter-Butte Bypass for juvenile rearing in the majority of years. Additionally, spring-run Chinook salmon in both Battle Creek and Clear Creek continue to repopulate those watersheds, and now fall into the moderate extinction risk category for abundance. In contrast, most dependent spring-run populations have been experiencing continued and somewhat drastic declines.

The CV spring-run Chinook salmon ESU has experienced two drought periods over the past decade. From 2007 to 2009, and 2012 to 2015, the Central Valley experienced drought conditions and low river and stream discharges, which are generally associated with lower survival of Chinook salmon (Michel et al. 2015). The impacts of the recent drought years and warm ocean conditions on the juvenile life stage (see Ocean Conditions discussion below) will not be fully realized by the viability metrics until data for 2015 through 2018 returns is available (Williams et al. 2016). Preliminary numbers for the return of CV spring-run Chinook salmon in 2015 are very low. The preliminary data for 2015 indicate only 1,195 in-river spring-run Chinook salmon returned to the CV. This compares to a range of 3,000 to 21,000 in-river spring-run Chinook salmon returns to the CV since 2000.

The recent drought impacts on Butte Creek can be seen from the lethal water temperatures in traditional and non-traditional spring-run Chinook salmon holding habitat during the summer. A large number of adults (903 and 232) were estimated to have died prior to spawning in the 2013 and 2014 drought respectively (Garman 2015). Pre-spawn mortality was also observed during the 2007 to 2009 drought with an estimate of 1,054 adults dying before spawning (Garman 2015). In 2015, late arriving adults in the Chico vicinity experienced exceptionally warm June air temperatures coupled with the PG&E flume shutdown resulting in a fish die off. Additionally, adult spring-run Chinook salmon in Mill, Deer, and Battle creeks were exposed to warm temperatures, and pre-spawn mortality was observed. Thus, while the independent CV spring-run Chinook populations have generally improved since 2010, and are considered at moderate (Mill and Deer) or low (Butte Creek) risk of extinction, these populations are likely to deteriorate over the next three years due to drought impacts, which may in fact result in severe declines.

Continued introgression between fall- and spring-run Chinook salmon in the FRFH breeding program and straying of FRFH spring-run Chinook salmon to other CV spring-run Chinook salmon populations where genetic introgression would be possible is unfavorable. However, beginning in 2015, and expected to continue, the FRFH released all spring-run Chinook salmon production into the Feather River rather than releasing in the San Francisco Bay which is hypothesized to reduce straying (California Hatchery Scientific Review Group 2012b).

At the ESU level, the spatial diversity within the CV spring-run Chinook salmon ESU is increasing, with presence (albeit at low numbers in some cases) in all four diversity groups. The continued repopulation and increasing abundance of spring-run Chinook salmon to Battle and Clear creeks is benefiting the viability of the ESU. Similarly, the reappearance of phenotypic spring-run Chinook salmon to the San Joaquin River tributaries may be the beginning of natural recolonization processes in rivers where they were once extirpated. Reintroduction planning on the upper Yuba River shows promise, and will be necessary for the ESU to reach viable status. Just as necessary is the active reintroduction efforts below Friant Dam on the mainstem San Joaquin River.

In summary, the status of the CV spring-run Chinook salmon ESU has probably improved since the 2010 status review. The largest improvements are due to extensive restoration, and increases in spatial structure with historically extirpated populations trending in the positive direction. Improvements, evident in the moderate and low risk of extinction of the three independent populations, however, are not enough to warrant the delisting of the ESU. The recent declines of many of the dependent populations, high pre-spawn and egg mortality during the 2012 to 2015 drought, uncertain juvenile survival during the drought, ocean conditions, and the level of straying of FRFH spring-run Chinook salmon to other CV spring-run Chinook salmon populations are all causes for concern for the long-term viability of the CV spring-run Chinook salmon ESU (National Marine Fisheries Service 2016b).

2.2.1.1.4 Critical Habitat and Physical and Biological Features for CV Spring-run Chinook Salmon

Critical habitat for the CV spring-run Chinook salmon includes stream reaches of the Feather, Yuba, and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, and the Sacramento River, as well as portions of the northern Delta. Critical habitat includes the stream channels in the designated stream reaches (70 FR 52488; September 2, 2005). Following are the statuses of the PBFs for CV spring-run Chinook salmon.

2.2.1.1.4.1 Spawning Habitat

PBFs for CV spring-run Chinook salmon include freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development (70 FR 52488; September 2, 2005). Most spawning habitat in the Central Valley for Chinook salmon is located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Spawning habitat for CV spring-run Chinook salmon occurs on the mainstem Sacramento River between the Red Bluff Diversion Dam (RBDD) and Keswick Dam and in tributaries such as Mill, Deer, and Butte creeks, as well as the Feather and Yuba Rivers, Big Chico, Battle, Antelope, and Clear creeks. Even in degraded reaches, spawning habitat has a high value for the conservation of listed salmonids as its function directly affects the spawning success and reproductive potential of listed salmonids.

2.2.1.1.4.2 Freshwater Rearing Habitat

PBFs for CV spring-run Chinook salmon include freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions that support juvenile growth and mobility; water quality and forage supporting juvenile salmonid development; and natural cover such as shade, submerged and overhanging large woody material, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks (70 FR 52488; September 2, 2005). Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system (*e.g.*, the lower Cosumnes River, Sacramento River reaches with setback levees [*i.e.*, primarily located upstream of the City of Colusa]) and flood bypasses (*i.e.*, Yolo and Sutter bypasses). However, the channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system typically have low habitat complexity, low abundance of food organisms, and offer little protection from piscivorous fish and birds. Freshwater rearing habitat also has a high intrinsic conservation value even if the current conditions are significantly degraded from their natural state.

2.2.1.1.4.3 Freshwater Migration Corridors

PBFs for CV spring-run Chinook salmon include freshwater migration corridors free of migratory obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large woody objects, aquatic vegetation, large rocks and boulders, side channels, and undercut banks that supporting juvenile and adult mobility and survival (70 FR 52488; September 2, 2005). Migratory corridors are downstream of the spawning areas and include the lower mainstems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream passage of adults and the downstream emigration of juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. The stranding of adults has been known to occur in flood bypasses and associated weir structures (Vincik and Johnson 2013) and a number of challenges exist on many tributary streams. For juveniles, unscreened or inadequately screened water diversions throughout their migration corridors and a scarcity of complex in-river cover have degraded this PBF. However, since the primary migration corridors are used by numerous populations, and are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic value for the conservation of the species.

2.2.1.1.4.4 Estuarine Areas

PBFs for CV spring-run Chinook salmon include estuarine areas, such as the San Francisco Bay and the downstream portions of the Sacramento-San Joaquin Delta, free of migratory obstruction and excessive predation with: water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater; natural cover such as submerged and overhanging large woody material, aquatic vegetation, large rocks and boulders, side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation (70 FR 52488; September 2, 2005).

The remaining estuarine habitat for these species is severely degraded by altered hydrologic regimes, poor water quality, reductions in habitat complexity, and competition for food and space with exotic species. Regardless of the condition, the remaining estuarine areas are of high value for the conservation of the listed species because they provide factors which function to provide predator avoidance, as rearing habitat and as an area of transition to the ocean environment.

2.2.1.2 Winter-run Chinook Salmon

- Sacramento River winter-run Chinook salmon evolutionarily significant unit (ESU) (*O. tshawytscha*) was first listed as threatened (54 FR 32085; August 4, 1989), reclassified as endangered (59 FR 440; January 4, 1994), and reaffirmed as endangered (70 FR 37160; June 28, 2005)
- Sacramento River winter-run Chinook salmon critical habitat was designated on June 16, 1993 (58 FR 33212)

2.2.1.2.1 Species Listing and Critical Habitat Designation History

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

On June 28, 2005, NMFS concluded that the winter-run ESU was "in danger of extinction" due to risks to the ESU's diversity and spatial structure and, therefore, continues to warrant listing as an endangered species under the ESA (70 FR 37160). In August 2011, NMFS completed a 5-year status review of five Pacific salmon ESUs, including the winter-run ESU, and determined that the species' status should again remain as endangered (76 FR 50447; August 15, 2011). The 2011 review concluded that although the listing remained unchanged since the 2005 review, the status of the population had declined over the past five years (2005–2010) (National Marine Fisheries Service 2011c).

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

NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). Critical habitat was delineated as the following waterways, bottom and water of the waterways and adjacent riparian zones: the Sacramento River from Keswick Dam at

RM 302 to Chipps Island, RM 0, at the westward margin of the Sacramento-San Joaquin Delta (Delta); all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge from San Pablo Bay to the Golden Gate Bridge.

2.2.1.2.2 Winter-run Chinook Salmon Life History

2.2.1.2.2.1 Adult Migration and Spawning

Winter-run exhibit a unique life history pattern (Healey 1994) compared to other salmon populations in the Central Valley (*i.e.*, CV spring-run, fall-run, and late-fall run Chinook salmon), in that they spawn in the summer, and the juveniles are the first to enter the ocean the following winter and spring. Adults first enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate up the Sacramento River, past the RBDD from mid-December through early August (National Marine Fisheries Service 1997). The majority of the run passes RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type (see Table 2-4below) (Yoshiyama et al. 1998, Moyle 2002).

Winter-run tend to enter freshwater while still immature and travel far upriver and delay spawning for weeks or months upon arrival at their spawning grounds (Healey 1991). Spawning occurs primarily from mid-May to mid-August, with the peak activity occurring in June and July in the upper Sacramento River reach (50 miles) between Keswick Dam and RBDD (Vogel and Marine 1991). Winter-run deposit and fertilize eggs in gravel beds known as redds excavated by the female who then dies following spawning. Average fecundity was 5,192 eggs/female for the 2006–2013 returns to LSNFH, which is similar to other Chinook salmon runs [*e.g.*, 5,401 average for Pacific Northwest (Quinn 2005)]. Chinook salmon spawning requirements for depth and velocities are broad, and the upper preferred water temperature is between 55–57°F (13–14°C) degrees (Snider et al. 2001). The majority of winter-run adults return after three years.

In Table 2-4, darker shades indicate months of greatest relative abundance.

Table 2-4. The Temporal Occurrence of Adult (A) and Juvenile (B) Winter-run in the Sacramento River

Winter run relative abundance	High				Medium				Low			
a) Adults freshwater												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River basin[a,b]	Medium	Medium	Medium	Medium	Medium	Medium	Medium				Medium	Medium
Upper Sacramento River spawning[c]					Low–Medium	High	High	Medium				
b) Juvenile emigration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River at Red Bluff[d]	Low	Low	Low				Low–Medium	Medium	Medium	Medium	Medium	Medium
Sacramento River at Knights Landing[e]	High	Medium	Low							Low	Medium	High
Sacramento trawl at Sherwood Harbor[f]	Medium	High	High	Low							Medium	High
Midwater trawl at Chipps Island[g]	Medium	Medium	High	High	Low							Low

Sources: [a] (Yoshiyama et al. 1998); (Moyle 2002); [b](Myers et al. 1998) ; [c] (Williams 2006) ; [d] (Martin et al. 2001); [e] Knights Landing Rotary Screw Trap Data, CDFW (1999-2011); [f,g] Delta Juvenile Fish Monitoring Program, USFWS (1995-2012)

2.2.1.2.2.2 Eggs/Fry Emergence

Winter-run incubating eggs are vulnerable to adverse effects from floods, flow fluctuations, siltation, desiccation, disease, predation during spawning, poor gravel percolation, and poor water quality. The optimal water temperature for egg incubation ranges from 46–56°F (7.8–13.3°C), and a significant reduction in egg viability occurs in mean daily water temperatures above 57.5°F (14.2°C) (Seymour 1956, Boles 1988, U.S. Fish and Wildlife Service 1998, U.S. Environmental Protection Agency 2003, Richter and Kolmes 2005, Geist et al. 2006).

The U.S Environmental Protection Agency (EPA) 2003 guidance for the Pacific Northwest (Region 10) is a 7 day average of the daily maximums of 13°C (55 °F) for salmon and trout spawning, egg incubation and fry emergence (U.S. Environmental Protection Agency 2003).

Total embryo mortality can occur at temperatures above 62°F (16.7°C; (National Marine Fisheries Service 1997). Depending on ambient water temperature, embryos hatch within 40-60 days and alevins (yolk-sac fry) remain in the gravel beds for an additional 4–6 weeks. As their yolk-sacs become depleted, fry begin to emerge from the gravel and start exogenous feeding in their natal stream, typically in late July to early August and continuing through October (Fisher 1994).

2.2.1.2.2.3 Juvenile/Outmigration

Juvenile winter-run Chinook salmon have been found to exhibit variability in their life history dependent on emergence timing and growth rates (Beckman et al. 2007). Following spawning, egg incubation, and fry emergence from the gravel, juveniles begin to emigrate in the fall. Some juvenile winter-run migrate to sea after only 4 to 7 months of river life, while others hold and rear upstream and spend 9 to 10 months in freshwater. Emigration of juvenile winter-run Chinook salmon fry and pre-smolts past RBDD (RM 242) may begin as early as mid-July, but typically peaks at the end of September (Table 2-4), and can continue through March in dry years (Vogel and Marine 1991, National Marine Fisheries Service 1997).

2.2.1.2.2.4 Estuarine/Delta Rearing

Juvenile winter-run Chinook salmon emigration into the estuary/Delta occurs primarily from November through early May based on data collected from trawls in the Sacramento River at Sherwood Harbor (West Sacramento), RM 57 (U.S. Fish and Wildlife Service 2001). The timing of emigration may vary somewhat due to changes in river flows, Shasta Dam operations, and water year type, but has been correlated with the first storm event when flows exceed 14,000 cfs at Knights Landing, RM 90, which triggers abrupt emigration towards the Delta (del Rosario et al. 2013). Residence time in the Delta for juvenile winter-run averages approximately 3 months based on median seasonal catch between Knights Landing and Chipps Island. In general, the earlier juvenile winter-run arrive in the Delta, the longer they stay and rear, as peak departure at Chipps Island regularly occurs in March (del Rosario et al. 2013). The Delta serves as an important rearing and transition zone for juvenile winter-run Chinook salmon as they feed and physiologically adapt to marine waters (smoltification). The majority of juvenile winter-run in the Delta are 104 to 128 mm in size based on U.S. Fish and Wildlife Service (USFWS) trawl data (1995-2012), and from 5 to 10 months of age, by the time they depart the Delta (Fisher 1994, Myers et al. 1998).

2.2.1.2.2.5 Ocean Rearing

Winter-run Chinook salmon smolts enter the Pacific Ocean mainly in spring (March–April) and grow rapidly on a diet of small fishes, crustaceans, and squid. Salmon runs that migrate to sea at a larger size tend to have higher marine survival rates (Quinn 2005). The diet composition of Chinook salmon from California consist of anchovy, rockfish, herring, and other invertebrates (in order of preference) (Healey 1991). Most Chinook from the Central Valley move northward into Oregon and Washington, where herring make up the majority of their diet. However winter-run Chinook salmon, upon entering the ocean, tend to stay near the California coast and distribute from Point Arena southward to Monterey Bay.

Winter-run Chinook salmon have high metabolic rates, feed heavily, and grow fast compared to other fishes in their range. They can double their length and increase their weight more than ten-fold in the first summer at sea (Quinn 2005). Mortality is typically highest in the first summer at sea, but can depend on ocean conditions. Winter-run Chinook salmon abundance has been correlated with ocean conditions, such as periods of strong up-welling, cooler temperatures, and

El Nino events (Lindley et al. 2009). Winter-run Chinook salmon spend approximately 1-2 years rearing in the ocean before returning to the Sacramento River as 2-3 year old adults. Very few winter-run Chinook salmon reach age 4. Once they reach age 3, they are large enough to become vulnerable to commercial and sport fisheries.

2.2.1.2.3 Description of Viable Salmonid Population (VSP) Parameters

2.2.1.2.3.1 Abundance

Historically, winter-run population estimates were as high as 120,000 fish in the 1960s, but declined to less than 200 fish by the 1990s (National Marine Fisheries Service 2011c). In recent years, since carcass surveys began in 2001 (Figure 2-9). This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley et al. 2009), drought conditions from 2007-2009, and low in-river survival (National Marine Fisheries Service 2011c). In 2013, the population increased to 6,075 adults, well above the 2007–2012 average, but below the high for the last ten years. Very low in-river survival of eggs and juveniles produced from naturally spawning Sacramento River winter-run Chinook salmon in 2014 and 2015 is likely to result in further declines in the population. This low survival is associated with the 2012-2015 drought.

Although impacts from hatchery fish (*i.e*., reduced fitness, weaker genetics, smaller size, less ability to avoid predators) are often cited as having deleterious impacts on natural in-river populations (Matala et al. 2012), the winter-run conservation program at LSNFH is strictly controlled by the USFWS to reduce such impacts. The average annual hatchery production at LSNFH is approximately 176,348 per year (2001–2010 average) compared to the estimated natural production that passes RBDD, approximately 4.7 million (2002–2010 average) (Poytress and Carrillo 2011). Therefore, hatchery production typically represents approximately 3-4 percent of the total in-river juvenile production in any given year. Due to drought conditions in 2015 and 2016 the proportion of hatchery winter-run Chinook salmon has drastically changed, with the hatchery fish making up the majority of the juvenile production.

Figure 2-9 shows winter-run Chinook salmon escapement numbers 1970-2013, which includes hatchery broodstock and tributaries, but excludes sport catch. RBDD ladder counts are used pre-2000; carcass surveys are used post 2001 (California Department of Fish and Game 2012).

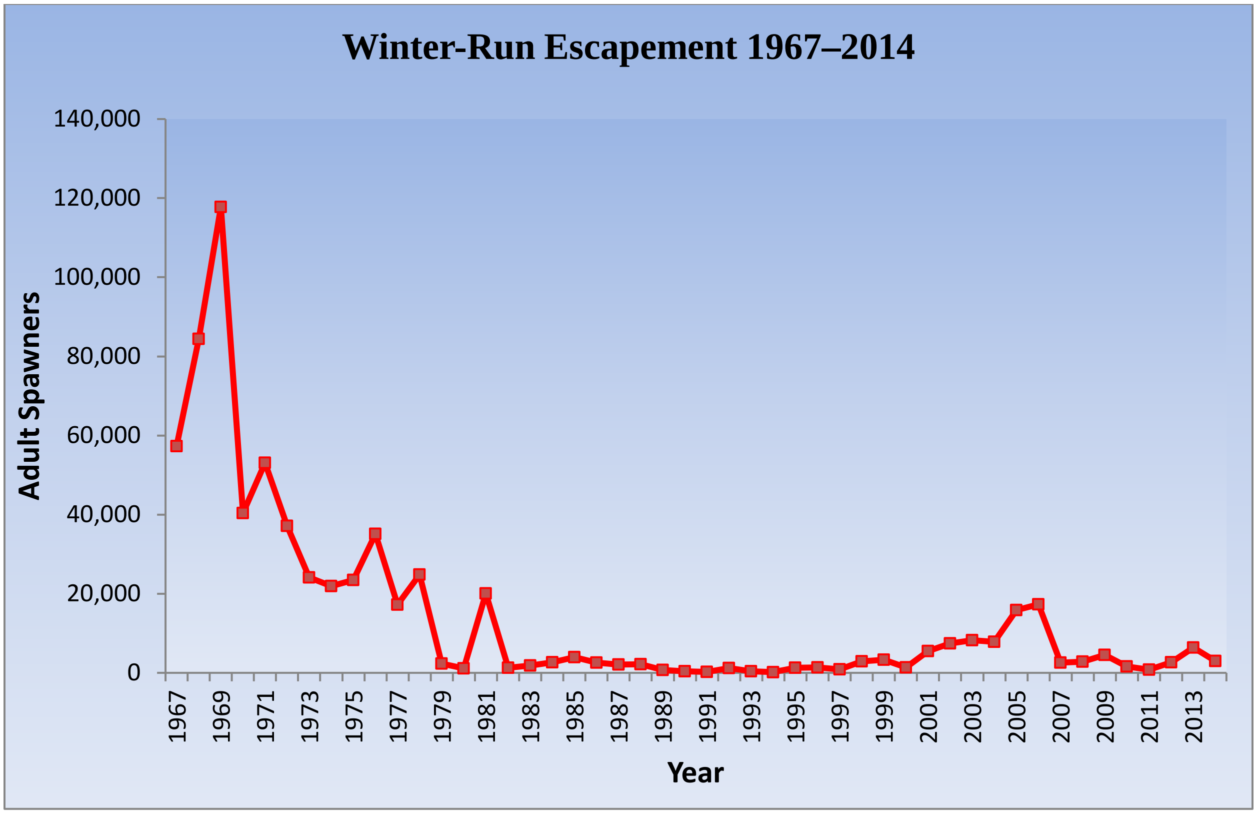


Figure 2-9. Winter-run Chinook Salmon Escapement Numbers 1970-2014

2.2.1.2.3.2 Productivity

ESU productivity was positive over the period 1998–2006, and adult escapement and juvenile production had been increasing annually until 2007, when productivity became negative (Figure 2-10) with declining escapement estimates. The long-term trend for the ESU, therefore, remains negative, as the productivity is subject to impacts from environmental and artificial conditions. The population growth rate based on CRR for the period 2007–2012 suggests a reduction in productivity (Figure 2-10), and indicates that the winter-run population is not replacing itself. In 2013, winter-run experienced a positive CRR, possibly due to favorable in-river conditions in 2011 (a wet year), which increased juvenile survival to the ocean.

Figure 2-10 shows the winter-run Chinook salmon population trend using cohort replacement rate derived from adult escapement, including hatchery fish, 1986–2013.

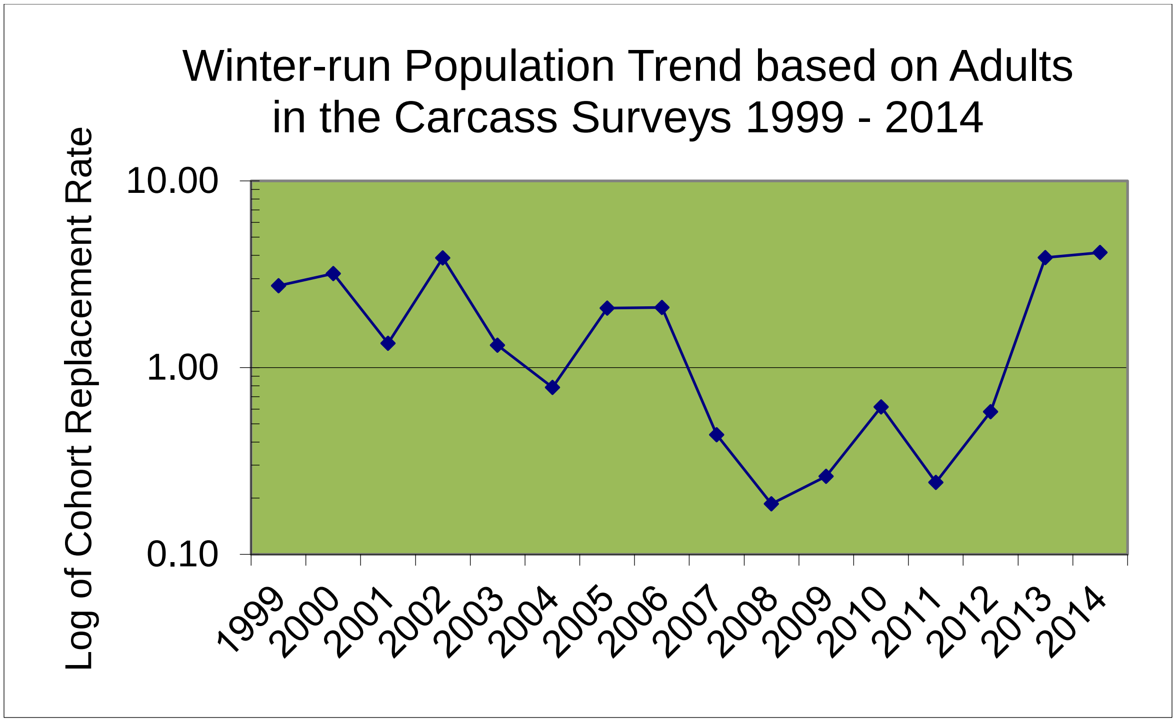


Figure 2-10. Winter-run Chinook Salmon Population Trend Based on Adults in Carcass Surveys, 1986–2014

An age-structured density-independent model of spawning escapement by (Botsford and Brittnacher 1998) assessing the viability of winter-run found the species was certain to fall below the quasi-extinction threshold of three consecutive spawning runs with fewer than 50 females (Good et al. 2005). Lindley and Mohr (2003)_ENREF_162 assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the growth rate for the winter-run population improved up until 2006, it exhibits the typical variability found in most endangered species populations. The fact that there is only one population, dependent upon cold-water releases from Shasta Dam, makes it vulnerable to periods of prolonged drought (National Marine Fisheries Service 2011c). Productivity, as measured by the number of juveniles entering the Delta, or juvenile production estimate (JPE), has declined in recent years from a high of 3.8 million in 2007 to 1.1 million in 2013 (Table 2-5). Due to uncertainties in the various factors, the JPE was updated in 2010 with the addition of confidence intervals (Cramer Fish Sciences model) and again in 2013 with a change in survival based on acoustic tag data (National Marine Fisheries Service 2014b). However, juvenile winter-run productivity is still much lower than other Chinook salmon runs in the Central Valley and in the Pacific Northwest (Michel 2010).

Table 2-5. Winter-run Chinook Salmon Adult and Juvenile Population Estimates Based on RBDD Counts (1986–2001) and Carcass Counts (2001–2013), With Corresponding 3-Year Cohort Replacement Rates

Return Year	Adult Population Estimate[a]	Cohort Replacement Rate[b]	NMFS-calculated Juvenile Production Estimate (JPE)[c]
1986	2596		
1987	2185		
1988	2878		
1989	696	0.27	
1990	430	0.20	
1991	211	0.07	
1992	1240	1.78	40,100
1993	387	0.90	273,100
1994	186	0.88	90,500
1995	1297	1.05	74,500
1996	1337	3.45	338,107
1997	880	4.73	165,069
1998	2992	2.31	138,316
1999	3288	2.46	454,792
2000	1352	1.54	289,724
2001	8224	2.75	370,221
2002	7441	2.26	1,864,802
2003	8218	6.08	2,136,747
2004	7869	0.96	1,896,649
2005	15839	2.13	881,719

Return Year	Adult Population Estimate[a]	Cohort Replacement Rate[b]	NMFS-calculated Juvenile Production Estimate (JPE)[c]
2006	17296	2.10	3,556,995
2007	2542	0.32	3,890,534
2008	2830	0.18	1,100,067
2009	4537	0.26	1,152,043
2010	1,596	0.63	1,144,860
2011	827	0.29	332,012
2012	2,671	0.59	162,051
2013	6,084	3.81	1,196,387
2014	3,015	3.65	
2015	3,440	1.29	
median	2,634	1.29	412,507

[a] Population estimates include adults taken into the hatchery and were based on ladder counts at RBDD until 2001, after which the methodology changed to carcass surveys (California Department of Fish and Game 2012).

[b] Assumes all adults return after three years. NMFS calculated a CRR using the adult spawning population, divided by the spawning population three years prior. Two year old returns were not used.

[c] JPE estimates include survival estimates from the spawning gravel to the point where they enter the Delta (Sacramento I St Bridge), but does not include through-Delta survival.

2.2.1.2.3.3 Spatial Structure

The distribution of winter-run Chinook salmon spawning and initial rearing historically was limited to the upper Sacramento River (upstream of Shasta Dam), McCloud River, Pitt River, and Battle Creek, where springs provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963) *op. cit.* (Yoshiyama et al. 1998). The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which currently has its own impediments to upstream migration (*i.e.*, a number of small hydroelectric dams situated upstream of the Coleman National Fish Hatchery weir). The Battle Creek Salmon and Steelhead Restoration Project (BCSSRP) is currently removing these impediments, which should restore spawning and rearing habitat for winter-run in the future. Approximately 299 miles of former tributary spawning habitat above Shasta Dam is inaccessible to winter-run. Yoshiyama et al. (2001)_ENREF_333 estimated that in 1938 the upper Sacramento River had a "potential spawning capacity" of approximately 14,000 redds equal to 28,000 spawners. Since 2001, the majority of winter-run redds have occurred in the first 10 miles downstream of Keswick Dam. Most components of the winter-run life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the construction of Shasta Dam.

The greatest risk factor for winter-run Chinook salmon lies within its spatial structure (National Marine Fisheries Service 2011c). The remnant and remaining population cannot access 95 percent of their historical spawning habitat, and must therefore be artificially maintained in the Sacramento River by: (1) spawning gravel augmentation, (2) hatchery supplementation, and (3) regulating the finite cold-water pool behind Shasta Dam to reduce water temperatures.

Winter-run require cold water temperatures in the summer that simulate their upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek is currently the most feasible opportunity for the ESU to expand its spatial structure, but restoration is not scheduled to be completed until 2022 (BCSSRP). The Central Valley Salmon and Steelhead Recovery Plan includes criteria for recovering the winter-run Chinook salmon ESU, including re-establishing a population into historical habitats upstream of Shasta Dam (National Marine Fisheries Service 2014a). Additionally, National Marine Fisheries Service (2009) included a requirement for a pilot fish passage program above Shasta Dam.

2.2.1.2.3.4 Diversity

The current winter-run Chinook salmon population is the result of the introgression of several stocks (*e.g.,* CV spring-run Chinook salmon and fall-run Chinook salmon) that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam which blocked access and did not allow spatial separation of the different runs (Good et al. 2005). Lindley et al. (2007) recommended reclassifying the winter-run population extinction risk from low to moderate if the proportion of hatchery origin fish from the LSNFH exceeded 15 percent due to the impacts of hatchery fish over multiple generations of spawners. Since 2005, the percentage of hatchery winter-run Chinook salmon recovered in the Sacramento River has only been above 15 percent in two years, 2005 and 2012 (Figure 2-11).

Concern over genetic introgression within the winter-run population led to a conservation program at LSNFH that encompasses best management practices such as: (1) genetic confirmation of each adult prior to spawning, (2) a limited number of spawners based on the effective population size, and (3) use of only natural-origin spawners since 2009. These practices reduce the risk of hatchery impacts on the wild population. Hatchery-origin winter-run Chinook salmon have made up more than 5 percent of the natural spawning run in recent years and in 2012 it exceeded 30 percent of the natural run (Figure 2-11). However, the average over the last 16 years (approximately 5 generations) has been 8 percent, still below the low-risk threshold (15 percent) used for hatchery influence (Lindley et al. 2007)_ENREF_166.

Figure 2-11 depicts the percentage of hatchery-origin winter-run Chinook salmon naturally spawning in the Sacramento River (1996–2013). Source: California Department of Fish and Wildlife (2013b).

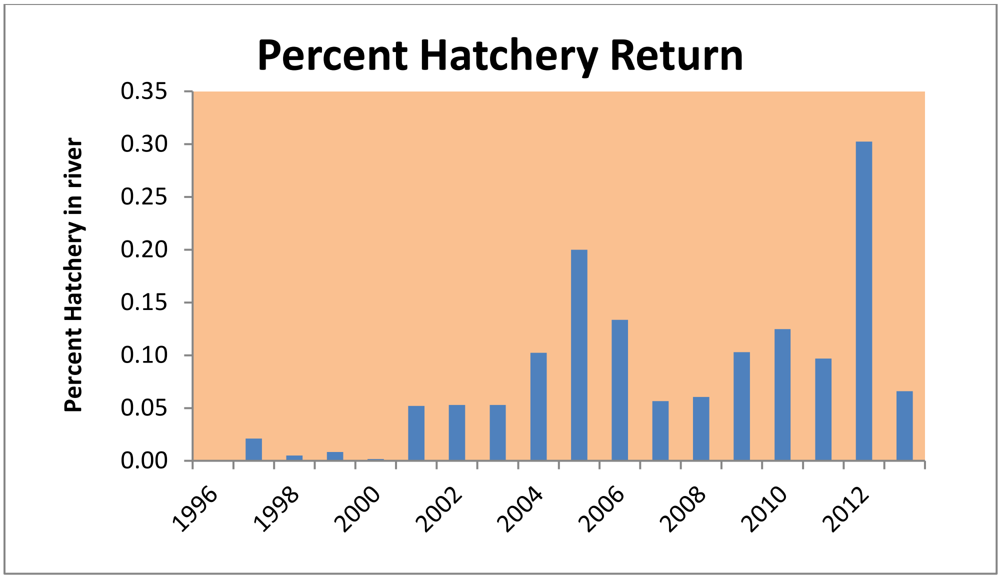


Figure 2-11. Percentage Hatchery Return, 1996–2013

2.2.1.2.3.5 Summary of ESU Viability

There are several criteria (only one is required) that would qualify the winter-run ESU at moderate risk of extinction, and because there is still only one population that spawns below Keswick Dam, that population is at high risk of extinction in the long-term according to the criteria in Lindley et al. (2007)_ENREF_166. Recent trends in those criteria are: (1) continued low abundance (Figure 2-9); (2) a negative growth rate over 6 years (2006–2012), which is two complete generations (Figure 2-10); (3) a significant rate of decline since 2006; and (4) increased risk of catastrophe from oil spills, wild fires, or extended drought (climate change).

Due to drought conditions, natural in-river production to the Delta declined to just 124,521 Sacramento River winter-run Chinook salmon juveniles in 2014. In 2014, water temperatures in the upper Sacramento River were elevated. In 2014 egg-to-fry survival to the RBDD was approximately 5 percent. Due to the anticipated lower than average survival in 2014, hatchery production was tripled (*i.e.*, 612,056 released) to offset the impact of the drought. In 2014, hatchery production represented 83% of the total in-river juvenile production. In 2015, egg-to-fry survival was the lowest on record (~4 percent), due to the inability to release cold water from Shasta Dam in the fourth year of a drought. Winter-run returns in 2016 are expected to be low as they show the impact of drought on juveniles from brood year 2013.

The most recent 5-year status review (National Marine Fisheries Service 2011c) on winter-run Chinook salmon concluded that the ESU had increased to a high risk of extinction. In summary, the most recent biological information suggests that the extinction risk for the winter-run Chinook salmon ESU has increased from moderate risk to high risk of extinction since 2005 (last review) and that several listing factors have contributed to the recent decline, including drought and poor ocean conditions (National Marine Fisheries Service 2011c).

2.2.1.2.4 Critical Habitat: Physical or Biological Features for Sacramento River Winter-run Chinook Salmon

Critical habitat for winter-run (Figure 2-12) includes specified waterways, bottom and water of the waterways (including those areas and associated gravel used by winter-run as spawning substrate), and adjacent riparian zone (58 FR 33212; June 16, 1993).

In the preamble to its final rule designating winter-run critical habitat, NMFS clarified that it was limiting "adjacent riparian zones" to only those areas above a stream bank that provide cover and shade to the near shore aquatic areas (58 FR 33212; June 16, 1993). Although the bypasses (*e.g.*, Yolo, Sutter, and Colusa) are not currently designated critical habitat for winter-run, NMFS recognizes that they may be utilized when inundated with Sacramento River flood flows and are important rearing habitats for juvenile winter-run. Also, juvenile winter-run may use tributaries of the Sacramento River for non-natal rearing. Critical habitat also includes the estuarine water column and essential foraging habitat and food resources used by winter-run as part of their juvenile outmigration or adult spawning migration.

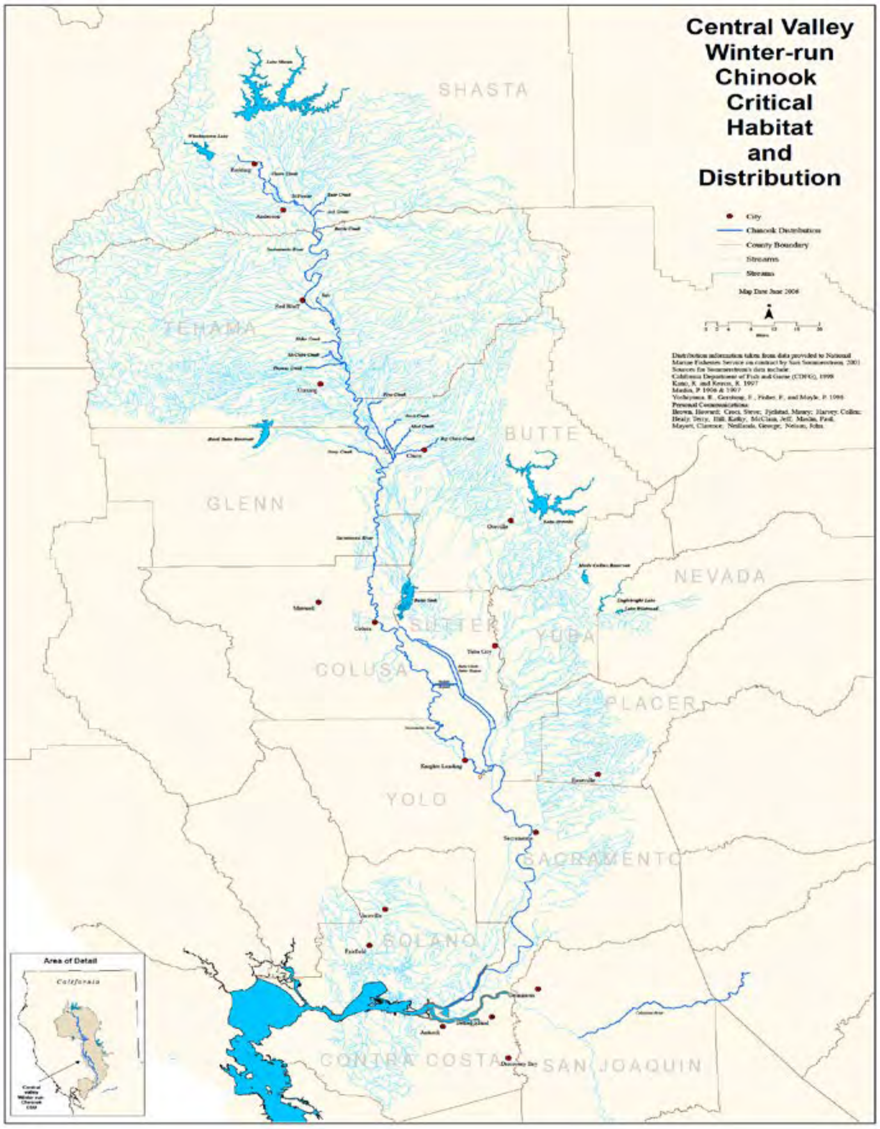


Figure 2-12. Winter-run Chinook Salmon Designated Critical Habitat and Distribution

The following is the status of the PBFs for winter-run critical habitat (58 FR 33212; June 16, 1993).

2.2.1.2.4.1 Access from the Pacific Ocean to Appropriate Spawning Areas in the Upper Sacramento River

Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover, shelter and safe passage conditions in order for adults to reach spawning areas. Adult winter-run generally migrate to spawning areas during the winter and spring. At that time of year, the migration route is accessible to the appropriate spawning grounds on the upper 60 miles of the Sacramento River; however, much of this migratory habitat is degraded and they must pass through a fish ladder at the Anderson-Cottonwood Irrigation Dam (ACID). Also, the many flood bypasses are known to strand adults in agricultural drains due to inadequate screening (Vincik and Johnson 2013). Because the primary migration corridors are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic value for the conservation of the species.

2.2.1.2.4.2 The Availability of Clean Gravel for Spawning Substrate

Suitable spawning habitat for winter-run exists in the upper 60 miles of the Sacramento River between Keswick Dam and RBDD. However, the majority of spawning habitat currently being used occurs in the first 10 miles below Keswick Dam. The available spawning habit is completely outside the historical range utilized by winter-run upstream of Keswick Dam. Because Shasta and Keswick dams block gravel recruitment, the U.S. BOR (Reclamation) annually injects spawning gravel into various areas of the upper Sacramento River. With the supplemented gravel injections, the upper Sacramento River reach continues to support a small naturally-spawning winter-run Chinook salmon population. Even in degraded reaches, spawning habitat has a high value for the conservation of the listed species as its function directly affects the spawning success and reproductive potential of listed salmonids.

2.2.1.2.4.3 Adequate River Flows for Successful Spawning, Incubation of Eggs, Fry Development and Emergence, and Downstream Transport of Juveniles

An April 5, 1960 Memorandum of Agreement between Reclamation and the CDFW (formerly California Department of Fish and Game) originally established flow objectives in the Sacramento River for the protection and preservation of fish and wildlife resources. In addition, Reclamation complies with the 1990 flow releases required in SWRCB Water Rights Order (WRO) 90-05 for the protection of Chinook salmon. This order includes a minimum flow release of 3,250 cfs from Keswick Dam downstream to RBDD from September through February during all water year types, except critically dry.

The lack of channel forming flows and the reversed natural flow pattern (high flows in summer, low flows in late fall/winter) modifies critical habitat, including impairing geomorphic processes, which has been identified as a stressor for Sacramento River winter-run Chinook salmon (National Marine Fisheries Service 2014a).

2.2.1.2.4.4 Water Temperatures at 5.8–14.1°C (42.5–57.5°F) for Successful Spawning, Egg Incubation, and Fry Development

Summer flow releases from Shasta Reservoir for agriculture and other consumptive uses drive operations of Shasta and Keswick dam water releases during the period of winter-run migration, spawning, egg incubation, fry development, and emergence. This pattern—the opposite of the pre-dam hydrograph—benefits winter-run by providing cold water for miles downstream during the hottest part of the year. The extent to which winter-run habitat needs are met depends on Reclamation’s other operational commitments, including those to water contractors, Delta requirements pursuant to State Water Rights Decision 1641 (D-1641), and Shasta Reservoir end-of-September storage levels required in the NMFS 2009 biological opinion on the long-term operations of the Central Valley Project and State Water Project (NMFS 2009a). WRO 90-05 and 91-1 require Reclamation to operate Shasta, Keswick, and Spring Creek Powerhouse to meet a daily average water temperature of 13.3°C (56°F) at RBDD. They also provide the exception that the water temperature compliance point (TCP) may be modified when the objective cannot be met at RBDD. Based on these requirements, Reclamation models monthly forecasts and determines how far downstream 13.3°C (56°F) can be maintained throughout the winter-run spawning, egg incubation, and fry development stages.

In every year since WRO 90-05 and 91-1 were issued, operation plans have included modifying the TCP to make the best use of the cold water available based on water temperature modeling and current spawning distribution. Once a TCP has been identified and established in May, it generally does not change, and therefore, water temperatures are typically adequate through the summer for successful winter-run egg incubation and fry development for those redds constructed upstream of the TCP (except for in some critically dry and drought years). However, by continually moving the TCP upstream, the value of that habitat is degraded by reducing the spawning area in size and imprinting upon the next generation to return further upstream.

2.2.1.2.4.5 Habitat Areas and Adequate Prey That Are Not Contaminated

Water quality conditions have improved since the 1980s due to stricter standards and Environmental Protection Agency (EPA) Superfund site cleanups. No longer are there fish kills in the Sacramento River caused by the heavy metals (*e.g.*, lead, zinc and copper) found in the Spring Creek runoff. However, legacy contaminants such as mercury (and methyl mercury), polychlorinated biphenyls (PCB), heavy metals and persistent organochlorine pesticides continue to be found in watersheds throughout the Central Valley. In 2010, the EPA listed the Sacramento River as impaired under the CWA, Section 303(d), due to high levels of pesticides, herbicides, and heavy metals (http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/category5_report.shtml).

Although most of these contaminants are at low concentrations in the food chain, they continue to work their way into the base of the food web, particularly when sediments are disturbed and previously entombed compounds are released into the water column.

Adequate prey for juvenile salmon to survive and grow consists of abundant aquatic and terrestrial invertebrates that make up the majority of their diet before entering the ocean. Exposure to these contaminated food sources such as invertebrates may create delayed sublethal effects that reduce fitness and survival (Laetz et al. 2009). Contaminants are typically associated with areas of urban development, agriculture, or other anthropogenic activities (*e.g.*, mercury contamination as a result of gold mining or processing). Areas with low human impacts frequently have low contaminant burdens and, therefore, lower levels of potentially harmful toxicants in the aquatic system. Freshwater rearing habitat has a high intrinsic value for the conservation of the listed species even if the current conditions are significantly degraded from their natural state.

2.2.1.2.4.6 Riparian Habitat that Provides for Successful Juvenile Development and Survival

The channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento River system typically have low habitat complexity, low abundance of food organisms, and offer little protection from predators. Juvenile life stages of salmonids are dependent on the natural functioning of this habitat for successful survival and recruitment. Ideal habitat contains natural cover, such as riparian canopy structure, submerged and overhanging LWM, aquatic vegetation, large rocks and boulders, side channels, and undercut banks that augment juvenile and adult mobility, survival, and food supply. Riparian recruitment is prevented from becoming established due to the reversed hydrology (*i.e.*, high summer time flows and low winter flows prevent tree seedlings from establishing). However, there are some complex, productive habitats within historical floodplains [*e.g.*, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa)] and flood bypasses (*i.e.*, fish in Yolo and Sutter bypasses experience rapid growth and higher survival due to abundant food resources) seasonally available that remain in the system. Nevertheless, the current condition of degraded riparian habitat along the mainstem Sacramento River restricts juvenile growth and survival (Michel 2010, Michel et al. 2012).

2.2.1.2.4.7 Access Downstream so that Juveniles Can Migrate from the Spawning Grounds to San Francisco Bay and the Pacific Ocean

Freshwater emigration corridors should be free of migratory obstructions, with water quantity and quality conditions that enhance migratory movements. Migratory corridors are downstream of the Keswick Dam spawning areas and include the mainstem of the Sacramento River to the Delta, as well as non-natal rearing areas near the confluence of some tributary streams.

Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. Unscreened diversions that entrain juvenile salmonids are prevalent throughout the mainstem Sacramento River and in the Delta. Predators such as striped bass (*Morone saxatilis*) and Sacramento pikeminnow (*Ptychocheilus grandis*) tend to concentrate immediately downstream of diversions, resulting in increased mortality of juvenile Chinook salmon.

Water pumping at the CVP/SWP export facilities in the South Delta at times causes the flow in the river to move back upstream (reverse flow), further disrupting the emigration of juvenile winter-run by attracting and diverting them to the interior Delta, where they are exposed to increased rates of predation, other stressors in the Delta, and entrainment at pumping stations. NMFS' biological opinion on the long-term operations of the CVP/SWP (National Marine Fisheries Service 2009) sets limits to the strength of reverse flows in the Old and Middle Rivers, thereby keeping salmon away from areas of highest mortality. Regardless of the condition, the remaining estuarine areas are of high value for the conservation of listed species because they provide factors that function as rearing habitat and as an area of transition to the ocean environment.

2.2.1.2.4.8 Summary of the Physical or Biological Features of Winter-run Chinook Salmon Critical Habitat

PBFs of critical habitat for winter-run include upstream and downstream access and the availability of certain habitat conditions necessary to meet the biological requirements of the species. Currently, many of these PBFs are degraded and provide limited high quality habitat. Conditions that lessen the quality of the migratory corridor for juveniles include unscreened diversions, altered flows in the Delta, and the lack of floodplain habitat.

In addition, water operations that limit the extent of cold water below Shasta Dam have reduced the available spawning habitat (based on water temperature). Although the habitat for winter-run has been highly degraded, the importance of the reduced spawning habitat, migratory corridors, and rearing habitat that remains is of high value for the conservation of the listed species.

2.2.1.3 California Central Valley Steelhead

The following federally listed DPS and designated critical habitat occurs in the action area and may be affected by the proposed action:

- California Central Valley Steelhead DPS was
  - originally listed as threatened on March 19, 1998 (63 FR 13347) and
  - reaffirmed as threatened on January 5, 2006 (71 FR 834).
- California Central Valley Steelhead critical habitat was
  - designated on September 2, 2005 (70 FR 52488)

2.2.1.3.1 Species Listing and Critical Habitat Designation History

The California Central Valley (CCV) steelhead DPS was originally listed as threatened on March 19, 1998 (63 FR 13347). Following a new status review (Good et al. 2005) and after application of the agency's hatchery listing policy, NMFS reaffirmed its status as threatened and also listed the Feather River Hatchery and Coleman National Fish Hatchery (Coleman) stocks as part of the DPS on January 5, 2006 (71 FR 834). On May 5, 2016, NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (National Marine Fisheries Service 2016a). Critical habitat was designated for CCV steelhead on September 2, 2005 (70 FR 52488).

2.2.1.3.2 California Central Valley Steelhead Life History

2.2.1.3.2.1 Egg to Parr

The length of time it takes for eggs to hatch depends mostly on water temperature. Steelhead eggs hatch in three to four weeks at 10°C (50°F) to 15°C (59°F) (Moyle 2002). After hatching, alevins remain in the gravel for an additional two to five weeks while absorbing their yolk sacs and emerge in spring or early summer (Barnhart 1986). Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Upon emergence, fry inhale air at the stream surface to fill their air bladders, absorb the remains of their yolks in the course of a few days, and start to feed actively, often in schools (Barnhart 1986, National Marine Fisheries Service 1996).

The newly emerged juveniles move to shallow, protected areas associated within the stream margin (McEwan and Jackson 1996). As steelhead parr increase in size and their swimming abilities improve, they increasingly exhibit a preference for higher velocity and deeper mid-channel areas (Hartman 1965, Everest and Chapman 1972, Fontaine 1988).

Productive juvenile rearing habitat is characterized by complexity, primarily in the form of cover, which can be deep pools, woody debris, aquatic vegetation, or boulders. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991). Optimal water temperatures for growth range from 15°C (59°F) to 20°C (68°F) (McCullough et al. 2001, Spina et al. 2006). _ENREF_71Cherry et al. (1975) found preferred temperatures for rainbow trout ranged from 11°C (51.8°F) to 21°C (69.8°F) depending on acclimation temperatures (cited in Myrick and Cech 2001).

2.2.1.3.2.2 Smolt Migration

Juvenile steelhead will often migrate downstream as parr in the summer or fall of their first year of life, but this is not a true smolt migration (Loch et al. 1988). Smolt migrations occur in the late winter through spring, when juveniles have undergone a physiological transformation to survive in the ocean and become slender in shape, bright silvery in coloration, with no visible parr marks. Emigrating steelhead smolts use the lower reaches of the Sacramento River and the Delta primarily as a migration corridor to the ocean. There is little evidence that they rear in the Delta or on floodplains, though there are few behavioral studies of this life-stage in the California Central Valley.

2.2.1.3.2.3 Ocean Behavior

Unlike Pacific salmon, steelhead do not appear to form schools in the ocean (Behnke 1992). Steelhead in the southern part of their range appear to migrate close to the continental shelf, while more northern populations may migrate throughout the northern Pacific Ocean (Barnhart 1986). It is possible that California steelhead may not migrate to the Gulf of Alaska region of the north Pacific as commonly as more northern populations such as those in Washington and British Colombia. (Burgner et al. 1993) reported that no CWT steelhead from California hatcheries were recovered from the open ocean surveys or fisheries that were sampled for steelhead between 1980 and 1988. Only a small number of disk-tagged fish from California were captured. This behavior might explain the small average size of Central Valley steelhead relative to populations in the Pacific Northwest, as food abundance in the nearshore coastal zone may not be as high as in the Gulf of Alaska.

Pearcy et al. (1990)_ENREF_246 found that the diets of juvenile steelhead caught in coastal waters of Oregon and Washington were highly diverse and included many species of insects, copepods, and amphipods, but by biomass the dominant prey items were small fishes (including rockfish and greenling) and euphausids.

There are no commercial fisheries for steelhead in California, Oregon, or Washington, with the exception of some tribal fisheries in Washington waters.

2.2.1.3.2.4 Spawning

CCV steelhead generally enter freshwater from August to November [with a peak in September (Hallock et al. 1961)] and spawn from December to April, with a peak in January through March in rivers and streams where cold, well oxygenated water is available (Hallock et al. 1961, McEwan and Jackson 1996, Williams 2006).

The timing of upstream migration is correlated with high flow events, such as freshets, and the associated change in water temperatures (Workman et al. 2002). Adults typically spend a few months in freshwater before spawning (Williams 2006), but very little is known about where they hold between entering freshwater and spawning in rivers and streams. The threshold of a 56°F maximum water temperature that is commonly used for Chinook salmon is often extended to steelhead, but temperatures for spawning steelhead are not usually a concern because this activity occurs in the late fall and winter months when water temperatures are low. Female steelhead construct redds in suitable gravel and cobble substrate, primarily in pool tailouts and heads of riffles.

Few direct counts of fecundity are available for CCV steelhead populations, but because the number of eggs laid per female is highly correlated with adult size, adult size can be used to estimate fecundity with reasonable precision. Adult steelhead size depends on the duration of and growth rate during their ocean residency (Meehan and Bjornn 1991). CCV steelhead generally return to freshwater after one or two years at sea (Hallock et al. 1961), and adults typically range in size from two to twelve pounds (Reynolds et al. 1993). Steelhead about 55-cm FL (fork length) long may have fewer than 2,000 eggs, whereas steelhead 85-cm FL long can have 5,000 to 10,000 eggs depending on the stock (Meehan and Bjornn 1991). The average for Coleman since 1999 is about 3,900 eggs per female (U.S. Fish and Wildlife Service 2011).

_ENREF_305Unlike Pacific salmon, steelhead are iteroparous, meaning they are capable of spawning multiple times before death (Busby et al. 1996). However, it is rare for steelhead to spawn more than twice before dying; and repeat spawners tend to be biased towards females (Busby et al. 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby et al. 1996). Although one-time spawners are the great majority, Shapovalov and Taft (1954) reported that repeat spawners were relatively numerous (17.2 percent) in Waddell Creek. Null et al. (2013) found between 36 percent and 48 percent of reconditioned kelts released from Coleman in 2005 and 2006 survived to spawn the following spring, which is in sharp contrast to what Hallock (1989) reported for Coleman in the 1971 season, where only 1.1 percent of adults were fish that had been tagged the previous year. Most populations have never been studied to determine the percentage of repeat spawners. Hatchery steelhead are typically less likely than wild fish to survive to spawn a second time (Leider et al. 1986).

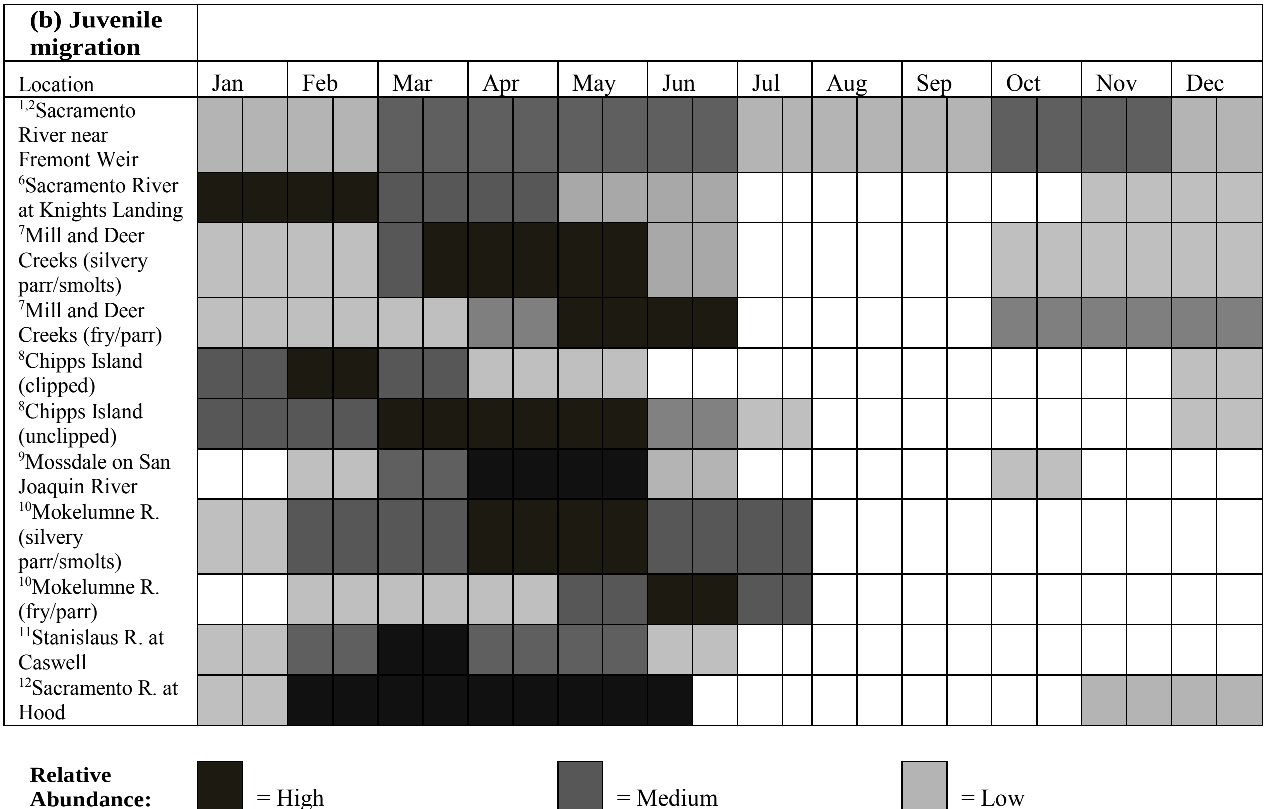
2.2.1.3.2.5 Kelts

Post-spawning steelhead (kelts) may migrate downstream to the ocean immediately after spawning, or they may spend several weeks holding in pools before outmigrating (Shapovalov and Taft 1954). Recent studies have shown that kelts may remain in freshwater for an entire year after spawning (Teo et al. 2011), but that most return to the ocean (Null et al. 2013).

In Table 2-6, darker shades indicate months of greatest relative abundance.

Table 2-6. The Temporal Occurrence of (a) Adult and (b) Juvenile California Central Valley Steelhead at Locations in the Central Valley

(a) Adult migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1]Sacramento River near Fremont Weir												
[2]Sacramento R. at Red Bluff												
[3]Mill and Deer Creeks												
[4]Mill Creek at Clough Dam												
[5]San Joaquin River												



Sources: [1](Hallock et al. 1957); [2](McEwan 2001); [3](Harvey 1995); [4]CDFW unpublished data; [5]CDFG Steelhead Report Card Data 2007; [6]NMFS analysis of 1998-2011 CDFW data; [7](Johnson and Merrick 2012); [8]NMFS analysis of 1998-2011 USFWS data; [9]NMFS analysis of 2003-2011 USFWS data; [10]unpublished EBMUD RST data for 2008-2013; [11]Oakdale RST data (collected by Fishbio) summarized by John Hannon (Reclamation); [12](Schaffter 1980).

2.2.1.3.3 Description of Viable Salmonid Population (VSP) Parameters

As an approach to evaluate the likelihood of viability of the CCV steelhead DPS, and determine the extinction risk of the DPS, NMFS uses the VSP concept. In this section, we evaluate the VSP parameters of abundance, productivity, spatial structure, and diversity. These specific parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of salmonids (McElhany et al. 2000).

2.2.1.3.3.1 Abundance

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s, the CCV steelhead run size had declined to about 40,000 adults (McEwan 2001). Hallock et al. (1961)_ENREF_118 estimated an average of 20,540 adult CCV steelhead per year from 1953-54 through 1958-59 in the Sacramento River upstream of the Feather River. During this same period of the 20,542 CCV steelhead, the average number of wild CCV steelhead per year were estimated to be 18,048. CCV steelhead counts at the RBDD declined from an average of 11,187 from 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). CCV steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations, and comprehensive CCV steelhead population monitoring has not taken place in the Central Valley since then, despite 100 percent marking of hatchery steelhead smolts since 1998. Efforts are underway to improve this deficiency, and a long-term adult escapement monitoring plan is being planned (Eilers et al. 2010).

Current abundance data is limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data is the most reliable because redd surveys for CCV steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period.

Coleman operates a weir on Battle Creek where all upstream fish movement is blocked August through February, during the hatchery spawning season. Counts of CCV steelhead captured at and passed above this weir represent one of the better data sources for the Central Valley DPS. However, changes in hatchery policies and transfer of fish complicate the interpretation of these data. In 2005, per NMFS request, Coleman stopped transferring all adipose-fin clipped CCV steelhead above the weir, resulting in a large decrease in the overall numbers of CCV steelhead above the weir in recent years (Figure 2-11). In addition, in 2003, Coleman transferred about 1,000 clipped adult CCV steelhead to Keswick Reservoir, and these fish are not included in the data. The result is that the only unbiased time series for Battle Creek is the number of unclipped (wild) CCV steelhead since 2001, which have declined slightly since that time, mostly because of the high returns observed in 2002 and 2003.

Prior to 2002, hatchery and natural-origin CCV steelhead in Battle Creek were not differentiable, and all CCV steelhead were managed as a single, homogeneous stock, although USFWS believes the majority of returning fish in years prior to 2002 were hatchery-origin. Abundance estimates of natural-origin CCV steelhead in Battle Creek began in 2001. These estimates of CCV steelhead abundance include all *O. mykiss*, including resident and anadromous fish.

Steelhead returns to Coleman NFH have increased over the last four years (National Marine Fisheries Service 2016a). After hitting a low of only 790 fish in 2010, the last two years have averaged 2,895 fish. Since 2003, adults returning to the hatchery have been classified as wild (unclipped) or hatchery produced (adipose fin clipped). Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relatively steady, typically 200–300 fish each year. Numbers of wild adults have ranged from 185 to 334 in the last five years [Figure 2-11; (National Marine Fisheries Service 2016a)].

Redd counts are conducted in the American River and in Clear Creek (Shasta County). An average of 151 redds have been counted in Clear Creek from 2001 to 2010, and an average of 154 redds have been counted on the American River from 2002-2010. (Data from Hannon et al. 2003, Hannon and Deason 2008, Chase 2010).

CCV steelhead have been counted at the Woodbridge Irrigation District Dam, 1990-2004 and 2010-2012. The counts prior to 1997 ended in December. The available data suggest a slightly increasing trend. However, it is generally believed that most of the *O. mykiss* spawning in the Mokelumne River are resident fish (Satterthwaite et al. 2010) that are not part of the CCV steelhead DPS.

The Clear Creek CCV steelhead population appears to have increased in abundance since Saeltzer Dam was removed in 2000, as the number of redds observed in surveys conducted by the USFWS has steadily increased since 2001. The average redd index from 2001 to 2011 is 157, representing somewhere between 128 and 255 spawning adult CCV steelhead on average each year. The vast majority of these CCV steelhead are wild fish, as no hatchery CCV steelhead are stocked in Clear Creek.

Catches of CCV steelhead at the fish collection facilities in the southern Delta are another source of information on the relative abundance of the CCV steelhead DPS, as well as the proportion of wild CCV steelhead relative to hatchery CCV steelhead (CDFG; ftp.delta.dfg.ca.gov/salvage). The overall catch of CCV steelhead at these facilities has been highly variable since 1993 (Figure 2-15). The percentage of unclipped CCV steelhead in salvage has also fluctuated, but has generally declined since 100 percent clipping started in 1998. The number of stocked hatchery CCV steelhead has remained relatively constant overall since 1998, even though the number stocked in any individual hatchery has fluctuated.

Redd counts have been conducted on the Feather River since 2003. The data is not used to estimate the number of natural spawners due to the difficulty of identifying CCV steelhead redds in certain conditions (turbidity, etc.) and also because late fall-run Chinook are often spawning concurrently with CCV steelhead. Additionally, the physical data is used to inform habitat improvement models targeted at CCV steelhead habitat restoration so it is even more important that only CCV steelhead redds (and not Chinook) are identified in the survey. What the data does suggest is that most of the spawning occurs in small side channels in the uppermost reaches of the low flow channel (Department of Water Resources 2003).

The returns of CCV steelhead to the Feather River Hatchery have decreased greatly over time, with only 679, 312, and 86 fish returning in 2008, 2009 and 2010, respectively (Figure 2-15). This is despite the fact that almost all these fish are hatchery fish, and stocking levels have remained fairly constant, suggesting that smolt or ocean survival was poor for these smolt classes. The average return in 2006-2010 was 649, while the average from 2001 to 2005 was 1,963. Since 2010 the numbers have rebounded, with a high of 1,797 in 2013, and have averaged over 1,100 fish over the last five years. Escapement at this hatchery seems to be quite variable over the years, despite the fact that stocking levels have remained fairly constant and that the vast majority of fish are of hatchery origin.

The years 2009 and 2010 showed poor returns of CCV steelhead to the Feather River Hatchery and Coleman Hatchery, probably due to three consecutive drought years in 2007-2009, which would have impacted parr and smolt survival in the rivers, and possibly due to poor coastal upwelling conditions in 2005 and 2006, which strongly impacted fall-run Chinook salmon post-smolt survival (Lindley et al. 2009). Wild (unclipped) adult counts appear not to have decreased as greatly in those same years, based on returns to the hatcheries and redd counts conducted on Clear Creek, and the American and Mokelumne Rivers. This may reflect greater fitness of naturally produced CCV steelhead relative to hatchery fish, and merits further study.

Overall, CCV steelhead returns to Central Valley hatcheries have fluctuated so much from 2001 to 2014 that no clear trend is present, other than the fact that the numbers are still far below those seen in the 1960s and 70s, and only a tiny fraction of the historical estimate. Returns of natural origin fish are very poorly monitored, but the little data available suggest that the numbers are very small, though perhaps not as variable from year to year as the hatchery returns.

Figure 2-13 shows the number of CCV steelhead that returned to the Coleman each year. Adipose fin-clipping of hatchery smolts started in 1998, and since 2003 all returning CCV steelhead have been categorized by origin.

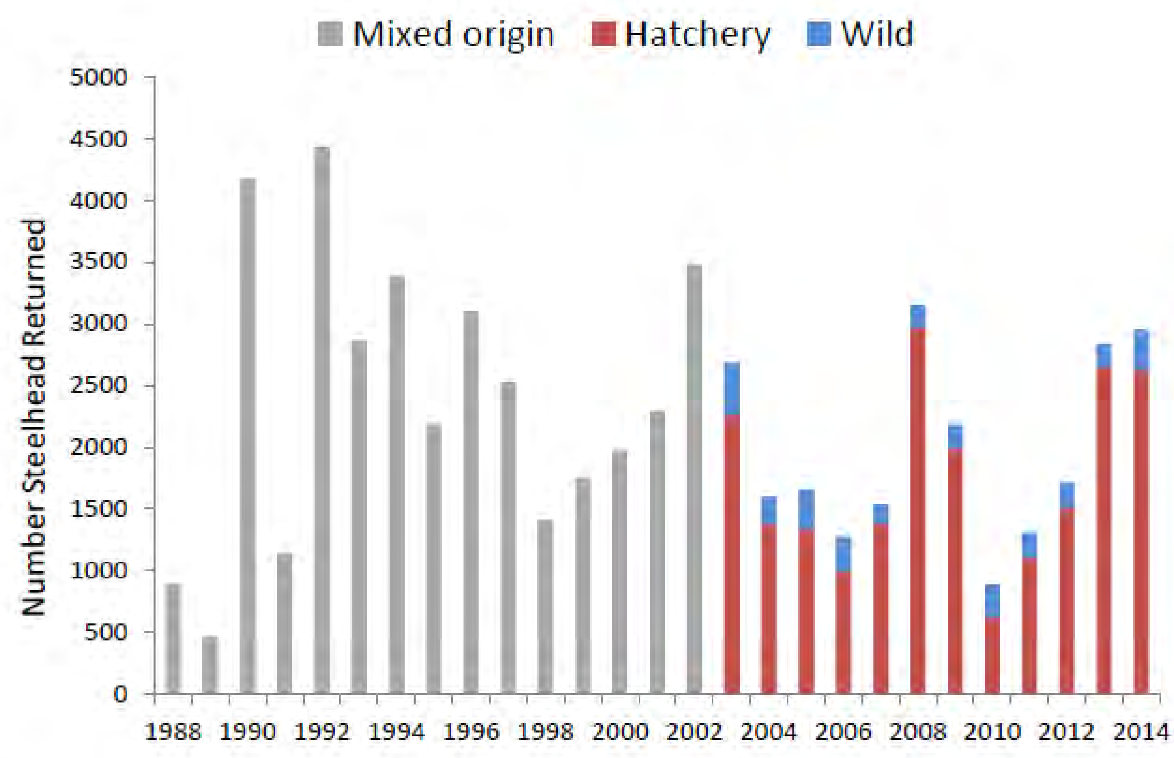


Figure 2-13. Steelhead Returns to Coleman

Figure 2-14 shows the number of CCV steelhead that returned to the FRFH each year. Almost all fish are hatchery origin.

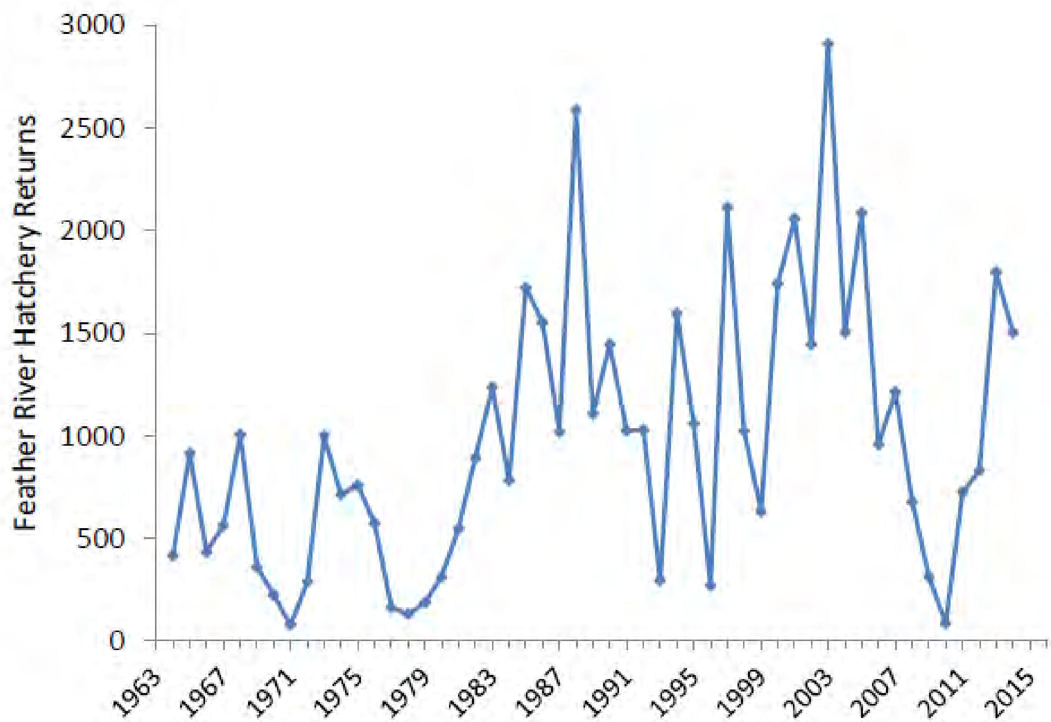


Figure 2-14. Feather River Hatchery Returns

2.2.1.3.3.2 Productivity

100,000 to 300,000 naturally produced juvenile CCV steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good et al. 2005). The Mossdale trawls on the San Joaquin River conducted annually by CDFW and USFWS capture steelhead smolts, although usually in very small numbers. These CCV steelhead recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest that the productivity of CCV steelhead in these tributaries is very low. In addition, the Chipps Island midwater trawl dataset from the USFWS provides information on the trend (Williams et al. 2011).

Nobriga and Cadrett (2001) used the ratio of adipose fin-clipped (hatchery) to unclipped (wild) CCV steelhead smolt catch ratios in the Chipps Island trawl from 1998 through 2000 to estimate that about 400,000 to 700,000 CCV steelhead smolts are produced naturally each year in the Central Valley. Good et al. (2005) made the following conclusion based on the Chipps Island data:

> *If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1 percent of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's*

> *(2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s.*

In the Mokelumne River, East Bay Municipal Utilities District (EBMUD) has included CCV steelhead in their redd surveys on the Lower Mokelumne River since the 1999-2000 spawning season (National Marine Fisheries Service 2011b). Based on data from these surveys, the overall trend suggests that redd numbers have slightly increased over the years (2000-2010). However, according to (Satterthwaite et al. 2010), it is likely that most of the *O. mykiss* spawning in the Mokelumne River are non-anadromous (or resident) fish rather than CCV steelhead. The Mokelumne River CCV steelhead population is supplemented by Mokelumne River Hatchery production. In the past, this hatchery received fish imported from the Feather River and Nimbus hatcheries (Merz 2002). This practice was discontinued for Nimbus stock after 1991, however, and discontinued for Feather River stock after 2008. Recent results show that the Mokelumne River Hatchery CCV steelhead are closely related to Feather River fish, suggesting that there has been little carry-over of genes from the Nimbus stock (Garza and Pearse 2008, Pearse and Garza 2015).

Analysis of data from the Chipps Island midwater trawl conducted by the USFWS indicates that natural CCV steelhead production has continued to decline and that hatchery origin fish represent an increasing fraction of the juvenile production in the Central Valley. Beginning in 1998, all hatchery-produced CCV steelhead in the Central Valley have been adipose fin clipped (ad-clipped). Since that time, trawl data indicates that the proportion of ad-clipped steelhead juveniles captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile CCV steelhead. The proportion of hatchery fish exceeded 90 percent in 2007, 2010, and 2011 (Figure 2-16). Because hatchery releases have been fairly consistent through the years, this data suggests that the natural production of CCV steelhead has been declining in the Central Valley.

Figure 2-15 depicts the catch of steelhead at Chipps Island by the USFWS midwater trawl survey from 1998 to 2011. All hatchery steelhead have been marked starting in 1998.

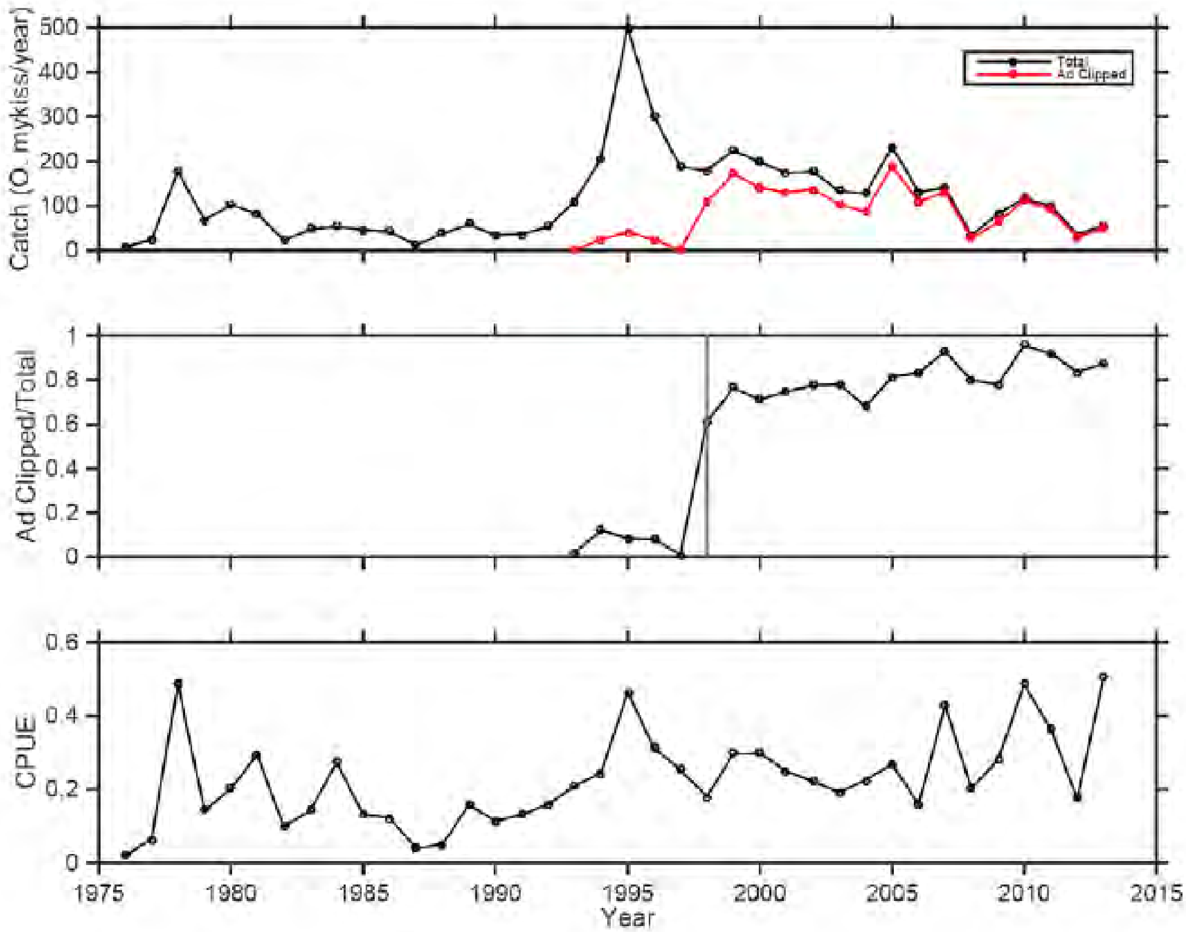


Figure 2-15. Catch of Steelhead at Chipps Island, 1998-2013.

Top: Catch of steelhead at Chipps Island by the USFWS midwater trawl survey.

Middle: Fraction of the catch bearing an adipose fin clip. 100% of steelhead production has been marked starting in 1998, denoted with the vertical gray line.

Bottom: CPUE in fish per million m-3 swept volume. CPUE is not easily comparable across the entire period of record, as over time, sampling has occurred over more of the year and catches of juvenile steelhead are expected to be low outside of the primary migratory season.

Salvage of juvenile steelhead at the CVP and SWP fish collection facilities also indicates a reduction in the natural production of CCV steelhead (Figure 2-16). The percentage of unclipped juvenile CCV steelhead collected at these facilities declined from 55 percent to 22 percent over the years 1998 to 2010 (National Marine Fisheries Service 2011b).

Figure 2-16 shows steelhead salvaged in the Delta fish collection facilities from 1993 to 2010. All hatchery steelhead have been adipose fin-clipped since 1998. Data are from CDFG, at: ftp.delta.dfg.ca.gov/salvage.

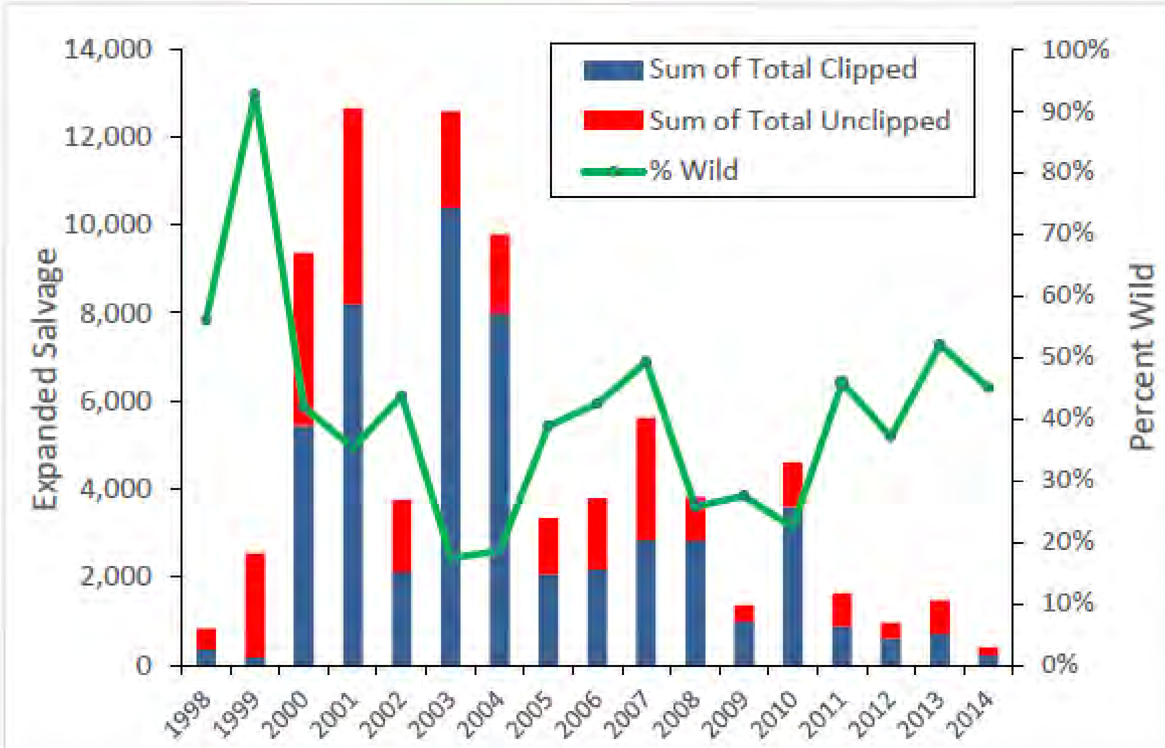


Figure 2-16. Steelhead Salvaged in the Delta Fish Collection Facilities, 1993-2010

In contrast to the data from Chipps Island and the CVP and SWP fish collection facilities, some populations of wild CCV steelhead appear to be improving (Clear Creek) while others (Battle Creek) appear to be better able to tolerate the recent poor ocean conditions and dry hydrology in the Central Valley compared to hatchery produced fish (National Marine Fisheries Service 2011a). Since 2003, fish returning to Coleman have been identified as wild (adipose fin intact) or hatchery produced (ad-clipped). Returns of wild fish to the hatchery have remained fairly steady at 200-300 fish per year, but represent a small fraction of the overall hatchery returns. Numbers of hatchery origin fish returning to the hatchery have fluctuated much more widely, ranging from 624 to 2,968 fish per year.

2.2.1.3.3.3 Spatial Structure

About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* in the Central Valley is now upstream of impassible dams (Lindley et al. 2006). The extent of habitat loss for CCV steelhead most likely was much higher than that for salmon because CCV steelhead were undoubtedly more extensively distributed. Due to their superior jumping ability, the timing of their upstream migration that coincided with the winter rainy season, and their less restrictive preferences for spawning gravels, CCV steelhead could have utilized at least hundreds of miles of smaller tributaries not accessible to the earlier-spawning salmon (Yoshiyama et al. 2001). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead were found as far south as the Kings River (and possibly Kern River systems in wet years) (McEwan 2001). Native American groups such as the Chunut people have had accounts of steelhead in the Tulare Basin (Gayton 1948, Yoshiyama et al. 2001).

CCV steelhead appear to be well distributed throughout the Central Valley below the major rim dams (Good et al. 2005, National Marine Fisheries Service 2011a). Zimmerman et al. (2009)_ENREF_336 used otolith microchemistry to show that *O. mykiss* of anadromous parentage occur in all three major San Joaquin River tributaries, but at low levels, and that these tributaries have a higher percentage of resident *O. mykiss* compared to the Sacramento River and its tributaries.

Monitoring has detected small numbers of CCV steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of CCV steelhead (McEwan 2001). On the Stanislaus River, CCV steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S. P. Cramer Fish Sciences 2000). A counting weir has been in place in the Stanislaus River since 2002 and in the Tuolumne River since 2009 to detect adult salmon. These weirs have also detected *O. mykiss* passage. In 2012, 15 adult *O. mykiss* were detected passing the Tuolumne River weir and 82 adult *O. mykiss* were detected at the Stanislaus River weir (FISHBIO LLC 2012, 2013a).

In addition, rotary screw trap sampling has occurred since 1995 in the Tuolumne River, but only one juvenile *O. mykiss* was caught during the 2012 season (FISHBIO LLC 2013b). Rotary screw traps are well known to be very inefficient at catching steelhead smolts, so the actual numbers of smolts produced in these rivers could be much higher. Rotary screw trapping on the Merced River has occurred since 1999. A fish counting weir was installed on this river in 2012. Since installation, one adult *O. mykiss* has been reported passing the weir. Juvenile *O. mykiss* were not reported captured in the rotary screw traps on the Merced River until 2012, when a total of 381 were caught (FISHBIO 2013). The unusually high number of *O. mykiss* captured may be attributed to a flashy storm event that rapidly increased flows over a 24-hour period. Annual Kodiak trawl surveys are conducted on the San Joaquin River at Mossdale by CDFW. A total of 17 *O. mykiss* were caught during the 2012 season (California Department of Fish and Wildlife 2013a).

The low adult returns to the San Joaquin tributaries and the low numbers of juvenile emigrants typically captured suggest that existing populations of CCV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed. The loss of these populations would severely impact CCV steelhead spatial structure and further challenge the viability of the CCV steelhead DPS.

Most of the steelhead populations in the Central Valley have a high hatchery component, including Battle Creek (adult intercepted at the Coleman NFH weir), the American River, Feather River, and Mokelumne River. This is confounded, of course, by the fact that most of the dedicated monitoring programs in the Central Valley occur on rivers that are annually stocked. Clear Creek and Mill Creek are the exceptions.

Implementation of CDFW’s Steelhead Monitoring Program began during the fall of 2015. Important components of the program include a Mainstem Sacramento River Steelhead Mark19 Recapture Program and an Upper Sacramento River Basin Adult Steelhead Video/DIDSON Monitoring Program. The monitoring program will use a temporally stratified mark-recapture survey design in the lower Sacramento River, employing wire fyke traps to capture, mark, and recapture upstream migrating adult steelhead to estimate adult steelhead escapement from the Sacramento-San Joaquin River Delta. Data collected from recaptured adult steelhead will provide additional information on tributary escapement, survival, population structure, population distribution, and spatial and temporal behavior of both hatchery- and natural-origin steelhead.

Efforts to provide passage of salmonids over impassable dams have the potential to increase the spatial diversity of CCV steelhead populations if the passage programs are implemented for CCV steelhead. Also, the San Joaquin River Restoration Program (SJRRP) calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of CV spring-run and fall-run Chinook salmon. If the SJRRP is successful, habitat improved for CV spring-run Chinook salmon could also benefit CCV steelhead (National Marine Fisheries Service 2011c).

2.2.1.3.3.4 Genetic Diversity

CCV steelhead abundance and growth rates continue to decline, largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley et al. 2006). Recent reductions in population size are also supported by genetic analysis (Nielsen et al. 2003). Garza and Pearse (2008)_ENREF_109 analyzed the genetic relationships among CCV steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to *O. mykiss* above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers.

The genetic diversity of CCV steelhead is also compromised by hatchery origin fish, which likely comprise the majority of the annual spawning runs, placing the natural population at a high risk of extinction (Lindley et al. 2007). There are four hatcheries (Coleman National Fish Hatchery, Feather River Fish Hatchery, Nimbus Fish Hatchery, and Mokelumne River Fish Hatchery) in the Central Valley which combined release approximately 1.6 million yearling steelhead smolts each year. These programs are intended to mitigate for the loss of CCV steelhead habitat caused by dam construction, but hatchery origin fish now appear to constitute a major proportion of the total abundance in the DPS. Two of these hatchery stocks (Nimbus and Mokelumne River hatcheries) originated from outside the DPS (primarily from the Eel and Mad rivers) and are not presently considered part of the DPS.

2.2.1.3.3.5 Life-History Diversity

O. mykiss have long been recognized as having one of the most complex and diverse life histories among all the salmonids. Populations may be entirely anadromous, partly anadromous, or entirely resident, and levels of anadromy can vary by age and sex. One of the difficulties in assessing any steelhead data in the Central Valley is the possibility that some individuals may actually be resident fish, as it is nearly impossible to visually distinguish the two life history forms when they are juveniles.

Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms, based on their state of sexual maturity at the time of river entry and the duration of their time in freshwater before spawning.

Between 1944 and 1947, annual counts of summer-run steelhead passing through the Old Folsom Dam fish ladder during May, June, and July ranged from 400 to 1,246 fish. After

1950, when the fish ladder at Old Folsom Dam was destroyed by flood flows, summer-run steelhead were no longer able to access their historic spawning areas, and perished in the warm water downstream of Old Folsom Dam (Gerstung 1971).

Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams (McEwan and Jackson 1996, Moyle 2002). Summer-run steelhead have been extirpated due to a lack of suitable holding and staging habitat, such as cold-water pools in the headwaters of CV streams, presently located above impassible dams (Lindley et al. 2006).

Juvenile steelhead (parr) rear in freshwater for one to three years before migrating to the ocean as smolts (Moyle 2002). The time that parr spend in freshwater is inversely related to their growth rate, with faster-growing members of a cohort smolting at an earlier age, but a smaller size (Seelbach 1993, Peven et al. 1994). Hallock et al. (1961)_ENREF_118 aged 100 adult steelhead caught in the Sacramento River upstream of the Feather River confluence in 1954 and found that 70 had smolted at age-2, 29 at age-1, and one at age-3. Seventeen of the adults were repeat spawners, with three fish on their third spawning migration, and one on its fifth. Age at first maturity varies among populations. In the Central Valley, most steelhead return to their natal streams as adults at a total age of two to four years (Hallock et al. 1961, McEwan and Jackson 1996).

Deer and Mill creeks were monitored from 1994 to 2010 by the CDFW using rotary screw traps to capture emigrating juvenile CCV steelhead (Johnson and Merrick 2012). Fish in the fry stage averaged 34 and 41 mm FL in Deer and Mill, respectively, while those in the parr stage averaged 115 mm FL in both streams. Silvery parr averaged 180 and 181 mm in Deer and Mill creeks, while smolts averaged 210 mm and 204 mm FL. Most silvery parr and smolts were caught in the spring months from March through May, while fry and parr peaked later in the spring (May and June) and were fairly common in the fall (October through December) as well.

In contrast to the upper Sacramento River tributaries, Lower American River juvenile CCV steelhead have been shown to smolt at a very large size (270 to 350 mm fork length), and nearly all smolt at age-1 (Sogard et al. 2012).

Current information suggests that restoration activities for CCV steelhead should focus on habitat improvements that both increase parr survival and growth in natal rivers, especially in the summer and fall period, and improve smolt survival in the lower river reaches, the Delta, and Bays (81 FR 33468 May 26, 2016).

2.2.1.3.3.6 Summary of ESU Viability

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good et al. 2005, National Marine Fisheries Service 2011a); the long-term trend remains negative. Hatchery production and returns are dominant over natural fish, and one of the four hatcheries is dominated by Eel/Mad River origin steelhead stock.

Continued decline in the ratio between naturally produced juvenile CCV steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin-clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years.

Although there have been recent restoration efforts in the San Joaquin River tributaries, CCV steelhead populations in the San Joaquin Basin continue to show an overall very low abundance and fluctuating return rates. Lindley et al. (2007)_ENREF_166 developed viability criteria for Central Valley salmonids. Using data through 2005, they found that data were insufficient to determine the status of any of the naturally spawning populations of CCV steelhead, except for those spawning in rivers adjacent to hatcheries, which were likely to be at high risk of extinction due to extensive spawning of hatchery-origin fish in natural areas.

The widespread distribution of wild CCV steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV populations are likely very small, are not monitored, and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change (National Marine Fisheries Service 2011a). The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish. The life-history diversity of the DPS is mostly unknown, as very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.

Overall, the status of CCV steelhead appears to have changed little since the 2011 status review when the Technical Recovery Team concluded that the DPS was in danger of extinction (81 FR 33468 May 26, 2016). Further, there is still a general lack of data on the status of wild populations. There are some encouraging signs, as several hatcheries in the Central Valley have experienced increased returns of steelhead over the last few years. There has also been a slight increase in the percentage of wild steelhead in salvage at the south Delta fish facilities, and the percentage of wild fish in those data remains much higher than at Chipps Island. The new video counts at Ward Dam show that Mill Creek likely supports one of the best wild steelhead populations in the Central Valley, though at much reduced levels from the 1950s and 60s. Restoration and dam removal efforts in Clear Creek continue to benefit CCV steelhead. However, the catch of unmarked (wild) steelhead at Chipps Island is still less than 5 percent of the total smolt catch, which indicates that natural production of steelhead throughout the Central Valley remains at very low levels. Despite the positive trend on Clear Creek and encouraging signs from Mill Creek, all other concerns raised in the previous status review remain.

2.2.1.3.4 Critical Habitat and Physical and Biological Features for CCV Steelhead

Critical habitat for CCV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; the San Joaquin River, including its tributaries, and the waterways of the Delta (Figure 2-17). Currently the CCV steelhead DPS and critical habitat extends up the San Joaquin River up to the confluence with the Merced River. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series) (Bain and Stevenson 1999, 70 FR 52488 September 2, 2005).

Following is the status of the habitat types used as PBFs for CCV steelhead critical habitat.

2.2.1.3.4.1 Spawning Habitat

PBFs for CCV steelhead include freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, egg incubation, and larval development. Most of the available spawning habitat for CCV steelhead in the Central Valley is located in areas directly downstream of dams due to inaccessibility to historical spawning areas upstream and the fact that dams are typically built at high gradient locations. These reaches are often impacted by the upstream impoundments, particularly over the summer months, when high temperatures can have adverse effects upon salmonids spawning and rearing below the dams. Even in degraded reaches, spawning habitat has a high value for the conservation of the listed species as its function directly affects the spawning success and reproductive potential of listed salmonids.

2.2.1.3.4.2 Freshwater Rearing Habitat

PBFs for CCV steelhead include freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging LWM, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system (*e.g.*, the lower Cosumnes River, Sacramento River reaches with setback levees [*i.e.*, primarily located upstream of the City of Colusa]) and flood bypasses (*i.e.*, Yolo and Sutter bypasses). However, the channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Freshwater rearing habitat also has a high value for the conservation of the listed species even if the current conditions are significantly degraded from their natural state. Juvenile life stages of salmonids are dependent on the function of this habitat for successful survival and recruitment.

2.2.1.3.4.3 Freshwater Migration Corridors

PBFs for CCV steelhead include freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large woody objects, aquatic vegetation, large rocks, and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. Migratory corridors are downstream of the spawning areas and include the lower mainstems of the Sacramento and San Joaquin rivers and the Delta. These corridors allow the upstream and downstream passage of adults and the emigration of smolts. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams (*i.e.*, hydropower, flood control, and irrigation flashboard dams), unscreened or poorly screened diversions, degraded water quality, or behavioral impediments to migration. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For this reason, freshwater migration corridors are considered to have a high value for the conservation of the listed species even if the migration corridors are significantly degraded compared to their natural state.

2.2.1.3.4.4 Estuarine Areas

PBFs for CCV steelhead include estuarine areas free of obstruction and excessive predation with: water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water; natural cover such as submerged and overhanging LWM, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. Estuarine areas are considered to have a high value for the conservation of listed species as they provide factors that function to provide predator avoidance and as a transitional zone to the ocean environment.

The Sacramento River San Joaquin River Delta and San Francisco Bay have been highly altered from a natural condition. Industrial activities and urban development have been detrimental to water quality and CCV steelhead habitat. Flows into the Delta and San Francisco Bay have also been altered. In addition, much of the estuary habitat has been separated from the aquatic environments with dikes.

Figure 2-17 depicts California Central Valley steelhead designated critical habitat.

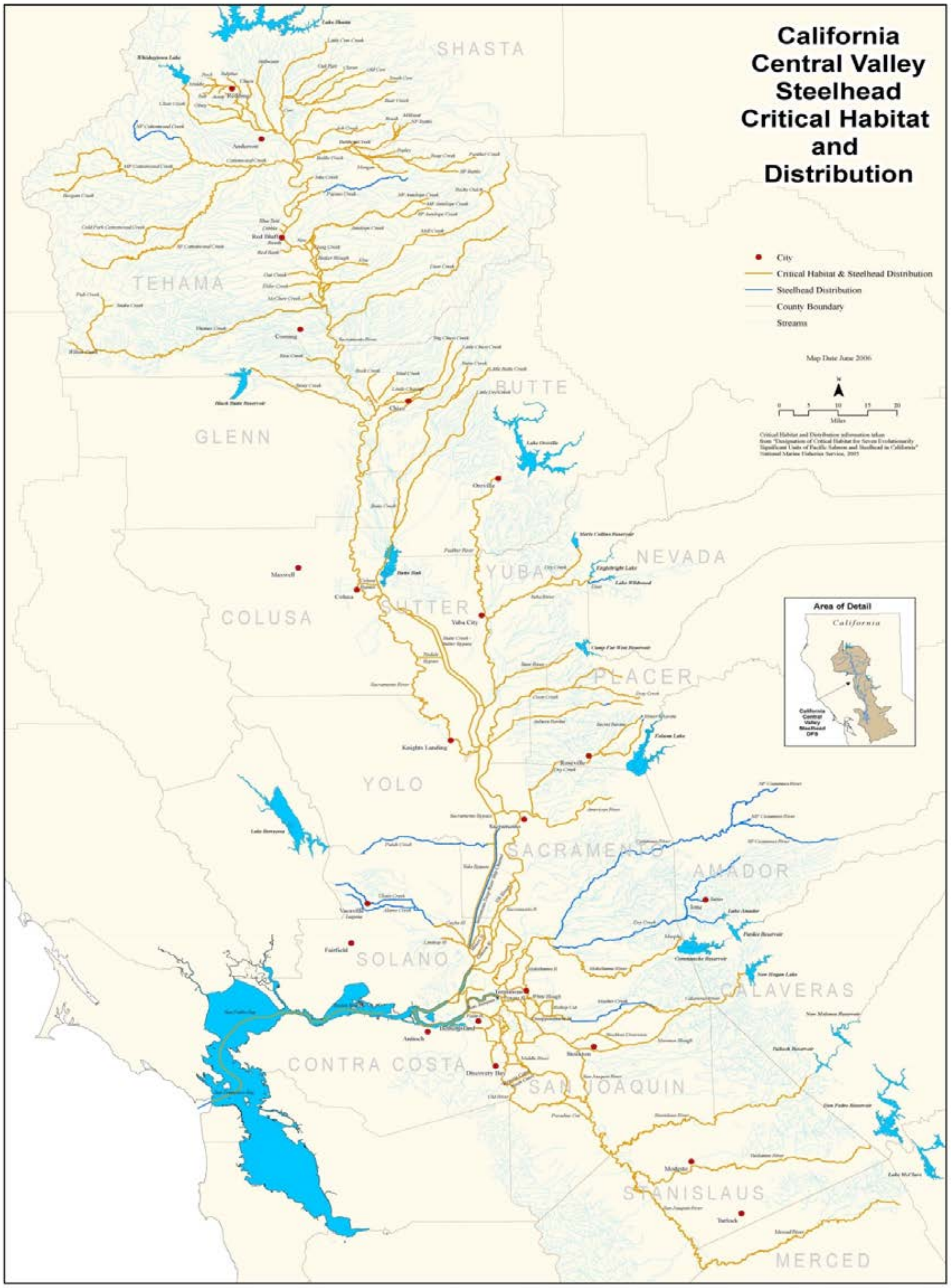


Figure 2-17. California Central Valley Steelhead Critical Habitat and Distribution

2.2.1.4 Green Sturgeon

- Southern DPS Green Sturgeon (*Acispenser medirostris*)

- Listed as threatened on April 7, 2006 (71 FR 17757 April 7, 2006)
- Critical habitat designated on October 9, 2009 (74 FR 52300 October 9, 2009).

2.2.1.4.1 Introduction

Green sturgeon (*Acipenser medirostris*) are a species of ancient fish, highly adapted to benthic environments, and very marine oriented, entering freshwater mainly to spawn, but residing in bays, estuaries, and near coastal marine environments for the vast majority of their lifespan. They are known to be long lived. Green sturgeon captured in Oregon have been age-estimated up to 52 years old, using a fin-spine analysis (Farr and Kern 2005). They are iteroparous, meaning they can spawn multiple times withing their lifespan. The details of their biology are described in section *2.2.1.4.3 Green Sturgeon Life History* and also in various literature sources such as (Moyle 2002, Adams et al. 2007, Beamesderfer et al. 2007, Israel and Klimley 2008) and in NMFS' 5-year status review (National Marine Fisheries Service 2015a).

Green sturgeon are broken into two distinct population segments (DPSs): a northern DPS (nDPS) and a southern DPS (sDPS) (Figure 2-19). While individuals from the two DPSs are visually indistinguishable and have significant geographical overlap, current information indicates that they do not interbreed, nor do they utilize the spawning areas of each other's natal rivers. The sDPS of green sturgeon is the only one that is listed under the ESA, although the nDPS is a species of concern.

The green sturgeon sDPS includes those green sturgeon that spawn south of the Eel River, and these fish primairly spawn within the Sacramento River (Figure 2-20).

Recent information indicates that sDPS green sturgeon will spawn in the Feather River (Figure 2-24) in some years (Seesholtz et al. 2014), and that spawning is also suspected in the Yuba River.

In this section we review the life history of sDPS green sturgeon, discuss population viability parameters, identify extinction risk, discuss critical habitat features and their values for the conservation of the species, and discuss the suite of factors affecting the species.

Note that while the information in this document is tailored to sDPS green sturgeon, much of this information is common to nDPS green sturgeon. Furthermore, in many instances where laboratory or field studies have been performed upon green sturgeon, the study subject has been exclusively nDPS green sturgeon. Where we are lacking equivalent information for sDPS green sturgeon, we use these informational results in order to paint a complete picture, noting that we are doing as such so that the reader remains informed. To a lesser extent, and only when necessary to fill in knowledge gaps, we also use information about white sturgeon (*Acipenser transmontanus*) and other sturgeon species, again keeping the reader informed of this cross-species informational exchange.

Figure 2-18 shows North American green sturgeon distribution.

Figure 2-18. North American Green Sturgeon Distribution

Figure 2-19 shows North American green sturgeon distribution within the California Central Valley.

Figure 2-19. North American Green Sturgeon Distribution, California Central Valley

Figure 2-20 depicts North American green sturgeon known spawning locations in the Sacramento and Feather Rivers.

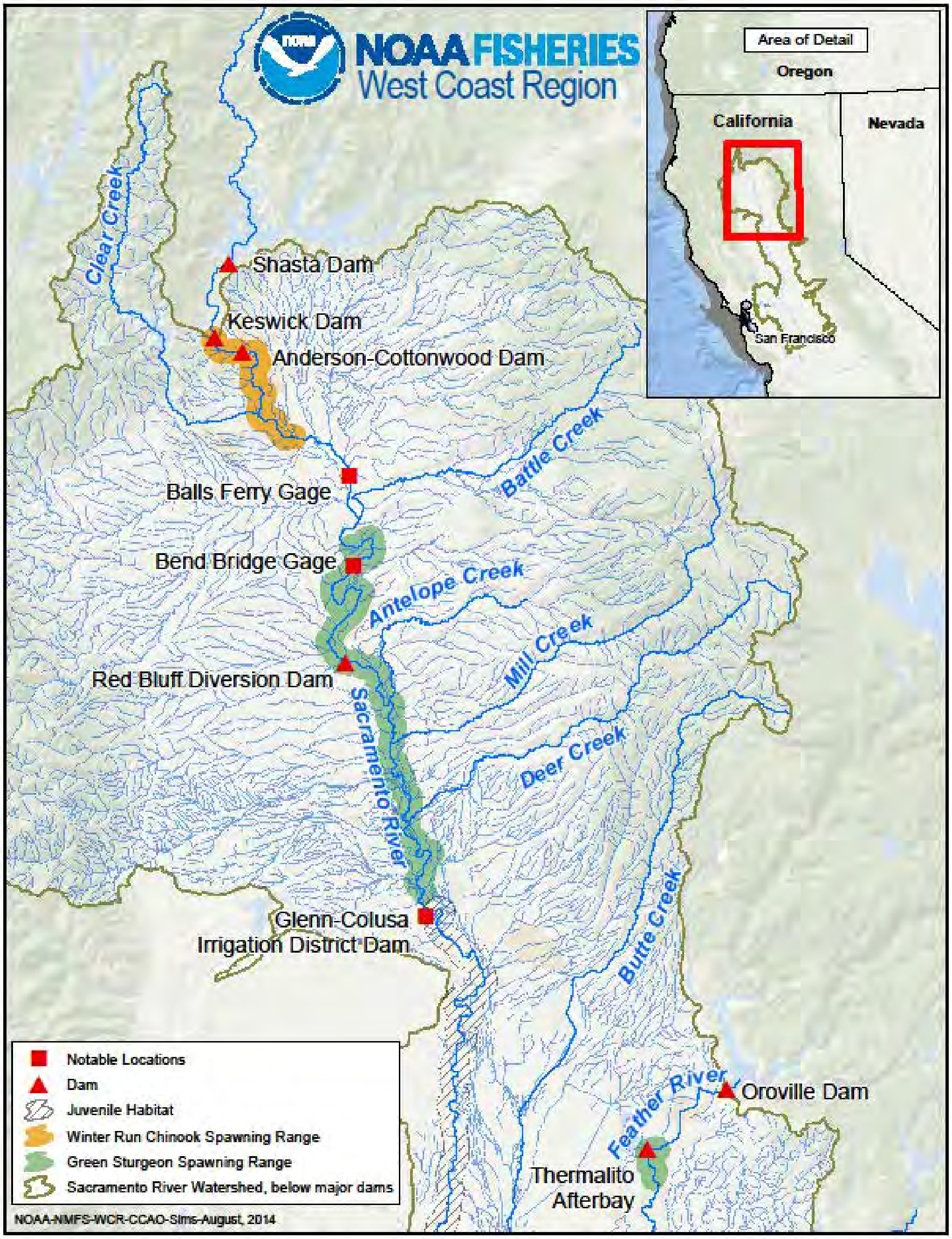


Figure 2-20. North American Green Sturgeon Known Spawning Locations, Sacramento and Feather Rivers.

2.2.1.4.2 Species Listing History

In June 2001, NMFS received a petition to list green sturgeon under the ESA and to designate critical habitat. After completing a status review (Adams et al. 2002), NMFS found that the species was comprised of two DPSs that qualify as species under the ESA, but that neither DPS warranted listing. In 2003 this "not warranted' decision was challenged in Federal court, and in 2004 a Federal district court issued an order setting aside the "not warranted" finding and remanding to NMFS to reconsider that determination. In April 2005 NMFS (70 FR 17386 April 6, 2005) revised its "not warranted" decision and proposed to list the sDPS as threatened. In its 2006 final rule listing the sDPS green sturgeon as threatened, NMFS cited concentration of the only known spawning population into a single river (Sacramento River), loss of historical spawning habitat, mounting threats to maintenance of habitat quality and quantity in the Delta and Sacramento River, and an indication of declining abundance based upon salvage data at the State and Federal salvage facilities. A more full account of this listing history and decision making process can be found in the final rule (71 FR 17757 April 7, 2006). Since the 2006 listing decision, much new information has become available. This new information has generally reinforced the original reasons and thought process for listing sDPS green sturgeon and reaffirmed NMFS concerns that sDPS green sturgeon face substantial threats that challenge their recovery.

2.2.1.4.3 Green Sturgeon Life History

2.2.1.4.3.1 General Information

When NMFS originally received a petition to list green sturgeon in 2001, scientific understanding of the species was in its infancy. Few scientific studies had been conducted, and what was known was subject to much uncertainity. In the early years of the 2000s, and most especially since sDPS green sturgeon were listed as threatened in 2006, information has been developing rapidly. Beginning in 2001, but most significanlty since 2007, the USFWS has been conducting monitoring and research of sDPS green sturgeon in the Sacramento River. In 2011 researchers at DWR gathered conclusive evidence that sDPS green sturgeon can spawn in the Feather River (Seesholtz et al. 2014). In 2013 researchers at UC Davis began to release research findings to shed light upon the population dyamics of breeding adults in Sacramento River, including abundance estimates and spawning periodicity. In this section we review what is known about sDPS green sturgeon life history to form a basis for understanding sDPS green sturgeon biology.

2.2.1.4.3.2 Green Sturgeon Life History Table

Table 2-7 gives a general timeline of sDPS green sturgeon development. Developmental stage is given by size, which is a common practice in fisheries biology to infer lifestage through the measured length of the fish. As Table 2-7 notes, there is considerable variability across categories, such as size or age at maturity. Although not a perfect method, length is often used to determine age or developmental stage in fish. Alternative methods for measuring age, such as counting bone growth rings, are possibly more accurate, but are far more invasive than taking a simple length measurement.

Table 2-7. A General Time-Table of sDPS Green Sturgeon Life History, From Egg to Adult, With Length-Lifestage Information Given

Timeline	Lifestage, Length-Age relationship
Fertilization of eggs (spawning)	Spawning occurs primarily in deepwater (>5m) pools[1] at very few select sites[2], predominantly in the Sacramento River, predominantly mid-April to mid-June[3].
144–192 hours (6-8 days) after fertilization of eggs	Newly hatched larve emerge. **Larvae are 12.6–14.5 mm** long[4].
6 days post hatch	Nocuturnal swim up, hide-by-day behavior observed[4].
10 days post hatch (dph)	Exogenous feeding begins around 10 dph[4]. Larvae begin to disperse downstream.
2 weeks old (approx)	Larvae appear in USFWS rotary screw traps at RBDD at lengths of 24–31 mm.
45 days post hatch	Larval to juvenile metamorphosis complete. Begin juvenile life stage. **Juveniles are 63–94 mm** long.
45 days to 1.5 years	Juveniles migrate downstream and into the Delta or the estuary and rear to the subadult phase. **Juveniles range in size from around 70 mm to 90 cm**. Little information available about this life stage.
1.5–4 years	Sometime between the age of 1.5 to 4 years, juvenile green sturgeon migrate to sea for the first time, thereby entering the subadult phase. **Subadults are 107 cm to 174[5] cm**.
1.5 years to 15-17 years	After green sturgeon enter the ocean for the first time, they grow and develop, reaching maturity between 15–17 years old.*
15–17 years*	Green sturgeon reach sexual maturity and become adults, with **males maturing around 120 cm and females maturing around 145 cm[6]** (based on Nakamoto's Klamath River studies).
15 years to 50+ years	Green sturgeon have a lifespan that can reach 50 or more years and can grow to a **total length of over 2 meters**.

References

1. Thomas et al. (2013a) 2. Mora (unpub, UC Davis) 3. Poytress et al. (2013a) 4. Deng et al. (2002) 5. Heppell (2007) 6. Nakamoto et al. (1995) found that green sturgeon in the Klamath River might reach sexual maturity as early as 13 years for females and 9 years for males. More research is needed to determine the typical age and size of sDPS green sturgeon at maturity._ENREF_320_ENREF_208

2.2.1.4.3.3 Distribution, Migration and Spawning

Green sturgeon reach sexual maturity around 15–17 years old (Beamesderfer et al. 2007), and they typically spawn once every 2-5 years (average is 3.75 years) (Mora unpublished data). Based on data from acoustic tags (unpublished data from California Fish Tracking Consortium database 2013, currently Hydra database) (Heublein et al. 2008), adult sDPS green sturgeon leave the ocean and enter San Francisco Bay between late January and early May and begin their spawning run. Migration through the estuary lasts about a week, and progress is fairly rapid to their upriver spawning sites. Larval sDPS green sturgeon hatch in the late spring or summer and progress downriver towards the Delta and estuary, rearing into juveniles. The time of first ocean entry marks the transition of a sDPS green sturgeon from juvenile to subadult. The table below gives relative abundance of various life stage categories by location.

Table 2-8. Migration Timing of sDPS Green Sturgeon by Location and Life Stage

Low | Medium | High | Medium | Low

a) Spawning adults

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Golden Gate entry, heading upstream	Low	High	High	High	Low							
Arrival at Rio Vista, heading upstream	Low	High	High	High	Low							
Arrival to spawning grounds on upper Sacramento River		Low	High	High	Medium	Low						
Sacramento River spawning period				Medium	High	High	Low					
Sacramento River upriver presence	High	Low	High	High	High	High	High	High	High	High	High	High
Arrival at Rio Vista, heading downstream	High	Low						Low		Low		High
Arrival at Golden Gate, heading seaward	High	Low								Medium		High

b) Summer and fall residence of subadults and non-spawning adults in the San Francisco Bay Estuary

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Golden Gate entry				Medium	Medium	High	High	Medium				
Residing in estuary				Medium	High	High	High	High	High	Medium	Low	
Golden Gate departure				Low	Low	High	Low	Medium	High	Medium	Low	

c) YOY/Juveneiles

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
YOY at Red Bluff Diversion Dam					High	High	High	Low	Low			
YOY at GCID					Medium	High	High	Medium	Low			
Juveniles from Delta salvage (<50cm TL)		Low	Medium	Low	Low	Low	Low	High	Low	Medium	Medium	Low
Juveniles residing in San Francisco Bay Estuary	High	High	High	High	High	High	High	High	High	High	High	High

It has long been known that sDPS green sturgeon spawn in the Sacramento River, but only in 2011 was spawning confirmed in the Feather River by DWR and suggested in the Yuba River by a report released by Cramer Fish Sciences (Bergman et al. 2011). As Table 2-8 shows, however, the vast majority of adult presence, and therefore spawning activity, is in the Sacramento River.

In Table 2-9, numbers given are likely unique individuals, although this is unverifiable given the survey methods used to collect this data.

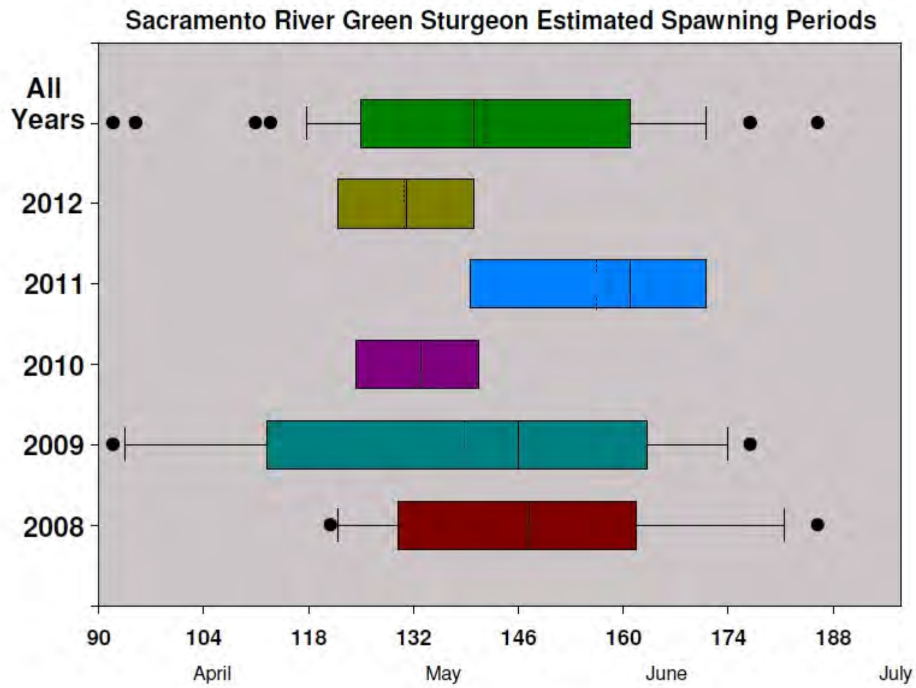
Table 2-9. Estimates of sDPS Adult Green Sturgeon Presence and Abundance in Known or Suspected Spawning Rivers

Year	Sacramento River	Feather River	Yuba River
2010	164	Data unavailable	Data unavailable
2011	220	25	4 or 5
2012	329	Data unavailable	Presumed to be zero, but data unavailable
2013	338	Data unavailable	Presumed to be zero, but data unavailable
2014	526	Data unavailable	Presumed to be zero, but data unavailable

Data sources: Sacramento River (National Marine Fisheries Service 2015b), Feather River, Yuba River (Cramer Fish Sciences, 2011).

Timing of migration and spawning varies by individual and from year to year (Figure 2-22), but in general sDPS green sturgeon leave the ocean and enter the SF Bay Delta and estuary in late winter/early spring and are spawning predominantly in May and June. Post spawning, adults have been observed to leave the system rapidly or to hold and migrate downriver in winter.

Figure 2-21 shows estimated Sacramento River sDPS Green Sturgeon spawning periods.



Boxplots displaying Julian days of median (line) and mean (dotted), 10th, 25th, 75th and 90th percentiles, and outliers of estimated spawning events derived from annual egg mat sample collections for the period 2008 through 2012. from Poytress *et al.* (2013)

Figure 2-21. Estimated Sacramento River sDPS Green Sturgeon Spawning Periods

Most sDPS green sturgeon spawning activity occurs in the Sacramento River. Although a number of spawning sites are known, just three sites on the Sacramento River account for over 50 percent of sDPS green sturgeon spawning (Mora unpublished data). Due to this concentration of spawning habitat, sDPS green sturgeon are particularly vulnerable to anything that might negaitvely affect these areas, such as an environmental disturbance.

Figure 2-22 shows sDPS green sturgeon known spawning locations on the upper Sacramento River, as identified by USFWS during the 2008-2012 field sampling seasons. Source: (Poytress et al. 2012). An unconfirmed sampling site indicates an area where sturgeon have been known to congregate, but where evidence of spawning could not be obtained in the study.

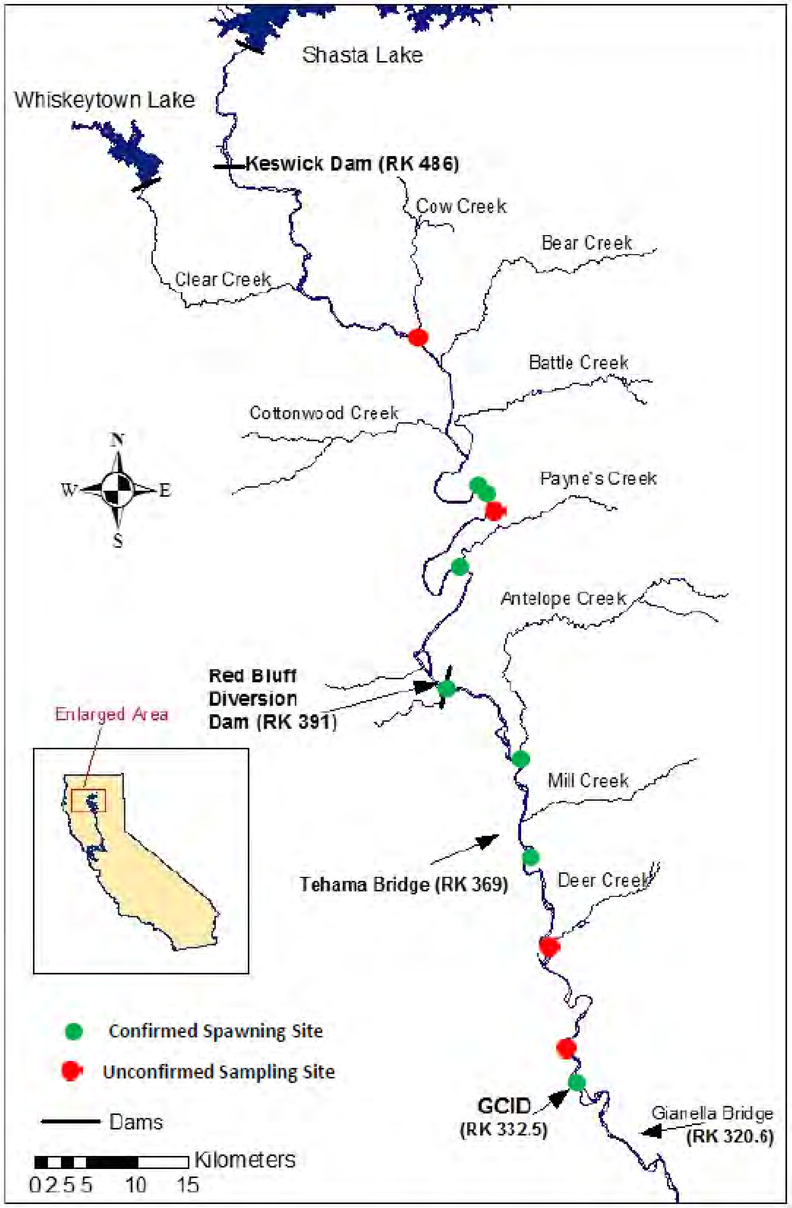


Figure 2-22. Green Sturgeon Known Spawning Locations on the Upper Sacramento River, 2008-2012

2.2.1.4.3.4 Egg and Larval Stages

Green sturgeon larvae hatch from fertilized eggs after approximately 169 hours at a water temperature of 15°C (59° F) (Van Eenennaam et al. 2001, Deng et al. 2002). Studies conducted at the University of California, Davis by Van Eenennaam et al. (2005)_ENREF_307 using nDPS green sturgeon juveniles indicated that an optimum range of water temperature for egg development ranged between 14°C (57.2°F) and 17.5°C (62.6°F). Temperatures over 23°C (73.4°F) resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5°C (63.5°F) and 22°C (71.6°F) resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 14°C (57.2°F), hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so (Van Eenennaam et al. 2005). Further research is required to identify the lower temperatures limits for eggs and larvae. Table 2-10 shows temperature tolerance by life stage for all stages of green sturgeon development.

Table 2-10. Green Sturgeon Temperature Tolerance Range by Life Stage

Green Sturgeon Temperature Tolerance by Life Stage

temperature °C	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
temperature °F	41.0	42.8	44.6	46.4	48.2	50.0	51.8	53.6	55.4	57.2	59.0	60.8	62.6	64.4	66.2	68.0	69.8	71.6	73.4	75.2	77.0	78.8	80.6	82.4
egg							b	b	b	b	b	b	b	b	b	b	b	b,i	b,i	b,i	b,i	b,i	b	b
larvae (<45 days post-hatch)[j]													c	i	dd,i	dd,i	dd,i	dd,i	dd,i	dd,i	dd,c,i	i	i	i
juvenile							a	a	a	a	a	a	a	a	a	a	a	a	a	a,d	a	a	a	a
sub-adult or adult, SF estuary										h	h	h	h	h	h	h	h							
adult (>152 cm), spawning						e	e	e,f	e,f	e,f	e,f	f												
sub-adult or adult, ocean			g	g	g	g	g	g	g	g	g													

Legend	
optimal temperature	a = Mayfield and Cech, 2004
acceptable temperature	b = Van Eenennaam *et al*, 2005
impaired fitness; avoid prolonged exposure; increasing chance of lethal effects	c = Werner *et al*, 2007
likely lethal	d = Allen et al, 2006
lethal	e = Poytress *et al*, 2012
unknown effect upon survival and fitness	f = Poytress *et al*, 2013
NOTES: a, b, c, d, dd, i used green sturgeon sourced from the Klamath River. E and f indicate water temperature during estimated spawning period on the upper Sacramento River which is temperature controlled for winter-run Chinook salmon. G used green strugeon captured in the Rogue River. H involved tracking acoustically tagged green sturgeon captured in San Pablo Bay	g = Erickson and Hightower, 2007 h = Kelly *et al*, 2007 i = Linares-Casenave *et al*, 2013 j = Deng 2002 dd = Allen *et al* 2006b

NOTES on variability of individual's fitness and varibality of themal stress effects: Linares-Casenave *et al* (2013) found varying levels of temperature tolerance by broodstock collected at different times of the year when river temperatures were different. Wener *et al* (2007) found that detrimental thermal stress efects (notochord deformity and impaired swimming) were reversible in 50% of larvae returned to cool water (17° C) after 3 days exposure to 26° C. Thus it is important to note that thermal stress effects are sometimes reversible and can also affect individuals differently. Allen (2006b) results show high temp tolerance of larvae given abundant food, but warns yolk-sac fish are more sensitive to elevated temperatures that are fish that are exogenously feeding.

Information about larval sDPS green sturgeon in the wild is very limited. The U.S. Fish and Wildlife Service (USFWS) conducted annual sampling for eggs and larvae in the mainstem Sacramento River from 2008 through 2012. Larval sDPS green sturgeon appear in USFWS rotary screw traps at RBDD from May through August (Poytress et al. 2010) and at lengths ranging from 24 to 31 mm FL, indicating they are approximately two weeks old (California Department of Fish and Game 2002, U.S. Fish and Wildlife Service 2002). USFWS data reveals some limited information about sDPS green sturgeon larvae, such as time and date of capture and corresponding river conditions such as temperature and flow parameters. Unfortunately, there is little information on diet, distribution, travel time through the river, and estuary rearing. Laboratory studies have provided some information about this initial life stage, but the relevance to fish in their natural habitat is unknown. There is some concern that the Sacramento River may have temperature regimes too cold for optimal larval growth or for optimal hatching success in the upper regions of the river (Poytress et al. 2013a, Poytress et al. 2013b).

2.2.1.4.3.5 Juvenile Development and Outmigration

Young sDPS green sturgeon appear to rear for the first one to two months in the Sacramento River (California Department of Fish and Game 2002). Growth is rapid as juveniles move downstream and reach up to 300 mm the first year and over 600 mm in the first 2 to 3 years (Nakamoto et al. 1995). Juvenile sDPS green sturgeon have been salvaged at the Federal and State pumping facilities (which are located in the southern region of the Delta) and collected in sampling studies by CDFW during all months of the year (California Department of Fish and Game 2002). Salvage data have been updated through 2012; see Figure 2-25.

The majority of juveniles that were captured in the Delta were between 200 and 500 mm indicating they were from 1 to 3 years of age, based on age and growth studies from the Klamath River (Nakamoto et al. 1995)_ENREF_201. The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures seems to suggest that individuals smaller than 200 mm simply are not present in the Delta, and therefore may be rearing in the Sacramento River or its tributaries. Possibly, juvenile sDPS green sturgeon hold in the mainstem Sacramento River for up to 10 months, as suggested by Kynard et al. (2005)_ENREF_172. Juvenile sDPS green sturgeon captured in the Delta by Radtke (1966)_ENREF_255 ranged in size from 200-580 mm, further supporting the hypothesis that juvenile sDPS green sturgeon do not enter the Delta until a certain age/size of approximatley 10 months/200mm. There is much that is unknown about the sDPS green sturgeon juvenile life stage in the wild, especially the first several months of life. What they do or where they go between the time they are detected as larvae in the mid-Sacrametno River and when they are detected again in the Delta as older juveniles around 200 mm is unknown.

Much of what is known about juvenile green sturgeon comes from laboratory studies. Both nDPS and sDPS green sturgeon juveniles tested under laboratory conditions, with either full or reduced rations, had optimal bioenergetic performance (*i.e.*, growth, food conversion, swimming ability) between 15ºC (59ºF) and 19ºC (66.2ºF) , thus providing a temperature related habitat target for conservation of this rare species (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed.

Radtke (1966)_ENREF_255 inspected the stomach contents of juvenile sDPS green sturgeon (range: 200-580 mm) in the Delta and found food items to include mysid shrimp (*Neomysis awatschensis)*, amphipods (*Corophium sp.)*, and other unidentified shrimp. In the northern estuaries of Willapa Bay, Grays Harbor, and the Columbia River, where both sDPS and nDPS green sturgeon exist, green sturgeon have been found to feed on a diet consisting primarily of benthic prey and fish common to the estuary. For example, burrowing thalassinid shrimp (mostly *Neotrypaea californiensis*) were important food items for green sturgeon taken in Willapa Bay, Washington (Dumbauld et al. 2008).

2.2.1.4.3.6 Estuarine Rearing

There is a fair amount of variability (1.5-4 years) in the estimates of the time spent by juvenile green sturgeon in fresh or brackish water before making their first migration to sea. Nakamoto et al. (1995)_ENREF_201 found that nDPS green sturgeon on the Klamath River migrated to sea on average by age three and no later than by age four. Moyle (2002)_ENREF_191 suggests juveniles migrate out to sea before the end of their second year and perhaps as yearlings. Laboratory experiments indicate that both nDPS and sDPS green sturgeon juveniles may occupy fresh to brackish water at any age, but they gain the physiological ability to completely transition to saltwater at around 1.5 years (Allen and Cech 2007). In studying nDPS green sturgeon on the Klamath River, Allen et al. (2009)_ENREF_11 devised a technique to estimate the timing of transition from fresh water to brackish water to seawater by taking a bone sample from the leading edge of the pectoral fin and anlyzing the ratios of stontium and barium to calcium. Results of this study indicate that green sturgeon move from freshwater to brackish water (such as the estuary) at ages 0.5–1.5 years and then move into seawater at ages 2.5-3.5 years.

2.2.1.4.3.7 Ocean Rearing

Once green sturgeon juveniles make their first entry into sea, they enter the subadult phase and spend a number of years migrating up and down the coast. While they may enter river mouths and coastal bays throughout their years in the subadult phase, they do not return to their natal freshwater environments before they are mature. In other words, sDPS green sturgeon subadults and adults may be found in various bays and estuaries and marine environments, from California to Canada, but they will not return to the Sacramento River or its tributaries until sexually mature and ready to spawn.

In the summer months, multiple rivers and estuaries throughout the sDPS range are visited by dense aggregations of green sturgeon (Moser and Lindley 2007, Lindley et al. 2011). Some of these aggregations are mixtures of both sDPS and nDPS green sturgeon, and there is considerable overlap in their ranges. However, nDPS green sturgeon do not appear to migrate into San Francisco Bay. Genetic studies on green sturgeon stocks indicate that the green sturgeon in the San Francisco Bay ecosystem belong to the sDPS (Israel et al. 2009). Capture of green sturgeon as well as tag detections in tagging studies have shown that green sturgeon are present in San Pablo Bay and San Francisco Bay at all months of the year (Kelly et al. 2006, Heublein et al. 2008, Lindley et al. 2011). An increasing amount of information is becoming available regarding green sturgeon habitat use in estuaries and coastal ocean and why they aggregate episodically (Lindley et al. 2008, Lindley et al. 2011).

Adult sDPS green sturgeon begin their upstream spawning migrations into freshwater as early as February, with spawning occuring between April and July, and most spawning activity concentrated in the mid-April to mid-June time period (Poytress et al. 2013a). Various studies of spawning site characteristics (for example,Poytress et al. 2010, Thomas et al. 2013a, Mora unpublished data) agree that spawning sDPS green sturgeon typically favor deep, turbulent holes over 5 meters deep, featuring sandy, gravel, and cobble type substrates. Water depth may be negotiable, as spawning has been documented in depths as shallow as 2 meters (Poytress et al. 2010). However, substrate type is likely constrained as the interstices of the cobble and gravel are probably important to catch and hold the eggs while they develop, or else the eggs would wash downstream. Temperature and flow characteristics are also very important, but in complicated ways not fully understood nor easily summarized. In general, flows need to be sufficient to create the deep, turbulent holes that green sturgeon seem to favor for spawning. Temperatures for successful egg development are too cold as they approach 11°C on the low end and too warm approaching 19°C on the upper end. Note that larvae and juveniles appear to have broader temperature tolerances than eggs. See Table 2-10 for more information and supporting references.

Poytress et al. (2012)_ENREF_282 conducted spawning site and larval sampling in the upper Sacramento River from 2008–2012 and has identified a number of confirmed spawning locations. Green sturgeon fecundity is approximately 50,000 to 80,000 eggs per adult female (Van Eenennaam et al. 2001). They have the largest egg size of any sturgeon. The outside of the eggs are mildly adhesive and are more dense than than those of white sturgeon (Kynard et al. 2005, Van Eenennaam et al. 2009).

Post spawning, green sturgeon may exhibit a variety of behaviors. Ultimately they will return to the ocean, but how long they take to do this and what they do along the way are topics of ongoing research. Benson et al. (2007)_ENREF_25 conducted a study in which 49 nDPS green sturgeon were tagged with radio or sonic telemetry tags and tracked manually or with receiver arrays from

2002 to 2004. Tagged individuals exhibited four movement patterns: upstream spawning migration, spring outmigration to the ocean, or summer holding, and outmigration after summer holding.

In the case of sDPS green sturgeon, a number of ongoing studies are using surgically inserted acoustic tags that can be detected by an array of sensors that extends through the Sacramento River watershed, the Bay-Delta, and the nearshore coast. The data from these tag detections helps biologists to understand where and when green sturgeon are occurring, revealing clues about the timing of their migration patterns, residence times in particular environments, and so forth. Much of the database for these acoustic tag detections contains data from the latter half of the decade from 2000-2010 (*i.e.*, 2006, 2007) and up to the present. Thus published papers on this data are not yet available, but should be forthcoming. Nevertheless, this database has been investigated by NMFS biologists and it appears that normal adult post-spawning behavior is that following spawning, sDPS green sturgeon will hold for several months in deep pools within their spawning reach. Then they migrate downstream toward the ocean, re-entering the ocean generally from November through January (with the onset of the first winter storms), with migration through the estuary lasting about a week.

In summary, and to reiterate the most important points briefly, a very general model of green sturgeon habitat usage, intended to inform management decisions, would be as follows. Adult sDPS green sturgeon enter the San Francisco Bay from late February through April and transition fairly quickly, maybe in just a week's time, towards their spawning grounds, primarily on the upper Sacramento River. There seems to be an overwhelming preference for just a few select spawning sites. Spawning occurs from April to July. Post spawning, adults may hold for up to several months before migrating in the winter downriver and back into the ocean. Larvae hatch in the spring and summer and migrate downriver fairly quickly, perhaps in just a couple of weeks. Juveniles rear in riverine and estuarine habitats for at least 1.5 years before making their first entry into the ocean whereupon they are classified as subadults. Subadults mature in coastal marine environments and in bays and estuaries until at least 9-17 years old before returning to their natal freshwater river to spawn. An individual may spawn once every 3-5 years and live for 50 years or more.

2.2.1.4.4 Description of Viable Population (VSP) Parameters

As an approach to evaluate the likelihood of viability of salmonids, and determine the extinction risk of salmonids, NMFS uses the VSP concept. We evaluate the VSP parameters of abundance, productivity, spatial structure, and diversity. These specific parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of salmonids (McElhany et al. 2000). Although the VSP concept was developed for Pacific salmonids, the underlying parameters are general principles of conservation biology and can therefore be applied more broadly. Thus, we use the VSP parameters for analyzing sDPS green sturgeon viability in this section.

2.2.1.4.4.1 Abundance

Abundance is one of the most basic principles of conservation biology, and from this measurement other parameters can be related. In applying the VSP concept, abundance is examined at the population level, and therefore population size is perhaps a more appropriate term. Historically, abundance and population trends of sDPS green sturgeon have been inferred in two ways. First by analyzing salvage numbers at the State and Federal pumping facilities (see below). And second by incidental catch of sDPS green sturgeon by the CDFW's white sturgeon sampling and tagging program.

Both methods of estimating sDPS green sturgeon abundance are problematic because biases in the data are evident. Recent studies provide more reliable indices such as a minimum effective spawner population size found in Israel et al. (2009)_ENREF_139 or the Sacramento River Dual Frequency Identification Sonar (DIDSON) counts, which provide annual total spawner estimates (National Marine Fisheries Service 2015b).

A decrease in sDPS green sturgeon abundance has been inferred from the amount of take observed at the south Delta pumping facilities; the Skinner Delta Fish Protection Facility (SDFPF), and the Tracy Fish Collection Facility (TFCF). This data should be interpreted with some caution because operations and practices at the facilities have changed over the decades, which may affect the salvage data shown below (Figure 2-25).

Figure 2-23 shows annual salvage of sDPS green sturgeon for the SDFPF and the TFCF from 1981 to 2012. Data source: ftp://ftp.delta.dfg.ca.gov/salvage.

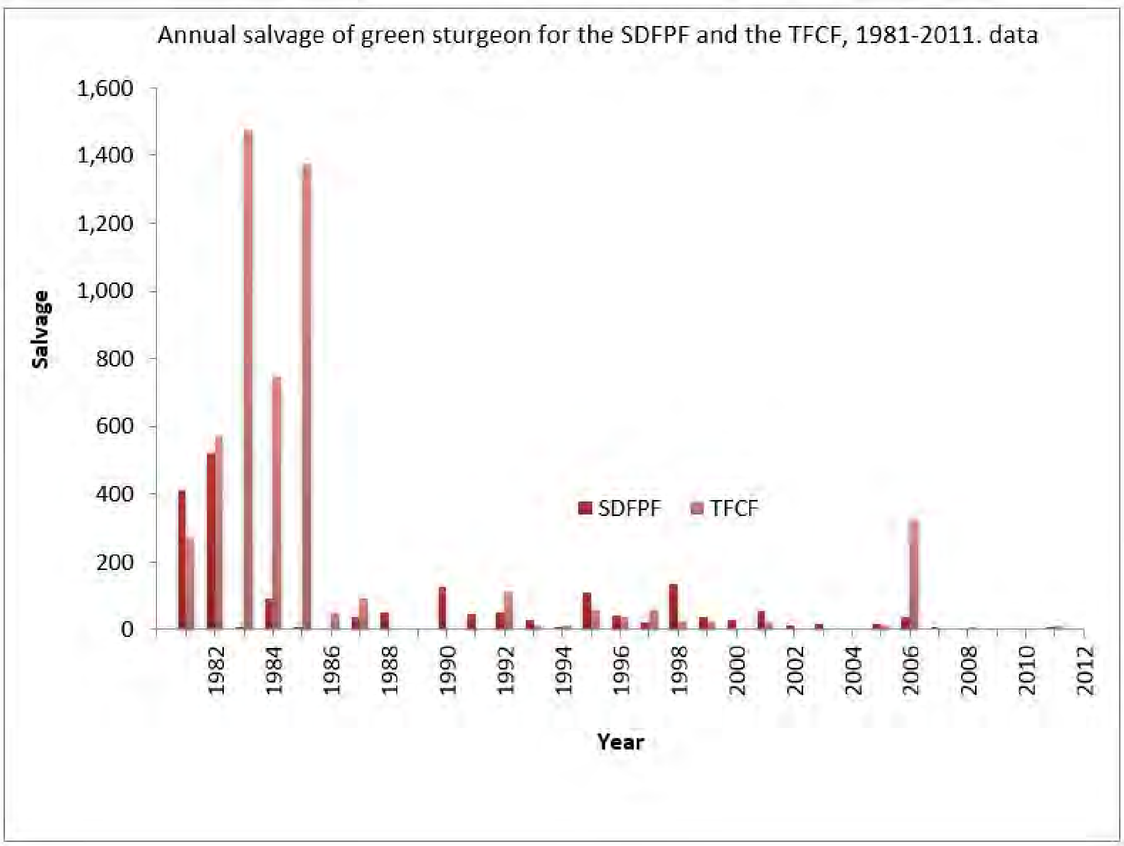


Figure 2-23. Annual Salvage of sDPS Green Sturgeon, SDFPF and TFCF, 1981-2012

Despite the potential pitfalls (National Marine Fisheries Service 2015b) of using salvage data to estimate an abundance trend line for sDPS green sturgeon, the above chart shows what appears to be a very steep decline in abundance, which is potentially a great cause for concern. It should be noted that the pre-1986 expansion values were larger than the expansion values used in 1986 and later. Prior to 1986, one observed sDPS green sturgeon was converted to 47.9 estimated fish. From 1986 on, one observed fish was converted into 9.7 estimated fish (Adams et al. 2007).

Beginning in 2010, more robust estimates of sDPS green sturgeon have been generated. As part of a doctorate dissertation at UC Davis, Ethan Mora has been using DIDSON to locate sDPS green sturgeon in the Sacramento River and to derive an adult spawner abundance estimate.

Results of these surveys indicate an average annual spawning run size of 364 fish, with a variance of 246 (Klimley et al. 2015). This estimate does not include the number of spawning adults in the Lower Feather River, where sDPS green sturgeon spawning was recently confirmed.

2.2.1.4.4.2 Productivity (Population Growth Rate)

We do have larval count data from rotary screw traps set seasonally near RBDD and GCID. This data, provided by the USFWS Red Bluff office, shows enormous variance between years and suggests that some years are highly successful larval production years. In particular, 2011 appears to have been a highly successful larval production year, with over 3,700 larvae captured (Poytress et al. 2012). In other years, larval counts were an order of magnitude lower.

However some caution is required as these data are not standardized between years, and lingering questions about sampling methodology exist. In general, sDPS green sturgeon year class strength appears to be episodic with overall abundance dependent upon a few successful spawning events (National Marine Fisheries Service 2010). It is unclear if the population is able to consistently replace itself or grow to greater abundance than levels currently observed. Other indicators of productivity, such as cohort replacement ratios and spawner abundance trends, require data sets that simply do not exist for sDPS green sturgeon. The long lifespan of the species and long age to maturity makes trend detection dependent upon data sets spanning decades, something that is currently lacking. The sonar coupled with acoustic telemetry work begun by Ethan Mora (UC Davis) on the Sacramento River and by Alicia Seesholtz (DWR) on the Feather River, as well as larval and juvenile studies begun by Bill Poytress (USFWS), may eventually produce enough data to gain statistically robust insights into productivity.

2.2.1.4.4.3 Spatial Structure

Green sturgeon, as a species, are known to range from Baja California to the Bering Sea along the North American continental shelf. The southern DPS (sDPS) consists of populations originating from coastal watersheds south of the Eel River. Telemetry data and genetic analyses suggest that sDPS green sturgeon generally occur from Graves Harbor, Alaska to Monterey Bay California, and within this range, most frequently occur in coastal waters of Washington, Oregon, Vancouver Island, and near San Francisco and Monterey baysIsrael et al. (2009), (National Marine Fisheries Service 2015b). Israel et al. (2009) found that green sturgeon within the inland waters of California are almost entirely sDPS green sturgeon. Further studies based upon work done with acoustic tagging of sDPS green sturgeon, enable us to state with high levels of certainty that those green sturgeon found within the San Francisco Bay estuary and further inland are mostly sDPS green sturgeon (National Marine Fisheries Service 2015a).

Considering the waters inland from the Golden Gate Bridge in California, sDPS green sturgeon are known to range through the estuary and the delta and range up the Sacramento River, Feather River, and the Yuba River. In the Yuba River, sDPS green sturgeon have been documented up to Daguerre Point Dam (Bergman et al. 2011). Migration past Daguerre Point Dam is not possible for sDPS green sturgeon, although potential spawning habitat upriver does exist. The same can be said about the Feather River, where sDPS green sturgeon have been observed by DWR staff up to the Fish Barrier Dam. On the Sacramento River, Keswick Dam, located at RK (river kilometer) 486, marks the highest point on the river accessible to sDPS green sturgeon, and sDPS green sturgeon may use habitat up to this point.

However, USFWS sampled for larvae in 2012 at RK 430 and at RK 470 and no larvae were caught at these locations. Habitat usage could not be confirmed any further upriver than the confluence with Ink's Creek (RK 426), which was a confirmed spawning site in 2011 (Poytress et al. 2012).

Adams et al. (2007)_ENREF_6 summarizes information that suggests sDPS green sturgeon may have been distributed above the locations of present day dams on the Sacramento and Feather rivers. Mora et al. (2009)_ENREF_188 analyzed and characterized known sDPS green sturgeon habitat and used that characterization to identify potential sDPS green sturgeon habitat within the Sacramento and San Joaquin River basins that now lies behind impassable dams. This study concludes that about 9 percent of historically available habitat is now blocked by impassible dams, but more importantly, this blocked habitat was of likely high quality for spawning.

Studies done by UC Davis (Mora unpublished data) have revealed that sDPS green sturgeon spawning sites are concentrated in just a handful of locations. Mora found that on the Sacramento River, just three sites accounted for over 50 percent of the adult sDPS green sturgeon documented in June 2010, 2011, and 2012. Based on the spawning timing of sDPS green sturgeon (April through early July) and the only time adult green sturgeon are known to move upstream is for spawning, all these sDPS green sturgeon were presumed to be there to spawn. This is a critical point regarding the application of the spatial structure VSP parameter, which is largely concerned with the spawning habitat spatial structure. Given a high concentration of individuals into just a few spawning sites, extinction risk due to stochastic events would be expected to increase.

Modeling indicates that sDPS green sturgeon spawning could have been supported in the San Joaquin River, and six sDPS green sturgeon were reported being caught in the San Joaquin River in 2007Radtke (1966), (National Marine Fisheries Service 2015c). Radtke (1966) reports catching sDPS green sturgeon at the Santa Clara Shoals (which is near the confluence of the San Joaquin River and the Sacramento River) and to a much lesser extent, west of Stockton. However, there is no known modern usage of the San Joaquin River by sDPS green sturgeon. Anglers have reported catching sDPS green sturgeon at various locations within the San Joaquin River basin; however, none of these reports have been verified and no photographic evidence has surfaced. Unless stronger evidence can be shown, it is currently believed that sDPS green sturgeon do not use the San Joaquin River or its tributaries.

In summary, current scientific information indicates that sDPS green sturgeon is composed of a single, independent population, which principally spawns in the mainstem Sacramento River, and also breeds opportunistically in the Feather River and possibly even the Yuba River. Concentration of adults into a very few select spawning locations makes the species highly vulnerable to poaching and catastrophic events. The apparent extirpation from the San Joaquin River narrows the habitat usage by the species, offering fewer alternatives to impacts upon any portion of that habitat.

2.2.1.4.4.4 Diversity

Diversity, as defined in the VSP concept in (McElhany et al. 2000), includes genetic traits such as DNA sequence variation and other traits that are influenced by both genetics and the environment, such as ocean behavior, age at maturity, and fecundity. Variation is important to the viability of a species for several reasons. First, it allows a species to utilize a wider array of environments than they could without it. Second, diversity protects a species from short-term spatial and temporal changes in the environment by increasing the likelihood that at least some individuals will have traits that allow them to persist in spite of changing environmental conditions. Third, genetic diversity provides the raw material necessary for the species to have a chance to adapt to changing environmental conditions over the long term.

While it is recognized that diversity is crucial to the viability of a species in general, it is not well understood how well sDPS green sturgeon display these diversity traits and if there is sufficient diversity to buffer against long-term extinction risk. This is due to limited historic information to which to compare the current condition of sDPS green sturgeon, and limit genetic information about the overall sDPS green sturgeon population. In general, a larger number of populations and number of individuals within those populations should offer increased diversity, and therefore greater chance of long-term viability. Recovery efforts for sDPS green sturgeon have focused on trying to bolster both the number of individuals of sDPS green sturgeon and to establish a second breeding population, outside the Sacramento River, with the Feather River being best positioned, and to a lesser extent, the Yuba River. The diversity of sDPS green sturgeon is probably low, given abundance estimates. Also, because human alteration of the environment is so pervasive in the California Central Valley, basic diversity principles such as run timing and behavior are likely adversely influenced through mechanisms such as diminished springtime flow rates as water is impounded behind dams, to give but one example.

2.2.1.4.4.5 Conclusion

The viability of sDPS green sturgeon is constrained by factors such as a small population size, lack of multiple populations, and concentration of spawning sites into just a few locations. NMFS has concluded the risk of extinction for sDPS green sturgeon is moderate because, although threats due to habitat alteration are thought to be high and indirect evidence suggests a decline in abundance, there is much uncertainty regarding the scope of threats and the viability of population abundance indices (National Marine Fisheries Service 2010). Viability is defined as an independent population having a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (McElhany et al. 2000). The best available scientific information does not indicate that the extinction risk facing sDPS green sturgeon is negligible over a long-term (approximately 100 years) time horizon; therefore the DPS is not believed to be viable. To support this statement, the PVA that was done for sDPS green sturgeon in relation to stranding events (Thomas et al. 2013b) may provide some insight. While this PVA model made many assumptions that need to be verified as new information becomes available, it was alarming to note that over a 50-year time period the DPS declined under all scenarios where stranding events were recurrent over the lifespan of a green sturgeon.

Although the population structure of sDPS green sturgeon is still being refined, it is currently believed that only one population of sDPS green sturgeon exists. Lindley et al. (2007)_ENREF_166, in discussing winter-run Chinook salmon, states that an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. This concern generally applies to any DPS or ESU represented by a single population, and if this were to be applied to sDPS green sturgeon specifically, it could be said that sDPS green sturgeon face a high extinction risk. However, as described above, NMFS has concluded the risk of extinction for sDPS green sturgeon is moderate because there is much uncertainty regarding, among other things, the scope of threats for sDPS green sturgeon (National Marine Fisheries Service 2010).

There is a strong need for additional information about sDPS green sturgeon, especially regarding a robust abundance estimate, a greater understanding of their biology, and further information about their habitat needs. We need to better understand how to manage river flows and temperatures to best balance the needs of sDPS green sturgeon with other considerations such as flood control and water storage for anthropogenic uses. In the past several years much new information has become available, but due to the longevity of sDPS green sturgeon and their complex life history, studies need to be conducted on decades-long time scales.

2.2.1.4.5 Critical Habitat Listing History and Description

NMFS designated critical habitat for sDPS green sturgeon on October 9, 2009 (74 FR 52300 October 9, 2009) (Figure 2-24).

In summary, critical habitat for sDPS green sturgeon includes, (1) the Sacramento River from the I-Street Bridge in Sacramento to Keswick Dam, including the Sutter and Yolo Bypasses and the American River to the highway 160 bridge; (2) the Feather River up to the Fish Barrier Dam; (3) the Yuba River up to Daguerre Point Dam; (4) the Sacramento-San Joaquin Delta (as defined by California Water Code Section 12220), but with many exclusions; (5) tidally influenced areas of San Francisco Bay, San Pablo Bay, and Suisun Bay; and (6) coastal marine areas to the 60-fathom depth bathymetry line, from Monterey Bay, California to the Strait of Juan de Fuca, Washington. For more details, see 74 FR 52300 (October 9, 2009).

PBFs for sDPS green sturgeon critical habitat include specific features of freshwater riverine systems, estuarine habitats, and nearshore coastal marine waters (74 FR 52300 October 9, 2009).

2.2.1.4.6 Freshwater Riverine Systems

Freshwater riverine systems are used by sDPS green sturgeon for spawning and for adult holding after spawning. The eggs of sDPS green sturgeon hatch in freshwater, and the larvae spend their initial days and weeks in freshwater, migrating to estuarine areas in a relatively short time. The typical length of this migration is a subject of ongoing research and is discussed more fully in the section *2.2.1.4.3 Green Sturgeon Life History*. Following is a discussion of PBFs for sDPS green sturgeon critical habitat in freshwater riverine systems.

2.2.1.4.6.1 Food Resources

PBFs for sDPS green sturgeon critical habitat in freshwater riverine systems include abundant prey items for larval, juvenile, subadult, and adult life stages. Abundant food items for larval, juvenile, subadult, and adult life stages for sDPS green sturgeon should be present in sufficient amounts to sustain growth, development, and support basic metabolism. Although specific information on food resources for green sturgeon within freshwater riverine systems is lacking, they are presumed to be generalists and opportunists that feed on similar prey as other sturgeons

(Israel and Klimley 2008). Seasonally abundant drifting and benthic invertebrates have been shown to be the major food items of shovelnose and pallid sturgeon in the Missouri River (Wanner et al. 2007), lake sturgeon in the St. Lawrence River (Nilo et al. 2006), and white sturgeon in the lower Columbia River (Muir et al. 2000). As sturgeons grow, they begin to feed on oligochaetes, amphipods, smaller fish, and fish eggs as represented in the diets of lake sturgeon (Nilo et al. 2006), pallid sturgeon (Gerrity et al. 2006), and white sturgeon (Muir et al. 2000).

Figure 2-24 shows sDPS Green Sturgeon Critical Habitat. The source is 50 CFR 226.219.

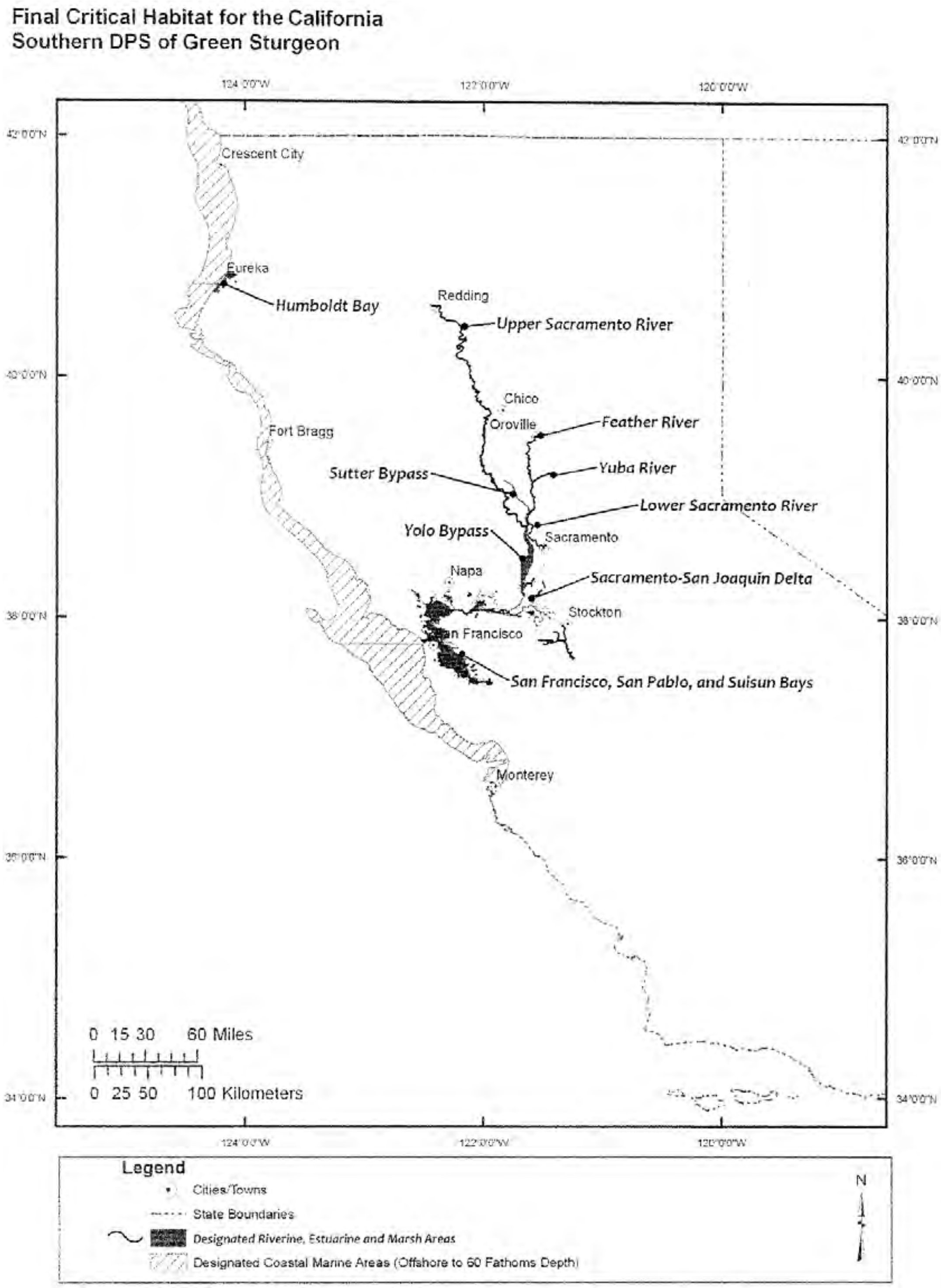


Figure 2-24. Green Sturgeon Critical Habitat

2.2.1.4.6.2 Substrate Type or Size

PBFs for sDPS green sturgeon critical habitat in freshwater riverine systems include substrate suitable for egg deposition and development, larval development, and subadult and adult life stages. It is generally believed that green sturgeon spawn over a range of substrates from clean sand to gravel. Poytress et al. (2010)_ENREF_251 conducted spawning substrate surveys at certain spawning locations on the Sacramento River and found that within the micro habitats where eggs were collected, pockets of small to medium gravel (gravel is defined as 2.0–64.0 mm) were consistently observed among generally larger substrate. Eggs are likely to adhere to substrates or settle into crevices between substrates (Van Eenennaam et al. 2001, Deng et al. 2002). Larvae exhibited a preference for benthic structure during laboratory studies (Van Eenennaam et al. 2001, Deng et al. 2002, Kynard et al. 2005) and may seek refuge within crevices, but use flat-surfaced substrates for foraging (Nguyen and Crocker 2006).

2.2.1.4.6.3 Water Flow

PBFs for sDPS green sturgeon critical habitat in freshwater riverine systems include a flow regime (*i.e.*, the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages. Such a flow regime should include stable and sufficient water flow rates in spawning and rearing reaches to maintain water temperatures within the optimal range for egg, larval, and juvenile survival and development (14–17.5°C) (Mayfield and Cech 2004, Van Eenennaam et al. 2005, Allen et al. 2006). Sufficient flow is also needed to reduce the incidence of fungal infestations of the eggs and to flush silt and debris from cobble, gravel, and other substrate surfaces to prevent crevices from being filled in and to maintain surfaces for feeding.

Successful migration of adult green sturgeon to and from spawning grounds is also dependent on sufficient water flow. Spawning in the Sacramento River is believed to be triggered by increases in water flow to about 14,000 cfs [average daily water flow during spawning months: 6,900–10,800 cfs; _ENREF_43Brown (2007)]. In Oregon's Rogue River, nDPS green sturgeon have been shown to emigrate to the ocean during the autumn and winter when water temperatures dropped below 10°C and flows increased (Erickson et al. 2002). On the Klamath River, the fall outmigration of nDPS green sturgeon has been shown to coincide with a significant increase in discharge resulting from the onset of the rainy season (Benson et al. 2007). On the Sacramento River, flow regimes are largely dependent on releases from Shasta Dam, thus the operation of this dam could have profound effects upon sDPS green sturgeon habitat.

2.2.1.4.6.4 Water Quality

PBFs for sDPS green sturgeon critical habitat in freshwater riverine systems include water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures, salinities, and dissolved oxygen levels are discussed in detail in section *2.2.1.4.3 Green Sturgeon Life History*.

2.2.1.4.6.5 Migratory Corridor

PBFs for sDPS green sturgeon critical habitat in freshwater riverine systems include a migratory pathway necessary for safe and timely passage of fish within riverine habitats and between riverine and estuarine habitats. Such a migratory pathway should include safe and timely passage for adult green sturgeon to migrate to and from spawning habitats and for larval and juvenile green sturgeon to migrate downstream from spawning/rearing habitats within freshwater rivers to rearing habitats within the estuaries. This PBF is highly degraded compared to its historical condition due to man-made barriers and alteration of habitat. Keswick Dam, at RM 302, forms a complete barrier to any potential sturgeon migration on the Sacramento River, but downstream of this point, good spawning and rearing habitat exists, primarily in the river reach between Keswick Dam and RBDD (RM 242). The Feather River and Yuba River also offer potential sDPS green sturgeon spawning habitat, but those rivers contain their own man-made barriers to migration and are highly altered environments. Within the California Central Valley, the conservation of sDPS green sturgeon depends heavily upon the functioning of this PBF and would benefit from improvement.

2.2.1.4.6.6 Depth

PBFs for sDPS green sturgeon critical habitat in freshwater riverine systems include deep (≥5m) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow to maintain the physiological needs of holding adult or subadult fish. Deep pools of five-meter or more depth are critical for adult sDPS green sturgeon spawning and for summer holding within the Sacramento River. Summer aggregations of sDPS green sturgeon are observed in these pools in the upper Sacramento River upstream of the Glen Colusa Irrigation District (GCID) diversion. The significance and purpose of these aggregations are presently unknown, but may be a behavioral characteristic of sDPS green sturgeon. Adult green sturgeon in the Klamath and Rogue rivers also occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, or refuge from high water temperatures (Erickson et al. 2002, Benson et al. 2007). As described above, approximately 54 pools with adequate depth have been identified in the Sacramento River upstream of the GCID location (Thomas et al. 2013a).

2.2.1.4.6.7 Sediment Quality

PBFs for sDPS green sturgeon critical habitat in freshwater riverine systems include sediment quality (*i.e.*, chemical characteristics) necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants (*e.g.*, elevated levels of heavy metals like mercury, copper, zinc, cadmium, and chromium; polycyclic aromatic hydrocarbons (PAHs); and organochlorine pesticides) that can result in negative effects on any life stage of green sturgeon or their prey. Based on studies of white sturgeon, bioaccumulation of contaminants from feeding on benthic species may negatively affect the growth, reproductive development, and reproductive success of sDPS green sturgeon (Kaufman et al. 2008).

2.2.1.4.7 Estuarine Habitats

2.2.1.4.7.1 Food Resources

PBFs for sDPS green sturgeon critical habitat in estuarine habitats include abundant prey items within estuarine habitats and substrates for juvenile, subadult, and adult life stages. Prey species for juvenile, subadult, and adult sDPS green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fish, including crangonid shrimp, callianassid shrimp, burrowing thalassinidean shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult sDPS green sturgeon within bays and estuaries.

The use of pesticides for agriculture and aquaculture, and pollution may affect sDPS green sturgeon though bioaccumulation through the food chain. For instance, the overbite clam (*Potamocorbula amurensis*) is known to bioaccumulate selenium, a toxic metal. The overbite clam is eaten by white sturgeon and has been found in green sturgeon. Sturgeon may also accumulate polychlorinated biphenyl, which along with selenium, is known to be detrimental to embryonic development.

2.2.1.4.7.2 Water Flow

PBFs for sDPS green sturgeon critical habitat in estuarine habitats include, within bays and estuaries adjacent to the Sacramento River (*i.e*., the Sacramento-San Joaquin Delta and the Suisun, San Pablo, and San Francisco Bays), sufficient flow into the bay and estuary to allow adults to successfully orient to the incoming flow and migrate upstream to spawning grounds is required. Sufficient flows are needed to attract sDPS adult green sturgeon to the Sacramento River from the Bay and to initiate upstream spawning migrations.

2.2.1.4.7.3 Water Quality

PBFs for sDPS green sturgeon critical habitat in estuarine habitats include water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures, salinities, and dissolved oxygen necessary for sDPS green sturgeon are discussed in detail in section *2.2.1.4.3 Green Sturgeon Life History*.

2.2.1.4.7.4 Migratory Corridor

PBFs for sDPS green sturgeon critical habitat in estuarine habitats include a migratory pathway necessary for the safe and timely passage of adult, subadult, and juvenile fish within estuarine habitats and between estuarine and riverine or marine habitats. Fish need the ability to freely migrate from the river through the estuarine waterways of the deltas and bays and eventually out into the ocean. Southern DPS green sturgeon use the Sacramento River and the Sacramento-San Joaquin Delta as a migratory corridor. Additionally, certain bays and estuaries throughout Oregon and Washington and into Canada are also utilized for rearing and holding, and these areas too must offer safe and unobstructed migratory corridors.

One of the key areas of concern are the Yolo and Sutter bypasses. These leveed floodplains are engineered to convey floodwaters of the greater Sacramento Valley. They include several concrete weir structures that allow flood flows to escape into the bypass channels. Adult sturgeon migrating upstream are attracted into the bypasses by these high flows. However the weirs can act as barriers and block the passage of fish. Fish can also be trapped in the bypasses as floodwaters recede (U.S. Fish and Wildlife Service 1995). Some weir structures have been designed with fish ladders to provide upstream adult salmon passage, but these ladders have been shown to be ineffective for providing upstream passage to adult sturgeon (Department of Water Resources and U.S. Bureau of Reclamation 2012). Also irregularities in the splash basins at the foot of these weirs and multiple road crossings and agricultural impoundments in the bypasses that block hydraulic connectivity can impede fish passage. As a result, sturgeon may become stranded in the bypasses and face delayed migration and lethal and sub-lethal effects from poaching, high water temperatures, low dissolved oxygen, and desiccation.

2.2.1.4.7.5 Water Depth

PBFs for sDPS green sturgeon critical habitat in estuarine habitats include a diversity of depths is necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Deep holding pools (5 meters or deeper) may be important for feeding and energy conservation, or may serve as thermal refugia (Benson et al. 2007). Tagged adults and subadults within the San Francisco Bay estuary primarily occupied waters with depths of less than 10 meters, either swimming near the surface or foraging along the bottom (Kelly et al. 2006). In a study of juvenile sDPS green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from 0.9-2.4 meters (3–8 feet) deep, indicating juveniles may require shallower depths for rearing and foraging (Radtke 1966).

2.2.1.4.7.6 Sediment Quality

PBFs for sDPS green sturgeon critical habitat in estuarine habitats include sediment quality (*i.e*., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants (*e.g.*, elevated levels of selenium, PAHs, and organochlorine pesticides) that can cause negative effects on all life stages of sDPS green sturgeon (see description of *sediment quality* for riverine habitats in section *2.2.1.4.6.7 Sediment Quality*.

2.2.1.4.8 Nearshore Coastal Marine Areas

PBFs for sDPS green sturgeon critical habitat in nearshore coastal marine areas include migratory corridor - a migratory pathway necessary for the safe and timely passage of Southern DPS fish within marine and between estuarine and marine habitats; water quality - nearshore marine waters with adequate dissolved oxygen levels and acceptably low levels of contaminants (*e.g.,* pesticides, organochlorines, elevated levels of heavy metals) that may disrupt the normal behavior, growth, and viability of subadult and adult green sturgeon and food resources; and food resources - abundant prey items for subadults and adults, which may include benthic invertebrates and fishes. NMFS has insufficient information to describe the condition of these PBFs.

2.2.1.4.9 Critical Habitat Summary

The current condition of critical habitat for sDPS green sturgeon is degraded over its historical condition. In particular, the migratory corridor and water flow PBFs have been particularly impacted by human actions, substantially altering the historical environmental characteristics in which sDPS green sturgeon evolved. Water temperature profiles, especially in the upper Sacramento River downstream of Keswick Dam, are currently managed for the benefit of winter-run Chinook salmon, producing water temperature regimes that may not be ideal for sDPS green sturgeon larval growth.

2.3 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR § 402.02).

Under the definition of "effects of the action" in 50 CFR § 402.02, in relevant part, the "*Effects of the action* refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline." The evaluation in this section of the current viability of each listed fish population and the condition of critical habitat for each population is focused on the Feather River Basin.[3] This evaluation provides a reference condition at the population scale to which NMFS will later add the effects of the proposed action.

2.3.1 Climate

Based on information discussed in *section 2.2 Rangewide Status of the Species and Critical Habitat*, increases of air temperatures will result in increases of water temperatures in the Feather River. Increases in the frequency and duration of droughts will also increase Feather River water temperatures. Due to water temperature increases associated with climate change, water temperatures in the Feather River are expected to be less favorable for CV spring-run Chinook salmon, CCV steelhead, and the sDPS of North American green sturgeon.

2.3.2 Feather River Setting

The Feather River has undergone many changes from its historical condition. These changes began in earnest with the California Gold Rush, and continued with the development of manmade dams and other structures to control the flow, storage, and transport of water, and the development of hydroelectric power. The largest dam on the Feather River, and in fact the tallest dam in the United States, is Oroville Dam. It is such a focal point of river alteration that the Feather River can effectively be divided into two parts; the Upper Feather River, including all streams, tributaries, and headwaters of the Feather River, and the Lower Feather River from Oroville Dam to the confluence with the Sacramento River at Verona (Figure 2-26).

2.3.3 Upper Feather River

The Upper Feather River includes the headwaters and the major tributaries that are: the West Branch, the North Fork Hamilton Branch, the North Fork East Branch (collectively the North Branch), the Middle Fork, and the South Fork. There are a number of dams on these branches and forks. If anadromous fish were to be reintroduced into their historic habitat in the Upper Feather River, the fish would be subject to adverse effects of these dams, including blocked passage, altered flow, altered water temperatures, and impaired recruitment of large woody material and sediment. There will also be less stream habitat than prior to the construction of the dams, due to the stream habitat that is inundated by the reservoirs.

2.3.4 Lower Feather River

The Lower Feather River is generally considered as that portion of the Feather River and its watershed that lies downstream of Oroville Dam, extending to the confluence with the Sacramento River at Verona. The Lower Feather River watershed encompasses about 803 square

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[3] As described in section 1.5, the primary focus area for our analyses will be on effects of Oroville Facilities operations within the Feather River basin. An exception is that effects of FRFH operations will be considered throughout a broader area.

miles. There are approximately 190 miles of major creeks and rivers, 695 miles of minor streams, and 1,266 miles of agricultural water delivery canals. The river flows approximately 60 miles north to south before entering the Sacramento River at Verona. The river is almost entirely contained within a series of levees as it flows through the agricultural lands of the Sacramento Valley. Oroville Dam is a major component of the SWP, and it provides virtually all the water delivered by the California SWP. Flows are regulated for water supply and flood control through releases at Oroville Dam, and to a lesser extent flows are regulated to maximize production of hydroelectric power.

Figure 2-25 shows the Feather River watershed.

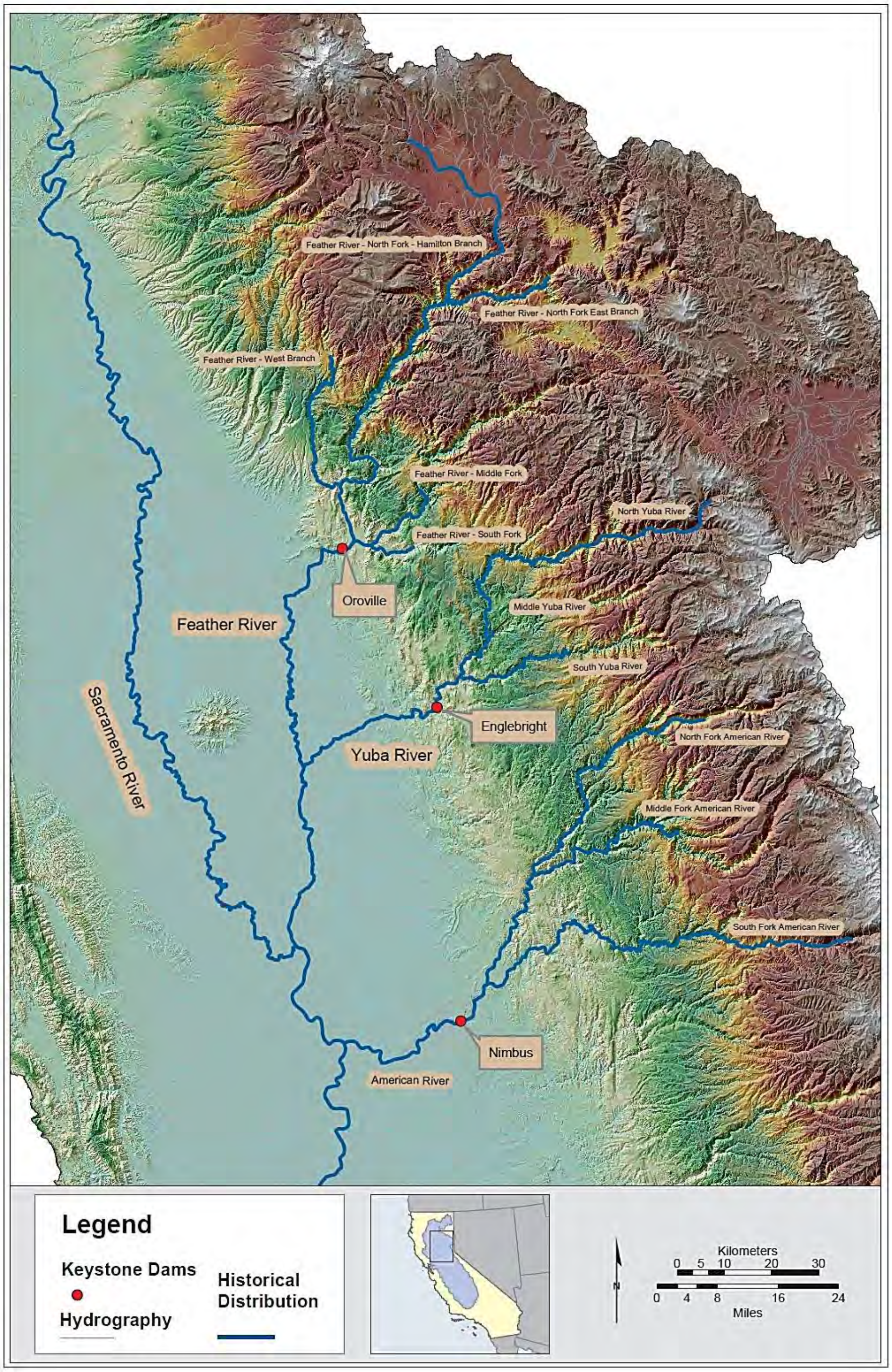

Figure 2-25. The Feather River Watershed

2.3.4.1 Factors Affecting Species and Critical Habitat in the Feather River

Oroville Dam, its associated structures, and the operation of these structures and facilities induce factors and effects to listed fish species and their critical habitat. Oroville Facilities impose a total barrier to migration of fish at the point of the Fish Barrier Dam structure. Operation of the facilities produces thermographs and hydrographs that differ from the historical (pre-dam) condition of the Feather River. Oroville Dam retains sediment and large woody material that would otherwise wash downstream and replenish spawning and rearing habitat. The FRFH also has effects upon listed fish species through several mechanisms. These and other factors are considered below.

2.3.4.2 Blocked Habitat

Oroville Facilities impose a total barrier to fish migration. Actually, a secondary structure downstream of Oroville Dam, the Fish Barrier Dam, marks the terminus of river accessibility to anadromous fish. For the fish species that historically utilized the upper Feather River, their descendants have suffered one of three fates: they are now permanently trapped above Oroville dam, they have been extirpated from the river entirely, or they are forced to use the remaining habitat below the Fish Barrier Dam.

The amount of habitat made inaccessible by Oroville Facilities varies by species. For sDPS green sturgeon, Mora et al. (2009)_ENREF_188 used a predictive model based on limited parameters (flow rates, gradient, and air temperatures in nearby rivers used by sDPS green sturgeon) to estimate that Oroville Dam blocks access to approximately 16 ± 4 kilometers of habitat in the Feather River. The Mora study states the blocked habitat is probably of relatively high value due to its upstream position in the river network, but acknowledges that the accuracy of the model is limited because just a few habitat conditions were considered. _ENREF_370For salmon, Yoshiyama et al. (2001) identified that salmon ascended all four branches of the Feather River. On the North Fork he identified that salmon most likely ascended several miles upstream of Lake Almanor (see Figure 2-33). Steelhead likely had a similar distribution as salmon.

Downstream of Oroville Dam, near the town of Live Oak, the Sutter Extension Water District (SEWD) operates a pumping facility known as Sunset Pumps. In order to raise the surface elevation of the river to allow the pumps to function properly, the SEWD maintains a boulder weir that stretches across the river. This structure does not have an engineered fish ladder or fish passage chute specifically designed for the passage of CCV steelhead, Chinook salmon, or sDPS green sturgeon. Because this structure blocks, or partially blocks, fish passage at low to moderate flows, the structure impacts listed fish species and contributes to their status in the Feather River. This structure is not associated with the proposed action or the FERC license for Oroville Facilities. Numerous additional dams exist above Oroville Dam.

Even if fish passage were provided past the Oroville Facilities, loss of access to historical spawning and rearing habitats upstream of the Oroville Facilities would probably continue somewhat into the foreseeable future due to the significant number of upstream hydroelectric projects that start at the upstream extent of the project facilities at Oroville Reservoir and extend into the upper watersheds of all main forks of the Feather River and their tributaries (Figure 2-27). Some otherwise suitable habitat is also blocked by natural barriers in the upper tributaries.

The absence of upstream and downstream fish passage at the dams in the upper Feather River has resulted in the loss of access to migratory habitat, spawning habitat, incubation habitat, and rearing habitat for CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. Habitat for these species has also been lost due to inundation by reservoirs. The lack of fish passage has restricted these species to habitat that has been degraded through the interruption of natural processes, and landscape alterations. CV spring-run Chinook salmon are further impacted due to impacts from fall-run Chinook salmon.

Figure 2-26 shows PG&E dams upstream of Oroville Reservoir on the West Fork and North Fork Feather River.

Figure 2-26. PG&E Dams Upstream of Oroville Reservoir, West Fork, and North Fork Feather River

2.3.4.3 Altered River Flow

The past and current operation of the Oroville Facilities creates a hydrograph that is markedly different from the historical condition. As Figure 2-27 shows, there is a consistent pattern of decreased springtime flows and increased summer flows across all water-year types. Marchetti and Moyle (2001) identified that restoration of natural flow regimes is necessary to reverse the decline of native fish populations. Healey (1991)_ENREF_128 stated that dams have probably had a much greater effect on stream-type Chinook salmon (*e.g.*, CV spring-run Chinook salmon) than ocean-type Chinook (fall-run Chinook) due to longer migrations and longer resident times in rivers. The NRC (1996) stated that salmon are very sensitive to changes in streamflow and time their life-cycle movements according to local discharge regimes. For fish species (*e.g.*, Chinook salmon, green sturgeon) that evolved in conditions of elevated springtime flows, such an altered hydrograph may have a negative effect. In some conditions, such as drought, the altered hydrograph can be beneficial.

Figure 2-27 shows the median weekly water flow in critical dry water years in the Feather River during pre-dam years (Oroville gage 1906-1965) and post-dam years (Gridley gage 1969-2012).

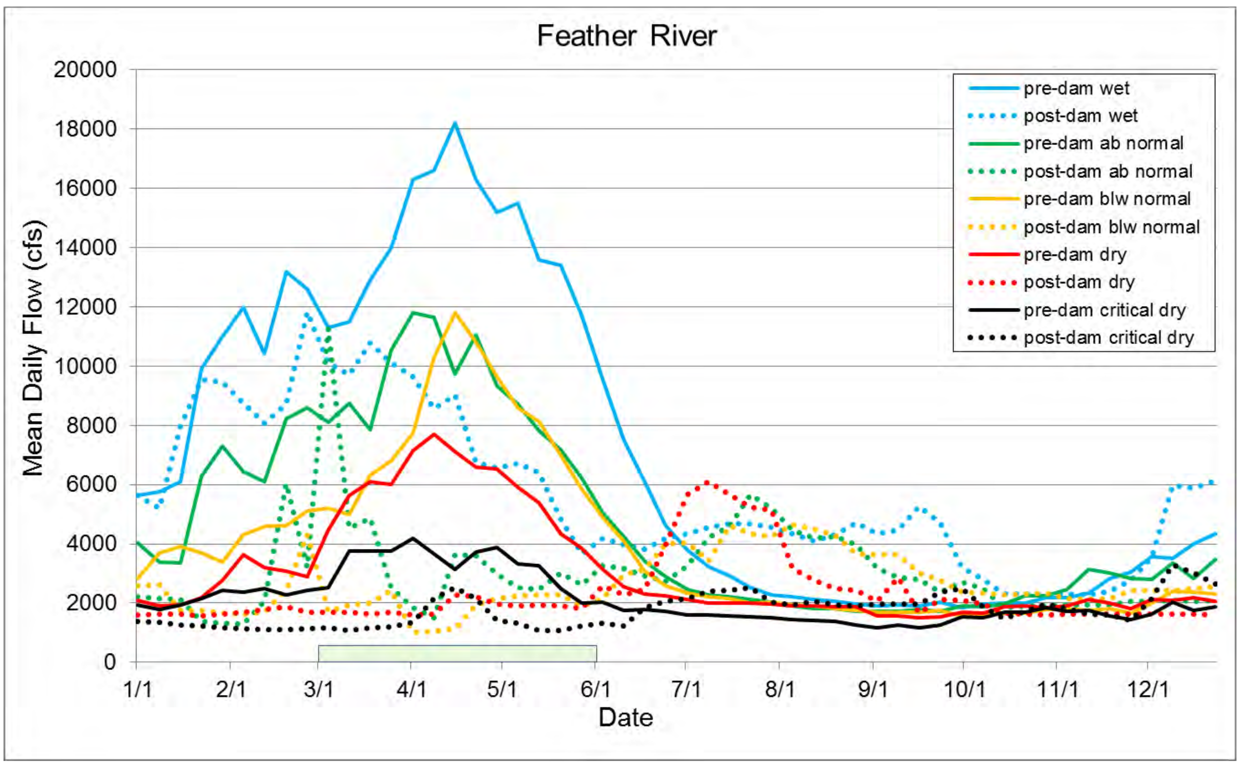

Figure 2-27. Median Weekly Water Flow in Critical Dry Water Years

Ramping Rates—Ramping rates are not required by the existing FERC license for the Oroville Facilities, but the rates that are proposed as part of the new license have been maintained in practice since 2004. Ramping rates are important because decreasing flows too quickly may result in stranded fish (Hunter 1992).

Instream Flows—DWR manages flows in the Feather River in a manner that reduces the potential for fish stranding and desiccation of redds. Minimum flows in the Feather River are currently set by an agreement between DWR and CDFW (Department of Water Resources and

California Department of Fish and Game 1983). The *Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish and Wildlife* established criteria for flow and water temperature in the LFC and the reach of the Feather River downstream of the Thermalito Afterbay Outlet to the confluence with the Sacramento River to preserve salmon and steelhead spawning and rearing habitat. The agreement specifies a minimum release of 600 cfs into the Feather River LFC from the Thermalito Diversion Dam for fisheries purposes. This is the total rate of flow from the diversion dam outlet, the diversion dam power plant, and the FRFH outlet.

When Lake Oroville surface elevation is greater than 733 feet, the minimum instream flow requirements on the Feather River, downstream of the Thermalito Afterbay Outlet, range from 1,000 to 1,700 cfs depending on unimpaired run-off forecasts. These flows are requirements in the existing project license. Under the DWR/DFW agreement, if the April 1 runoff forecast in a given water year indicates that, under normal operation of the SWP, the reservoir level will be drawn down to elevation 733 feet (approximately 1.5 million acre feet), releases for fish life prescribed in the agreement (i.e., the minimum instream flow requirements on the Feather River downstream of the Thermalito Afterbay Outlet) may suffer monthly reductions in the same proportion as the respective monthly reductions imposed upon deliveries of water for agricultural use from the SWP. However, in no case shall the fish water releases prescribed in the agreement be reduced by more than 25 percent.

Under the DWR/DFW agreement, if the hourly flow exceeds 2,500 cfs anytime between October 15 and November 30, DWR must maintain a flow equal to that hourly flow amount less 500 cfs until the following March unless the high flow was a result of flood management operations or mechanical problems. This requirement ensures flow levels are high enough to keep the overbank areas submerged to protect any fish spawning that could occur. In practice, the flows are maintained below 2,500 cfs from October 15 to November 30 to prevent fish from spawning in the overbank areas.

While flows are managed to protect fish and fish eggs, the modified flow regime has reduced the frequency of channel forming flows. This along with levees has reduced the lateral movement of the Feather River. This has resulted in a more channelized river, with reduced sinuosity. This reduces the amount of some types of habitat that are productive for salmonids. Flood management has also reduced the frequency of the inundation of flood plains, which are areas that are very productive for salmonids.

Flow alterations have impacted natural channel processes related to habitat creation. This includes interruption of the downstream movement of gravel and wood, stopping the lateral movement of the river that forms side channels, and inundation of the floodplain. Altered flows may also be impacting downstream migration and survival through increased travel time, due to decreased flows. Flood management has reduced losses of incubating eggs due to reduced frequency of scour events

2.3.4.4 Altered River Temperatures

The past and current operation of Oroville Dam and associated facilities affects water temperature in the Feather River below Oroville Dam. Water temperatures may be colder or warmer than historic norms in the river depending upon a number of parameters including the large, naturally occurring variability in Feather River hydrology (unimpaired Feather River flow has varied from

1 million acre feet to nearly 10 million acre feet over the roughly 100-year gage record), operation of dams further upstream, and a variety of operations conducted at Oroville Dam, a majority of which are not elective for DWR, such as flood control, and riparian water right deliveries.

DWR releases water from Lake Oroville under a prescribed statutory and contractual hierarchy. These are, in order of priority, flood control releases, Feather River instream flow and temperature requirements that are primarily the result of biological opinions, Delta water quality requirements that are permit conditions associated with DWR's water rights on the Feather River, contractual water supply obligations to senior Feather River water rights diverters, and lastly, SWP water supply deliveries to the 29 public agencies with SWP water supply contracts. Power generation releases through Hyatt Powerplant and releases through the RVOS from Lake Oroville are made subordinate to the hierarchy noted above. These priorities may be adjusted in specific situations if rigid adherence to them would compromise the ability to meet legally mandated water quality, flow, or temperature requirements in other parts of the river system.

With respect to the Hyatt Powerplant intake located just upstream of the left abutment of Oroville Dam, water can be drawn from Lake Oroville over a range of depths by adding or removing shutters on the Hyatt Power Plant intake, thus permitting water to be drawn into the turbines over all or limited intervals of the upper 287 feet of Lake Oroville. Because Lake Oroville stratifies with respect to temperature, especially during summer, deeper water below the thermocline tends to be colder. The Hyatt Intake is very effective, under most operating conditions, at regulating the temperature of the water released from Oroville Dam to meet all current Oroville Facilities temperature requirements. Essentially, Lake Oroville must approach elevation 700 feet or lower for the Hyatt Intake to be ineffective in drawing cold water below the Lake Oroville thermocline. This elevation at Lake Oroville is typically only reached in dry or drought conditions or when such conditions persist over several years.

Oroville Dam, as required by dam safety regulations, also has a low level outlet accessing elevation 225 feet in Lake Oroville called the River Valve Outlet System (RVOS). The RVOS was designed to serve as a bypass around Hyatt Powerplant in the event of an outage of the plant and was also designed to serve as a low level outlet in case emergency evacuation of Lake Oroville is required. Both these operating scenarios are extreme events that are not expected to occur (especially the emergency evacuation scenario).

The two 54-inch Fixed Cone Valves (FCV) comprising the RVOS that discharge into Hyatt Tailrace Tunnel 2 have a design discharge capacity that varies with Lake Oroville elevation. Their capacity ranges from approximately 4,000 cfs at lake elevation 640 feet to about 2,000 cfs at Lake Oroville dead pool at elevation 340 feet. Lake Oroville has never been lower than elevation 645 feet. Because the two 54-inch FCVs are guarded by 72-inch spherical valves with no means to be isolated from the nearly 700 feet of head on the reservoir side, it is clear the design intent of the RVOS was for emergency or only occasional use. That said, the RVOS has been used in 5 separate years since the completion of Oroville Dam in 1967 to access cold Lake Oroville water for blending with Hyatt Powerplant releases to meet FRFH and Feather River temperature requirements deemed necessary for the protection of special status anadromous fish.

However, a malfunction and resulting accident occurred with the RVOS in 2009 that resulted in significant restrictions being placed on their operation. At this time (2016), through agreement with Division of Occupational Safety and Health, Department of Industrial Relations and others, the RVOS is approved for limited operations during the current (2016) drought emergency. DWR is working with dam safety regulatory agencies and others towards a long-term solution for use of the RVOS, which is intended to restore the full original design capacity of 4,000 cfs at lake elevation 640 feet for the RVOS.

As water flows downstream of Oroville Dam, most water is typically diverted into the Thermalito Forebay-Afterbay Complex to meet the aforementioned senior Feather River water rights obligations, which are primarily for agricultural beneficial use. A substantial portion of the April to October releases from Oroville Dam is for this purpose.

By design, the water residence time in the relatively shallow 40,000-acre Thermalito Afterbay warms the water. On average, about one-third of this water flows back into the Feather River at the Thermalito Afterbay Outlet. The diversion of water through the Thermalito Complex can warm the water as much as 6°F. Thermalito Afterbay was originally designed, in part, to warm the river water downstream to mimic the warmer water temperatures that occurred in the Feather River before Oroville Dam was constructed (and before its cold water pool was established). Oroville Dam operations provide colder water to the Feather River, under a broad range of hydrologic conditions, compared to the pre-Oroville Dam conditions. Warmer river water is more conducive to rice farming, which has been identified as a beneficial use of Feather River water since before the Oroville Facilities were built as recognized in the senior water rights along the Feather River.

The operation of Oroville Dam and associated facilities produce complicated effects upon water temperature in the Feather River below Oroville Dam. Water temperatures may be colder or warmer than historic norms in the river depending upon how operations are conducted. Within Lake Oroville, water can be drawn from a variety of depths by adding or removing shutters on the Hyatt Power Plant intakes. Because deeper water tends to be colder, this type of manipulation is effective, up to a point, at regulating the temperature of the water released from Oroville Dam. Also, the dam structure has river valves that allow deep, cold water to be released if desired. As water flows downstream of Oroville Dam, most water is typically diverted into the Thermalito Complex where its residence time in a broad, shallow lake-type area tends to warm the water, which then flows back into the Feather River at the Thermalito Afterbay Outlet. The diversion of water through the Thermalito Complex can warm water as much as 6°F and significantly reduces the amount of cold water habitat available in the Feather River. Furthermore, pump back operations[4] can also contribute to the artificial warming of river water.

Additionally, other FERC-licensed projects in the upper Feather River can influence the water temperature in the FRFH and the LFC. The South Feather Power Project discharges water in the Lower Feather River immediately downstream from Oroville Dam and affects water temperatures at the FRFH and the LFC. Water is diverted from the South Feather River at Ponderosa Dam and

4Overall, the SWP uses more energy than it produces. Pump-back operations allow DWR to minimize the cost of the power it purchases. Pump-back operations are a practice where water is pumped from an afterbay (*e.g.*, Thermalito Afterbay) up to a forebay (*e.g.*, Thermalito Forebay or the Diversion Pool) during off-peak periods when power costs are lower. The water is then sent back through the power plant to generate power when power values are higher to offset the costs of water conveyance. A side effect of this practice is the warming of the water due to its retention time in the system. When the water eventually does exit the system at the Thermalito Afterbay, it is likely warmer than it would have been had it been initially discharged from Lake Oroville.

conveyed via tunnel and conduit to Miner's Ranch Reservoir and then via tunnel and penstock to the Kelly Ridge Powerhouse, through which up to 260 cfs is discharged to the Feather River downstream of Oroville Dam. Data and analyses indicate the flows diverted at Ponderosa Dam experience heating in transit to the Kelly Ridge Powerhouse, especially within Miner's Ranch Reservoir. The temperatures of the Kelly Ridge discharges are of greatest concern from summer through fall (August through October) because: (1) this interval is critical for anadromous fish holding, spawning, and incubation in the Feather River; (2) the intake of water to the Feather River Hatchery occurs from the Thermalito Diversion Pool, and cold water requirements must be maintained; (3) colder releases through the Hyatt Powerhouse (Oroville Facilities) are reduced or periodically halted as Lake Oroville elevations fall in late summer and fall, and as consumptive needs and power demands lessen; and (4) late summer or fall meteorological conditions (heat storms) may cause appreciable heating in the FRFH and the LFC.

Collectively, all these operations may produce a thermograph that is similar or different to that in which ESA listed anadromous fish species evolved. Figure 2-8 shows the overall water temperature trends in the Feather River for a current time period (2002-2012) compared to a historical, pre-dam time period (1958-1967). A variety of temperature control devices have been engineered into the Oroville Facilities, allowing DWR to adjust river temperatures to better suit the needs of listed fish species. As shown in Figure 2-8, DWR has been able to substantially reduce river temperatures from approximately May 1 until November 1 compared to pre-dam conditions. This type of temperature control was not available before the Oroville Facilities were built.

Figure 2-28 depicts median daily maximum water temperature in the Feather River at Oroville during pre-dam years 1958-1967, at Oroville during post-dam years 1969-1992, and at Gridley during post-dam years 2002-2012.

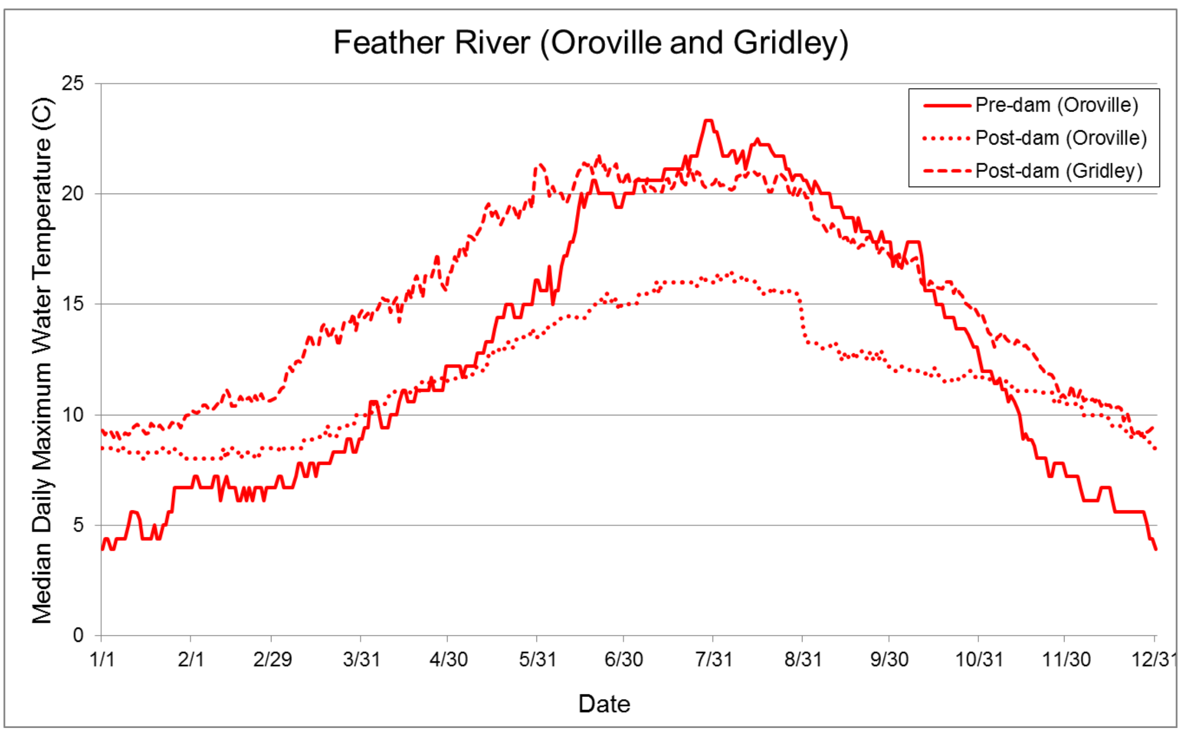

Figure 2-28. Median Daily Maximum Water Temperature

The water temperatures downstream of Oroville Dam have been significantly altered. With the Oroville Facilities, at Oroville, the temperatures are warmer in the winter and cooler in the summer than prior to the Oroville Facilities. While the cooler temperatures at Oroville represent an improvement in the habitat to which CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon have been restricted, it is unclear how the water temperatures compare to the spawning, incubation and rearing habitat to which they were adapted, prior to the construction of the dams in the Feather River.

2.3.4.5 Impaired Recruitment of Large Woody Material (LWM) and Sediment

Oroville Dam blocks important physical transport mechanisms, most notably the inhibition of downstream transport of gravel and large woody material. Gravel transport is important for the maintenance of favorable spawning habitat. Without human intervention, the habitat below Oroville dam becomes increasingly devoid of suitable spawning substrates as this material is washed downstream during periods of heavy flow and is not replaced naturally with the dam in place. Therefore, a gravel augmentation program, though expensive and labor intensive, is the only way to maintain suitable spawning habitat below Oroville Dam. The same is true for large woody material, which is important for maintaining habitat complexity, and providing refuge areas for juvenile fish (salmonids and sturgeon) and for creating habitat that encourages a complex and thriving ecosystem, ideally one that is hospitable to native fish.

The conditions downstream of the Fish Barrier Dam are impacted and the spawning and rearing functions are impaired due to the interruption of the natural processes that move gravel and wood downstream.

2.3.4.6 Susceptibility to Disease

A number of factors—such as fish species, fish densities, the presence and amounts of pathogens in the environment, and water quality conditions (*e.g.* temperature, DO, and pH)—relate to the susceptibility of listed species to disease within the action area. Oroville Facilities, and associated programs, have affected all these factors since operations began and are expected to continue to do so under current operations.

Several endemic salmonids pathogens occur in the Feather River basin, including *Ceratomyxa shasta* (salmonids ceratomyxosis), *Flavobacterium columnare* (columnaris), the infectious hematopoietic necrosis (IHN) virus, *Renibacterium salmoninarum* (bacterial kidney disease [BKD]), and *Flavobacterim psychrophilum* (cold water disease) (Department of Water Resources 2004c) . Although all these pathogens occur naturally in the Feather River Basin, the Oroville Facilities may have produced environmental conditions that are more favorable than under historical conditions. Such conditions include: 1) impediments to upstream migration altering timing, frequency, and duration of exposure of anadromous salmonids to certain pathogens; 2) inadvertent introduction of foreign diseases through out-of-basin transplants as part of the Lake Oroville Coldwater Fishery Improvement Program; 3) the transmission of disease from FRFH fish to wild or natural populations of listed salmonids; and 4) water transfers, pump-back operations, and flow manipulation resulting in changes in water quality conditions (*e.g.*, temperatures, DO, pH, etc.).

Across the entire Central Valley, including the Feather River, there is no evidence that CV spring-run Chinook salmon have experienced unusual levels of disease in the wild. There have been numerous outbreaks of infectious hematopoietic necrosis virus (IHNV) in Chinook salmon at the FRFH. Although the virus has been detected in stream salmonids, there have been no reported epizootics of IHNV in Central Valley stream populations (*i.e.*, the virus was detected but the fish themselves were asymptomatic of the disease) (Chappell 2009). It appears that IHNV is not readily transmitted from hatchery fish to salmon and other fish in streams, estuary, or the ocean (Chappell 2009).

2.3.4.7 Water Quality

Water quality parameters that may affect fish species within the Feather River basin include: (1) DO and pH; 2) turbidity and total suspended solids (TSS) levels; (3) metals, petroleum by-products; (4) pesticide concentrations; and 5) nutrient concentrations. The CVRWQCB has listed the lower Feather River as impaired by sources of mercury, certain pesticides, and toxicity of unknown origin (Department of Water Resources 2007).

Findings and other pertinent information related to monitored water quality parameters have been reported by DWR (2004c). For the most part, DO and pH levels in the Feather River downstream of Oroville Dam comply with objectives established by the CVRWQCB. Turbidity and TSS levels were typically low in the upper watershed (above Lake Oroville), except during storm events. Because Lake Oroville acts as a sediment trap, turbidity and TSS levels are also generally low between Oroville dam and the Thermalito Afterbay Outlet. Downstream of the Thermalito Afterbay Outlet, turbidity and TSS concentrations generally increase, presumably related to inputs from downstream tributaries in the lower Feather River (Department of Water Resources 2007).

Exceedance of water quality objectives for aluminum, iron, and copper were observed in DWR’s water quality studies (Department of Water Resources 2004c), but could not be associated with project operations or recreational activities. Petroleum products and pesticides were largely undetected in water samples collected for DWR’s (Department of Water Resources 2007). Nutrient concentrations measured in the Feather River were consistently below most Basin Plan objectives for the protection of beneficial uses, which includes freshwater habitat, fish migration and spawning (Department of Water Resources 2007).

It is expected that water quality parameters will continue to be monitored by the CVRWQCB and may remain at current levels into the foreseeable future.

2.3.4.8 Bank Modification and Riparian Habitat Loss

Bank modification (the construction of levees and bank armoring) changes the geomorphic processes affecting the lower Feather River. Continued deprivation of the sediment load in the lower Feather River is expected to result in reduced formation of sediment benches important to the colonization and succession of riparian vegetation (Department of Water Resources 2007). Riparian vegetation is important to aquatic habitats because it provides overhanging cover for rearing fish, stream side shading, and a source of terrestrial and aquatic invertebrate contributions to the fish food base (Department of Water Resources 2007). Riparian vegetation is also an important source of future LWM contributions to the aquatic system. Bank modification has reduced habitat quality and the productivity of the lower Feather River.

2.3.4.9 Water Diversions

DWR has settlement agreements with six local agencies along the Feather River (including the Thermalito Afterbay) from Lake Oroville to the confluence with the Sacramento River. They receive water according to the terms of settlement stemming from the original construction of the Oroville Facilities. These settlements recognized the senior water rights of those agencies and that DWR would provide them certain quantities of water from storage in Lake Oroville in accordance with those senior water rights. Four of these agencies are allowed to divert up to 955,000 af during the irrigation season (April 1 through October 31), subject to provisions for reduction in supply under certain specific low-inflow conditions. The agreements with these agencies also indicate that an unspecified amount may be diverted for beneficial use outside of the contract irrigation season (November 1 through March 31). The remaining two agencies are allowed to divert up to 19,000 af annually, also subject to provisions for reduction in supply under certain specific low-inflow conditions.

The actual amount diverted varies from year to year depending on the local hydrology. These diversions are made at one location in Lake Oroville, one location in the Thermalito Power Canal, four locations in Thermalito Afterbay, and five locations on the Feather River below Thermalito Afterbay. The agencies that divert directly from the Thermalito Afterbay are collectively referred to as the Feather River Service Area (FRSA) water users and are responsible for most of the local diversions.

DWR has also executed a number of contracts with riparian landowners along the Feather River downstream of Oroville Dam. Riparian owners are entitled to divert unimpaired flow for use on riparian land, but are not entitled to augmented flow made available as a result of project storage. Although the quantities of water are relatively small and do not ordinarily influence SWP operations, in certain years riparian diversions can affect Oroville releases.

Water diversions have the potential to affect listed fish species in two ways: direct fish entrainment and habitat alteration through changes to water flow, temperature, hydrology, or by creating predation hotspots. Entrainment risk is primarily a concern for water diversions that are unscreened and the fry or juvenile life stages are most vulnerable. An unscreened water diversion can entrain a fish by sucking it up into the pump, where it might be killed or injured by the pump, or, should the fish survive transport through the pump, it will be transported to a canal or ditch where long-term survival is unlikely. Entrainment experiments have shown that a juvenile Chinook salmon's entrainment risk ranges from 0.3 to 2.3 percent and a juvenile green sturgeon's entrainment risk ranges from 4.2 to 22.3 percent when encountering a single unscreened pump (Mussen et al. 2014).

Risk of entrainment varies by year and location and can be significantly affected by river velocity, the rate of water diversion, and the number of pumps encountered during migration (Mussen et al. 2014). On the Feather River there are 120 diversion pumps downstream of the Fish Barrier Dam, only four of which are screened (Figure 2-29). The unscreened diversions pose a potential entrainment risk to larval and juvenile fish. The combined effect of all unscreened water diversions is unknown and requires further study. Fish screen criteria for green sturgeon have not been developed and it is unclear whether the current application of salmonid criteria is sufficient to protect sDPS green sturgeon.

Periods of high water diversion may result in low flows along the Feather River. Salmon, steelhead, and green sturgeon are attracted by increased flows, so low flows in the Feather River may be insufficient to provide attraction cues to these fish species, thereby inhibiting spawner returns. Low flows may also lead to higher in-river water temperatures, perhaps to sub-optimal levels. Low flows may also result in barriers to migration at locations such as the Sunset Pumps, where a boulder weir stretches across the river, inhibiting fish passage at low to moderate flows (the exact flow thresholds that pose a fish passage problem at the Sunset Pumps boulder weir is not yet clearly defined).

Reduction in flows has reduced the quantity and quality of habitat in the lower Feather River during some periods of the year.

Figure 2-29 shows locations of water diversions in the Feather River. Of the approximately 120 water diversions in the lower Feather River, only 4 are screened.

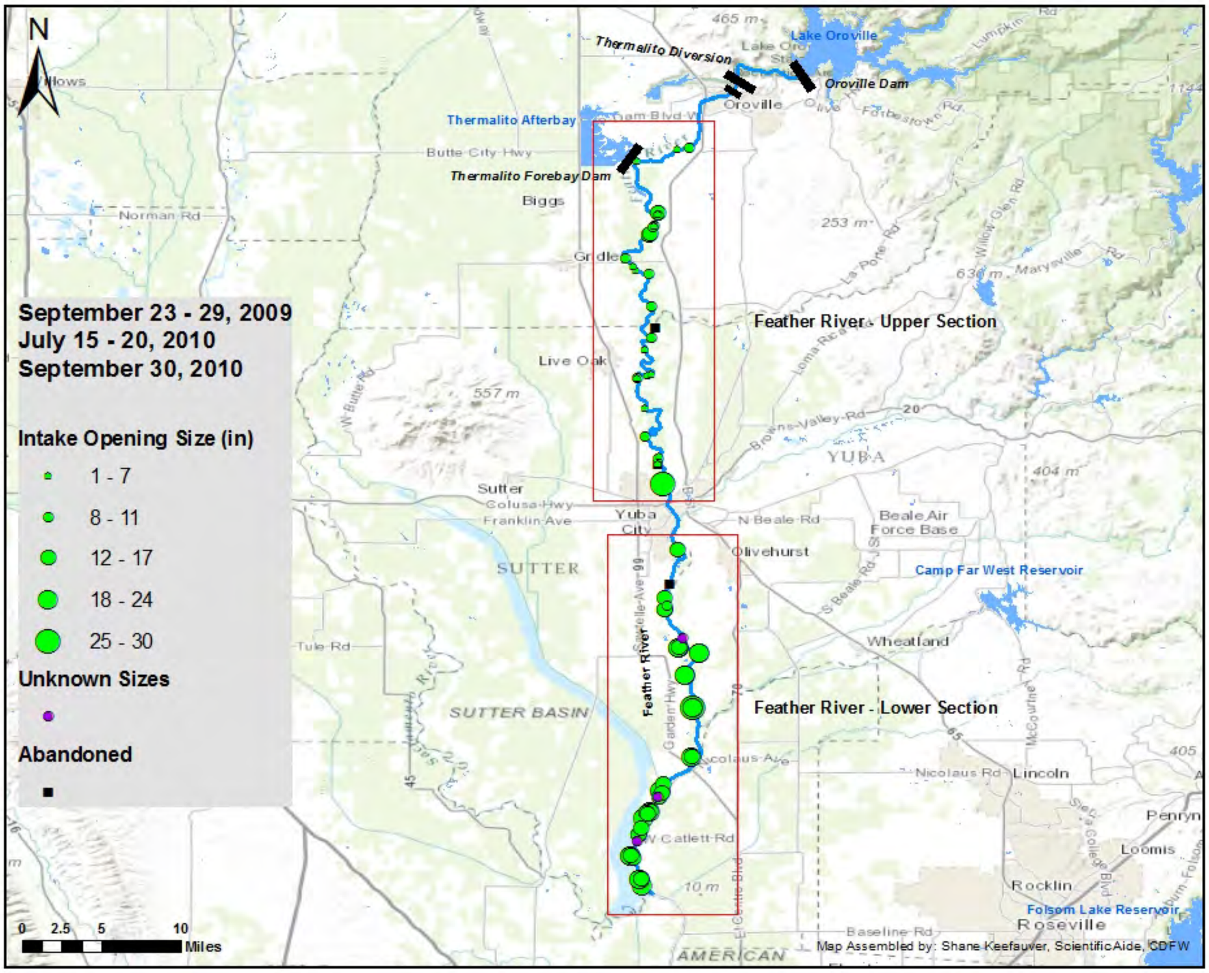

Figure 2-29. Locations of Water Diversions in the Feather River

2.3.4.10 Monitoring, Research, and Adaptive Management of Feather River Water Diversions.

The collective impact of water diversions to listed fish species in the Feather River is not well understood. The SWRCB regulates water diversions through their Water Rights Permitting program in coordination with the California Department of Fish and Wildlife. The SWRCB has stepped up monitoring requirements due to drought, requiring reporting of diversion amounts and ceasing diversions when precipitation and other factors limit available flows. Increased monitoring, and enforcement of water right restrictions may provide improved fish habitat.

2.3.4.11 Water Management

As an integral part of the California SWP, the Oroville Facilities are operated in coordination with the Federal CVP to provide water deliveries to a large portion of California. SWP water flow management activities must comply with the State/Federal Coordinated Operations Agreement (COA); SWRCB water quality control plans (which include Delta flow and water quality standards to be met); previous salmon, CCV steelhead, sDPS green sturgeon, and delta smelt biological opinions issued by either NMFS or USFWS; and other agreements.

Many early restrictions placed on project operations primarily focused on Sacramento River winter-run Chinook salmon because this was the first species to be listed in the Sacramento River watershed. More recent restrictions on combined CVP/SWP operations have also considered CV spring-run Chinook salmon, CCV steelhead, and the sDPS of green sturgeon. During the recent drought (2012-2016) modifications of CVP/SWP operations have included modification of flows to conserve water in Shasta Lake. In 2016, in order to meet water quality requirements in the Delta, releases were increased from Lake Oroville and Folsom Lake. Increased releases from Lake Oroville may reduce the cold water pool in Lake Oroville. Increased releases in one year may impact the Oroville Facilities' ability to meet water temperature requirements in that year, and depending on precipitation, in following years.

2.3.4.12 Flood Control

The Oroville Facilities are also operated as an integral component of the flood management system for areas along the Feather and Sacramento Rivers downstream of Oroville Dam. This flood management system is called the Sacramento River Flood Control Project.

From September to June, the Oroville Facilities are operated under flood control requirements specified by the Army Corps of Engineers (Corps), the agency primarily responsible for flood control operations. Historically, flood control releases have not been necessary every year. When they are necessary, however, they can be substantial. Peak flood control releases during major spill events between January 1970 and December 1996 ranged from 77,000 cfs to 160,000 cfs (Department of Water Resources 2007).

Flood control operations have simplified the hydrograph by reducing the frequency of bankfull and greater flows that shape and maintain the morphology of the river channel and associated fish habitats. This has simplified habitat conditions for fish and reduced the inundation of floodplain habitats that when inundated are known to improve the growth and survival of juvenile salmonids when compared to rearing conditions in the main channel (Jeffres et al. 2008).

2.3.4.13 Recreational Fishing

Fishing regulations currently prohibit fishing of any type above the Table Mountain Bridge on the Feather River, but limited fishing for CCV steelhead, salmon, and sturgeon is permitted below this bridge. While hatchery CCV steelhead, Chinook salmon, and white sturgeon are targeted, incidental catch of protected species such as naturally produced CCV steelhead, CV spring-run Chinook salmon, and sDPS green sturgeon does occur. The areas open to fishing include some of the best spawning habitat for listed salmonids on the Feather River, introducing the possibility that spawning redds might be disturbed by anglers.

Since 1998, all hatchery CCV steelhead have been marked with an adipose fin clip, allowing anglers to tell the difference between hatchery and wild CCV steelhead. Current regulations restrict anglers from keeping unmarked CCV steelhead in Central Valley streams, except in the upper Sacramento River.

Current sport fishing regulations do not prevent wild CCV steelhead from being caught and released many times over, while on the spawning grounds where they are more vulnerable to fishing pressure. Recent studies on hooking mortality based on spring-run Chinook salmon have found a 12 percent mortality rate for the Oregon in-river sport fishery (Lindsay et al. 2004). Applying a 30 percent contact rate for Central Valley rivers (*i.e.*, the average of estimated Central Valley harvest rates), approximately 3.6 percent of adult steelhead die before spawning from being caught and released in the recreational fishery. Studies have consistently demonstrated that hooking mortality increases with water temperatures. Mortality rates for steelhead may be lower than those for Chinook, due to lower water temperatures.

In addition, survival of CCV steelhead eggs is reduced by fishermen walking on redds in spawning areas while targeting hatchery CCV steelhead or salmon. Roberts and White (1992)_ENREF_260 identified up to 43 percent mortality from a single wading over developing trout eggs, and up to 96 percent mortality from twice daily wading over developing trout eggs. Salmon and trout eggs are sensitive to mechanical shock at all times during development (Leitritz and Lewis 1980). Typically, CCV steelhead and salmon eggs are larger than trout eggs, and are likely more sensitive to disturbance than trout eggs. Currently, there are no regulations restricting river access to provide protection for spawning areas in the Feather River.

2.3.5 Feather River Fish Hatchery Operations

2.3.5.1 Background and Overview

The FRFH was constructed in 1967 to mitigate for the loss of Chinook salmon and CCV steelhead spawning habitat blocked by Oroville Dam. FRFH facilities are operated on contract by CDFW. The main Feather River Hatchery consists of an office and maintenance building, fish ladder, gathering tank, spawning building, main hatchery building, four holding and twelve juvenile rearing ponds (ten raceways and two rearing channels), ultraviolet water treatment building, and hatchery buildings. A secondary hatchery facility, the FRFH Annex, is located at RM 55 and includes an office, maintenance building, and four rearing raceways. The FRFH breeds fall-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead. In this Opinion we are most concerned with federally listed fish: CV spring-run Chinook salmon and CCV steelhead. The hatchery makes no provisions for sDPS green sturgeon.

The original purpose of the FRFH spring-run Chinook salmon program was solely to mitigate for construction of Oroville Dam and associated facilities. While this remains a goal of the program, the primary purpose of the program has shifted toward aiding in the recovery and conservation of the state and federally listed CV spring-run Chinook salmon.

FRFH-produced CV spring-run Chinook salmon are intended to be an integrated hatchery program. A fundamental purpose of an integrated hatchery program is to increase abundance, while minimizing the genetic divergence of a hatchery broodstock from a naturally spawning population (Hatchery Scientific Review Group 2009). In its report to Congress (Hatchery Scientific Review Group 2014), the Hatchery Scientific Review Group (HSRG) identified that in an ideal integrated hatchery program natural-origin and hatchery-origin fish represent two components of a single gene pool that is locally adapted to the natural habitat. The current goal for the number of adult CV spring-run Chinook salmon returning to the hatchery for broodstock selection is 1,500. The goal for juvenile production is to release 2 million CV spring-run Chinook salmon smolts sized at 60 fish per pound (fpp). Prior to 2015 the goal was to release at least half in-river (versus being released in the Delta). Starting in 2015, the goal is to release all of the CV spring-run Chinook salmon smolts in river.

The FRFH steelhead program produces fish to mitigate for construction of the Oroville Dam and associated facilities and supports recreational fishing opportunities. The steelhead program also strives to aid in the recovery and conservation of the Federal ESA listed CCV steelhead DPS. The program traps and artificially spawns both marked hatchery-origin and unmarked natural-origin CCV steelhead. Only a few unmarked fish are trapped annually, indicating that the wild population of steelhead in the Feather River is probably small. The FRFH CCV steelhead are intended to migrate to the ocean and return to provide recreational fishing opportunities and hatchery broodstock as mitigation for construction of the Oroville Facilities. The production goal for the program is to release 400,000 yearling CCV steelhead annually at 3 fpp. The FRFH also has a goal of raising an additional 50,000 CCV steelhead for the Delta Fish Agreement (also known as the Four Pumps Agreement) between DWR and DFW, which addresses impacts from SWP pumping in the Delta. During the initial 5 to 10 years of hatchery operation, experimentation occurred with stocks from the Coleman, Mokelumne, Nimbus, Washougal (WA), Sacramento, and Feather hatcheries (using juvenile fish, eggs, and some broodstock). For the last 20 years, only fish returning to the Feather River basin have been used for broodstock.

2.3.5.1.1 Hatchery Operations and Practices

The FRFH has affected salmonids in the Feather River. Historical hatchery practices contributed to the mixing of fall-run and CV spring-run Chinook salmon, leading to some genetic introgression and some loss of genetic diversity between the two runs. Prior to 2004, FRFH staff differentiated CV spring-run Chinook salmon from fall-run Chinook salmon by opening the ladder to the hatchery on September 1 (Department of Water Resources 2007). Those fish ascending the ladder from September 1 through September 15 were assumed to be CV spring-run Chinook salmon while those ascending the ladder after September 15 were assumed to be fall-run (Kastner 2003) (as cited in NMFS 2009). This practice led to considerable hybridization between CV spring-run and fall-run Chinook salmon (Department of Water Resources 2004c).

Since 2004, the FRFH fish ladder remains open during the spring months, closing on June 30, and those fish ascending the ladder are marked with an external tag and returned to the river. The fish ladder is reopened on about September 15 to allow fish to enter the hatchery for sorting and artificial spawning. Consistent with hatchery physical constraints and water quality, all returning fish are allowed free access to the hatchery after that date. This practice allows FRFH staff to identify those previously marked fish as CV spring-run Chinook salmon when they re-enter the ladder in September. Only tagged fish are spawned as CV spring-run Chinook salmon. No other fish are spawned during this time, as part of an effort to prevent hybridization with fall-run Chinook salmon and to introduce a temporal separation between stocks in the hatchery.

Because of the long history of hatchery practices that interbred CV spring-run and fall-run Chinook salmon within the hatchery and because fall-run and CV spring-run Chinook salmon that reproduce naturally in the river are forced to occupy the same habitat and therefore interbreed, the genetic integrity of fall-run and CV spring-run Chinook salmon in the Feather River is highly compromised. Loss of genetic diversity is generally recognized in conservation biology as a negative influence upon a species. A further concern is straying, whereby those Chinook salmon that are of Feather River origin may stray to other rivers and breed with other populations of Chinook salmon.

Straying and genetic introgression (hybridization)—Although data are limited, the general consensus is that there were once genetically distinct Chinook salmon runs in the Feather River system (Yoshiyama et al. 2000, Lindley et al. 2004, Department of Water Resources 2007).

It is commonly thought that CV spring-run and fall-run Chinook salmon spawning were spatially and temporally separated in the Feather River basin before construction of dams (including Oroville dam) (Department of Water Resources 2007).

CV spring-run Chinook are thought to have spawned higher in the watershed and earlier in the year when compared to fall-run Chinook salmon historically in the Feather River.

Today, the Oroville Facilities block upstream migration of both CV spring-run and fall-run Chinook salmon beyond the Fish Barrier Dam causing both runs to spawn in the same locations. In addition, overlap in the timing of spawning between the two runs occurs. This combination of limited spawning area and the overlap in timing of spawning has resulted in genetic introgression (hybridization) between the two races of salmon. Compounding the problem is the operation of the FRFH. Therefore, three opportunities for genetic introgression (hybridization) between CV spring-run and fall-run Chinook salmon exist on the Feather River today. These are: (1) introgression between natural (or wild) spawners within the river itself; (2) introgression between natural (or wild) spawners and hatchery produced spawners in the river; and (3) introgression of Feather River CV spring-run Chinook salmon and those from other nearby river systems (*e.g.*, Mill, Deer, and Butte creeks) as a result of straying.

Based on data from tagged fish, considerable cross-fertilization may have occurred between CV spring-run and fall-run Chinook salmon at the FRFH since it began operation in 1967 (Department of Water Resources 2007). Compounding the issue are questions regarding the genetic integrity of Feather River CV spring-run Chinook salmon. Comparisons of genetic characteristics indicate that Feather River CV spring-run Chinook are more closely related to fall- and late fall-run Chinook salmon than other CV spring-run populations in Butte, Mill and Deer creeks (Hedgecock et al. 2001, Department of Water Resources 2007). Furthermore, pre-Oroville Facilities genetic data are not available to help ascertain the genetic identity of historical Feather River CV spring-run Chinook salmon. Naturally spawning (those spawning in the river as opposed to the FRFH) CV spring-run Chinook salmon on the Feather River are particularly susceptible to pre-spawning mortality due to competition for space with the later arriving fall-run Chinook adults (Hedgecock et al. 2001, Department of Water Resources 2007). Also, spawning success by CV spring-run Chinook adults may be significantly reduced due to redd superimposition by the later arriving fall-run Chinook adults. The disruption of previously constructed redds may result in poor egg-to-fry survival (through increased egg and alevin mortality), leading to reduced CV spring-run Chinook salmon juvenile production (Department of Water Resources 2007).

Previous FRFH operations included the transport and release of FRFH produced CV spring-run Chinook salmon into San Pablo Bay. While this practice was designed to reduce or avoid mortality associated with juvenile migration through the Sacramento-San Joaquin Delta it resulted in an increase in the incidence of straying of FRFH produced CV spring-run to other river systems. Straying is a concern because it can lead to increased competition for limited habitat, an exchange of genetic material between races of salmon and the spread of disease between populations. Starting in 2015, the goal is to release all CV spring-run Chinook salmon smolts in the Feather River.

Some studies conducted by CDFW indicate that 8 percent of FRFH produced fish returning to the Central Valley strayed to streams outside the Feather River Basin. Other studies suggest straying rates of between 4 and 10 percent (Department of Water Resources 2007). To date, only a few FRFH produced Chinook salmon have been observed in Butte, Mill and Deer creeks, which have CV spring-run Chinook salmon populations distinct from the Feather River CV spring-run Chinook salmon population. In addition, interbreeding between FRFH CV spring-run Chinook salmon and CV spring-run Chinook salmon in Butte, Mill and Deer creeks appears to have been minimal (Department of Water Resources 2007).

2.3.5.1.1.1 Release Locations and Practices

The current goal of the CV spring-run Chinook salmon program is to release up to 2 million CV spring-run Chinook salmon smolts annually at a minimum size of 60 fpp. In the past, all or proportions of the production have been released in San Francisco and San Pablo Bays. Prior to 2015, the strategy was to release 50 percent of FRFH spring-run Chinook salmon juveniles in the Feather River. Starting in 2015 the strategy is to release all of these fish in the Feather River. Release sites that include Boyd’s Pump Launch Ramp (RM 22) or south of Yuba City near the intersection of Oswald Road and the Garden Highway. Alternative locations may be used for small experimental groups to study the effects of release location on survival.

Depending on water temperatures and growth rates, fish are typically released during April or May. Fish are transported to the release sites using fish transport tank trucks. The transport tank is filled with fresh water from the hatchery water supply and, if necessary, the transport tank water may be chilled to cool the transport water to 47 to 53°F. Transportation time from the hatchery to the release site is typically less than one hour and fish are released directly into the receiving water. Since 2002, DWR personnel have attempted to mark (using CWTs and adipose fin-clipping) 100 percent of CV spring-run Chinook salmon smolts produced and released (California Hatchery Scientific Review Group 2012a). Since 2004, 100 percent of the CV spring-run Chinook salmon smolts have been marked.

In a recent study of spring-run Chinook salmon smolts released in the Feather River, smolts generally survived at a lower rate while traveling through the Feather River than the Sacramento River or Delta (Amman et al. 2014) (Figure 2-31). Specific reaches of the Feather River were identified by the investigators as trouble areas, or “mortality hotspots” (Figure 2-32) and may warrant further investigation. However, CWT data from paired releases of CV spring-run Chinook salmon smolts released in the river and in San Pablo Bay reveal relatively equal return rates as adults to the Feather River. Data from other years show that smolts released in the bay perform better, suggesting there are no clear answers regarding the survival of hatchery smolts released in the lower river.

Figure 2-30 shows results of a study of CV spring-run Chinook salmon smolt survival in 2013 and 2014 where smolts were released in the Feather River, and survival tracked through the Feather River, Sacramento River, and the Delta. Survival was lowest in the Feather River. Source: presentation by Arnold Amman, NMFS/SWFSC, at the Bay Delta Science Conference, 2014.

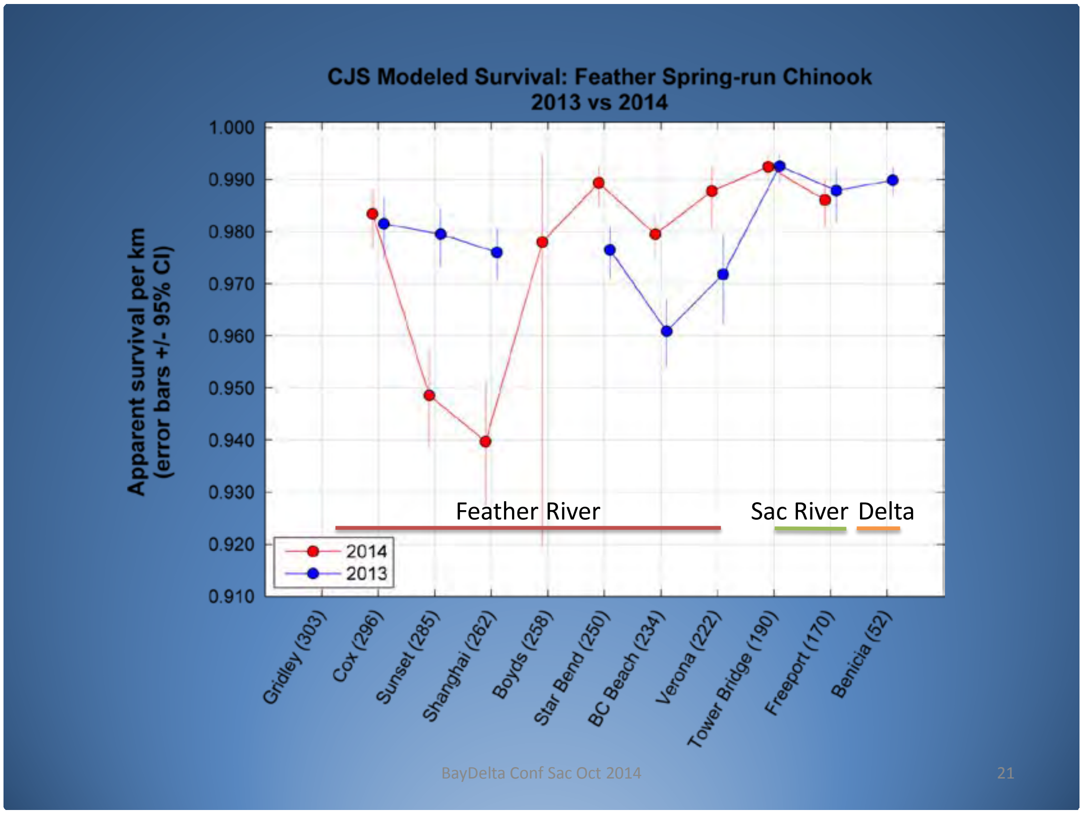

Figure 2-30. Study Results of CV Spring-run Chinook Salmon Smolt Survival, 2013-2014

Figure 2-31 shows mortality hotspots in the Feather River in 2013 and 2014, as indicated by a CV spring-run Chinook salmon smolt tagging study. Source: presentation by Arnold Amman, NMFS/SWFSC, at the Bay Delta Science Conference, 2014.

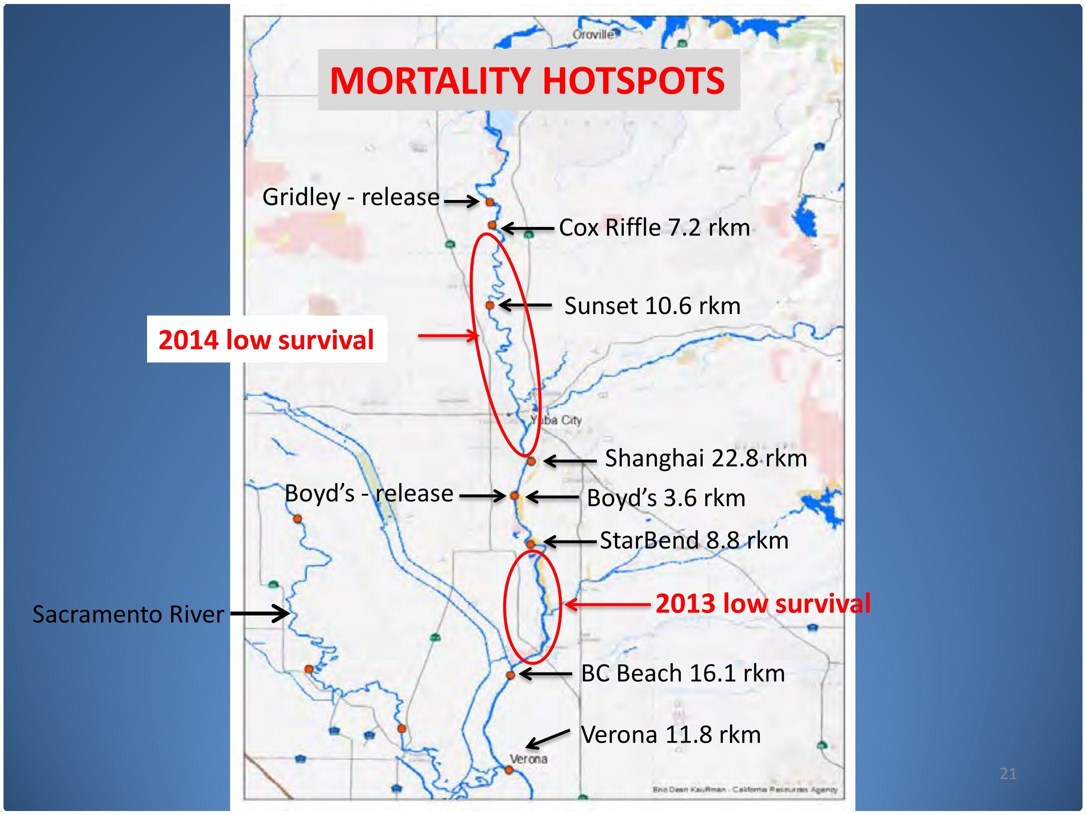

Figure 2-31. Mortality Hotspots in the Feather River, 2013-2014

The number of juvenile CCV steelhead currently being released annually is 450,000. Of that amount 400,000 juveniles at 4 fpp or larger (generally released at 3 fpp) are mitigation for the construction of Oroville Dam. An additional 50,000 juvenile CCV steelhead of a similar size are reared and released as part of the 1986 Delta Fish Agreement (formerly known as the "Four Pumps Agreement"). In the past, juvenile CCV steelhead reared at the FRFH have been released (trucked) to several locations in the Feather and Sacramento rivers, but current releases occur at one of three locations:

- Boyd's Pump Launch Ramp, Feather River (RM 22)
- Live Oak Boat Ramp, Feather River (RM 38)
- Verona Marina, confluence of Feather and Sacramento Rivers (RM 0)

Juvenile CCV steelhead are released from late January through February (the target is February 1), with specific release dates dependent on fish size, equipment, and personnel availability. Regardless of size, juvenile CCV steelhead are not held past March 15th because of increased water temperatures and greater likelihood of predation. Juvenile CCV steelhead are moved from the rearing ponds to the fish transportation tank and transported to the release site. No specific acclimation procedures are conducted before fish release. Efforts are made to maintain the transportation tank water temperatures at the same temperature of the hatchery and river during transportation. Since broodyear 1998, 100 percent of the juvenile hatchery-origin CCV steelhead released from California fish hatcheries into anadromous waters have been adipose fin-marked (*California Hatchery Review Project Appendix VIII Feather River Hatchery Steelhead Program Report June 2012*).

2.3.5.1.1.2 Feather River Hatchery Water Temperature Objectives

Since 2004, DWR has targeted a mean daily water temperature objective of less than or equal to 65°F from June 1 through September 30 at Robinson Riffle on the lower Feather River (RM 61.6). This affects the water temperatures in the FRFH. In critically dry water years, the coldwater pool in Lake Oroville may be exhausted or inaccessible, resulting in warmer water than desired (Federal Energy Regulatory Commission 2007). FRFH temperature objectives are shown in Table 2-11.

Table 2-11. Feather River Fish Hatchery Temperature Objectives (+4ºF) (DWR, 1983)

Period	Temperature (ºF)
April 1–May 15	51
May 16–31	55
June 1–15	56
June 16–August 15	60
August 16–31	58
September 1–30	52
October 1–November 31	51
December 1–March 31	55

2.3.5.1.1.3 Summary of Hatchery Practices

Past operations of the FRFH have contributed to some introgression of CV spring-run and fall-run Chinook salmon. This has contributed to a loss of genetic diversity between the races to the point where CV spring-run Chinook salmon are no longer genetically distinct. While some Chinook salmon exhibit a CV spring-run Chinook salmon phenotype, genetically they appear to be the same as the fall-run Chinook salmon. The release of hatchery CV spring-run Chinook in the Bay or Delta has been shown to increase the straying of these fish to other rivers, compared to the releases made at the hatchery, or in the upper Feather River. This may have adverse effects on the Chinook salmon populations in the streams where the straying fish spawn. The FRFH produces a consistent quantity of yearling CCV steelhead (450,000) and CV spring-run Chinook salmon (2,000,000) every year independent of external environmental conditions that could adversely affect naturally spawning CCV steelhead or CV spring-run Chinook salmon.

2.3.5.1.1.4 Hatchery Scientific Review Group Recommendations for the Feather River Fish Hatchery

In 2000, the U.S. Congress established and funded a hatchery review process because it recognized that, while hatcheries have a necessary role to play in meeting harvest and conservation goals for Pacific salmonids, the hatchery systems were in need of comprehensive reform. Most hatcheries were producing fish for harvest primarily to mitigate for past habitat loss (rather than for conservation of at-risk populations) and were not taking into account the effects of their programs on naturally spawning populations. With numerous species listed as threatened or endangered under the Endangered Species Act, Congress identified salmon conservation as a high priority. Genetic resources in the region were at risk and many hatchery programs were contributing to those risks. Congress intended that the reviews be scientifically founded and evaluated; that independent scientists would interact with agency and tribal scientists to provide direction and operational guidelines; and that hatchery systems as a whole would be evaluated for compliance with science-based recommendations.

Hatchery program reviews were completed in Puget Sound and coastal Washington (2004) and then in 2005. Congress directed NMFS to replicate the process in the Columbia River Basin. The scope of that review broadened and evaluation tools were refined. Implementation successes led Congress to further expand the geographic scope in 2010 and funds were appropriated to conduct a scientific review of hatchery programs in California. DWR and CDFW are in the process of incorporating many of the HSRG recommendations into HGMPs for the FRFH. A number of the recommendations are already being implemented.

The HSRG made the following general recommendations for the FRFH programs(California Hatchery Scientific Review Group 2012b):

- Clear goals should be established for the program. Program production goals should be expressed in terms of the number of age-3 ocean recruits just prior to harvest (Chinook salmon), and the number of adults returning to freshwater (steelhead).
- Transporting and releasing juveniles to areas outside of the Feather River and near or downstream of the confluence of the Yuba River should be discontinued. Juvenile fish should be released at the hatchery, or if not possible, as far upstream in the Feather River from the confluence of the Yuba River as possible to reduce adult straying and increase the number of adult fish returning to the hatchery. Consider necessary facility modifications or equipment purchases that will facilitate onsite releases. Release locations for steelhead may take into consideration ecological and predation effects on other fish populations but should not compromise homing of adults to the hatchery.
- Managers should investigate the feasibility of collecting natural-origin adult fish at alternate locations. The existing trapping location is very limited in its ability to capture fish representing the entire spectrum of life history diversity. Only fish that migrate to the furthest upstream reaches are susceptible to capture.
- Adult holding facilities should be upgraded and/or expanded to provide adequate space, water flows and temperature regimes to hold the number of adults required for broodstock at high rates of survival (greater than 90 percent). In addition, because of a lack of adult holding space, fall Chinook are returned to the river to make room for late arriving spring Chinook. Evaluate the prospects of using the Thermalito Annex Facility for the long-term

holding of spring Chinook broodstock. While the Annex water temperature is relatively high, a pilot study could be used to determine whether any associated increased holding mortality was sufficiently offset by the Annex's otherwise excellent water quality.

- Natural-origin fish should be incorporated into broodstock at a minimum rate of 10 percent to prevent divergence of the hatchery and natural components of the integrated population. This may require auxiliary adult collection facilities or alternative collection methods (e.g., seining or trapping).
- A Monitoring and Evaluation Program should be developed and implemented and a Hatchery Coordination Team formed for the program. Implementation of these processes will inform hatchery decisions and document compliance with best management practices defined in this report.
- Performance standards for each phase of the fish culture process should be established and tracked annually. Summaries of data collected with comparisons to established targets must be included in annual hatchery reports.
- CDFG should develop and promulgate a formal, written fish health policy for operation of its anadromous hatcheries through the Fish and Game Commission policy review process. Hatchery compliance with this policy should be documented annually as part of a Fish Health Management Plan. The current CDFG fish health policy is inadequate to protect native stocks.
- CDFG should develop an updated Hatchery Procedure Manual which includes performance criteria and culture techniques presented in (Integrated Hatchery Operations Team 1995), Fish Hatchery Management (Wedemeyer 2001) or comparable publications. The fish culture manual (Leitritz and Lewis 1976) is outdated and does not reflect current research and advancements in fish culture.

The HSRG made the following specific recommendations for the FRFH fall-run Chinook salmon program (California Hatchery Scientific Review Group 2012a):

- Use of the Feather River Annex for rearing should be discontinued unless juveniles are released in the vicinity of the Annex and an adult collection facility is installed in the downstream outlet of the Thermalito Afterbay.
- The program should limit the number of eggs taken to the number necessary to meet production goals (which would include a reasonable overage to account for egg loss and culling of spring x fall crosses). On average, the program takes about 20 million eggs to produce 6 million juveniles.
- Tag analysis should be used to determine the fall and spring hatchery-origin Chinook spawned during the suspected period of run overlap (e.g., fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).
- Only unmarked fish should be spawned in the fall brood (FRH spring Chinook are 100 percent adipose fin-clipped, FRH fall Chinook are 25 percent adipose fin-clipped) to reduce the need for culling. Any spring x fall Chinook crosses of hatchery-origin fish

(e.g., due to marking or mark detection errors) should be identified by coded wire-tag analysis and eggs should be culled soon after spawning.

- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.
- Program fish should be 100 percent coded wire-tagged and 25 percent adipose fin-clipped.

The HSRG made the following specific recommendations for the FRFH spring-run Chinook salmon program (California Hatchery Scientific Review Group 2012b):

- Tag analysis should be used to determine the number of fall and spring Chinook spawned during the suspected period of run overlap (e.g., fish spawned in the last two weeks of spring Chinook spawning and the first two weeks of fall Chinook spawning). Tags should be read and egg lots tracked and eliminated from production as appropriate to reduce introgression of the two runs. Incubation techniques should therefore allow for separation of eggs from individual parents/families (no more than two families per tray).
- Until all off-site releases of Chinook salmon are eliminated in the entire Central Valley, coded wire tag analysis should be used to identify stray hatchery-origin fish among those fish selected for broodstock. Strays from other hatchery programs should not be used as broodstock, or if eggs are collected from or fertilized by such fish, they should be culled soon after spawning.

The HSRG made the following specific recommendations for the FRFH steelhead program (California Hatchery Scientific Review Group 2012b):

- A Hatchery Coordination Team should be established to review the status of the FRFH steelhead program.
- The number of eggs taken annually should be reduced to a level appropriate to produce 450,000 juveniles and the transfer of eggs to other programs terminated. Collection of excess eggs is permissible to increase effective population size as long as culling is done representatively.
- Broodstock for the program should only come from native, locally adapted stocks. Out-of-subbasin importation of eggs, juveniles or adults should not occur, even if it means juvenile production targets will not be achieved in some years.
- Non-anadromous (resident) fish should not be used as broodstock and the current 16-inch minimum length for broodstock should be continued.
- Hatchery-origin adult steelhead returns to the hatchery should be treated as follows: (1) unspawned males should be extended reconditioned and released; (2) unspawned females should be stripped of eggs, extended reconditioned and released; and (3) spawned fish should be removed from the system, or extended reconditioned and released.
- Natural-origin adult steelhead returns to the hatchery, whether spawned or unspawned, should be released. Fish may be reconditioned prior to release.

2.3.6 Status of Species and Critical Habitat in the Action Area

2.3.6.1 Background

Before the construction of Oroville Dam the Feather River was impacted by gold mining. The effects of the dredging are still very visible just downstream of the city of Oroville, along the low flow channel. The effects of hydraulic mining over 100 hundred years ago still results in increased amounts of sediment in the rivers today, and modifications in stream channels also persist. Before the Oroville Dam was built a number of dams were built further upstream (Figure 2-33).

Besides those upstream dams, two dams downstream of the present-day Oroville Dam were constructed for agricultural diversions. Both dams were constructed prior to 1920 and were replaced by the construction of Thermalito Afterbay. Additionally both dams required reinstallation or reconstruction after high-flow events.

The Western Canal Dam was seasonal. Flashboards would not have been installed until the flows were reduced in the later spring. Once the lower flows occurred, not much gravel or LWD movement would have occurred.

Hazelbush Dam, a year-round installation, would have had some temporary effect on gravel and LWD, but this temporary effect on the movement of gravel and LWD would have been effectively erased every time the dam was washed out by a flood event. These dams may have contributed to some warming of water temperatures in the lower Feather River at some times of the year, although this is speculative as no supporting data could be located.

It is also possible that the Western Canal and Hazelbush dams partially blocked upstream adult anadromous fish migration. However, this blockage was likely only partial, flow dependent, or just a migration impediment because CDFG did much of its fish counting in the Feather River at a counting weir that was located near the current Oroville Dam location for a number of years (before Oroville Dam was built).

_ENREF_369Yoshiyama et al. (1998) describes Hazelbush Dam in his treatment of historic anadromous salmonid presence in the Central Valley as

> *The Sutter-Butte Dam, 6 miles below Oroville, was a 5-ft-high irrigation diversion dam with a reportedly ineffective fishway, and lacking fish screens on the intake ditches, although the salmon nonetheless surmounted it (Clark 1929).*

Yoshiyama's reference to the Sutter-Butte Dam is believed to refer to Hazelbush Dam, which was the diversion dam for the Sutter-Butte Canal located just downstream of the Thermalito Afterbay Outlet. The pools impounded by these dams likely also had an effect on juvenile rearing habitat.

While the extent of upstream passage had been altered by earlier dams (Figure 2-33), the construction of Oroville Dam changed the amount and extent of available habitat for upstream migrating salmonids (Figure 2-33). Before Oroville Dam some separation of spawning CV spring-run Chinook salmon and fall-run Chinook salmon still existed. It is likely that there was some overlap of spring-run Chinook salmon and fall-run Chinook salmon spawning at the time of construction of Oroville Dam. Since the Oroville Dam and corresponding facilities were built (without fish passage), both of these populations have been spawning in the same geographical area and with overlapping spawning timing.

Although some overlap of CV spring-run and fall-run Chinook salmon spawning areas was already occurring before the Oroville Dam was built, competition for use of the existing downstream spawning areas increased with the construction of Oroville Dam and ancillary facilities. Chinook salmon that now return to the Feather River are able to ascend no further upriver than the Fish Barrier Dam at RM 67. The amount of habitat available within the Feather River is reduced by Oroville Dam, and CV spring-run Chinook salmon are now forced to spawn in the same areas used by fall-run Chinook salmon. This leads to a number of problems, such as redd superimposition, hybridization, competition for resources. Furthermore, Oroville Dam has changed the river's natural hydrology, blocked sediment transport, and blocked recruitment of large woody material.

Figure 2-32shows fish passage barriers upstream of Oroville Dam. Source: DWR DEIR 2007.

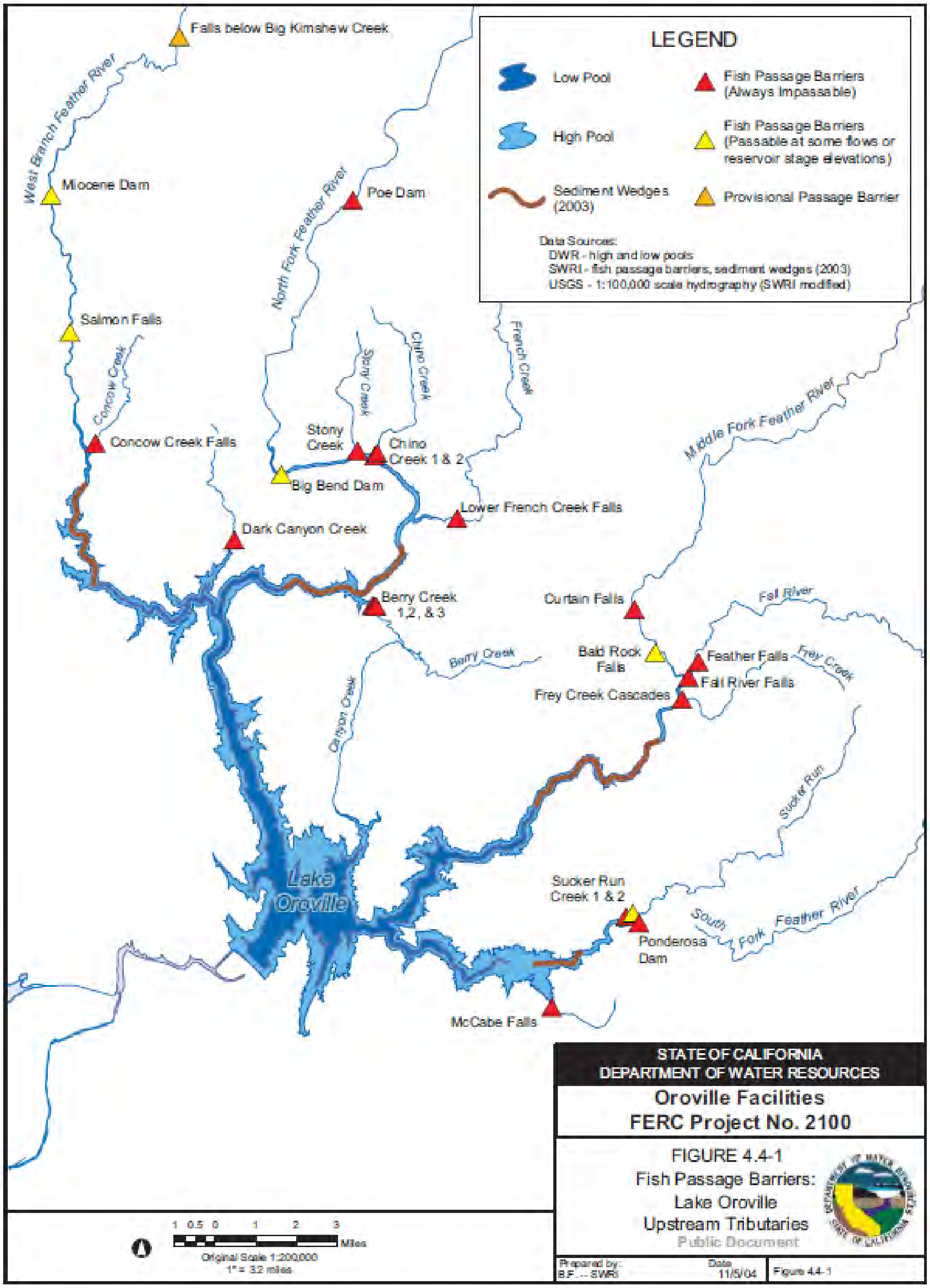

Figure 2-32. Fish Passage Barriers Upstream of Oroville Dam

Figure 2-33 shows the historic range of salmonid habitat upstream of Oroville Dam. Source: DWR 2005 License application.

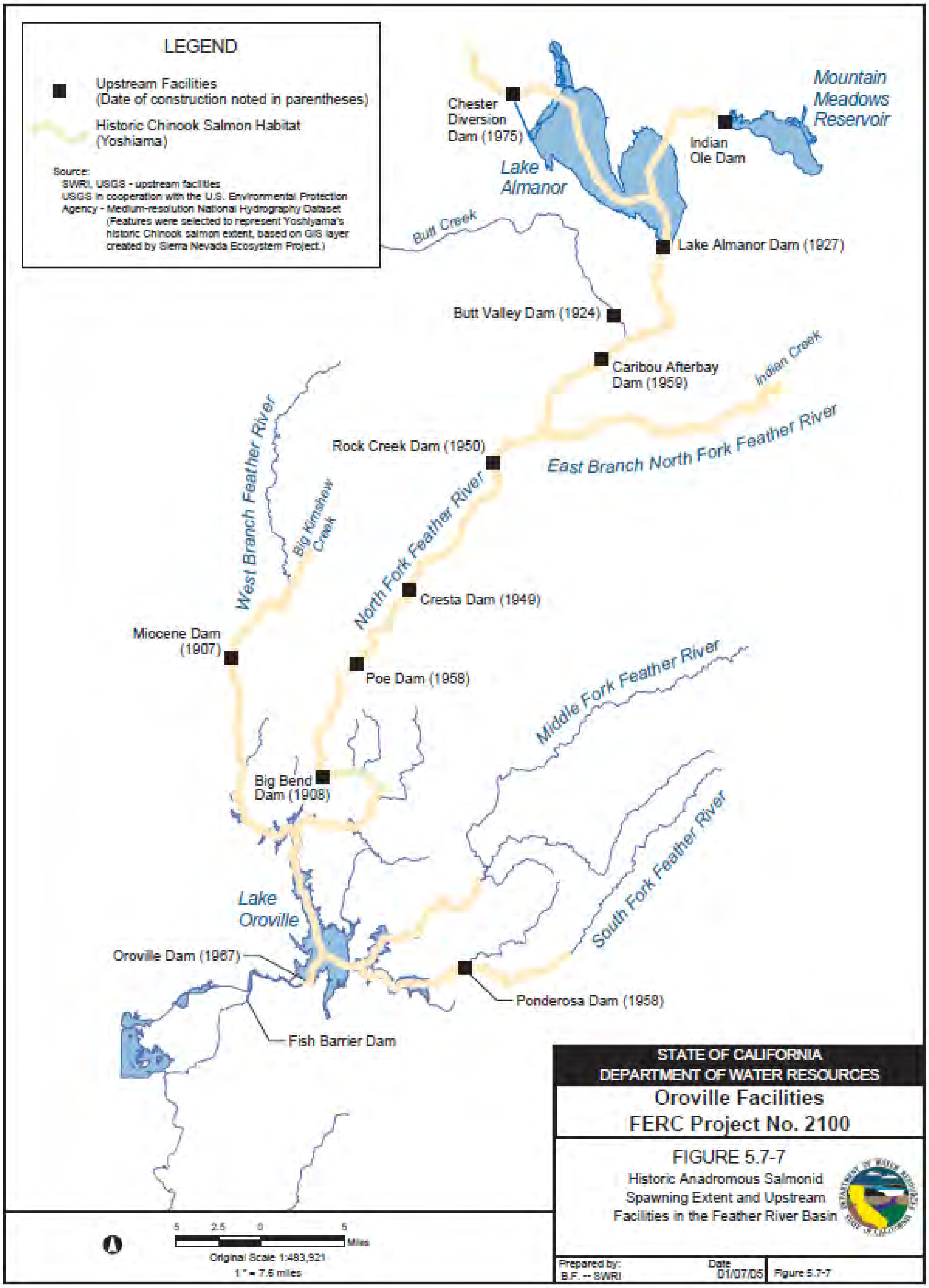

Figure 2-33. Historic Range of Salmonid Habitat Upstream of Oroville Dam

2.3.6.2 Sacramento River Winter-run Chinook Salmon

The Sacramento River winter-run Chinook salmon ESU is restricted to one population that spawns entirely within the mainstem Sacramento River upstream of the Red Bluff Diversion

Dam, 163 river miles (RM) upstream of the confluence of the Feather River. Winter-run Chinook salmon do not occur within the project boundary, nor are they currently identified as spawning in the Feather River. Winter-run Chinook salmon do occur in the Sacramento River from the confluence of the Feather River (at Sacramento RM 80) downstream through the Delta and the Suisun Bay-San Pablo Bay-San Francisco Bay complex. The Sacramento River at the confluence with the Feather River is used primarily as a migration corridor for adults and juveniles on their way to and from spawning and rearing areas further upstream on the Sacramento River. Records do not indicate that the lower Feather River is used by adults for spawning or juveniles for rearing.

2.3.6.2.1 Sacramento River Winter-run Chinook Salmon Critical Habitat

Critical habitat for winter-run Chinook salmon does not include the Feather River.

2.3.6.3 Central Valley Spring-run Chinook Salmon

2.3.6.3.1 Synopsis

The CV spring-run Chinook salmon ESU includes all naturally spawned populations in the Feather River as well as fish from the FRFH CV spring-run Chinook salmon program. NMFS' Central Valley Technical Recovery Team believes that the existing CV spring-run Chinook salmon population in the Feather River, including the hatchery fish, may be the only remaining representatives of an important component of the ESU, and that the Feather River hatchery CV spring-run Chinook salmon stock may play an important role in the recovery of CV spring-run Chinook salmon in the Feather River Basin (Lindley et al. 2004, Federal Energy Regulatory Commission 2007).

Before construction of Oroville Dam, CV spring-run Chinook salmon utilized the upper tributaries of the Feather River for spawning. CV spring-run Chinook salmon would ascend the Feather River in the spring and summer as sexually immature fish, and develop to maturity by fall and then spawn. Since the construction of Oroville Dam, fish passage has been halted on the Feather River at the Fish Barrier Dam just downstream of Oroville Dam. For the CV spring-run Chinook salmon that now return to the river, the options are to either spawn naturally in the river, utilizing the remaining habitat in the lower reaches of the Feather River below the Fish Barrier Dam, or to ascend the fish ladder which begins at the Fish Barrier Dam and enters the FRFH where the fish are then artificially propagated.

There is some natural production of CV spring-run Chinook salmon in the river, and these natural spawners are of greatest interest for conservation. DWR and CDFW have good data on CV spring-run Chinook salmon that return to the FRFH in the fall; however, data on natural spawners is less clear. The DWR escapement surveys monitor for Hallprint-tagged CV spring-run Chinook salmon and collect length, spawn condition, and other biological data, but the surveys cannot estimate the number of spawners because of the overlap in spawning with fall-run. Data does indicate, however, that CV spring-run Chinook salmon do spawn successfully in the river.

There are multiple issues of concern with both the FRFH, and the naturally spawning fish in the river. Primarily the problem is the overlap in time and space with fall-run Chinook salmon leading to hybridization between the two runs in the river, and also poor hatchery practices that historically led to mixing and interbreeding of the two runs within the hatchery. Although hatchery practices have improved, and strong efforts are made to differentiate and breed separately CV spring-run Chinook salmon from fall-run Chinook salmon in the Feather River, the CV spring-run Chinook salmon in the Feather River have nevertheless been compromised such that their genetics are something of a mix between fall-run and CV spring-run Chinook salmon. While hatchery practices may be able to alleviate some of the problems of genetic mixing of the two runs, those fish that spawn in the river are still able to mix and interbreed. For this reason, a separation weir has been included in the proposed action to physically separate CV spring-run and fall-run Chinook salmon in the river.

CV spring-run Chinook salmon were impacted by a number of past human activities. Dams have eliminated access to historic holding, spawning, and rearing habitat and have resulted in CV spring-run Chinook salmon and fall-run Chinook salmon spawning and rearing in the same areas, at the same times. This has resulted in increased competition, superimposition of redds, and interbreeding of the two populations. Other anthropogenic activities that have impacted CV spring-run Chinook salmon include modification of the hydrograph, loss of sediment and large wood transport, restriction of lateral movement of the river channel, mining, unscreened water diversions, and riparian vegetation removal. Changes in the hydrograph can impact the duration of downstream migration, exposing migrating salmonids to increased predation. Changes in the hydrograph can also reduce lateral movement of the river and along with the loss of sediment and large wood transport downstream of Oroville Dam result in decreases in habitat value for CV spring-run Chinook salmon spawning and rearing. Mining, levee and dike construction, and removal of riparian vegetation have also resulted in adverse effects to habitat for spawning and rearing salmonids. Unscreened water diversion may entrain salmonids and result in the loss of a significant number of CV spring-run Chinook salmon.

2.3.6.3.2 CV Spring-run Chinook Salmon Life History in the Feather River

Adult CV spring-run Chinook salmon enter the Feather River as immature adults from March to June (Painter et al. 1977, Reynolds et al. 1993, California Department of Fish and Game 1998, Yoshiyama et al. 1998, Sommer et al. 2001b) and spawn in the autumn during September and October (Sommer et al. 2001b). Spawning occurs in gravel beds that are often located at the tails of holding pools (U.S. Fish and Wildlife Service 1995) and most CV spring-run Chinook salmon spawn in the upper reaches of the low flow channel (Department of Water Resources 2007, Bilski 2008, Clark et al. 2008, Chappell 2009).

Fall-run Chinook salmon return to the Feather River as sexually mature fish. They spawn from September into December. Prior to the construction of the Oroville Facilities, the two runs were separated spatially as the CV spring-run Chinook salmon would ascend to the upper reaches of the Feather River and its tributary branches, spawning primarily in the Middle Fork, with a few CV spring-run Chinook salmon entering the North Fork, South Fork and West Branch. Meanwhile, the fall-run Chinook salmon spawned largely in the mainstem Feather River. So although the two runs have an overlapping spawning season, they previously utilized different parts of the Feather River and were not in direct competition with each other. With the construction of the dams, particularly the Oroville Facilities, the CV spring-run Chinook salmon cannot access their historic habitat. They are restricted to the Feather River downstream of the Fish Barrier Dam. This restricts the CV spring-run Chinook salmon to the same areas for spawning as the fall-run Chinook salmon. While adult CV spring-run Chinook salmon enter the Feather River in the spring, they hold in the river until fall to spawn. The fall-run Chinook salmon enter freshwater in the fall and spawn shortly after arriving on the spawning grounds. While the

CV spring-run Chinook salmon start spawning prior to fall-run Chinook salmon, their spawning times overlap. This results in competition between CV spring-run Chinook salmon and fall-run Chinook salmon for spawning habitat. With the fall-run Chinook salmon spawning later than the CV spring-run Chinook salmon there are effects due to superimposition of fall-run Chinook salmon redds on top of CV spring-run Chinook salmon redds. Superimposition can result in mortality of the earlier laid eggs, due to later spawners digging up the eggs (losses are due to exposure to light and predation), or disturbing the gravel adjacent to earlier laid eggs during times that they are sensitive to disturbance.

Suitable water temperatures for spawning are 42°F to 58°F (~5.6 to 14.4°C). Incubation may extend through March with suitable incubation temperatures between 48°F and 58°F (~8.8 to 14.4°C) (Department of Water Resources 2007). Studies have confirmed that juvenile rearing and probably some adult spawning are associated with secondary channels within the Feather River LFC. The lower velocities, smaller substrate size, and greater amount of cover (compared to the main river channel) likely make these side-channels more suitable for juvenile CV spring-run Chinook salmon rearing. Currently, this type of habitat comprises less than one percent of the available habitat in the LFC (Department of Water Resources 2007).

Juvenile Chinook salmon in the Feather River have been reported to emigrate as young of year (Seesholtz et al. 2004) and most appear to migrate out of the Feather River within days of emergence (Department of Water Resources 2002a, 2007, Federal Energy Regulatory Commission 2007, Bilski and Kindopp 2009).

Juvenile emigration from the Feather River is generally from mid-November through June, with peak emigration occurring from January through March (Painter et al. 1977, Department of Water Resources 2004c, Yuba County Water Agency et al. 2007, Bilski and Kindopp 2009).

Rotary screw trap data for 1998 to 2000 documented emigration of CV spring-run Chinook salmon from the Feather River peaking in December, followed by another pulse of juvenile young-of-year emigrants at Live Oak in April and May (Department of Water Resources 2002a, Seesholtz et al. 2004).

Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December and again in March and April. However, juveniles also are observed between November and the end of May (Snider and Titus 2000).

2.3.6.3.2.1 Abundance

The abundance of CV spring-run Chinook salmon in the Feather River is highly variable by year, and natural in-river spawners should be counted separately from those fish that are spawned in the hatchery (Figure 2-35). In general terms, fisheries biologists are concerned with escapement. Escapement is the number of adult fish that return to the river to spawn. Escapement numbers are not known for natural, in-river CV spring-run Chinook salmon spawners. Yet it is these fish, the natural in-river spawners, which are of greatest interest for conservation. The in-river spawners represent the wild-type fish, whose progeny are subject to the full gamut of natural selection, and whose members might exhibit the greatest genetic diversity.

Considering the data available to indicate CV spring-run Chinook salmon abundance in the Feather River, caution is advised. The inability to count all CV spring-run Chinook salmon as they enter the low flow channel and the inability to count CV spring-run Chinook salmon and fall-run Chinook salmon separately on the spawning grounds makes accurate abundance estimates for CV spring-run Chinook salmon difficult to determine. Furthermore, historic data for CV spring-run Chinook salmon is based primarily on September hatchery counts (Figure 2-36) which we now know most likely included large numbers of fall-run Chinook salmon in many years, making it essentially useless as a metric of individual abundance for each of the two Chinook runs. Additionally, CDFW GrandTab data only reports CV spring-run Chinook salmon adults that returned to the hatchery to spawn in the fall, completely ignoring the much greater number that return to the hatchery in the spring, the peak of CV spring-run Chinook salmon migration.

One method of estimating the number of CV spring-run Chinook salmon adults spawning in river is to subtract the number of CV spring-run Chinook salmon that return to the hatchery in the fall from the total number of CV spring-run Chinook salmon marked in the spring. This "left-over" portion of CV spring-run Chinook salmon would presumably spawn in-river. Certainly, some fish will die, be harvested, or leave the river between July and September, but this could be a reasonable index of abundance until more accurate tools are in place (*e.g.*, segregation weir). Estimating the number of returning CV spring-run Chinook salmon adults that spawn in river is challenging, but this method may prove useful as a long-term metric of abundance, until the segregation weir is installed and complete counts are performed. The trend is at least based on a consistent methodology, and if consistent behavior across years can be presumed, then this method may serve as a proxy for the magnitude of annual in-river spawners (Figure 2-35).

Figure 2-34 depicts estimated spring-run Chinook salmon that spawned in-river.

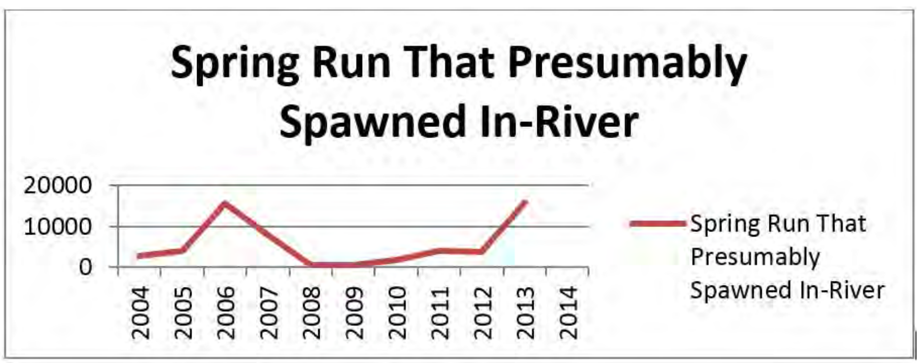

Figure 2-34. Estimated Spring-run Chinook Salmon Spawned In-River

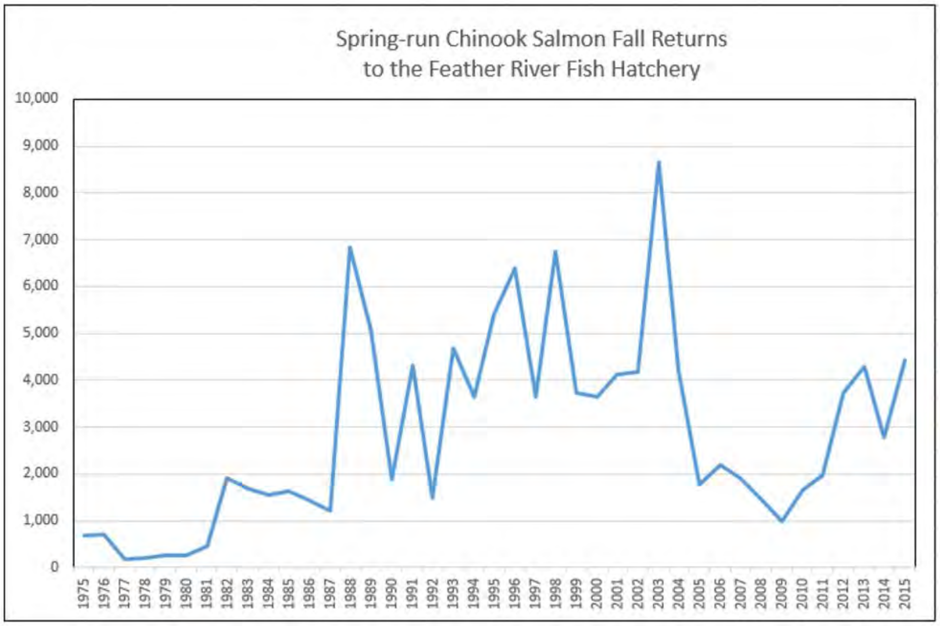

Figure 2-35 shows fall returns of spring-run Chinook salmon to the FRFH.

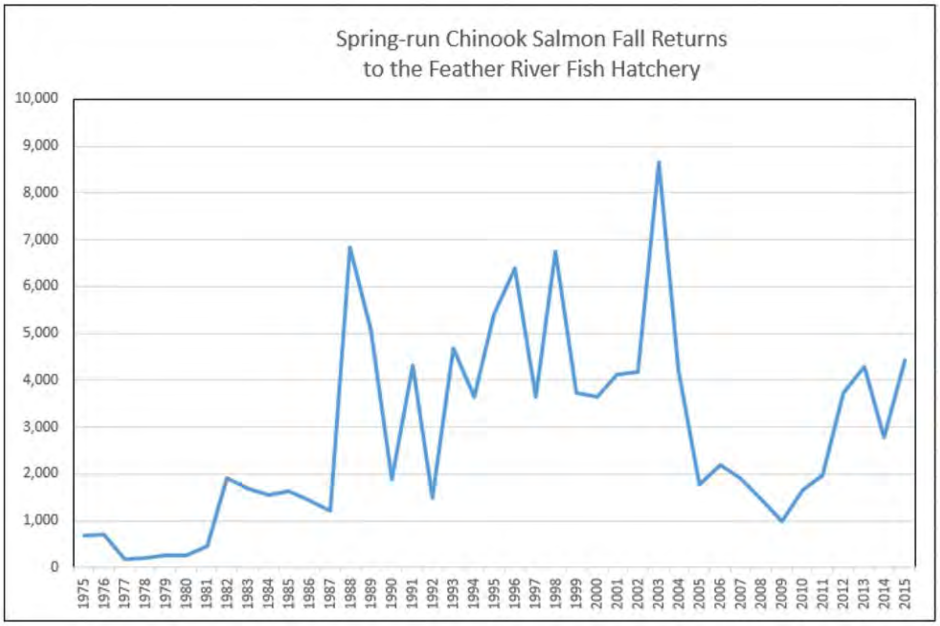

Figure 2-35. Fall Returns of Spring-run Chinook Salmon to the FRFH

2.3.6.3.2.2 Productivity (population growth rate)

There is presently insufficient data to determine the population growth rate for naturally produced in-river CV spring-run Chinook salmon. The population growth rate for fish born in the hatchery is artificially maintained, and the FRFH has an annual production goal of 2 million CV spring-run Chinook salmon smolts per year.

2.3.6.3.2.3 Spatial Structure

The most obvious pattern of salmonid distribution observed in the Feather River is the difference in density between the LFC and the HFC. The LFC is far more likely to contain both spawning adults and juveniles than is the HFC. All out-migrating juvenile salmonids must pass through the HFC on their way to the Sacramento River and San Francisco Bay.

While observations of juvenile salmonids have been very rare in the HFC, observations of salmonid predators are common (Department of Water Resources 2012b). Juvenile salmonids are found at higher frequencies where substrate is larger than sand and small in-stream cover and overhanging vegetation is present (Department of Water Resources 2012a). Side channels and riffles appear to be important areas for spawning activity, where suitable gravel can be found for redd construction. Thus it appears that the LFC contains the most important habitat for both juvenile and adult CV spring-run Chinook salmon, and the micro characteristics of that habitat include such variables as cover for young fish and adequate gravel and flow characteristics for spawning adults. Figure 2-37 shows the locations of snorkel survey sites and this gives a good indication of where sampling efforts are conducted and helps relate the geography of where fish are found.

Figure 2-36 shows the areas of the Feather River described as the HFC and LFC. The LFC contains the vast majority of both spawning adults and juveniles.

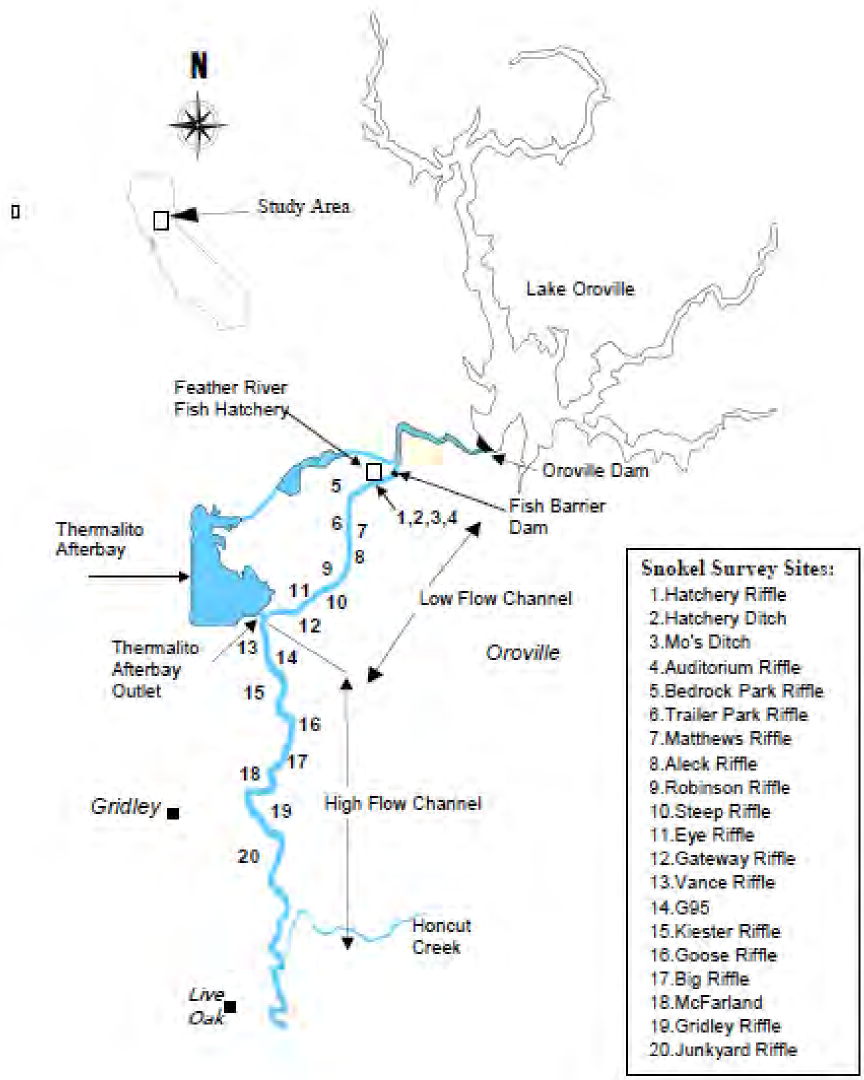

Figure 2-36. Feather River HFC and LFC

2.3.6.3.2.4 Diversity

In the spatial structure section (*2.3.6.3.2.3 Spatial Structure*), we noted that most CV spring-run Chinook salmon observation in the Feather River occurred within the LFC. Thus the following discussion about diversity is also heavily related to the LFC.

The diversity of CV spring-run Chinook salmon in the Feather River is highly compromised. Based on the historic geographical separation of CV spring-run and fall-run Chinook salmon during spawning, we would expect the two populations to be genetically separate. From a phenotypic perspective, there is characteristic behavior of an earlier entry into fresh water, as evidenced by the timing of Chinook salmon being in the low flow channel and the hatchery in the spring. However, genetic analysis using neutral microsatellite markers reveals that CV spring-run Chinook salmon in the Feather River are genetically very similar to fall-run Chinook salmon.

Garza et al. (2008)_ENREF_108 showed that Feather River Hatchery "spring-run" Chinook salmon were found to be genetically differentiated from Feather River Hatchery fall-run fish, although just marginally, as well as from naturally spawning Feather River fall-run fish. So although some genetic differentiation was evident between fall-run and CV spring-run Chinook salmon, and hatchery versus non-hatchery, the overall picture was that the fish are so heavily introgressed with one another that defining features such as run identity (spring-run vs. fall-run) and production source (hatchery vs. natural origin) are not very distinct. From the perspective of conservation biology, these facts are deleterious to the long-term viability of the species and the Feather River CV spring-run Chinook population. In other rivers that support CV spring-run Chinook salmon populations, namely Butte, Deer, and Mill creeks, we do not see the same flow of genes between CV spring-run Chinook salmon and fall-run Chinook salmon, and the two runs do not appear to interbreed much, if at all.

Between 1967 and 2004, CV spring-run Chinook salmon were differentiated at the FRFH from fall-run Chinook salmon by opening the ladder at the FRFH on September 1. Those fish ascending the ladder from September 1 through September 30 were assumed to be CV spring-run Chinook salmon (Kastner 2003). This practice led to hybridization between CV spring-run and fall-run Chinook from the Feather River (Brown et al. 2004). Since 2004, FRFH staff keeps the fish ladder open during the spring months and those fish entering the ladder are marked with external tags and returned to the river. When these fish reenter the ladder in September, the hatchery staff can easily identify them as CV spring-run Chinook salmon and reduce the potential for hybridization between spring and fall runs (Brown et al. 2004). However, it is not easy to distinguish between CV spring-run and fall-run Chinook salmon in the river.

2.3.6.3.3 Viability of Central Valley Spring-run Chinook Salmon in the Action Area

The viability of CV spring-run Chinook salmon in the Feather River is difficult to analyze, because earlier evaluations did not make complete estimates of the CV spring-run Chinook salmon returning to the Feather River. This has made long-term analysis of escapement trends impracticable.

In NMFS' 2005 listing determination (70 FR 37160; June 28, 2005), NMFS included the Feather River CV spring-run Chinook salmon hatchery stock in the listed CV spring-run Chinook ESU because it contained the remaining genetic legacy of the historic CV spring-run Chinook salmon population in the Feather River and also continued to exhibit a CV spring-run Chinook salmon migration timing. In 2011 NMFS identified that overall, the negative impacts of the FRFH CV spring-run Chinook salmon program on naturally produced CV spring-run Chinook salmon as being not likely to have changed substantially since the 2005 review. _ENREF_251In the 2016 status review, the National Marine Fisheries Service (2016b) identified that the adverse impacts of the FRFH CV spring-run Chinook salmon were not likely to have changed substantially since the 2011 review, but that the new management efforts are expected to reduce impacts in the future.

In the absence of a hatchery program, the populations of Feather River CCV steelhead and Chinook salmon would likely be very small, perhaps only 10 percent of current numbers as a rough estimate. The NMFS 2016 status review (National Marine Fisheries Service 2016b) of CV spring-run Chinook salmon discussed that since 2002, DFW, DWR, and NMFS have worked to reinforce the expression of a spring-run Chinook salmon life history at the Feather River hatchery by adopting new broodstock protocols designed to reduce or minimize the introgression of spring-run and fall-run Chinook salmon at the hatchery. In recent years, the FRFH has modified its protocols for the CV spring-run Chinook salmon program. The new protocols include in river releases of juvenile CV spring-run Chinook salmon, instead of a mix of in river and estuary releases. This is being done to reinforce the homing of CV spring-run Chinook salmon back to the Feather River and to minimize straying into other watersheds.

The NMFS 2016 status review of CV spring-run Chinook salmon also discussed the status of the Feather River population and that the most recent genetic analysis on this stock (Garza and Pearse 2008) found subtle, but significant, differentiation between the Feather River Hatchery spring- and fall-run Chinook salmon stocks. Garza and Pearse (2008)_ENREF_109 found that existing genetics supports the hypothesis that the Feather River population is a remnant of the ancestral Feather River CV spring-run Chinook salmon that has been heavily introgressed with fall-run Chinook.

2.3.6.3.4 Central Valley Spring-run Chinook Salmon Critical Habitat

2.3.6.3.4.1 Delineation of Critical Habitat for Central Valley Spring-run Chinook Salmon in the Action Area

The Feather River downstream of Fish Barrier Dam is designated critical habitat for CV spring-run Chinook salmon (70 FR 52488 September 2, 2005, 70 FR 52488; September 2, 2005). Areas upstream of Oroville Dam were used historically by anadromous salmonids, but are not currently accessible, and are not designated as critical habitat for CV spring-run Chinook salmon.

2.3.6.3.4.2 Status of Critical Habitat Physical and Biological Features for Central Valley Spring-run Chinook Salmon in the Action Area

The critical habitat designation also describes PBFs for CV spring-run Chinook salmon critical habitat. Within the Feather River these PBFs include: (1) freshwater spawning areas; (2) freshwater rearing areas; and (3) a freshwater migration corridor.

Spawning Habitat

PBFs for CV spring-run Chinook salmon include freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development (70 FR 52488 September 2, 2005, 70 FR 52488; September 2, 2005). Spawning habitat for CV spring-run Chinook salmon occurs on the mainstem Feather River and Yuba River downstream of dams. Even in degraded reaches, spawning habitat has a high value for the conservation of listed salmonids as its function directly affects the spawning success and reproductive potential of listed salmonids. DWR has recently improved spawning habitat in the upper part of the LFC with gravel augmentation and breaking up consolidated riverbed. The Corps of Engineers is implementing a gravel augmentation project on the Yuba River.

Freshwater Rearing Habitat

PBFs for CV spring-run Chinook salmon include freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions that support juvenile growth and mobility; water quality and forage supporting juvenile salmonid development; and natural cover such as shade, submerged and overhanging large woody material, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks (70 FR 52488 September 2, 2005, 70 FR 52488; September 2, 2005). Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and the presence of predators of juvenile salmonids. The LFC has many of these features. The HFC has less habitat complexity and is channelized, leveed, and riprapped and offer little protection from piscivorous fish and birds. Freshwater rearing habitat has a high intrinsic value for the conservation of the species even if the current conditions are significantly degraded from their natural state.

Freshwater Migration Corridors

PBFs for CV spring-run Chinook salmon include freshwater migration corridors free of migratory obstructions and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large woody objects, aquatic vegetation, large rocks and boulders, side channels, and undercut banks that supporting juvenile and adult mobility and survival (70 FR 52488; September 2, 2005). Migratory corridors are downstream of the spawning areas and include the HFC. The HFC allows the upstream passage of adults and the downstream emigration of juveniles. There are a number of unscreened diversions in the HFC. For juveniles, unscreened or inadequately screened water diversions throughout their migration corridors and a reduction of complex in-river cover have degraded this PBF in the HFC. However, since the primary migration corridors are essential for connecting early rearing habitat with the ocean, even the degraded reaches are considered to have a high intrinsic value for the conservation of the species.

2.3.6.3.4.3 Summary of Critical Habitat for Central Valley Spring-run Chinook Salmon in the Action Area

Although habitat conditions within the action area are degraded, the importance of this area for the conservation of CV spring-run Chinook salmon is considered to be high. This is mainly due to the fact that there is very little suitable CV spring-run Chinook salmon habitat remaining in the Central Valley, and any habitat that is currently available has a high value for the conservation of the ESU.

2.3.6.4 California Central Valley Steelhead

2.3.6.4.1 Synopsis

The CCV steelhead DPS final listing determination was published on January 5, 2006 (71 FR 834) and included all naturally spawned populations of CCV steelhead (and their progeny) below natural and manmade barriers in the Sacramento and San Joaquin Rivers and their tributaries, including the Feather River below the Oroville Facilities. FRFH CCV steelhead are also included in this designation. The current Feather River CCV steelhead population appears to be almost entirely supported by the FRFH and is restricted to the river reaches downstream of the Fish Barrier Dam (RM 67).

Historical accounts rarely mention CCV steelhead distribution and abundance in the Feather River Basin. Based on creel surveys and interim trap counts at the Oroville dam site, the

Department of Fish and Game estimated that at least 2,000 CCV steelhead passed into the habitat upstream of Oroville dam. From run years 1963 to 1966 the trap counts of CCV steelhead passed upstream of the dam construction site were 416, 914, 434, and 563, respectively (Wooster 1966). However, because CCV steelhead have similar spawning and rearing preferences as CV spring-run Chinook salmon, the two species are believed to have occupied the same areas with the exception that CCV steelhead are thought to have migrated further upstream in the watershed (DWR 2007). Due to the construction and operation of hydropower projects, including the Oroville facilities (*i.e*., Oroville Dam and the Fish Barrier Dam), the upper Feather River basin is no longer accessible to CCV steelhead. The FRFH was designed and is operated to replace reduced CCV steelhead production, attributable to the construction of the Oroville Facilities.

2.3.6.4.2 Abundance

The number of CCV steelhead entering the FRFH each year generally increased between 1967 and 2003 (Figure 2-37). CCV steelhead returns to the FRFH have varied substantially over the past several years, with very low returns in some years (2009), and above average returns in others (2013 and 2014). Because almost all returning fish are of hatchery origin and stocking levels have remained fairly constant over the years, the data suggest that adverse freshwater or ocean survival conditions have caused or at least contribute to variability in hatchery returns. The Central Valley experienced three consecutive years of drought (2007-2009) which would likely have impaired survival of naturally produced parr and smolts. However, hatchery origin CCV steelhead are reared and released as one-year olds so drought conditions would likely not have significantly affected this life stage. There may have been a drought effect during freshwater migration. However, poor ocean conditions are known to have occurred in at least 2005 and 2006 (which impacted Chinook populations in the Central Valley) and may well have also impacted CCV steelhead populations of both hatchery and natural origin. The current drought (2012-2015) has also likely impacted CCV steelhead populations. Returns have varied widely over the years (Figure 2-37).

Figure 2-37 shows adult CCV steelhead returns to FRFH, 1969-2015.

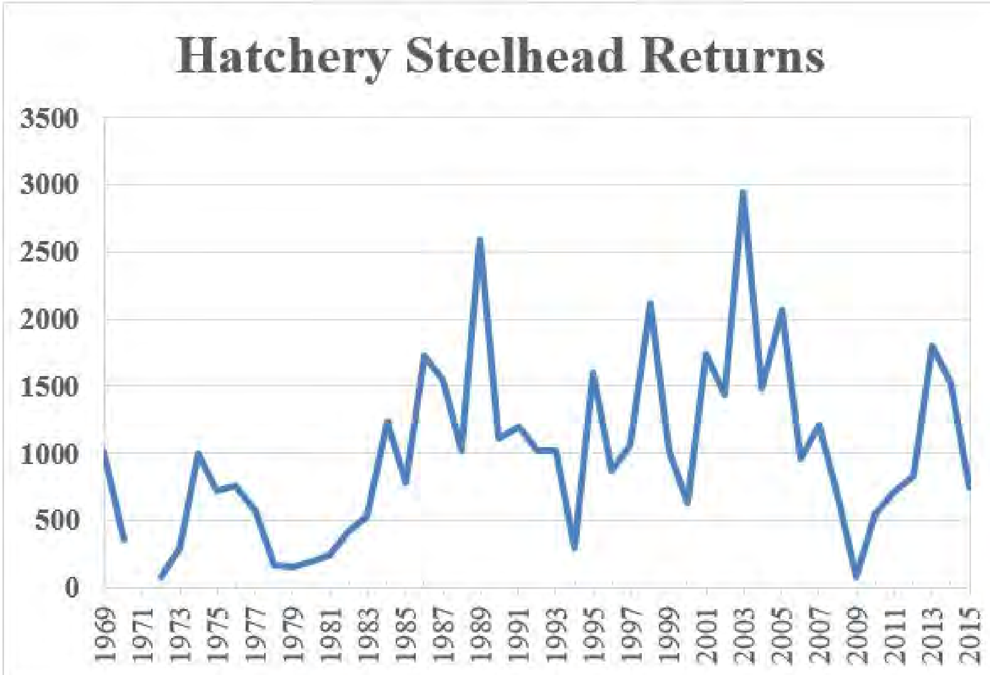

Figure 2-37. Adult CCV Steelhead Returns to FRFH, 1969-2015

2.3.6.4.3 Productivity (Population Growth Rate)

Data on the population of naturally produced CCV steelhead in the Feather River does not exist. The population of fish produced in the FRFH is artificially maintained. The FRFH has an annual production goal of 400,000 yearling CCV steelhead to mitigate for construction of the Oroville Facilities. The FRFH also has a goal of raising an additional 50,000 CCV steelhead for the Delta Fish Agreement (also known as the Four Pumps Agreement) between DWR and DFW, which addresses impacts from SWP pumping in the Delta. There is no specific target set for adult abundance.

2.3.6.4.4 Spatial Structure

CCV steelhead spawn in the Feather River between December and March, with the peak spawning occurring in late January (Department of Water Resources 2007). Most of the natural CCV steelhead spawning in the Feather River occurs in the LFC, particularly in its upper reaches near the Hatchery Side Channel, a side-channel located between RM 66 and 67, and between the Table Mountain Bicycle Bridge and Lower Auditorium Riffle. Flows in the Hatchery Side Channel are fed by the discharge from the FRFH. Limited spawning has also been observed below the Thermalito Afterbay Outlet. The smaller substrate size and greater amount of cover in the side channels (compared to the main river channel) also make these areas more suitable for juvenile CCV steelhead rearing. Currently, this type of habitat comprises less than 1 percent of the available habitat in the LFC (Department of Water Resources 2007). Studies have confirmed that juvenile CCV steelhead rearing, and probably adult spawning, within the Feather River is associated with secondary channels within the LFC (Department of Water Resources 2005a, 2007).

Most naturally produced CCV steelhead rear in freshwater for two years before emigration (McEwan and Jackson 1996). Feather River CCV steelhead generally emigrate from about February through September, with peak emigration occurring from March through mid-April. However, empirical and observational data show that juvenile CCV steelhead potentially emigrate during all months of the year from the Feather River. Water temperatures of 54°F or less are considered optimal for smolting and emigrating CCV steelhead.

More than 99 percent of the CCV steelhead that enter the FRFH fish are of direct hatchery origin (Brown et al. 2004). The NMFS 2011 and 2016 status reviews of CCV steelhead discussed that currently, nearly all the CCV steelhead that return to the Feather River Hatchery are hatchery fish.

2.3.6.4.5 Diversity

CCV steelhead in the Feather River belong to the Northern Sierra Nevada Diversity Group. Within the Feather River, CCV steelhead diversity is governed by the abundance of in-river spawners and the interaction with resident rainbow trout and hatchery produced fish, both of which may breed with anadromous, naturally produced CCV steelhead. Straying of CCV steelhead to or from other rivers affects diversity. Ideally, hatcheries and management programs could seek to foster viable, independent populations of CCV steelhead across the Central Valley, with the Feather River playing an integral role. Improved water management practices and habitat restoration may help to better establish a viable population of naturally spawning CCV steelhead in the Feather River. Currently, the population of CCV steelhead in the Feather River appears to be largely hatchery-dependent, making progress toward long-term diversity challenging.

2.3.6.4.6 Viability

There is a scarcity of information on the abundance and survival of naturally produced CCV steelhead in the Feather River. Because abundance data on naturally spawning CCV steelhead is extremely limited, their viability is unknown, but is presumed to be low, based on hatchery counts alone. FRFH data shows that nearly all returning adults are of hatchery origin, suggesting that natural reproduction is low and possibly unsustainable on its own (National Marine Fisheries Service 2016a).

However, more data is needed to determine the number of adults that return to the Feather River that are of natural origin and that spawn naturally in the river, and not in the FRFH. Even with a scarcity of data on natural origin abundance, in order to have a viable population of CCV steelhead in the Feather River, natural in-river spawner numbers most likely need to improve. Currently, the CCV steelhead population in the Feather River appears to be almost totally dependent upon the FRFH, placing even more importance on proper hatchery management and habitat restoration. The viability of this population will remain heavily dependent upon the hatchery until hatchery and genetic management plans are fully implemented and natural origin CCV steelhead are replacing themselves at a sustainable level.

2.3.6.4.7 California Central Valley Steelhead Critical Habitat

2.3.6.4.7.1 Delineation of Critical Habitat for Central Valley Steelhead in the Action Area

Critical habitat for CCV steelhead was designated on September 2, 2005 (70 FR 52488), and includes the Feather River from its confluence with the Sacramento River upstream to the Fish Barrier Dam at RM 67. The critical habitat designation also describes PBFs for CCV steelhead critical habitat. Within the Feather River these PBFs include: 1) freshwater spawning areas; 2) freshwater rearing areas, and 3) a freshwater migration corridor.

2.3.6.4.7.2 Status of Critical Habitat for Central Valley Steelhead in the Action Area

Although habitat conditions within the action area are degraded, the importance of this area for the conservation of CCV steelhead is considered to be high. This is mainly due to the fact that there is very little suitable steelhead habitat remaining in the Central Valley and any habitat that is currently available has a high value for the conservation of the DPS.

The conditions of the PBFs for CCV Steelhead in the Feather River are the same as for CV spring-run Chinook salmon.

2.3.6.5 Green Sturgeon (Southern Distinct Population Segment)

Green sturgeon are long-lived and widely ranging across the North American west coast, but the southern distinct population segment (sDPS) breeds exclusively in the freshwater rivers of California, predominantly in the Sacramento River, and to a smaller extent in the Feather River. Some sDPS green sturgeon activity has also been noted in the Yuba River. In this section we focus on sDPS green sturgeon usage of the Feather River. The Feather River contains at least one known sDPS green sturgeon spawning area (Figure 2-38), and also provides for a migratory corridor to access the Yuba River.

Figure 2-38 shows Feather River sDPS Green Sturgeon spawning areas.

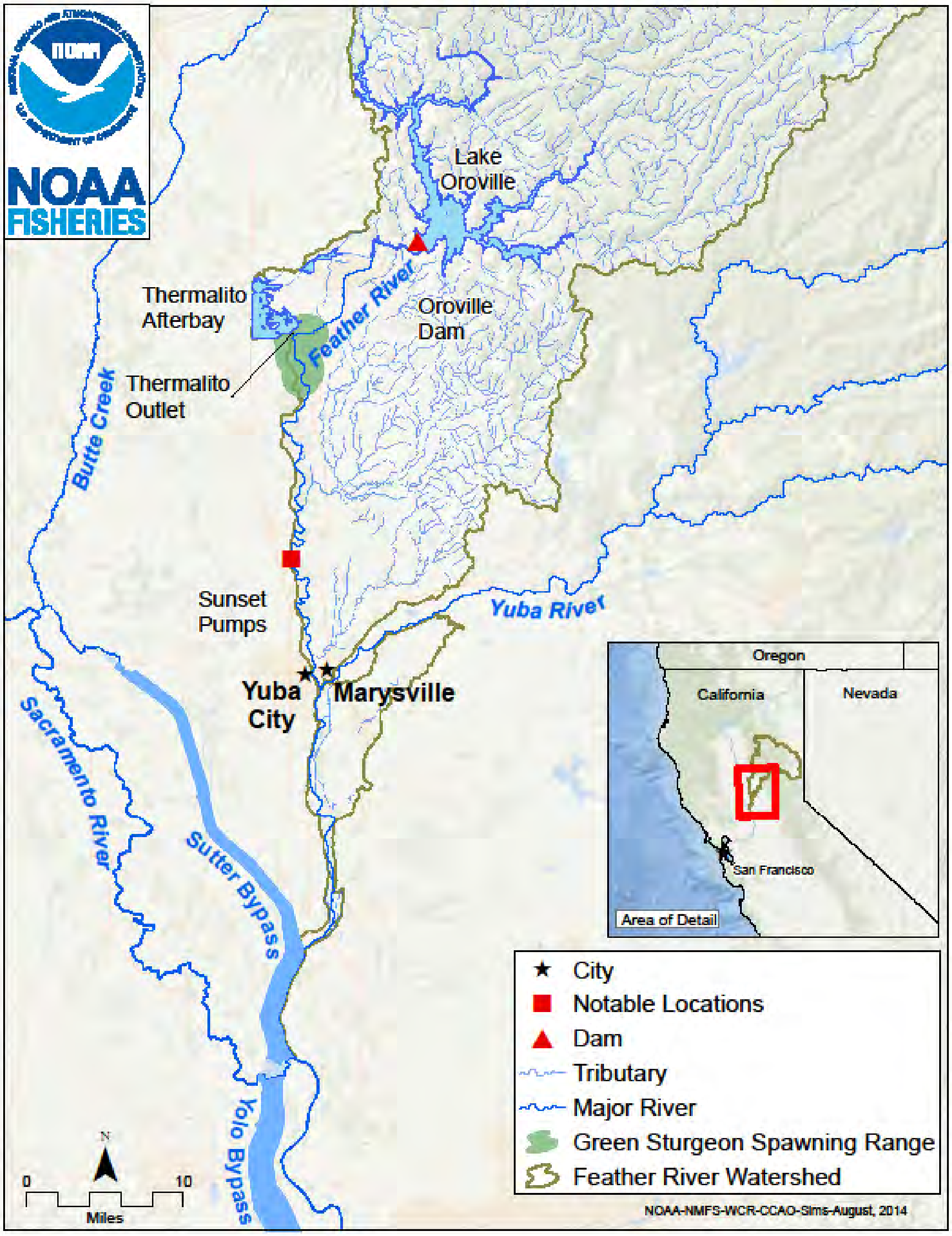

Figure 2-38. Feather River sDPS Green Sturgeon Spawning Areas

2.3.6.5.1 Abundance

Southern DPS Green sturgeon are monitored on the Feather River in a variety of ways: they are detected using DIDSON surveys; they are observed in angling sample surveys; and for those sDPS green sturgeon already implanted with acoustic telemetry tags, they can be detected by hydrophone stations along the river. By applying presumed age-class proportions, abundance of juveniles and subadults can also be extrapolated from the Sacramento River survey data, but these estimates rely upon untested assumptions. Section *2.2 Rangewide Status of the Species and Critical Habitat* of this Opinion contains more information.

So far, the work done by UC Davis has not included the Feather River in their annual sampling for adult sDPS green sturgeon, so the population numbers derived so far may be slightly underestimating the Central Valley sDPS green sturgeon adult population size. There is an estimated average of 364 adult fish spawning in the Sacramento River per year (Klimley et al. 2015, National Marine Fisheries Service 2015b) and an estimated 25 or fewer sDPS green sturgeon utilizing the Feather River per year

Further investigation is needed to determine how sDPS green sturgeon utilize the Feather River compared to the Sacramento River. Information from 2015 indicates that sDPS green sturgeon use the two rivers interchangeably. A robust study design is needed to ensure fish counted in the Feather River are not the same fish being counted in the Sacramento River. Given these cautions, we can tentatively say that the Feather River accounts for perhaps 2 to 9 percent of the sDPS green sturgeon population. While these numbers may seem low and perhaps insignificant, it is important to realize that the Feather River is highly valuable from a sDPS green sturgeon conservation perspective because the Feather River is the **only** place outside the Sacramento River where sDPS green sturgeon spawning has been documented, giving the Feather River a prominent role in the recovery of the species.

Data for sDPS green sturgeon habitat in the Feather River and sDPS green sturgeon interaction with Feather River habitat is limited. The number of adult green sturgeon in the Feather River is likely dependent on flow conditions and associated passage issues. In low flow years it is likely that no sDPS green sturgeon migrate upstream of Sunset Pumps, and in the past Shanghai Bench was also a passage barrier. The Feather River provides an essential migration corridor for sDPS green sturgeon to access the Yuba River. Table 2-12 gives the adult abundance data that is known so far.

Table 2-12 lists the number of sDPS adult sturgeon observed in the Sacramento, Feather, and Yuba Rivers. Data provided by Ethan Mora of UC Davis (Sacramento River), Alicia Seesholtz of DWR (Feather River), and Cramer Fish Sciences (Yuba River). Additionally, there have been sDPS green sturgeon observed in the Yuba River in 2016.

Table 2-12. Number of Adult Sturgeon Observed in the Sacramento, Feather, and Yuba Rivers

Year	Sacramento River (green sturgeon)	Feather River (all sturgeon)	Yuba River (green sturgeon)
2010	164	No sturgeon observed with Didson; one green detected in lower River with Vemco and another captured at Thermalito Afterbay Outlet	Data unavailable
2011	220	25	4 or 5 (likely green)

Year	Sacramento River (green sturgeon)	Feather River (all sturgeon)	Yuba River (green sturgeon)
2012	329	3 or 4 (species ID unknown; both species observed in area)	Presumed to be zero, but data unavailable
2013	338	6 (likely green based on acoustically tagged sturgeon)	Presumed to be zero, but data unavailable
2014	526	5 to 7 (species ID unknown but likely white based on sturgeon observed in area)	Presumed to be zero, but data unavailable

2.3.6.5.2 Productivity

There is no available data on sDPS green sturgeon productivity in the Feather River. Spawning occurs episodically and opportunistically, as a function of suitable environmental conditions that probably do not occur every year. The population growth rate is unknown. The population structure is also unknown, and the relationship of spawner success in the Feather River to spawner returns (in the Feather River or Sacramento River) is also unknown. It will take at least a couple of decades to get this type of data, given the long life span of sDPS green sturgeon and the age at maturity. However, this would be valuable data to obtain so that a population trajectory can be determined.

2.3.6.5.3 Spatial Structure

Historically, sDPS green sturgeon likely used a good deal of the Feather River, including reaches upstream of Oroville Dam. There have been numerous non-specific historical reports of sDPS green sturgeon spawning in the Feather River (Wang 1986, U.S. Fish and Wildlife Service 1995, California Department of Fish and Game 2002, Department of Water Resources 2007) but they were not corroborated by observations of eggs, young fish or significant numbers of adults in focused sampling efforts (Schaffter and Kohlhorst 2002, Niggemyer and Duster 2003, Seesholtz 2003, Beamesderfer et al. 2004, Beamesderfer and Gray 2009). This changed in 2011 when sDPS green sturgeon spawning in the Feather River was confirmed (Seesholtz et al. 2014). In 2011, sDPS green sturgeon spawning was recorded at the Thermalito Afterbay Outlet.

Although now blocked by the Fish Barrier Dam, favorable sDPS green sturgeon habitat exists on the Middle Fork and North Fork of the Feather River. Mora et al. (2009)_ENREF_188 modeled that in the absence of impassable dams and altered hydrographs, sDPS green sturgeon would utilize certain areas of the upper Feather River. _ENREF_210Based on the Mora et al. (2009) analysis, the construction of the Oroville Facilities has blocked sDPS green sturgeon access to what were likely historic spawning and rearing grounds upstream and has altered habitat conditions below the dam for adult migration, spawning, and juvenile rearing. Presently, sDPS green sturgeon use the Feather River up to the Fish Barrier Dam, at which point their passage is completely blocked. Consistent with observations in other rivers, sDPS green sturgeon in the Feather River appear to have a preference for large, deep holes featuring a cobble or mixed substrate, and with turbulent flows.

The spatial structure of sDPS green sturgeon in the Feather River is difficult to determine because the main population breeds in the Sacramento River, with occasional spawning in the Feather River; the relationship of these two spawning rivers in terms of population structure is not fully understood. It remains to be determined if sDPS green sturgeon in the Feather River represent an independent population or are part of the Sacramento River population. McElhany et al. (2000)_ENREF_178 provides simplistic hypothetical models of spatially structured populations. The most applicable model to sDPS green sturgeon is unknown.

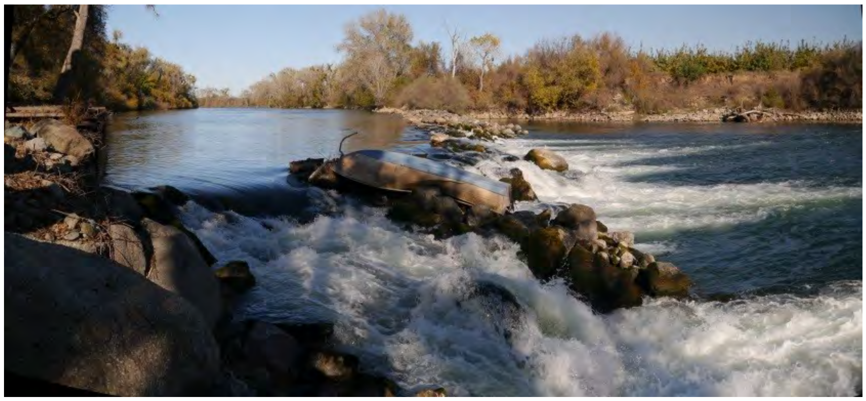

Figure 2-39. The Boulder Weir at Sunset Pumps

Southern DPS Green sturgeon distribution in the Feather River appears to be heavily influenced by flow rates. High springtime flows may provide environmentally attractive cues to sDPS green sturgeon and may encourage their migration up the Feather River. High flows are also necessary to achieve passage at Sunset Pumps (Sutter Extension Water District, Figure 2-40) where a manmade rock weir stretches across the entire river, denying access to upriver spawning habitat until flows are sufficient for sDPS green sturgeon to pass over and above this impediment. Discussions, unrelated to the Oroville Facilities, are ongoing to address the effects of the Sunset Pumps weir on anadromous fish.

2.3.6.5.4 Diversity

Diversity can be discussed in terms of behavioral traits or genetic traits. There is no information available about the genetic diversity of sDPS green sturgeon in the Feather River, although DWR does take tissue samples from the sDPS green sturgeon they catch. Publications or reports regarding an analysis of these genetic samples are not yet available. Behaviorally, there is a good deal of diversity, although it is difficult to know if environmental or human induced conditions produce the variety of behaviors observed, or if sDPS green sturgeon possess an innate variability in their behavioral characteristics, perhaps lending to a variety of survival strategies across the population. For example, in some years sDPS green sturgeon are seen to enter the Yuba River, but this is probably related to available flow much more than it is to an innate trait driving some individuals to seek out new territory. There are also a variety of residence times observed by sDPS green sturgeon in the Feather River. The only way in which this type of data can be obtained is by observing acoustic telemetry data, or catch and recapture studies, both of which do occur on the Feather River. However, acoustic tagging studies are relatively new, and much of the current data is for fish that were tagged immediately before the observed behavior.

Therefore, behaviors observed such as residence time in the Feather River might be more of a response to the invasive surgical tag implant procedure rather than any inherent variability in behavioral traits. In coming years, data should improve in this regard, and as sample sizes increase and the effects of tagging are no longer factors. As fish tagged in previous years return to the river, we may begin to get a feel for the range of behaviors that sDPS green sturgeon naturally exhibit as they use the Feather River.

2.3.6.5.5 Viability

The best available information shows that access to historic sDPS green sturgeon habitat upstream of the Fish Barrier Dam in the Feather River that may have been used by sDPS green sturgeon is now blocked due to the construction of Oroville Dam (National Marine Fisheries Service 2005). Southern DPS green sturgeon are now limited to downstream habitat, primarily below the Thermalito Afterbay Outlet, although some usage as far upstream as the Fish Barrier Dam has been observed. This loss of potential upstream habitat, downriver limitations, altered hydrograph, altered temperature regime, other changed or degraded environmental or habitat conditions, overfishing, poaching, diversions of water, predation, ocean survival , and other factors have greatly impacted the sDPS green sturgeon in the Feather River. This has resulted in low abundance and future uncertainty regarding viability of the species.

Given that the Fish Barrier Dam is likely to persist into the foreseeable future as a total migration barrier to sDPS green sturgeon, the habitat below the Fish Barrier Dam becomes the sole focus for sDPS green sturgeon conservation in the Feather River. Unlike Chinook salmon or CCV steelhead, there is not a hatchery for sDPS green sturgeon to mitigate the impacts to the species. Therefore, the condition of the Feather River below Oroville Dam is of utmost concern for the conservation of sDPS green sturgeon. Attention is focused upon water releases from Oroville Dam sufficient to provide suitable flows and temperatures. Additionally, habitat conditions necessary to support a healthy population of sDPS green sturgeon in the Feather River are influenced by a variety of other impacts such as sport fishing regulations, water diversions, contributions from tributaries such as the Yuba River, levee maintenance and construction, and so forth. Presently, most, if not all, of these factors are at levels that are insufficient to achieve sDPS green sturgeon viability.

The long-term viability of sDPS green sturgeon is potentially impacted by three important types of factors: 1) catastrophic events, 2) long-term demographic processes, and 3) long-term evolutionary potential.

In terms of catastrophic event risk, sDPS green sturgeon in the Feather River are at high risk. With only one known spawning location in the Feather River (the Thermalito Afterbay Outlet), a single catastrophe or environmental change (manmade or natural) that damages this habitat or affects the fish in this location could have a significant detrimental effect on the sDPS green sturgeon using the Feather River. During site visits to the Feather River in 2014, the characteristic voluminous discharge flow of water out of Thermalito Afterbay Outlet, which creates the hydrologic conditions that sDPS green sturgeon apparently favor, was absent, raising concerns that operational changes in water flow might be precluding sDPS green sturgeon spawning. However, it is unknown whether sDPS green sturgeon would relocate to another location or return to the ocean without spawning should a catastrophic event occur.

Drought conditions in California from 2012-2015 have also taken their toll, and the flows in the Feather River have not been adequate to permit unimpeded sDPS green sturgeon passage at Sunset Pumps. We know that elevated flows in the Sacramento River are important for sDPS green sturgeon, where higher river flows have been shown to be important for triggering adult migrations, spawning and play a role in juvenile recruitment.

In the Sacramento River spawning is believed to be triggered by increases in water flow to about 14,000 cfs (average daily water flow during spawning months: 6,900-10,800 cfs; Brown 2007). In other rivers, post-spawning downstream migrations are triggered by increased flows. For example, in the Sacramento River migration flows range from 6,150–14,725 cfs in the late summer (Vogel 2005), and in the Rogue, Klamath, and Trinity rivers flows greater than 3,550 cfs in the winter were identified (Erickson et al. 2002, Benson et al. 2007). Good recruitment of juvenile sDPS green sturgeon in the Delta was observed during years where the mean monthly February through May flows ranged from 3,488 to 20,505 cfs at Gridley, and 7,028 to 35,234 cfs at Nicolaus (U.S. Fish and Wildlife Service 1995). The current suitability of habitat in the Feather River is almost entirely dependent on releases from Oroville Facilities, and continued current operations of Oroville Facilities are likely to further attenuate high flow events.

2.3.6.5.6 Green Sturgeon Critical Habitat in the Action Area

Critical habitat has been designated for the sDPS of North American green sturgeon and includes riverine habitat from the Feather River’s confluence with the Sacramento River, upstream to the furthest accessible point below the Fish Barrier Dam (74 FR 52300; October 9, 2009).

PBFs for riverine systems include features related to passage of sDPS fish to spawning sites and suitable habitat necessary for each riverine life stage (*e.g.*, spawning, egg incubation, larval rearing, juvenile feeding, passage throughout the river, or passage into and out of estuarine or marine habitat).

The PBFs for sDPS green sturgeon critical habitat have been discussed in detail in section *2.2 Rangewide Status of the Species and Critical Habitat*, and these same PBFs are applied in the Feather River for those PBFs that are specific to riverine systems. These include:

- food resources
- substrate type or size
- water flow
- water quality
- migratory corridor
- water depth
- sediment quality

Information about each of the above PBFs that is specific to the Feather River has already been discussed (*2.2.1.4.6 Freshwater Riverine Systems*). To reiterate, sDPS green sturgeon require adequate food resources and spawning substrate. A migratory corridor that is attractive to sDPS green sturgeon is necessary for sDPS green sturgeon to access spawning grounds and to access other tributaries such as the Yuba River. The rock weir at Sunset Pumps is believed to impair upstream fish passage of sDPS green sturgeon at low flows. Pool depths of equal to or greater than 5 m appear important for holding and spawning. Sediment quality must be sufficient for all life stages. Flows from the Yuba River can also be an important contribution to the HFC flows.

Currently we do not fully understand how sDPS green sturgeon respond to the differences in flows and water temperatures between the Feather and Yuba rivers.

2.3.6.5.6.1 Status of Green Sturgeon Critical Habitat in the Action Area

Southern DPS green sturgeon critical habitat is much degraded in the action area. Within the Feather River habitat quality and quantity is an important issue for sDPS green sturgeon viability. Critical habitat for sDPS green sturgeon is designated downstream from the Fish Barrier Dam to the mouth of the Feather River. Within this context, the most problematic issue for sDPS green sturgeon is probably flow. Oroville Dam, and to a lesser extent other upstream dams, impound flows that would otherwise have naturally flowed down the river during winter and spring storms, and with spring snow melt, flows which provided the necessary environmental cues for sDPS green sturgeon to migrate up the Feather River in search of spawning grounds. In the absence of these flows, sDPS green sturgeon appear to underutilize the Feather River. Furthermore, migration barriers such as the boulder weir at Sunset Pumps (Sutter Extension Water District) prohibit sturgeon passage at low flows, thereby exacerbating the problem of low flows.

The migratory PBF is also problematic as the habitat in the lower Feather River is heavily impacted by unscreened water diversions that impose a potential serious mortality risk for larval and juvenile sDPS green sturgeon.

Past investigations of suitable deep pools indicate that there are up to 12 deep holes over 13 miles, from the Fish Barrier Dam at RM 67 downstream to RM 54, with characteristics attractive to sDPS green sturgeon. Seven of these holes are greater than 5 meters deep, and 5 of the pools are between 3 and 5 meters. One of these holes is located directly downstream below the Thermalito Afterbay Outlet and may have been created or enhanced by releases from the Thermalito Afterbay Outlet. The total area of the pools is greater than 164,500 m^2.

The adequacy of other PBFs for sDPS green sturgeon is unknown because little investigation has been done thus far to look at food resources, contaminants, or sediments in the Feather River.

2.3.7 Summary

Many of the alterations of the Feather River have resulted in negative effects to ESA listed anadromous fish species and their designated critical habitats. For example, barriers to fish passage prevent ESA listed anadromous fish from utilizing habitat they previous occupied. This results in a reduction in habitat. CV spring-run Chinook salmon have not only lost access to habitat, but they have lost genetic integrity due to intermingling with fall-run Chinook salmon, and experience losses from superimposition of fall-run Chinook salmon redds on top of spring-run Chinook salmon redds, resulting in increased egg mortality. Dams have not only blocked fish migrations, but also interrupted natural processes, such as the movement of gravel and large woody material. This has degraded the quality of the habitat to which ESA listed anadromous fish species are limited (downstream of Oroville Dam). Hatchery operations have resulted in domestication of fish, such that they are not as successful in the wild. This also negatively impacts fish in the wild through interbreeding between wild and hatchery fish. Water management has affected habitat quality through lack of channel forming flows, and changes in the hydrograph. Dikes, levees, and flood management have also impacted habitat and natural channel forming processes. Water temperatures have also been modified from historic conditions; however, these changes have some beneficial effects. Areas to which fish such as CV spring-run Chinook salmon are now restricted likely have cooler temperatures than prior to the construction of the Oroville Facilities. However, downstream of the Thermalito Afterbay Outlet water temperatures may be warmer, due to the effects of the Thermalito facilities.

There are a number of factors for which data is not available, and for which the effects of multiple activities are intermixed and complex. For example, predation effects on ESA listed anadromous fish in the Feather River have not been quantified. Looking at survival between fish released at the hatchery and fish released in San Pablo Bay, the differences may be due to predation. But it is not possible to determine if the predation is worse than it was prior to the effects of various actions in the Feather River, because there is no data to support such a determination. Also, some of the differences in survival may be due to other factors such as water diversions, and/or pollution, and/or lack of floodplain rearing, and/or reduced flows during times when juvenile fish are migrating downstream. Additionally, the difference in survival based on release location is variable.

2.4 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR § 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

2.4.1 Approach to the Assessment

This section of the Opinion assesses the effects of the proposed action on endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CCV steelhead, their designated critical habitat, and the sDPS of North American green sturgeon and its critical habitat.

Section *2.1 Analytical Approach* provided a detailed description of the analytical approach used by NMFS to evaluate the effects of the proposed action on listed species under NMFS jurisdiction and critical habitat for those species.

Section *1.3 Proposed Action* provided an overview of the action. Section *2.2 Rangewide Status of the Species and Critical Habitat* and section *2.3 Environmental Baseline*, respectively, give an overview of the status of the threatened and endangered species and critical habitat considered in this Opinion, first overall (*e.g.*, ESU or DPS wide) and then in the action area for this consultation.

To evaluate the effects of the proposed action, we examined the proposed action, including anticipated habitat change or loss and planned conservation or environmental measures, to identify likely impacts to listed anadromous salmonids and sDPS green sturgeon and critical habitat for these species within the action area based on the best available information.

The primary information used in this assessment includes fishery information previously described in section *2.2 Rangewide Status of the Species and Critical Habitat* and section *2.3 Environmental Baseline* sections of this Opinion; studies and accounts of the impacts of past operations of the Oroville Facilities on anadromous species; documents prepared in support of the proposed action (Department of Water Resources 2007); and other documents available during the consultation (U.S. Bureau of Reclamation 2008c).

2.4.2 Deconstruct the Action

The proposed action of relicensing the Oroville Facilities includes certain actions that can create stressors that affect one or several life stages of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS North American green sturgeon. The stressor is typically described as the physical, chemical or biotic changes that flow from an action, not the action itself. Stressors result from FERC's proposal to issue a license for the operation of the Oroville Facilities for another 30 to 50 years.

Adverse effects to these species and their habitats may result from the continued presence and operation of the project, project environmental measures, and project construction activities associated with implementing certain environmental enhancement measures. Although the proposed action's environmental measures include protection, mitigation, and enhancement components (PM&Es) with the potential to benefit listed species, most of the PM&Es will develop and become more fully described over the term of the new license as described in the Settlement Agreement.

In order to assess the effects of the proposed action, we separated the action into its component parts that create physical, chemical, or biotic changes to which the federally listed species or their designated critical habitat are directly or indirectly exposed.

Figure 2-40 depicts deconstruction of the proposed action showing the environmental stressors that are expected to act on the federally listed fish species and their designated critical habitat.

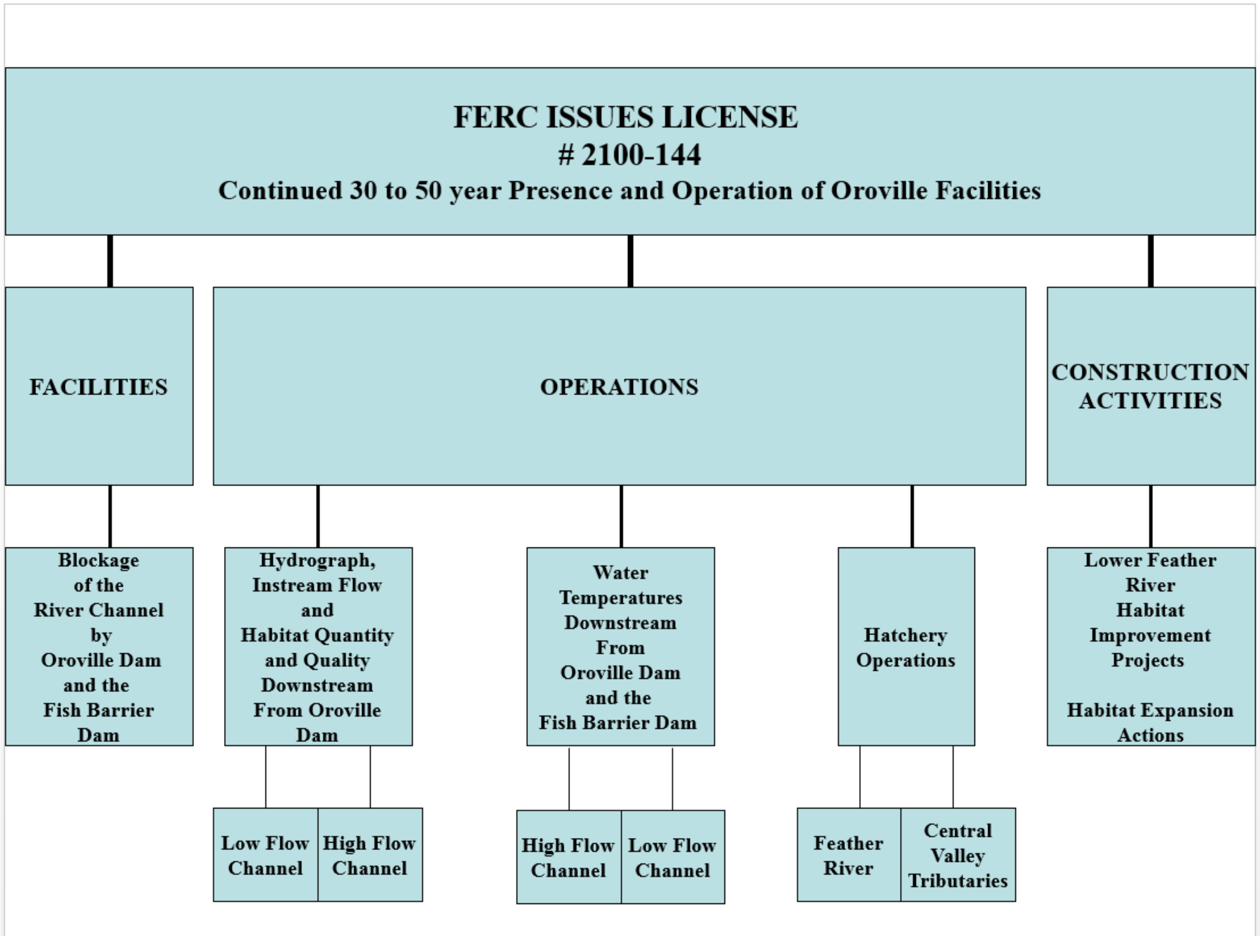

Figure 2-40. Deconstruction of the Oroville Facilities Relicensing

2.4.3 Stressors and Exposure

For the purposes of this analysis, "exposure" is defined as the temporal and spatial co-occurrence of listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon life stages with the stressors associated with the proposed action.

A few steps are involved in assessing species exposure. First, life stages and associated temporal occurrences are identified. The second step in assessing exposure is to identify the spatial distribution of each life stage. The details of life-stage timing and spatial distribution within the action area were previously described in section *2.3 Environmental Baseline* of this Opinion. The last step in assessing exposure is to overlay the temporal and spatial distributions of project-related stressors on top of the temporal and spatial distribution of the species in the action area. This overlay completes the exposure analysis.

Once a species exposure has been described, the next step is to assess how these fish are likely to respond to the proposed action-related stressors. In general, responses to stressors fall on a continuum from no response to slight behavioral modifications to certain death.

Life stage-specific responses to specific stressors related to the proposed project are presented in Table 2-20, Table 2-26, and Table 2-30.

Of the salmonids, CV spring-run Chinook salmon and CCV steelhead face the greatest amount of exposure to proposed action related stressors in the Feather River. Southern DPS Green sturgeon are also expected to be exposed to the proposed action in the Feather River, although the details about their presence, utilization, and status are not as clear as with salmon and CCV steelhead. Sacramento River winter-run Chinook may use the lower Feather River near the confluence with the Sacramento River as rearing habitat, but the effects of the proposed action on rearing conditions and habitat value in this area are relatively minor and difficult to discern.

Much of the following analysis will focus on two distinct reaches of the Lower Feather River: the LFC, which is located immediately downstream from Fish Barrier Dam and continues for approximately 8 miles downstream to the Thermalito Afterbay Outlet, and the HFC, which includes the Thermalito Afterbay Outlet pool and continues downstream to the confluence with the Sacramento River, near Verona, CA.

As described in section *1.3 Proposed Action* of this Opinion, much of the water that is released through Oroville Dam is circumvented around the LFC and into the Thermalito Forebay and Afterbay before being released back into the Feather River from the Thermalito Afterbay Outlet (Figure 2-41).

Figure 2-41 is a Map of the Lower Feather River depicting the LFC and HFC.

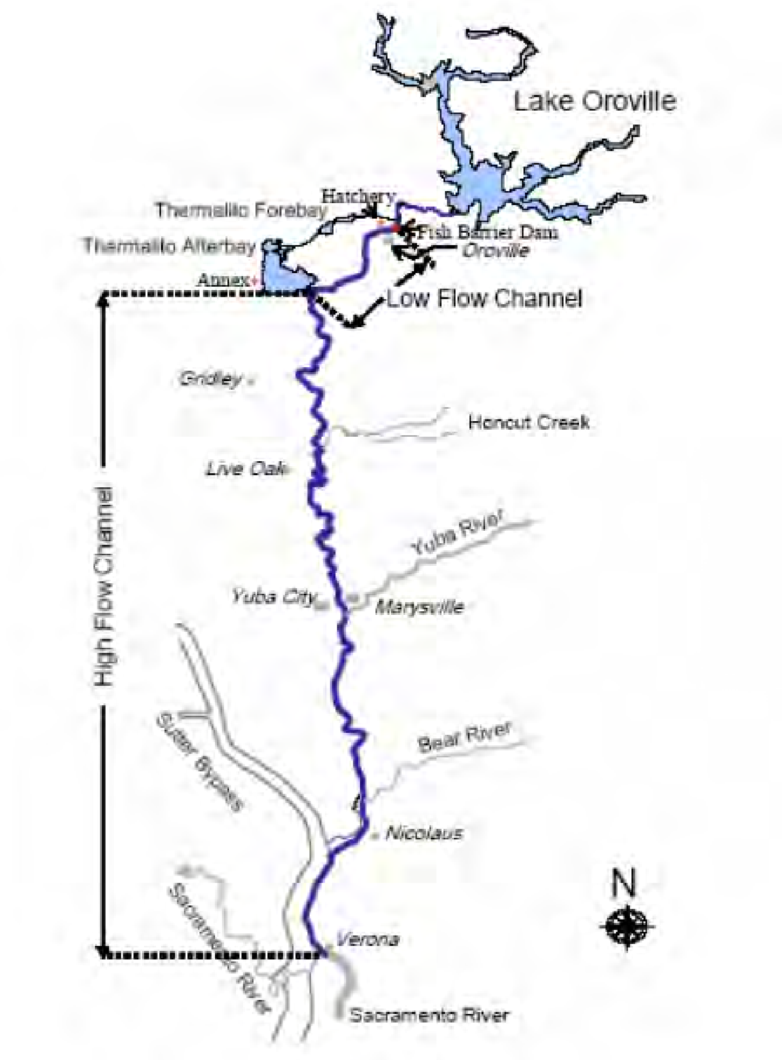

Figure 2-41. Map of the Lower Feather River Depicting the LFC and HFC

Water passing through the Oroville Facilities can contribute up to 25 percent of flow delivered to the Delta for water quality control and diversion at south Delta pumps. Thus the Oroville Facilities have an influence on flows, temperatures, and habitat quality downstream from the mouth of the Feather River. This influence likely extends through the Delta and exposes Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, and the southern DPS of North American Green Sturgeon to project-related stressors that extend downstream through these areas. However, the specific exposure to project-related stressors downstream from the mouth of the Feather River is difficult to separate from the overall operation of the CVP, and there currently is not sufficient information to separate potential project-related stressors and their effects from the operation of the CVP and SWP and other ongoing stress regimes. As described in section *1.2 Consultation History*, the broader effects of the Oroville Facilities as part of the coordinated operations of the CVP and SWP are analyzed in the CVP/SWP BO (National Marine Fisheries Service 2009, 2011e). These include the effects of the co-mingled flows of the CVP and SWP in the lower Sacramento River, downstream from the confluence of the Feather River with the Sacramento River, through the Sacramento-San Joaquin River Delta, Suisun Bay, San Pablo Bay, San Francisco Bay, and westward to the Pacific Ocean. In addition, because the proposed Oroville Facilities flow and temperature management represents an improvement over the operations of the Oroville Facilities at the time of the CVP/SWP BO, it is expected that the proposed action will not result in additional adverse effects to ESA listed anadromous fish species downstream of the mouth of the Feather River beyond the effects of coordinated operations of the CVP and SWP analyzed in the CVP/SWP BO. The effects analyzed in the CVP/SWP BO, however, are considered in sections 2.2 *Rangewide Status of Species and Critical Habitat* in the Action Area and 2.6 *Integration and Synthesis* of this Opinion.

The FRFH is located on the Feather River, but the hatchery trucks some juvenile fish downstream to San Pablo Bay. Adults are known to stray to several streams and rivers in the Central Valley. This exposure to hatchery operations may extend throughout anadromous fish-bearing streams in the Central Valley, so the analysis of hatchery related exposure and effects will consider this broad geographic scope.

Tables 2-13, 2-21, 2-27, and 2-30 summarize project-related stressors by species and life stage; the exposure period of each species and life stage based on the species expected occurrence in the action area, as described in section *2.3 Environmental Baseline*; and the response and fitness reaction of fish exposed to these stressors. These species and life-stage specific exposures, stressors, and individual and population-level responses and effects to critical habitat are evaluated in this Effects of the Action section.

2.4.4 Sacramento River Winter-Run Chinook Salmon

2.4.4.1 Sacramento River Winter-run Chinook Salmon Adult Migratory Corridors

The adult migration corridors for Sacramento River winter-run Chinook salmon in the Sacramento River are from Keswick Dam downstream through the lower Sacramento River and the Delta. This is outside the action area for the proposed action.

2.4.4.2 Spawning Habitat

Sacramento River winter-run Chinook salmon spawn in the upper Sacramento River are not expected to reside in the Feather River. Therefore, no effects on Sacramento River winter-run Chinook spawning habitat are expected from the proposed action. Operation of the FRFH has not affected (and is not expected to affect) the winter-run Chinook salmon genome. This conclusion is based on the winter run’s unique May through July spawning timing and the location of spawning in the Sacramento River between Keswick Dam and Redding. Any spring-run Chinook salmon strays from the FRFH would not arrive on the spawning grounds mature enough to participate in winter-run Chinook spawning. The location of the winter-run Chinook salmon on a separate branch of the Central Valley genetic tree supports the conclusion that the race continues to be isolated from the other three races.

2.4.4.3 Rearing Habitat and Juvenile Migratory Corridors

The juvenile rearing corridors for Sacramento River winter-run Chinook salmon in the Sacramento River are from Keswick Dam downstream through the lower Sacramento River and the Delta. This is outside the action area for the proposed action.

2.4.4.4 Sacramento River Winter-run Chinook Salmon Critical Habitat

Sacramento winter-run Chinook salmon designated critical habitat is outside the action area.

2.4.5 Central Valley Spring-run Chinook Salmon

2.4.5.1 Water Temperature

In order to provide a broad view of Feather River water temperature information associated with CV Spring-run Chinook salmon, general water temperature information is presented here, and Oroville Facilities effects analysis are presented after the CV Spring-run Chinook Salmon exposure table.

This section will assess the exposure and response of the different life-history stages of CV spring-run Chinook salmon to water temperatures within the Feather River. The information that will be used in the water temperature analysis includes:

- DWR's proposed water temperature standards listed in Table 2-13 through Table 2-15,
- Water temperature exceedance distributions provided by DWR during the relicensing process (Future Benchmark Water Temperatures), (U.S. Bureau of Reclamation 2008b),
- The water temperature analysis in the Oroville Facilities biological assessment (Department of Water Resources 2007),
- The water temperature requirements of CV spring-run Chinook salmon life stages as described in section *2.3 Environmental Baseline* of this Opinion,
- The *Evaluation of Oroville Facilities Operations on Water Temperature Related Effects on Pre-Spawning Adult Chinook Salmon and Characterization of Holding Habitat, Appendix F* (Department of Water Resources 2004a).

Water temperature is one of the most important environmental parameters affecting the distribution, growth, and survival of fish populations. Lethal water temperatures impact fish populations by directly reducing population size, while sub-lethal water temperatures can impact fish populations through effects on the physiology of fish life stages. Water temperatures can be particularly problematic for fish populations that are near their latitudinal distributional extremes where environmental conditions (*e.g.,* water temperature) may also be near the boundaries of conditions that allow the populations to persist. For example, California's Central Valley is at the southern limit of Chinook salmon distribution, and studies have demonstrated that direct effects of high water temperatures are an important source of juvenile Chinook salmon mortality (Baker et al. 1995). Mortality associated with high water temperatures along with other sources of mortality have led to serious declines in Pacific salmonid populations to levels that require Federal and state protection.

Water temperatures in the Lower Feather River are strongly influenced by releases from Oroville Dam and the Thermalito Afterbay. DWR operates releases from Oroville dam by withdrawing water at depths that will provide cold water to meet FRFH and the Robinson Riffle temperature requirements. Releases from Thermalito Afterbay generally raise the water temperature of the river in the HFC. The reservoir depth from which water is released initially determines the river temperatures, but atmospheric conditions, which fluctuate from day to day, modify downstream river temperatures.

Water temperature targets and criteria have been established for three locations along the Lower Feather River: (1) at the FRFH, (2) at Robinson Riffle, near the downstream end of the LFC, and (3) at the downstream end of the Oroville Facilities Project Boundary, approximately 5 miles downstream from the Thermalito Afterbay Outlet. The targets and criteria for each location are shown below in Table 2-13 through Table 2-15. Temperature measurements indicate that the Robinson Riffle criterion is almost always satisfied when the Feather River Hatchery objectives are met. The reservoir depth from which water is released initially determines the river temperatures, but atmospheric conditions, which fluctuate from day to day, modify downstream river temperatures.

The water temperature standards will be targets for the first approximately 10 years of the license, until facilities modifications are implemented, and then will become required criteria. When the targets become required under the license differs somewhat at each of the three locations described above. For purposes of analysis in this discussion, however, we estimate the time when these targets would become requirements at approximately 10 years after license issuance.

Under SA Article A107.2, temperatures for the FRFH listed in Table 2-13 become requirements of the license upon completion of facilities modifications, but no later than the end of year ten following license issuance.

Table 2-13. Water Temperature Targets and Criteria for the FRFH

Period	Temperature* (°F)
April 1–May 15	55 (59)
May 16–May 31	55 (59)
June 1–June 15	60 (60)
June 16–August 15	60 (64)
August 16–August 31	60 (62)
September 1–September 30	56 (56)
October 1–November 30	55 (55)
December 1–March 31	55 (55)

* These water temperatures are targets until water temperature control improvements are implemented, or the end of year ten of the license, then they become requirements. These numbers come from the Settlement Agreement for Licensing of the Oroville Facilities. The numbers in parenthesis are the maximum temperatures allowed during the term of the license. During April 1 through May 31 the temperature is not to fall below 51 degrees Fahrenheit.

Under SA Article 108.1, temperatures for the LFC listed in Table 2-14 become requirements upon completion of facilities modifications. DWR's Explanatory Statement of the SA, March 24, 2006, (in Figure 2) provides that facilities modifications construction may be completed eight years after license issuance.

Table 2-14. Water Temperature Targets and Criteria for Robinson Riffle

Maximum Daily Mean Water Temperature Targets and Criteria for the LFC (measured at Robinson Riffle, RM 61.6)	
Period	**Temperature (°F)**
January 1–March 31	56
April 1–30	56
May 1–15	56–63*
May 16–31	63
June 1–August 31	63
September 1–8	63–58*
September 9–30	58
October 1–31	56
November 1–December 31	56

*Indicates a period of transition from the first temperature to the second temperature.

Under SA Article A108.5, temperatures for the HFC listed in Table 2-15 (with potential revisions as described in Articles A108.4 and A108.5) become requirements after completion of Facilities Modifications and a five-year testing period. The purpose of the testing period is to determine the effectiveness of facilities modifications in meeting temperatures listed in Table 2-15.

Table 2-15. Water Temperature Targets and Criteria for the HFC Measured at the Downstream End of the Project Boundary

Maximum Daily Mean Water Temperature for the HFC (measured at the downstream project boundary[1])	
Period	**Temperature (°F)**
January 1–March 31	56
April 1–30	61
May 1–15	64
May 16–31	64
June 1–August 31	64
September 1–8	61
September 9 - 30	61
October 1-31	60
November 1–December 31	56

[1] This was to be measured at RM 58, but due to temperature irregularities is measured at River Mile 54.4.

Also, until the targets become requirements, interim measures required under the license at each of these three locations differ somewhat. Under SA Article A107.2, there are specific maximum water temperatures for the FRFH during the interim period. Under SA Article A108.1, there are specific changes in operations required to attempt to meet the targets during the interim period. Under SA Article A108, there are no specific interim measures for the HFC during the interim period.

The initial new license period would include non-facilities modifications such as augmentation of minimum flow releases (up to 1,500 cfs or the total releases into the HFC, whichever is less), shutter manipulation, or adjustments to pump-back operations to meet temperature targets in the LFC until facilities modifications to provide colder water for coldwater fisheries protection to the LFC are constructed. In addition, river valves may be used to meet hatchery temperature targets. Facilities modifications could include Palermo Canal improvements, Hyatt Intake extension, River Valve improvements, a canal around Thermalito Afterbay, a canal through Thermalito Afterbay, an alternate Afterbay outlet and Channel, or a Thermalito Afterbay Temperature Curtain.

During drier years, the coldwater pool in Lake Oroville could become exhausted, making it difficult to meet temperature objectives. Because the temperature objectives would become license requirements after facility modifications are completed, this potential condition should not exist beyond year 10 of any new license issued. Therefore, the adverse temperature effects could occur during the 10 years following issuance of the license.

Conference Years and Actions—During conference years after completion of facilities modifications, when the OTMI is equal or less than 1.35 MAF (calculated in May), the project may have difficulty meeting water temperature targets and criteria. Under the circumstances, conference actions will be undertaken and a strategic plan will be prepared that states the specific actions that DWR would take to manage the coldwater pool to minimize exceedances of approved water temperatures. Our review of OCAP CALSIM modeling results (U.S. Bureau of Reclamation 2008c) show that this is expected to occur in less than 10 percent of the project years (Figure 2-42).

Figure 2-42 depicts an Oroville storage exceedance plot for the month of May for Oroville reservoir storage from the CVP/SWP ESA consultation, with climate change (CVP/SWP BA, OCAP CALSIM modeling). The climate change information is for 2025. It is the California Water Fix no action alternative (NAA) early-long-term (ELT) scenario characterizing land use, build out, and water demands as projected for approximately 2025. This CalSimII modeling for CWF NAA ELT assumes all operations and reasonable and prudent actions as specified in the 2008 USFWS and 2009/2011 NMFS CVP/SWP biological opinions and amendments, to the extent that those constraints can be characterized by the model. The scenario has incorporated projected effects of climate change by using a multi-model ensemble-informed approach to identify a best estimate of the consensus of climate projections from the third phase of the Coupled Model Intercomparison Project (CMIP3) which informed the Intergovernmental Panel on Climate Change’s Fourth Assessment Report (Bay Delta Conservation Plan 2013). This information identifies that in the year 2025 climate change will result in May storage levels being at or below 1.35 MAF with about the same frequency as under current conditions and with implementation of the conditions considered under the other ESA consultations. However, it also shows that with climate change May storage will be lower than without climate change. Therefore, based on modeling data, with climate change we would not expect the frequency of

May storage being at or less than 1.35 MAF (resulting in Conference Years) to occur more often prior to the implementation of facility modifications.

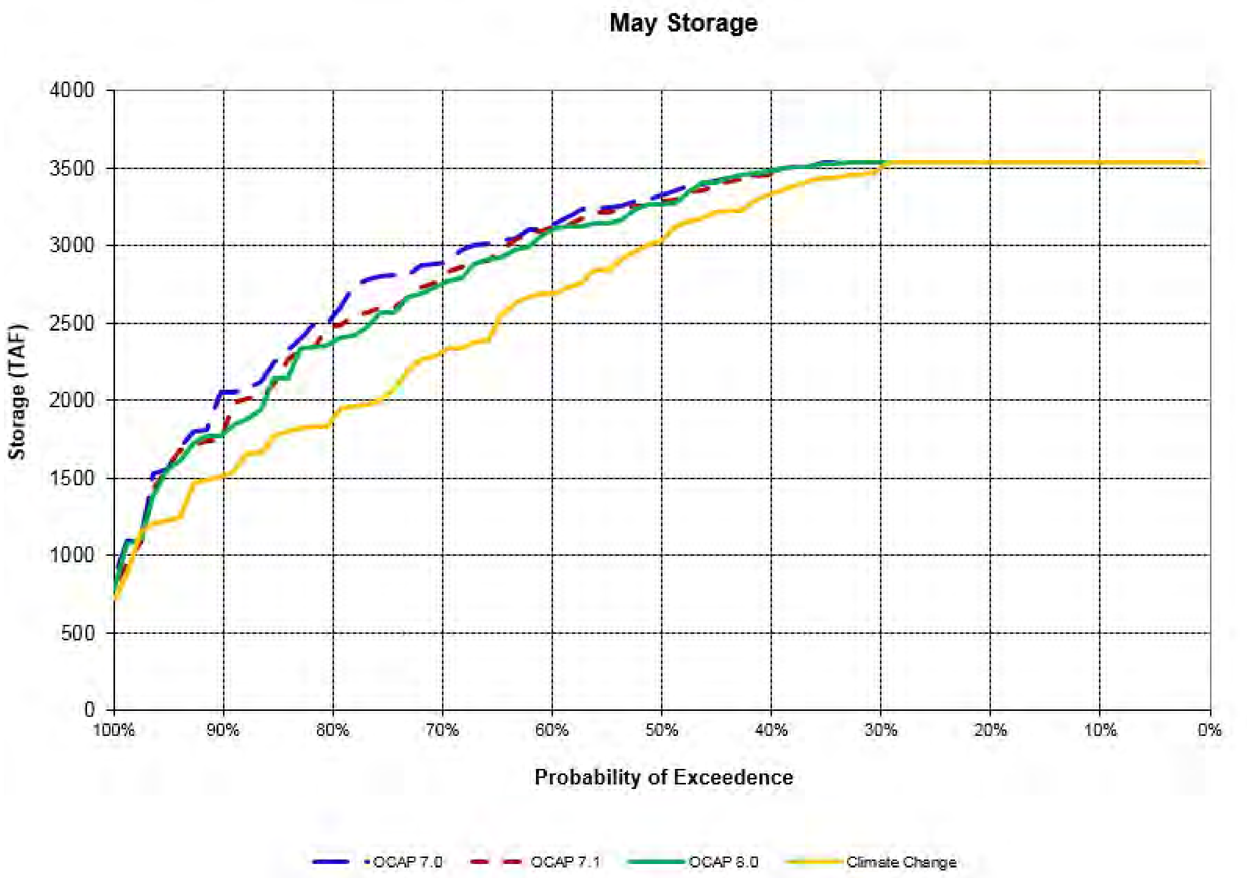

Figure 2-42. Oroville Storage Exceedance Plot

Figure 2-43 through Figure 2-49 on the following pages provide information about observed water temperatures in the Feather River.

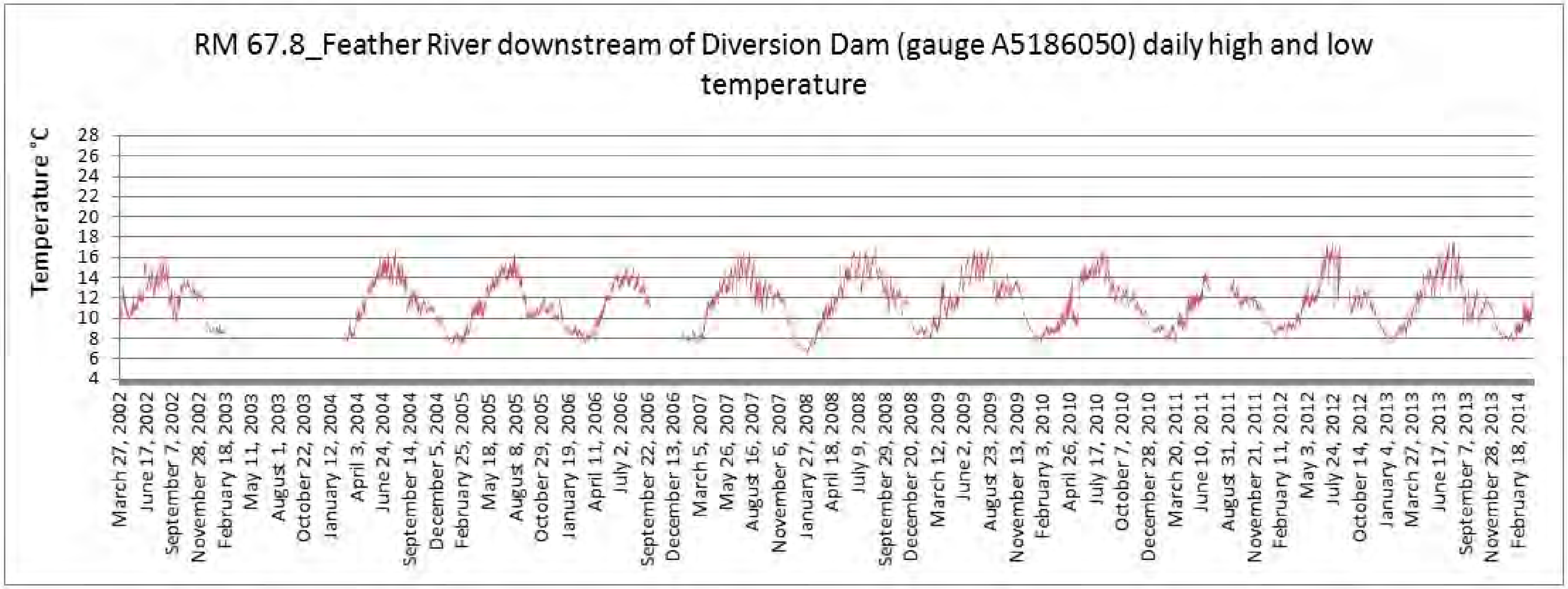

Figure 2-43. Feather River Water Temperatures at RM 67.8

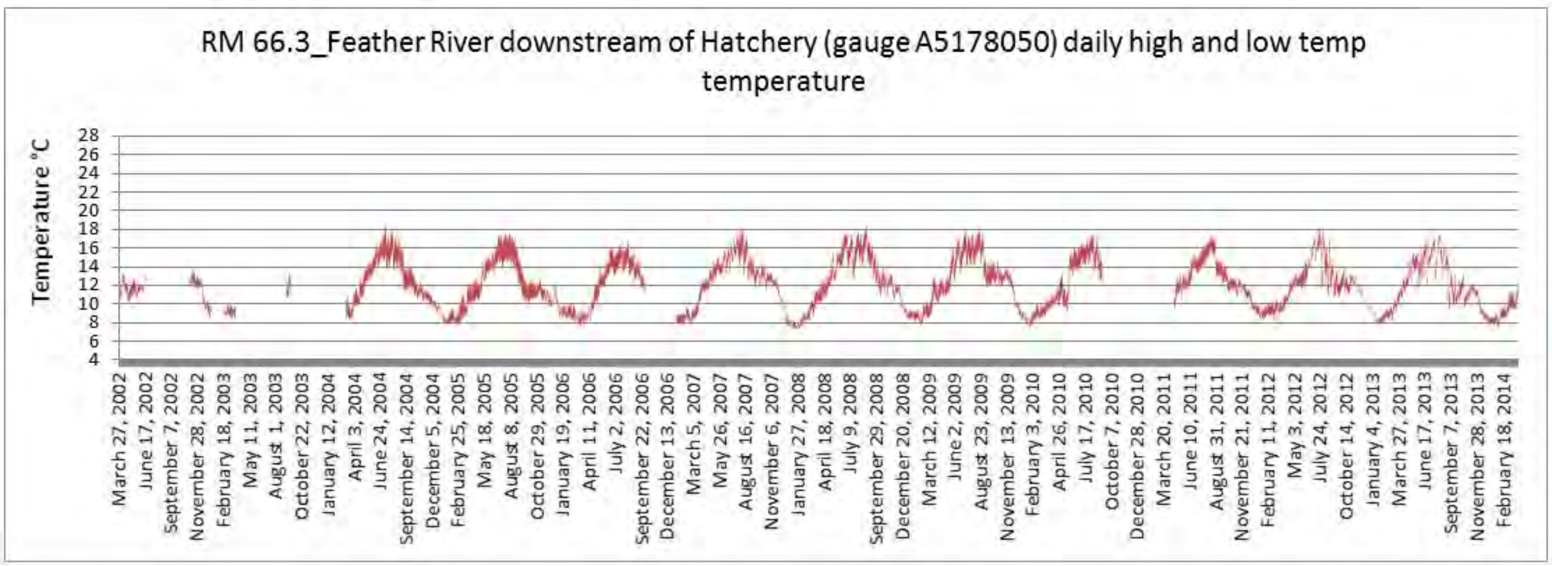

Figure 2-44. Feather River Water Temperatures at RM 66.3

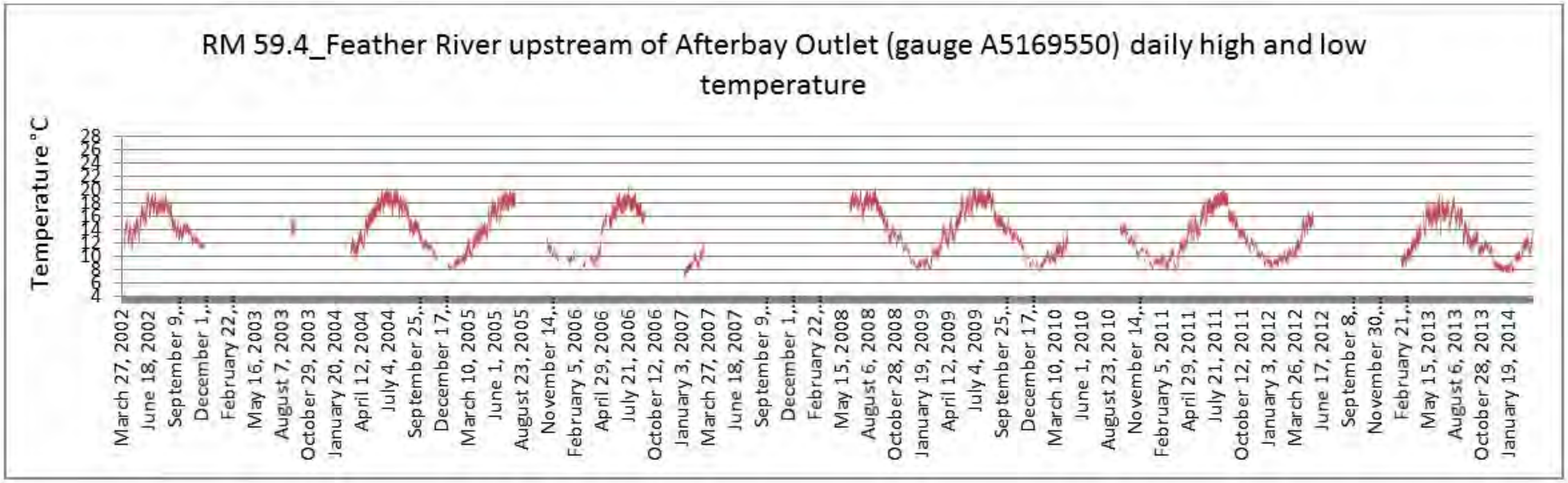

Figure 2-45. Feather River Water Temperatures at RM 59.4

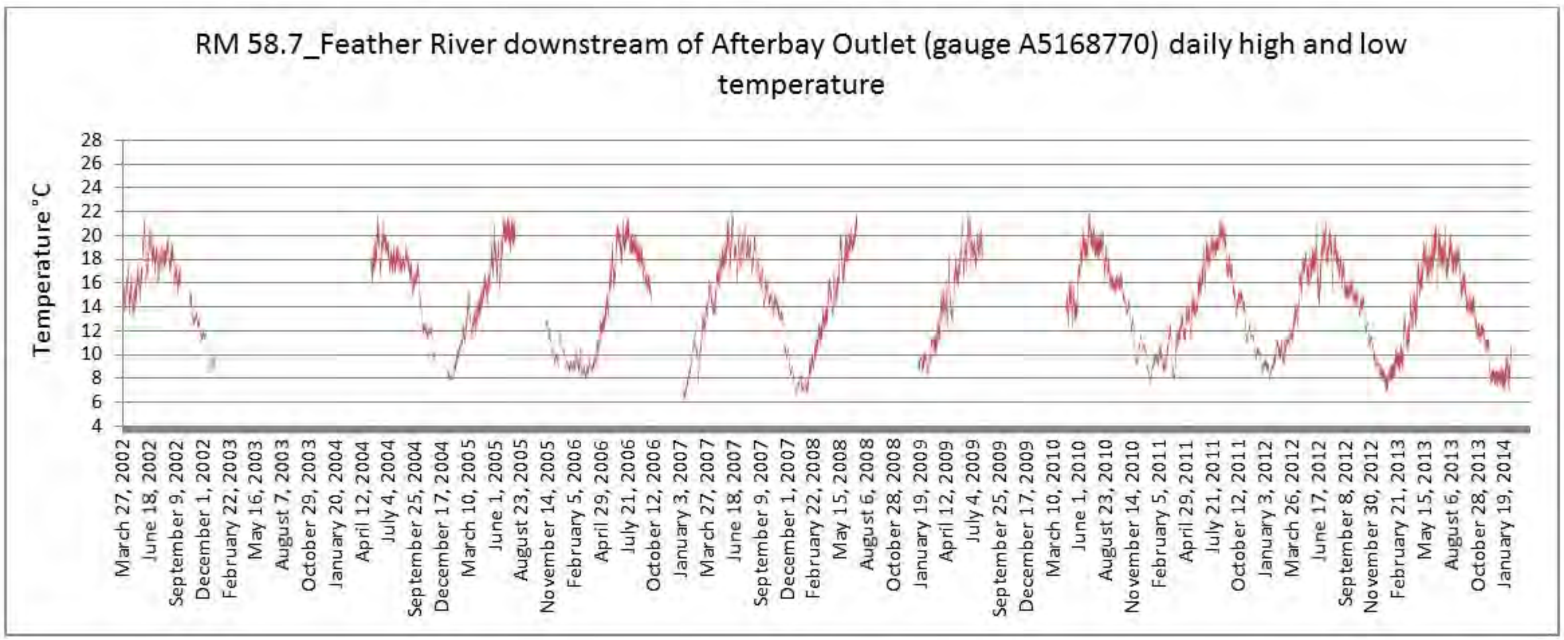

Figure 2-46. Feather River Water Temperatures at RM 58.7

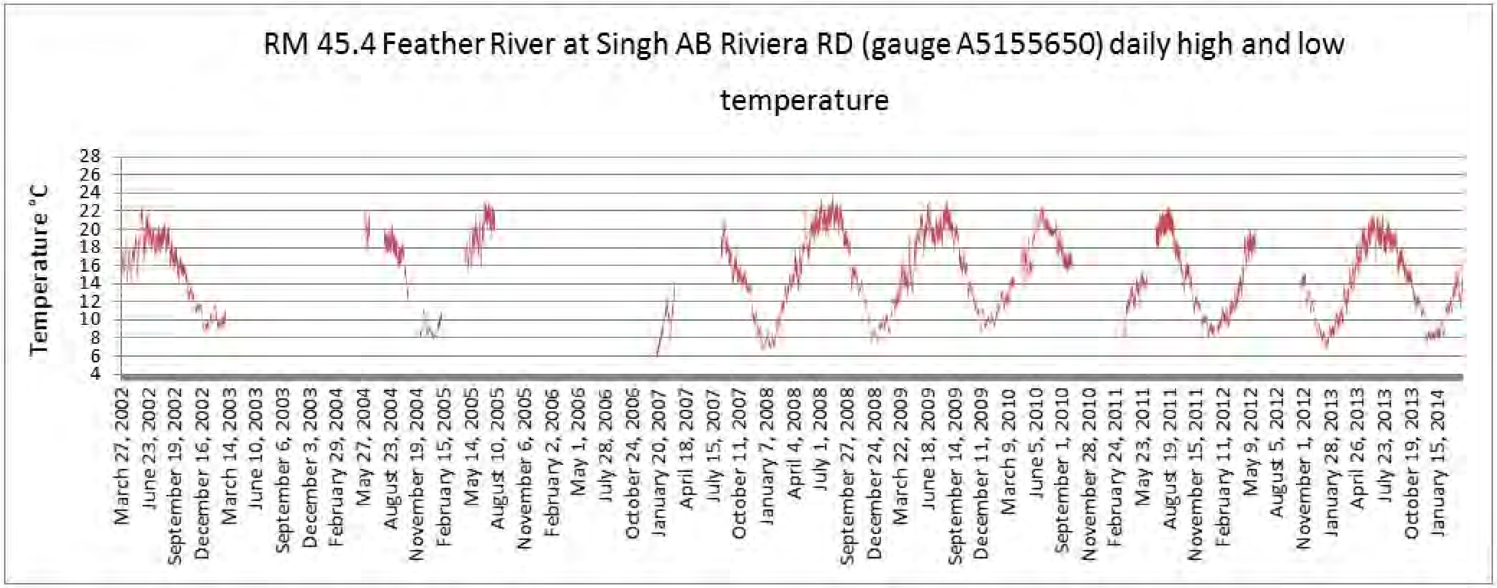

Figure 2-47. Feather River Water Temperatures at RM 45.4

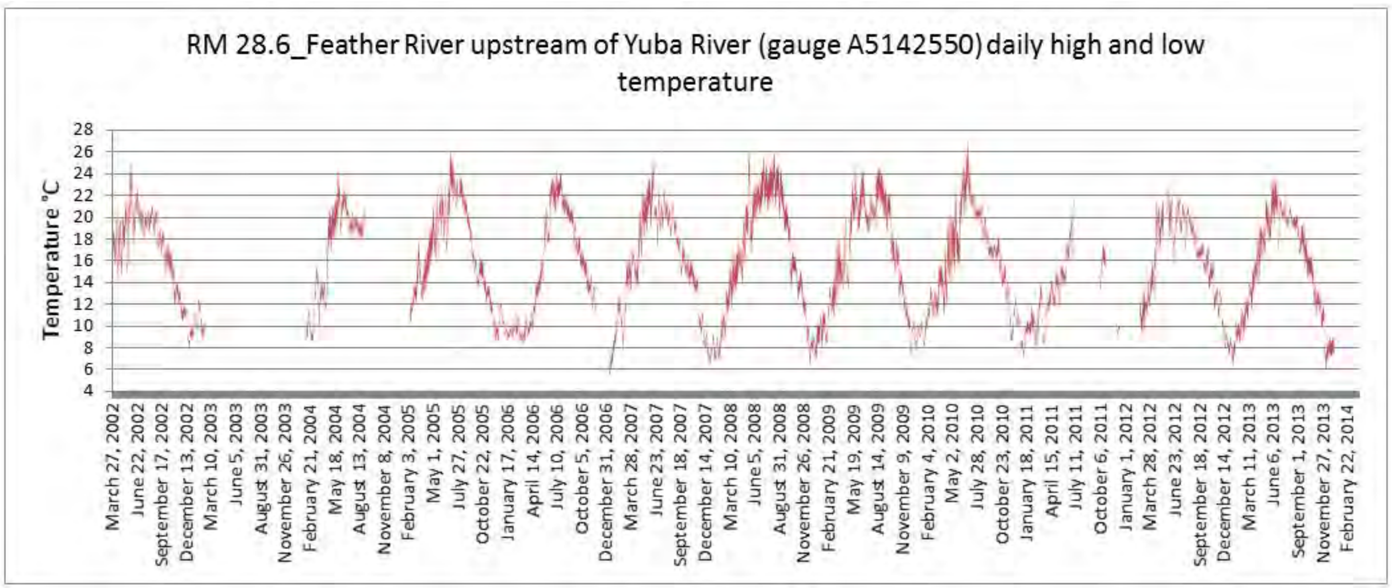

Figure 2-48. Feather River water temperatures at RM 28.6

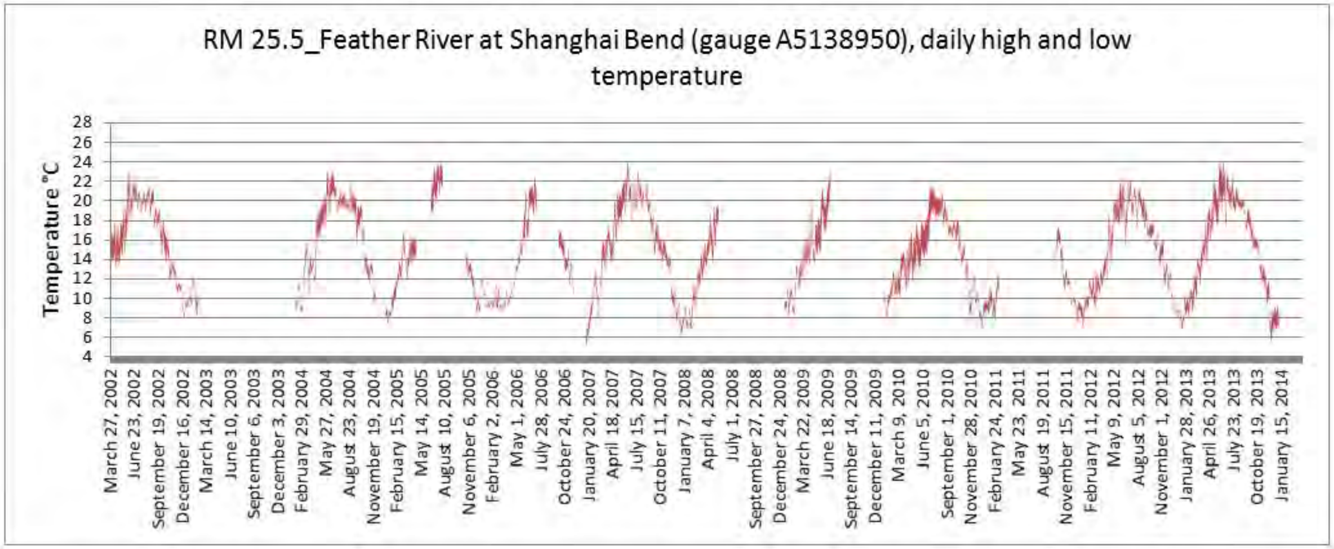

Figure 2-49. Feather River Water Temperatures at RM 25.5

2.4.5.1.1 Robinson Riffle

We present two charts here (Figure 2-50 and Figure 2-51), one showing the daily range of temperatures and the other showing the daily average temperature, each plotted against the temperature criteria that have been established for the LFC at Robinson Riffle.

The chart showing the daily range of temperature represents what the fish actually experience, and this is the more useful of the two charts from a biological perspective.

The daily average chart is shown only because temperature criteria that have been established in the past have called for values as daily averages. Daily averages can mask temperature spikes that may reach lethal or sub-lethal thresholds.

The charts below show that in every year for which data is presented (2002-2013), temperatures are virtually always in excess of maximum allowable criteria from the end of May to mid-September. At times the minimum daily temperature has exceeded the proposed maximum temperature criteria. This shows that the proposed temperature criteria will provide improved conditions over what has occurred in the past.

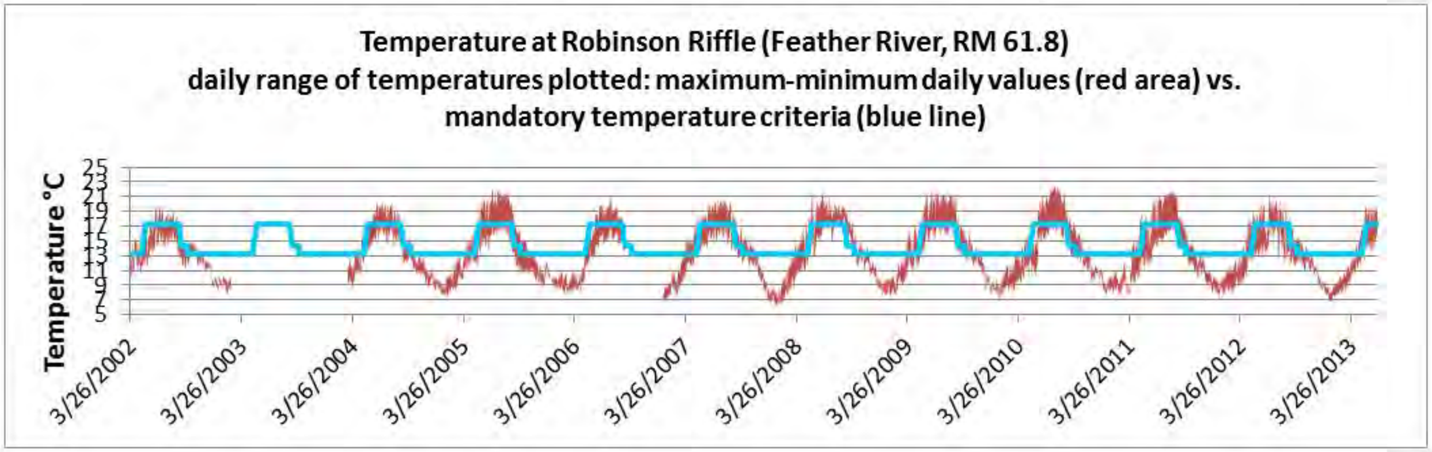

Figure 2-50. Temperature Ranges at Robison Riffle

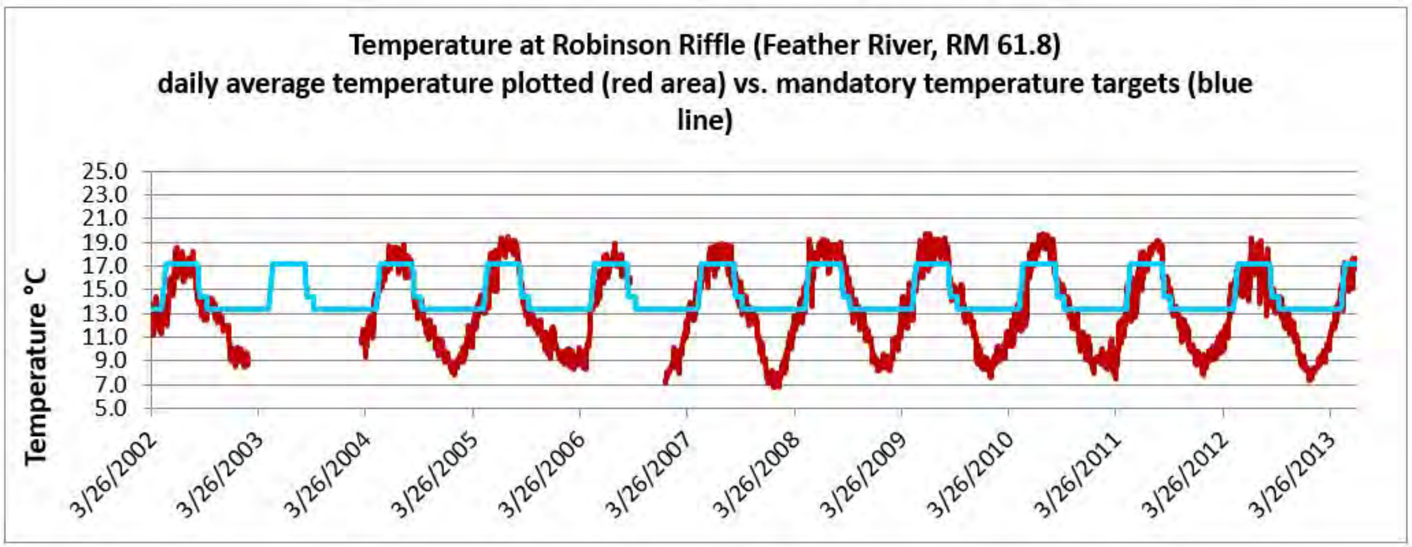

Figure 2-51. Average Temperature Ranges at Robinson Riffle

2.4.5.2 Approach to the Water Temperature Analysis

Throughout this Opinion, we use an exposure-response approach to our analysis. We look at the exposure of the fish to a stressor, in this case temperature, and then assess their response. The exposure and response of CCV steelhead, CV spring-run Chinook salmon, and sDPS green sturgeon to temperature stressors is discussed below.

Our goal is to determine the suitability of the Feather River, on the basis of temperature, for CCV steelhead, CV spring-run Chinook salmon, and sDPS green sturgeon. In order to establish temperature ranges for each species, we used a variety of information sources. We started with information presented in the draft Oroville Biological Opinion submitted to DWR in 2009 and we also used the information presented in section *2.2 Rangewide Status of the Species and Critical Habitat* and section *2.3 Environmental Baseline* of this Opinion. This formed the basis for the below temperature tables. We then cross-checked key references commonly used in Central Valley fisheries biology (Moyle 2002, U.S. Environmental Protection Agency 2003). We also used temperature information presented in the NMFS Recovery Plan for salmonids (National Marine Fisheries Service 2014a). Finally, we consulted with fish biology experts at NMFS and DWR to peer review these temperature tables.

It should be noted that in many cases, through the process of determining temperature ranges, the body of scientific literature provided overlapping temperature values and sometimes conflicting values. This is not entirely surprising because studies were designed for different purposes.

Context is important too. For example, juvenile fishes tend to have maximum growth rates near the upper end of their physiological temperature tolerances if they have unlimited food availability. Most river environments in the Central Valley, including the Feather River, do not provide an unlimited supply of food. Lacking abundant food supplies, temperatures at the upper end of physiological temperature tolerances may be quite detrimental. It should be noted that in some cases, while we are using the best available information, the amount or type of information is limited. This is particularly true in the yellow (acceptable) and orange (impaired fitness) regions of the table, where the exact distinction between an acceptable temperature and an undesirable temperature is either not well known or varies between populations and even between years. This uncertainty is not reflected in the tables because there is no easy way to show in a single table the vast complexity of what is known and unknown about fish biology related to water temperatures.

The EPA developed guidance for Pacific northwest state and tribal temperature water quality standards in 2003 (U.S. Environmental Protection Agency 2003). This guidance specifically addresses water temperatures and salmonids. Agencies and researchers have used a variety of temperature measurement criteria. Some of the criteria that have been used included constant temperatures, daily average temperatures (DAT), maximum weekly average temperature (MWAT), 7-day moving average of maximum daily temperatures (7DMAVG), and maximum 7-day average of the daily maxima (7DADM). The U.S. Environmental Protection Agency (2003) recommended the use of 7DADM as the water temperature metric for numeric criteria that is applied to specific species and lifestages of salmonids.

Research clearly supports assigning optimal temperature ranges and assigning lethal limits. For example, Moyle (2002) notes that few Chinook salmon can survive temperatures greater than 24°C (75°F) for even short periods of time. Also, much of the information reported in the literature is derived from laboratory or hatchery studies, where water temperatures are more uniform than in rivers, where diurnal temperatures usually vary.

With these caveats, temperature tables shown in Figure 2-50 and Figure 2-51 provide a sound resource in establishing temperature conditions that are suitable, optimal, stressful, or lethal to anadromous fish.

The effects of water temperature on Chinook salmon has been extensively analyzed and reviewed. Individual and population-level responses to water temperatures are highly variable and are often related to a number of influencing factors that cannot be uniformly applied to all situations. For example, Chinook salmon in southern latitudes may be exposed to warmer in-river temperature regimes than salmon in northern latitudes and may have become more tolerant to higher water temperatures. For the purpose of evaluating water-temperature stressors, however, we considered the wide range of available information and identified more specific water temperature index values, in great part from Appendix F ((Department of Water Resources 2004a)), for each life stage and evaluated potential fish responses to exposure to those values (Table 2-16 and Table 2-17).

These index values are useful as screening tools for identifying potential conditions that are suitable, optimal, stressful, or lethal to anadromous fish. They are not meant to be considered as absolute thresholds.

Table 2-16 lists CV spring-run Chinook salmon water temperature index values that are used as technical analytical guidelines for this Opinion.

Table 2-16. CV spring-run Chinook Salmon Water Temperature Index Values

Life Stage	Period	EPA 2003 Water Temperature Criteria (7DADM)	Water Temperature Index Maximum Values	Rationale
Spawning LFC Only	Mid-September–October	55 ºF	56ºF	41–56ºF Maximum survival of eggs (U.S. Fish and Wildlife Service 1995). Upper limit of thermal optimum (U.S. Bureau of Reclamation 2008c). Maximum water temperature above which egg mortality occurs.
Immigration	March–August	68 ºF	64ºF	Immigration from March through June with holding from May through August. Acceptable water temperatures for adults migrating upstream range from 57°F to 67°F; Disease risk becomes high at water temperatures above 64.4°F (U.S. Environmental Protection Agency 2003). Latent embryonic mortalities and abnormalities associated with water temperature exposure to pre-spawning adults occur at 63.5°F to 66.2°F (Berman 1990).

Life Stage	Period	EPA 2003 Water Temperature Criteria (7DADM)	Water Temperature Index Maximum Values	Rationale
Holding	March–July	61 °F	65°F	Immigration from March through June with holding from May through August. For chronic exposures, an incipient upper lethal water temperature limit for pre-spawning adult salmon probably falls within the range of 62.6°F to 68.0°F (Marine 1992); CV spring-run Chinook salmon embryos from adults held at 63.5°F to 66.2°F had greater numbers of pre-hatch mortalities and developmental abnormalities than embryos from adults held at 57.2°F to 59.9°F (Berman 1990); Water temperatures of 68°F resulted in nearly 100 percent mortality of Chinook salmon during columnaris outbreaks (Ordal and Pacha 1963). CV spring-run Chinook salmon in Butte Creek holding in high densities experience outbreaks of columnaris outbreaks when exposed to average daily temperatures exceeding of 67.1°F.

Life Stage	Period	EPA 2003 Water Temperature Criteria (7DADM)	Water Temperature Index Maximum Values	Rationale
Egg Incubation	September–February	55ºF	56ºF	Less than 56°F results in a natural rate of mortality for fertilized Chinook salmon eggs (USBR Unpublished Work). Optimum water temperatures for egg development are between 43°F and 56°F (National Marine Fisheries Service 1993). Upper value of the water temperature range (*i.e.,* 41.0°F to 56.0°F) suggested for maximum survival of eggs and yolk-sac larvae in the Central Valley of California (U.S. Fish and Wildlife Service 1995). Upper value of the range (*i.e.*, 42.0°F to 56.0°F) given for the preferred water temperature for Chinook salmon egg incubation in the Sacramento River (National Marine Fisheries Service 1997). Incubation temperatures above 56°F result in significantly higher alevin mortality (U.S. Fish and Wildlife Service 1999). 56.0°F is the upper limit of suitable water temperatures for CV spring-run Chinook salmon spawning in the Sacramento River.

Life Stage	Period	EPA 2003 Water Temperature Criteria (7DADM)	Water Temperature Index Maximum Values	Rationale
Juvenile Rearing	Mid November–March in LFC Through April and May in HFC	61 ºF	60°F-64ºF	Upper preferred limit for CV spring-run Chinook salmon fry/fingerling growth (Department of Water Resources 2004a). Preferred for growth and development of CV spring-run Chinook salmon fry/juveniles in the Feather River (DWR 2004g, NMFS 2002). Water temperatures greater than 64.0°F are considered not "properly functioning" by NMFS in Amendment 14 to the Pacific Coast Salmon Plan (NMFS 1995); Fatal infection rates caused by *C. columnaris* are high at temperatures greater than or equal to 64.0°F (Fryer and Pilcher 1974)
Smoltification	March-May	Not applicable	64ºF	< 64ºF (Cech and Myrick 1999)

Table 2-17. Spring-run Chinook Salmon Temperature Tolerances

spring-run - Feather River																																																
values in degrees Fahrenheit																																																
eggs/embryos																																																
October-March	eggs present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
April-August	no eggs present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
September	eggs present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
Juveniles																																																
October	juveniles not present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
November-December	juvenile emigration	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
January-March	peak juvenile emigration	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
April-June	juvenile emigration	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
July	few juveniles present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
August-September	juveniles not present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
Parr/smolt transformation																																																
October-September	most smolt outside of FR	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
adults																																																
October	spawning adults	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
November-February	adults die after spawning	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
March-June	adult immigration to Feather River	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
July-August	adult holding	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
September	spawning adults	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81

Green=optimal yellow=acceptable orange=impaired fitness red=likely lethal black=lethal

Table 2-18 and Table 2-19 provide the proposed flows for the LFC and the HFC.

Table 2-18. LFC Minimum Flows

Low Flow Channel Minimum Instream Flows	
Months	**Flow**
April 1–September 8	700 cfs
September 9–March 31	800 cfs

Table 2-19. HFC Minimum Flows

High Flow Channel Minimum Instream Flow			
Percent of Normal Runoff *	**Oct–Feb (cfs)**	**March (cfs)**	**April–Sept (cfs)**
≥55%	1,700	1,700	1,000
<55%	1,200	1,000	1,000

2.4.5.3 Central Valley Spring-run Chinook Salmon Stressors and Responses

Table 2-20 summarizes the proposed action's CV spring-run Chinook salmon potential stressors, exposure, and response. Following the table each potential stressor is discussed, which does not include expected responses to proposed action conservation measures.

Table 2-20. Exposure and Summary of Responses of CV Spring-run Chinook Salmon to the Proposed Action

Life Stage/Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
Adult Migration				
The Feather River from the confluence with the Sacramento River, upstream to historic habitat below the PG&E Poe Hydroelectric Project	Feather River Fish Barrier Dam Oroville Dam	March-June	March-June	Blocked access to historical habitat upstream from Oroville Dam. (By blocking upstream migration of adults, all other life stages that would have used this habitat also are affected.)
The Feather River from the confluence with the Sacramento River, upstream to the Feather River Fish Barrier Dam	Water Temperatures	March-June	June	Water temperatures in the lower river in June may exceed 65 degrees, however we expect CV spring-run Chinook to have moved upstream by this time of year. The lower river water temperature is also affected by other tributaries. In the upper part of this reach, water temperatures are and will be cooler due to the proposed action temperature management operations.

Life Stage/Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
Adult Holding				
LFC and upstream	Reduced holding habitat, holding areas lower in watershed	May through October	May through October	Blocked access to historical habitat upstream from Oroville Dam (by blocking upstream migration of adults, all other life stages that would have used this habitat also are affected).
LFC	Water Temperatures	May through October	May through October	Elevated water temperatures may result in mortalities, or decreased embryo survival.
Spawning				
Upstream of the Fish Barrier Dam	The Oroville Facilities blocks access to historic habitat	September through October	September through October	Hybridization resulting in life history and genetic biosimplification.
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Oroville releases—flow related habitat availability	September through October	September through October	Reduced habitat quality and availability. Competition for spawning area, reduced reproductive success.

Life Stage/Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Competition for space and superimposition related to co-occurrence with spawning fall-run Chinook salmon, due to blockage to historic habitat	September through October	September through October	Hybridization resulting in life history and genetic biosimplification. Egg mortality. Reduced reproductive success.
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Low and Declining Habitat Availability from gravel depletion	September through October	September through October	Reduced spawning habitat availability. Competition for spawning area, reduced reproductive success. The proposed action has addressed this in part in 2014, and the project will place more gravel over the term of the license.
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Elevated Water Temperatures	September through October	September	Reduced egg survival, latent mortality, abnormalities. Reduced juvenile survival and abundance.

Life Stage/Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
Feather River Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Hatchery Operations	September through October	September through October	Reduced genetic diversity and reduced reproductive success associated with interbreeding between hatchery and wild CV spring-run Chinook, interbreeding with fall-run Chinook, and straying.
Embryo Incubation				
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Oroville releases—flow fluctuations associated with flood events.	December-February	December-February	Redd dewatering and isolation prohibiting successful completion of spawning. Scour occurs in some years, but the proposed action reduces the number of scour events. These events are associated with high reservoir conditions. Reduced reproductive success.
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Oroville spillway releases—redd scour	September-January	December - February	Egg and alevin mortality. Reduced survival, reduced abundance. Scour occurs in some years, but the proposed action reduces the number of scour events. These events are associated with high reservoir conditions.

Life Stage/Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Water temperatures warmer than life stage requirements	September-January	September	Reduced egg and larval survival. Reduced survival, reduced population abundance.
Juvenile Rearing				
Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Oroville releases—flow fluctuations; low flows and habitat availability	Year-round is possible but generally November through May	Year-round is possible but generally November through May	Fry stranding and juvenile isolation associated with flood management releases; low flows limiting the availability of quality rearing habitat including predator refuge habitat. Reduced survival, reduced abundance.
Thermalito Afterbay Outlet pool downstream to Verona	Water temperatures warmer than life stage requirements	Year-round is possible but generally November through May	June - October	Physiological effects—growth rates, susceptibility to disease, predation Reduced growth; reduced survival, reduced abundance.
Smolt Emigration				

Life Stage/Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
Juvenile Rearing and Smolt Emigration	Oroville releases—flow fluctuations; low flows and habitat availability	March - June	June	Fry stranding and juvenile isolation; low flows limiting the availability of quality rearing habitat including predator refuge habitat. Reduced survival, reduced abundance.
Smolt emigration HFC only	Water temperatures warmer than life stage requirements	March-June	June	Physiological effects—reduced ability to successfully complete the smoltification process, increased susceptibility to disease and predation Reduced growth; reduced survival, reduced abundance.

2.4.5.3.1 CV Spring-run Chinook Salmon Adult Migration Stressors and Exposure

The Oroville Facilities are located on the Feather River. Several tributaries flow into Lake Oroville, including the North Fork, West Branch, South Fork, and the Middle Fork of the Feather River. Oroville Dam is a permanent structure that is in the Feather River channel near the City of Oroville. The Fish Barrier Dam blocks upstream migration of anadromous fish to historical holding, spawning, and rearing habitat, and the proposed action does not include any fishways to provide upstream and downstream passage of anadromous fish through or around the Oroville Facilities. Oroville Dam changes the hydrology and morphology of the channel downstream from Oroville Dam and restricts the flow of sediment and bedload to river reaches downstream.

CV Spring-run Chinook salmon in the Feather River have been significantly impacted by the development of hydroelectric facilities within the basin. These facilities have reduced access to historical upstream spawning and rearing habitat. This includes lost access to 25 river miles up to Miocene Dam on the West Branch, 21 river miles up to Poe Powerhouse on the North Fork, 19 river miles up to Curtain Falls on the Middle Fork, and 8 river miles up to Ponderosa Dam on the South Fork; a total loss of 73 river miles. The loss of access is due to the Oroville Facilities and other hydroelectric facilities upstream of the Oroville Facilities that block anadromous fish passage. The hydroelectric projects on the upper Feather River block varying amounts of historic CV spring-run Chinook salmon habitat. However, the Fish Barrier Dam (part of the Oroville Facilities) is the furthest downstream and completely blocks anadromous fish passage. As a result of the construction and continued operation of hydroelectric facilities in the Feather River that do not include fishways for upstream and downstream passage of anadromous fish, particularly the Oroville Facilities, the CV spring-run Chinook salmon cannot access their historic habitat, and their spawning and rearing activities will continue to be restricted to the Feather River downstream of the Fish Barrier Dam. This restricts the CV spring-run Chinook salmon to the same areas for spawning and rearing as the fall-run Chinook salmon. While adult CV spring-run Chinook salmon enter the Feather River in the spring, they hold in the river until fall to spawn. The fall-run Chinook salmon enter freshwater in the fall and spawn shortly after arriving on the spawning grounds. While the CV spring-run Chinook salmon start spawning prior to fall-run Chinook salmon, their spawning times overlap. This results in competition between CV spring-run Chinook salmon and fall-run Chinook salmon for spawning habitat. With the fall-run Chinook salmon spawning later than the CV spring-run Chinook salmon there are effects due to superimposition of fall-run Chinook salmon redds on top of CV spring-run Chinook salmon redds. Superimposition can result in mortality of the earlier laid eggs, due to later spawners digging up the eggs (losses are due to exposure to light and predation), or disturbing the gravel adjacent to earlier laid eggs during times that they are sensitive to disturbance. For juvenile CV spring-run Chinook salmon, there is competition with fall-run Chinook salmon for rearing habitat and for food.

Historical distribution and abundance of Chinook salmon in the Feather River was reviewed by Yoshiyama et al. (2001)_ENREF_333. Historically, fall-run Chinook salmon spawned primarily in the mainstem river downstream of the present site of Lake Oroville, while CV spring-run Chinook salmon ascended all three upstream branches.

Figure 2-52 shows the escapement of fall-run Chinook salmon to the Feather River Hatchery and the Feather River from 1953 to 1994 (Sommer et al. 2001b). Fry (1961) reported fall-run Chinook salmon escapement estimates of 10,000 to 86,000 for 1940-1959, compared to 1,000 to about 4,000 for CV spring-run Chinook salmon (Figure 2-52 and Figure 2-53).

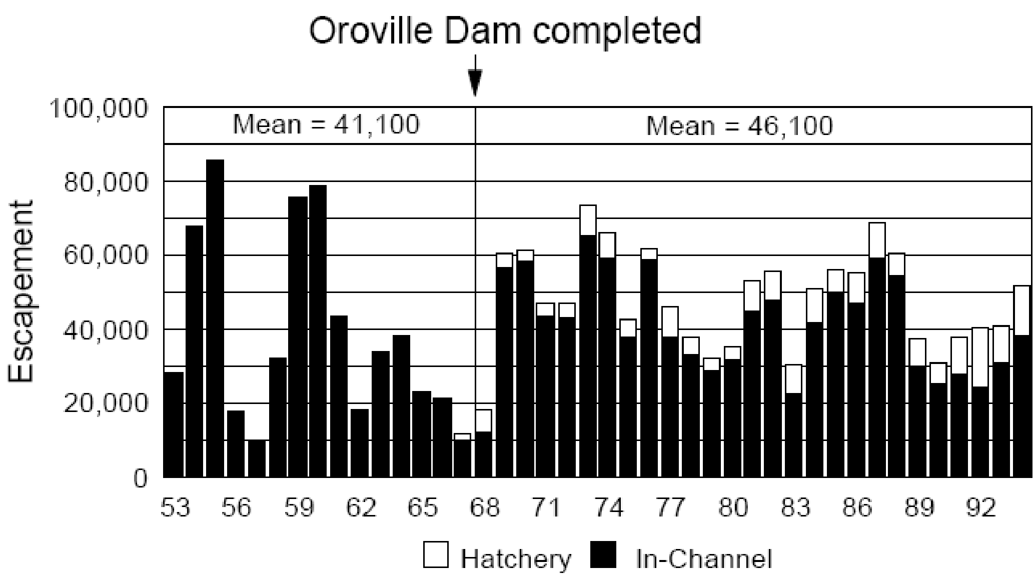

Figure 2-52. Escapement of Fall-run Chinook Salmon, Feather River Hatchery and Feather River, 1953-1994

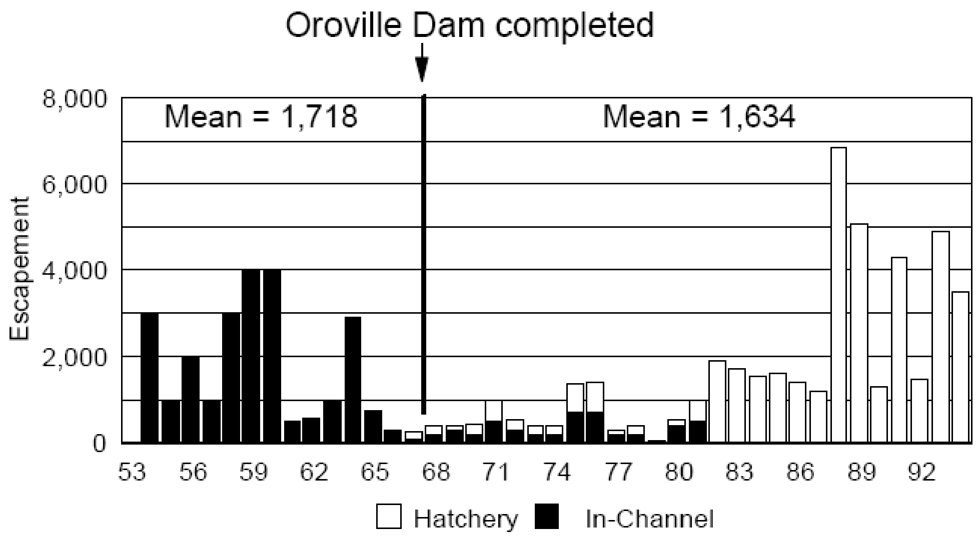

Figure 2-53. Escapement of CV Spring-run Chinook Salmon, Feather River Hatchery and Feather River, 1953-1994

The post-dam abundance of CV spring-run Chinook salmon is similar or higher compared to available pre-dam information (Sommer et al. 2001b, Brown et al. 2004, California Department of Fish and Game 2012).

To a large extent, however, the runs are comprised of fish produced by the FRFH, and naturally-spawning CV spring-run Chinook salmon are now restricted to the cold-water habitat located downstream from the Fish Barrier Dam, where they compete for space and hybridize with fall-run Chinook salmon. Therefore, although the abundance of adult CV spring-run Chinook salmon is similar or greater than the number of fish before construction of Oroville Dam, most of these are hatchery fish that have spatial distribution and genetic and life history diversity that differ from naturally spawning fish.

With the proposed action, regulated instream flows in the LFC generally will be a constant 700 cfs during the adult upstream migration and holding period. These flows are adequate for CV spring-run Chinook salmon to migrate through the LFC.

Water temperature is an important factor influencing the suitability of adult CV spring-run Chinook salmon immigration corridors. Exposure to cool migration water in the Feather River depends largely on the operations of the Oroville-Thermalito Complex. This is especially true for the LFC. If water temperatures encountered by upmigrating salmonids in the Feather River are cooler than those in the Sacramento River, the Feather River salmonids may be encouraged to continue their migration to their natal spawning grounds in the Feather River, thus decreasing the likelihood of straying into the upper Sacramento River.

2.4.5.3.2 CV Spring-run Chinook Salmon Adult Migration Response

For adult upstream migration, CV spring-run Chinook salmon require stream flows that are sufficient to trigger migration cues and to allow fish to locate natal streams (DFG 1998).

Furthermore, CV spring-run Chinook salmon must migrate during high flow periods to successfully ascend high gradient channel segments that may be impassable or difficult to pass at low flows (Lindley et al. 2004). The HFC is a low-gradient channel, with no significant water falls. While the rock weir at Sunset Pumps may be a partial impediment to upstream fish passage, based on fish entering the FRFH salmonids are able to pass this structure. Currently, the extent of the delay of salmonid fish passage at Sunset Pumps is unknown. Extensive evaluations of critical riffles have not revealed any passage limitations at riffles; therefore, the proposed flows are expected to provide adequate depths and velocities for upstream migration. The proposed ramping rates are expected to avoid stranding of migrating adult CV spring-run Chinook salmon.

Based on observations of CV spring-run Chinook salmon immigration in the Feather River, adults are likely to migrate upstream through the action area during the period between February and July where they hold in deep coldwater pools until spawning. The LFC is a low-gradient channel, with no water falls or constructed passage impediments. Extensive evaluations of critical riffles have not revealed any passage limitations at riffles; therefore, the proposed flows are expected to provide adequate depths and velocities for upstream migration. The HFC is considered a migratory corridor for adult CV spring-run Chinook salmon and few, if any of these fish are thought to hold or spawn there.

Adult CV spring-run Chinook salmon are unable to migrate upstream of the Fish Barrier Dam, and no fish passage to historic upstream habitat is included in the proposed action.

2.4.5.3.3 CV Spring-run Chinook Salmon Adult Holding Stressors and Exposure

After migrating, and prior to spawning, CV spring-run Chinook salmon adults need areas to reside for months, or hold, prior to spawning. CV spring-run Chinook salmon can migrate to holding areas as early as May and need safe areas to mature, until spawning (September – November). Ideally, the holding areas have cold water and large deep pools and cover to provide the fish protection from predators.

With construction of Oroville Dam and the Fish Barrier Dam, the historic areas for CV spring-run Chinook salmon holding are no longer accessible. These fish now must find holding areas downstream of the Fish Barrier Dam.

Instream flows in the HFC will be a minimum of 1,000 cfs from April through September, then 1,200 to 1,700 cfs from October through February. Ramping criteria for the Feather River that were established in a 1983 agreement between DWR and DFG will continue under the proposed action. This agreement requires flows below the Thermalito Afterbay that are less than 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood control.

The current understanding is that the HFC is primarily used for adult migration and as a juvenile migration and rearing corridor. Therefore this section will not address the effects of water temperature-related stressors on adult holding, spawning, and egg incubation in the HFC because these life history stages are carried out upstream in the LFC. Adults are expected to migrate upstream through the HFC between February and June. Juvenile rearing and emigration is expected from December through May. Mean total flow is presently lower than historical levels during April and May, but higher from June through March. Average monthly flows are now at least 23 percent lower in April and 33 percent lower in May than pre-dam flows.

The LFC, where most CV spring-run Chinook salmon hold, has regulated flows, which are altered from pre-Oroville dam regimes, the water temperatures have been altered, and the habitat has been greatly altered. While HFC flows are higher now than pre-Oroville Dam in most months, the LFC flows are now lower in every month than pre-Oroville Dam (Figure 2-54). It is likely that the amount of holding habitat in the LFC is less than of historic holding habitat upstream of Oroville Dam. However, with reduced flows in the LFC and alteration of the LFC habitat, there are likely fewer deep holding pools in the LFC than prior to construction of Oroville Dam. Not all of the hatchery CV spring-run Chinook salmon enter the FRFH. All of the CV spring-run Chinook salmon that enter the FRFH are returned to the Feather River. The hatchery CV spring-run Chinook salmon compete for holding habitat with the non-hatchery CV spring-run Chinook salmon. In addition, when some CV spring-run Chinook salmon are holding in the LFC prior to their spawning, there is likely competition for habitat between CV spring-run Chinook salmon and fall-run Chinook salmon when both are present (September – November).

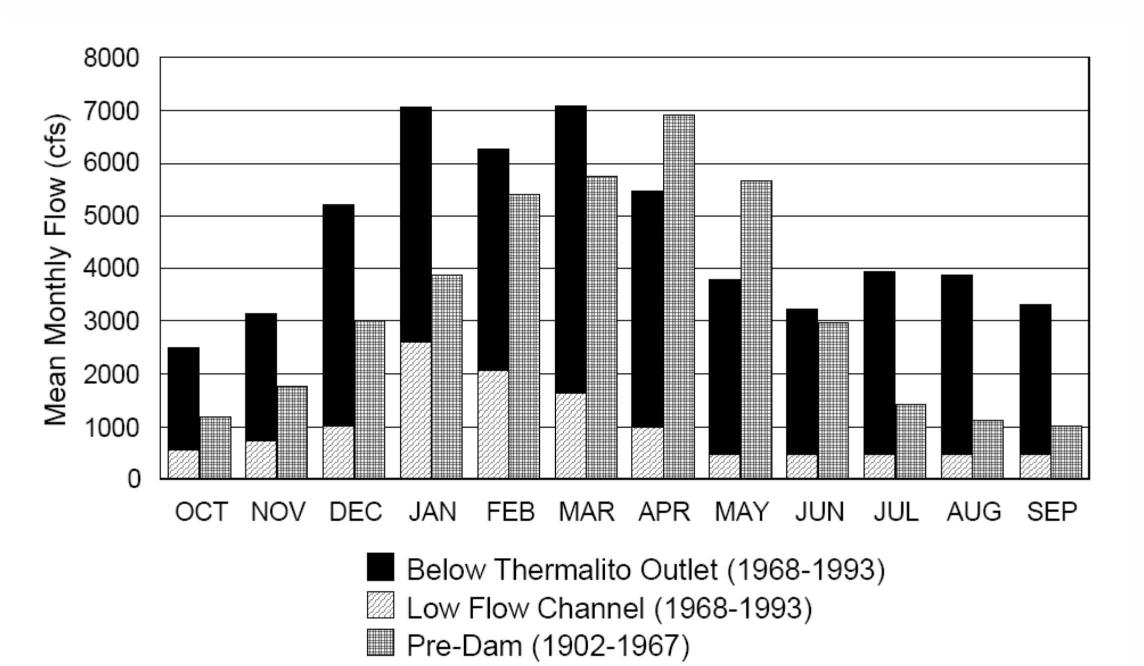

Figure 2-54. Average Monthly Flows, Feather River Pre- (1902-1967) and Post Oroville Dam (1968-1993)

With the proposed action, the instream flows in the LFC will generally be a constant 700 cfs from April 1 through September 8, then 800 cfs from September 9 through March 31.

2.4.5.3.4 CV Spring-run Chinook Salmon Adult Holding Response

As with adult migration, the Fish Barrier Dam and Oroville Dam block access to historic holding habitat.

Water temperature is an important factor influencing the suitability of adult CV spring-run Chinook salmon immigration holding habitat. Exposure to cool holding water in the Feather River depends largely on the operations of the Oroville-Thermalito Complex. While water temperatures in the lower part of the HFC may exceed 65°F, this will occur at the end of the migration period and be in the lower HFC. It is expected that by the time the water temperatures in the lower HFC become elevated that the adult CV spring-run Chinook salmon will be in the upper HFC and in the LFC. In the upper part of the HFC water temperatures will be managed to be 64°F, or less (maximum mean daily temperature). Based on available information, the proposed temperatures will be adequate for upstream migrating CV spring-run Chinook salmon.

2.4.5.3.5 CV Spring-run Chinook Salmon Spawning Stressors and Exposure

As with migration and holding habitat, CV spring-run Chinook do not have access to their historic spawning habitat upstream of Oroville Dam, and are limited to spawning habitat downstream of the Fish Barrier Dam. As with migration and holding habitat, flows have been altered (Figure 2-55).

Due to the limited suitable spawning and rearing habitats currently available on the Feather River downstream of the Fish Barrier Dam, CV spring-run and fall-run Chinook salmon are forced to occupy the same locations. This results in interbreeding between the two populations, and superimposition of fall-run Chinook salmon redds on spring-run Chinook salmon redds. Superimposition results is the eggs that were spawned earlier being dislodged from the gravel and swept downstream. These eggs die.

The primary function of the dam is to store winter and spring runoff for release into the Feather River as necessary for project purposes. This results in an altered hydrologic regime that includes changes to the yearly, monthly, and daily stream flow distributions; bankfull discharge, flow exceedance, peak flow, and other hydraulic characteristics (Buer 2004). The most significant effect may be that minimum instream flows in the LFC and the HFC are substantially reduced when compared to pre-dam average monthly flow conditions (Figure 2-55). The current flow patterns in the Feather River downstream from Oroville dam are different than pre-dam conditions, particularly in the LFC reach. The proposed action results in the continuation of an impaired hydrograph in the LFC and HFC.

Instream flows in the LFC generally will be a constant 800 cfs during spawning. Flows may be periodically increased above 800 cfs during December and January during high water events. These high flows occur in approximately 3 percent of years in December and 10 percent of years in January. Flows that exceed 10,000 cfs may mobilize gravels up to 1 inch in diameter, while larger materials such as cobbles are mobilized at 25,000 cfs.

Another significant alteration is that flow that historically passed through the LFC is now diverted into the Thermalito complex. Average monthly flows through the LFC are now at least 5 to 38 percent of pre-dam levels. Mean total flow is presently lower than historical levels during February through June, but higher during July through January. Mean total flow in the HFC is presently lower than historical levels during April and May, but higher from June through March. Average monthly flows in the HFC are now at least 23 percent lower in April and 33 percent lower in May than pre-dam flows (Sommer et al. 2001b). Figure 2-55 shows that median monthly flows are even more significantly impaired with major deviations in the magnitude and frequency of peak flows from winter and spring to summer months. Figure 2-55 also shows that actual flows are often higher than minimum flow requirements. The frequency and magnitude of high flow events are also significantly reduced due to project operations.

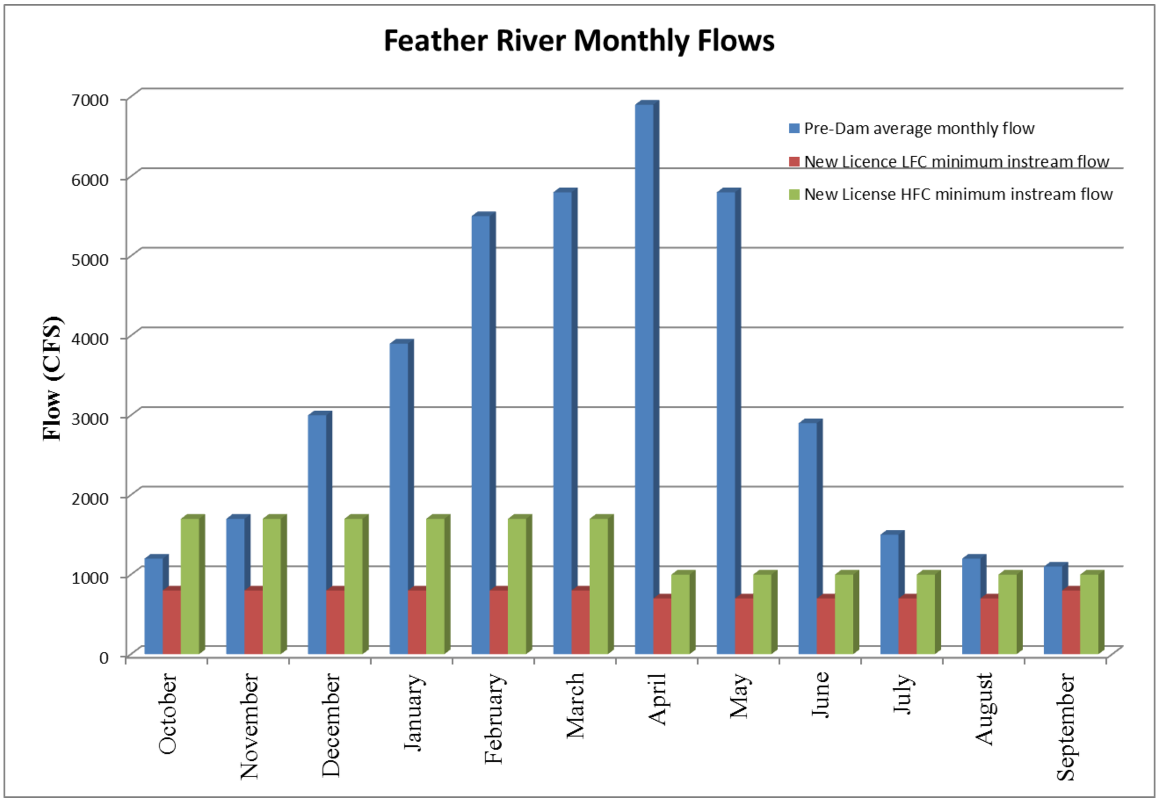

Figure 2-55 Comparison of Pre-dam Feather River flows to proposed minimum instream flows in the LFC and the HFC illustrating that there has been a seasonal shift of peak flow events from late winter and spring months to summer months. Source for pre-dam average monthly flow: (Sommer et al. 2001b).

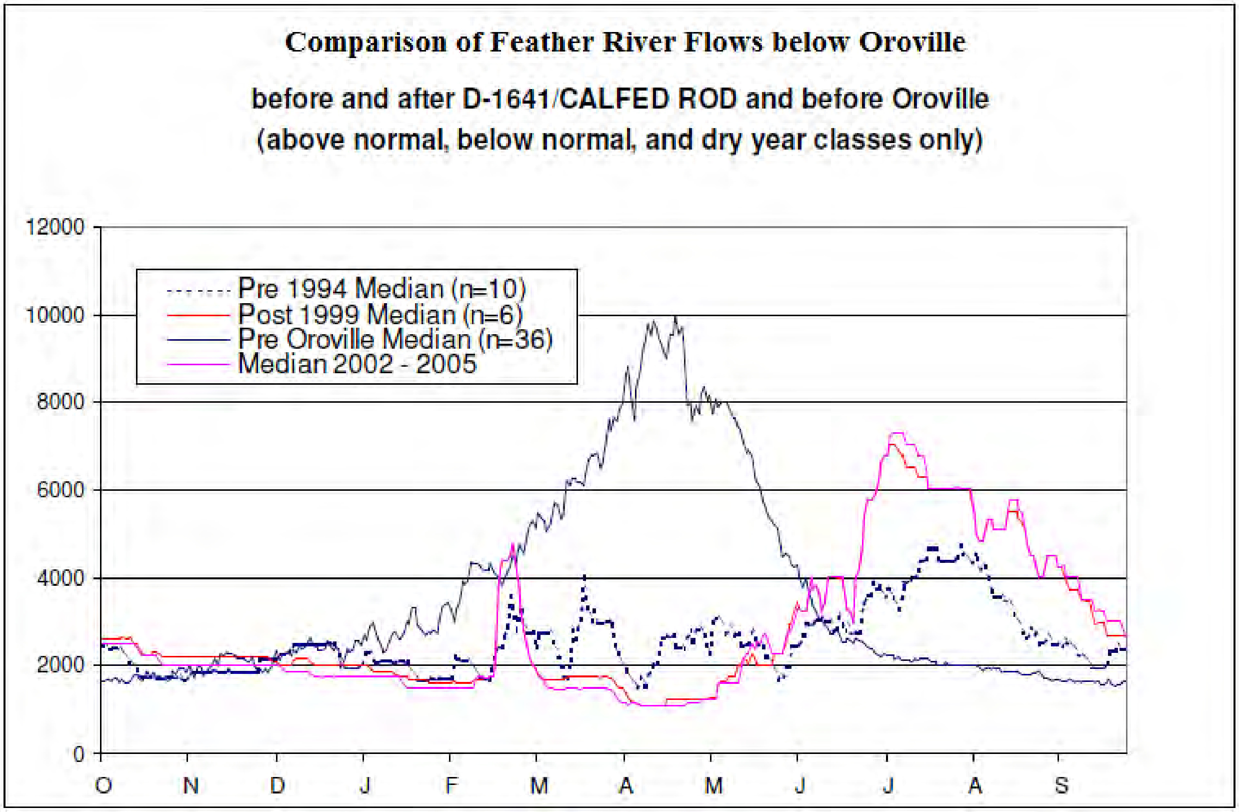

Figure 2-56. Comparison of Feather River Flows Downstream of Oroville Dam in the HFC. Source: (Cain and Monohan 2008).

The frequency and magnitude of channel forming flows has changed dramatically. Bankfull flow events are the flows that normally occur every 1 to 2 years (Rosgen and Silvey 1996). They are defined as the flows that begin to inundate floodplains (Dunne and Leopold 1978) and are responsible for the formation and maintenance of channel characteristics. They in turn form and maintain the habitats that are used by anadromous fish in the Feather River (Buer et al. 2004).

The pre-dam bankfull discharge (two-year flow event) for the Feather River at Oroville gage was about 65,000 cfs. The post-dam two-year recurrence interval event for the low flow reach is about 2,000 cfs, a much smaller event that is not capable of transporting significant quantities of bedload or eroding river banks. The 65,000- cfs flow now occurs at a lower frequency level of about every 10 years. The high flow reach now has a two-year discharge of 26,000 cfs, also significantly smaller than the pre-project event of 65,000 cfs.

Flood frequency calculations show that the pre- and post-project flood frequency curves have changed. The two-year recurrence interval decreased an order of magnitude, from 65,000 to 3,000. The 10-year recurrence event decreased from 160,000 to 75,000. The 50-year event decreased from 240,000 to 180,000 cfs (Buer et al. 2004).

The presence and operation of the Oroville Facilities has eliminated the contribution of bed material from the upper watershed. Regulated flows from Oroville Dam have dampened the magnitude and frequency of low and high flow events downstream (Buer et al. 2004). A reduction in overbank flooding, combined with the elimination of upstream bed material, halts natural sedimentation processes and contributes to channel degradation. These changes to the river hydrology and sedimentation patterns have, in turn, altered channel morphology, including habitat quantity and quality, as well as changes to the channel shape, stability, and capacity.

Currently, sediment from the upstream watershed is reduced by an estimated 97 percent downstream of Lake Oroville, resulting in sediment deprivation downstream. Only silt, clay, and a very small amount of sand—and no gravel or cobble-sized substrates—are currently discharged to the Feather River downstream of Oroville Dam. The resulting substrate in the Lower Feather River is armored by cobbles and boulders, mainly due to the lack of gravel recruitment to riffles since the 1960s when Oroville Dam was completed. Substrate evaluations using Wolman Pebble Counts show that spawning gravel in the LFC has become progressively larger and more armored over the past 16 years (Sommer et al. 2001a). The changes affect the amount of habitat available for adult spawning, which in turn affects reproductive success. Changes in the amount of habitat for fry and juvenile rearing may affect growth and survival.

CV spring-run Chinook salmon spawning is confined to the LFC, the majority (75 to 80 percent) of in-river CV spring-run Chinook salmon spawning occurring in the uppermost three miles of accessible habitat in the Feather River below the FRFH (Department of Water Resources 2001). The remainder of the in-river spawning occurs downstream to Robinson Riffle, and possibly the lowest part of the LFC near the Lower Eye Pool, just upstream from the Thermalito Afterbay Outlet.

Several conservation measures have been developed to address the ecological effects associated with blocking the river channel with Oroville Dam and other facilities. These measures were described in detail in section *1.3 Proposed Action* of this Opinion.

Another significant measure is the HEA, which was developed to specifically address the blockage and loss of historical habitat for CV spring-run Chinook salmon. This agreement was finalized in August 2007 with the specific goal of expanding habitat within the Sacramento River basin sufficient to accommodate an increase of approximately 2,000 to 3,000 spawning CV spring-run Chinook salmon (which is also expected to accommodate some amount of habitat for spawning CCV steelhead). Potential actions include, but are not limited to, dam removal, dam reoperation, flow and water temperature improvements, fish passage, and physical habitat improvements.

In November 2010, DWR and PG&E submitted a final HEP to NMFS. The final HEP was a proposal for habitat improvements in the Yuba River watershed. In NMFS' review of the new HEP, NMFS determined that it did not meet several of the NMFS Approval Criteria in the Amended HEA (2011). However, NMFS noted that its determination was subject to additional procedures described in the Amended HEA.

NMFS and DWR are continuing discussions about measures needed to implement the HEA. Although the exact actions and locations have not been finally determined, the long-term implementation of the HEA would increase the spatial distribution and abundance of CV spring-run Chinook salmon and reduce the risks to the ESU related to catastrophic events. NMFS reserves its authority under FPA Section 18 to prescribe the construction, operation, and maintenance of fishways for the Oroville Facilities and other hydroelectric projects in the Feather River basin during the terms of the licenses as provided in the HEA. If the HEP does not meet the requirements of the agreement and there is no agreement on an alternative habitat expansion plan that would meet the requirements of the HEA, the HEA would be terminated, and

NMFS is expected to prescribe fishways based on previous fishway prescriptions for hydroelectric projects in the Feather River basin.

As is described in section *1.3 Interrelated and Interdependent Actions* in this Opinion, the HEA is not part of FERC's proposed action for purposes of this Opinion, but is interrelated to the proposed action, and the effects of the action are analyzed as such for purposes of this Opinion to the extent that NMFS has available information on those effects. Any specific effects of the selected habitat expansion actions will be analyzed in applicable regulatory proceedings when the action is selected and specific effects can be determined.

Habitat suitability was evaluated for the LFC, extending from the Fish Barrier Dam to the Thermalito Afterbay Outlet, and in the HFC extending from the Thermalito Afterbay Outlet downstream to the confluence with Honcut Creek, near Live Oak.

Habitat suitability was determined based on observations at over 400 Chinook salmon redds, 200 "unoccupied" areas, and 75 CCV steelhead redds in the Feather River and related measurements of water velocity, water depth, and sediment type (Department of Water Resources 2004d). Flow/habitat availability curves, constructed from the results of the PHABSIM model simulations, are provided to show predicted instream flow and the corresponding habitat WUA for adult spawning and fry and juvenile rearing.

PHABSIM is a "fixed bed" model, and results will remain applicable only if the river channel maintains similar proportions of mesohabitat types. In addition, due to the generalized nature of the WUA index and the inherent limitations in the methodology associated with the PHABSIM model, exact changes in WUA were not able to be determined by investigators when small changes in modeled flows occurred (Department of Water Resources 2005b). Also the WUA is only a relative indicator of suitability, not actual physical area, and cannot be directly related to numbers of fish that may occupy the Feather River at the modeled flows. Further details on the advantages and limitations of the modeling effort are found in Oroville Relicensing Study Report SP-F16 (Department of Water Resources 2005b). However, WUA/RSI runs represent the best available information for reviewing flow related habitat availability.

Water temperature information is shown in Figure 2-57 through Figure 2-60. Water temperatures during the spawning period exceed 56°F near the FRFH in 10 percent of the years between mid-September and November and may reach 57°F during 5 percent of years. Spawning temperatures are warmer at Robinson Riffle, and appear to exceed 56°F in approximately 25 percent of years between mid-September and November, reaching as high as 58°F in 5 percent of years. The proposed criteria would establish a maximum mean temperature at the Robinson Riffle of 58°F in September, and 56°F from October 1 through April.

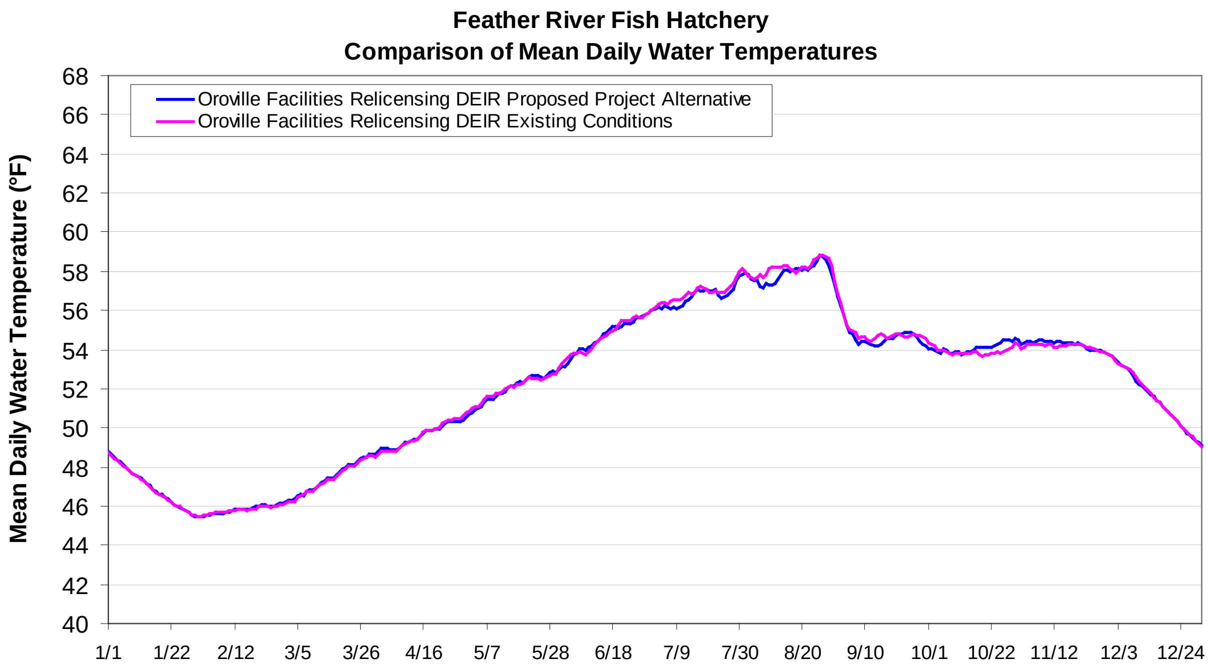

Figure 2-57. Comparison of Simulated Mean Daily Seasonal Water Temperature at the FRFH, 1922-1994

Figure 2-58 shows simulated seasonal water temperature exceedances at the FRFH for the DEIR existing conditions (1922-1994). This is used in the analysis as the initial new license conditions (approximately 10 years).

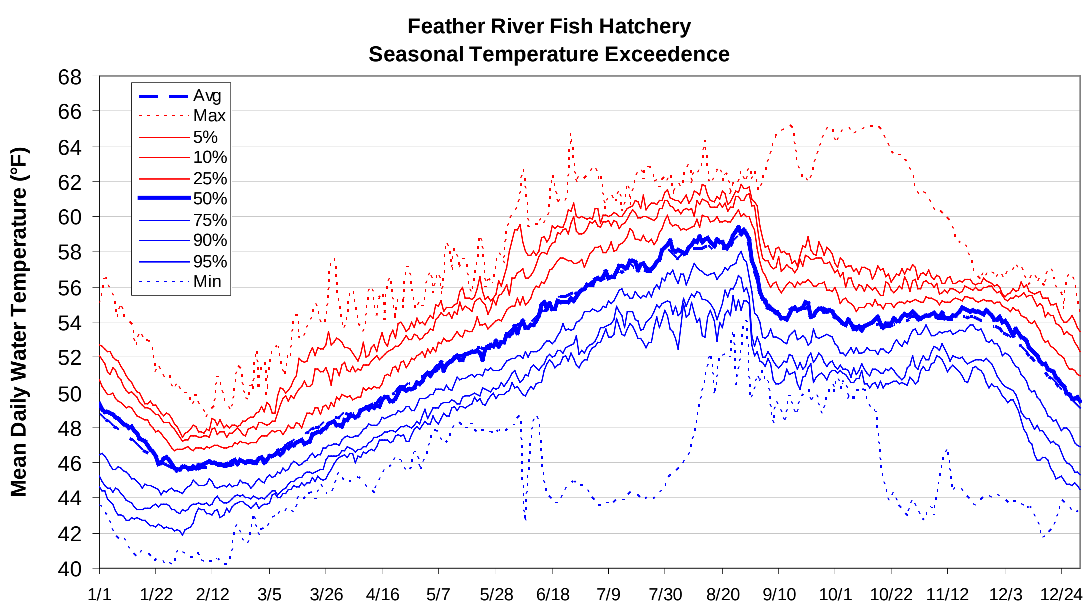

Figure 2-58. Simulated Seasonal Water Temperature Exceedances at the FRFH for the DEIR Existing Conditions, 1922-1994

Figure 2-59 shows simulated season water temperature exceedances at the FRFH for the DEIR existing conditions (1922-1994). This is used in the analysis as the initial new license conditions (approximately 10 years).

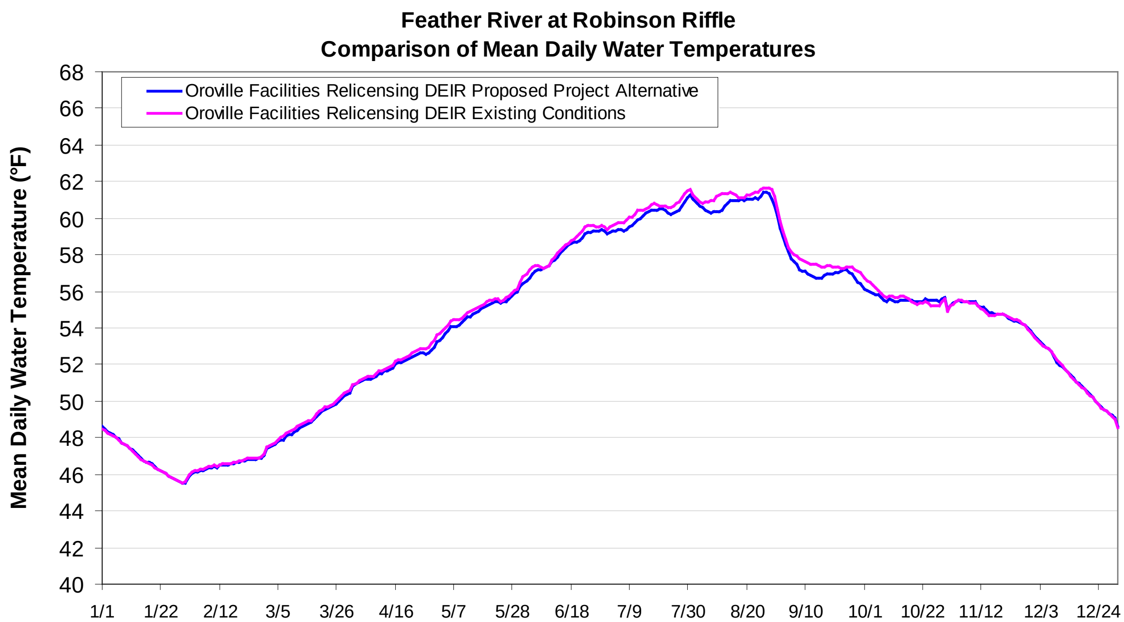

Figure 2-59. Comparison of Simulated Mean Daily Seasonal Water Temperature at Robinson Riffle, 1922-1994

Figure 2-60 shows simulated seasonal water temperature exceedances at Robinson Riffle for the DEIR existing conditions (1922-1994). This is used in the analysis as the initial new license conditions (approximately 10 years).

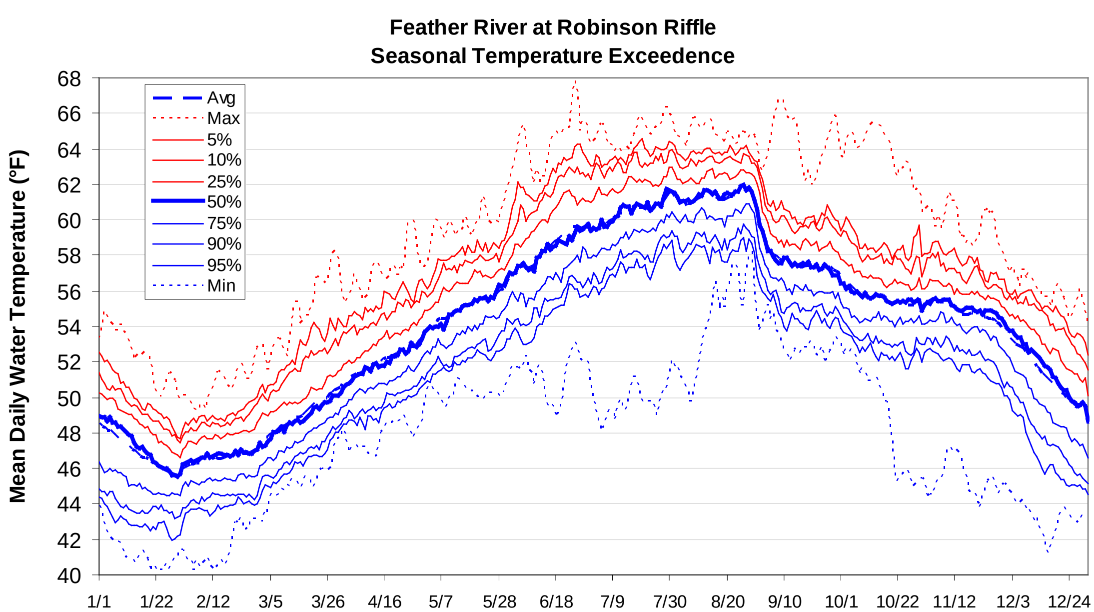

Figure 2-60. Simulated Seasonal Water Temperature Exceedances at Robinson Riffle for the DEIR Existing Conditions, 1922-1994

Due to CV spring-run Chinook being forced to spawn in the same area as fall-run Chinook, the two groups of Chinook end up interbreeding. This has resulted in a loss of the distinct genetics of the historic CV spring-run Chinook in the Feather River. Hybridization with fall-run Chinook salmon is threatening the genetic diversity of spring-run Chinook salmon in the Feather River through genetic homogenization. Lindley and others (2004) reported that Feather River spring-run Chinook salmon were most similar to fall-run Chinook salmon, and concluded that while the phenotype for early entrance into freshwater still persists in the Feather River, the mixing of gametes of these fish with fall run fish has led to homogenization of these runs

In addition to genetic intermixing with fall-run Chinook salmon, there is genetic intermixing between the hatchery and wild CV spring-run Chinook salmon. The CV spring-run Chinook that enter the hatchery are tagged and returned to the LFC, where they hold with the wild CV spring-run Chinook salmon. Because not all of the tagged hatchery CV spring-run Chinook salmon return to the hatchery, it is likely that some stay in the LFC and spawn with the wild CV spring-run Chinook salmon.

2.4.5.3.6 CV Spring-run Chinook Salmon Spawning Response

As with migration and holding, CV spring-run Chinook salmon are not able to access their historic spawning and are limited to the spawning habitat downstream of the Fish Barrier Dam. The CV spring-run Chinook salmon, spawning takes place in the LFC, and occurs primarily during September and October, with eggs incubating into December or January (Department of Water Resources 2007). The loss of access to historic habitat has reduced the amount of spawning habitat available to CV spring-run Chinook salmon. The proposed action does not include fish passage, and NMFS reserved its authority to prescribe fish passage measures. NMFS's reservation of prescription of fish passage measures is based on implementation of the interrelated HEA. The HEA calls for new spawning habitat for CV spring-run Chinook salmon. Absent implementation of the HEA, it is expected that NMFS will assert prescription of measures for fish passage upstream and downstream of the Fish Barrier Dam and Oroville Dam.

The LFC is a low-gradient channel, with no water falls or constructed passage impediments. Extensive evaluations of critical riffles have not revealed any passage limitations at riffles; therefore, the proposed flows are expected to provide adequate depths and velocities for upstream migration. Flow/habitat availability curves (Figure 2-68) show instream flow and the corresponding spawning habitat WUA for Chinook salmon. Evaluation of the WUA for the adult spawning life stage of Chinook salmon indicates that the maximum amount of spawning area in the LFC, given the current channel configuration, would occur at flows between 800 and 825 cfs. Therefore, given the geometry of the channel, the proposed river flow during the spawning period maximizes habitat availability.

Figure 2-61 shows weighted usable area for Chinook salmon and CCV steelhead spawning in the LFC (DWR 2004F).

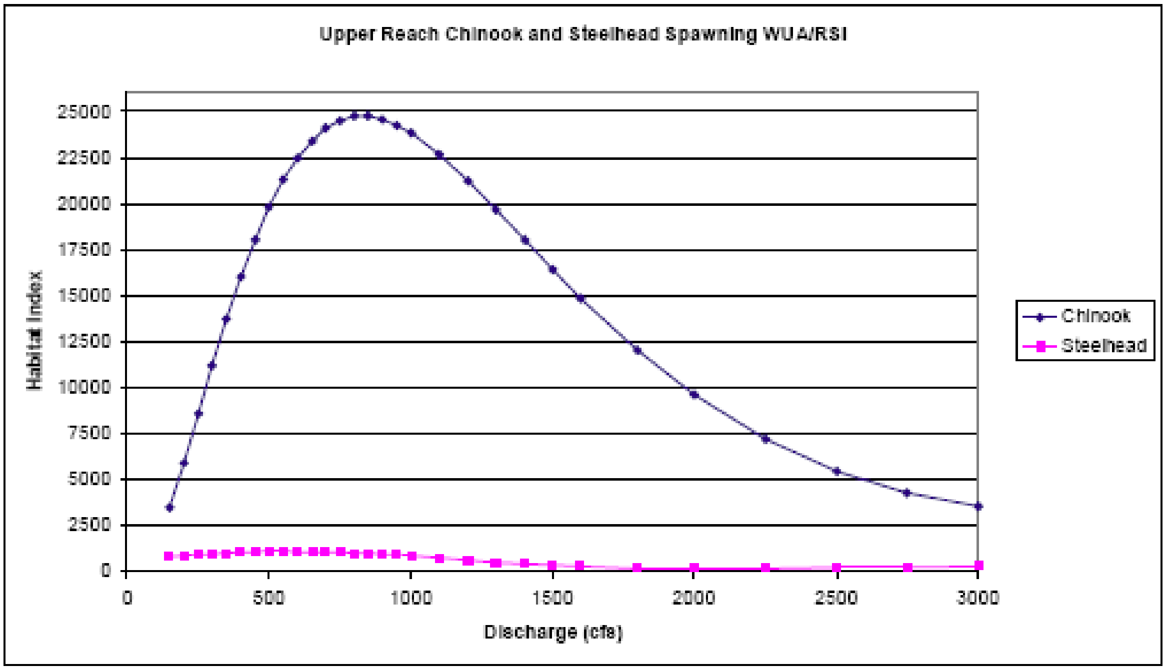

Figure 2-61. Weighted Usable Area for Chinook Salmon and CCV Steelhead Spawning in the LFC

The coarsening of the river bed has reduced the quality and quantity of gravel in the LFC. Sommer et al. (2001b) also showed that coarsening of spawning gravels and large number of fall-run Chinook salmon in the LFC has increased competition for spawning habitat, increased redd superimposition, and reduced spawning success and egg survival.

The most significant stressors affecting spring-run population abundance and diversity in the Lower Feather River are primarily related to the loss of spawning gravel in the LFC, the co-occurrence with fall-run Chinook during the spawning season, and the impaired hydrograph. These stressors are affecting behavior, growth, and survival of individuals and the abundance and life history and genetic diversity of the population. Loss of flow related migration cues in the Lower Feather River is another stressor that could be affecting abundance and life history diversity.

Most significantly, hybridization with fall-run Chinook salmon is threatening the genetic diversity of spring-run Chinook salmon in the Feather River through genetic homogenization. Lindley and others (2004) reported that Feather River spring-run Chinook salmon were most similar to fall-run Chinook salmon (Figure 2-62), and concluded that while the phenotype for early entrance into freshwater still persists in the Feather River, the mixing of gametes of these fish with fall run fish has led to homogenization of these runs. However, Hedgecock (2002) found small but statistically significant allele frequency differences between Feather River spring-run Chinook salmon and fall-run Chinook salmon, and suggested there has been a minimal exchange between these groups in recent years. This is somewhat surprising considering the extent of hybridization that has occurred over the past 40 years, and suggests that through segregation, this genotype can be preserved. Lindley *et al.,* (2004) reports that:

> *The genetic results from Hedgecock (2002), the existence of springtime freshwater entry, and the possible segregational natural spawning of spring-run fish in the Feather River system suggest that rescue of a spring run in the Feather may be possible, even though there has been extensive introgression of the fall run gene pool into that of the spring run. Further, the capacity of salmonid fishes to rapidly establish different run timings may make reestablishing discrete temporal runs possible if separate spawning habitats can be made available. It is doubtful that this phenotype will persist without immediate and direct intervention to preserve the genetic basis of spring run timing.*

Spring-run Chinook salmon captured in the river formed a homogeneous group with spring-run Chinook salmon captured in the hatchery, which suggests that the naturally spawning population is not independent from the federally listed hatchery spawners.

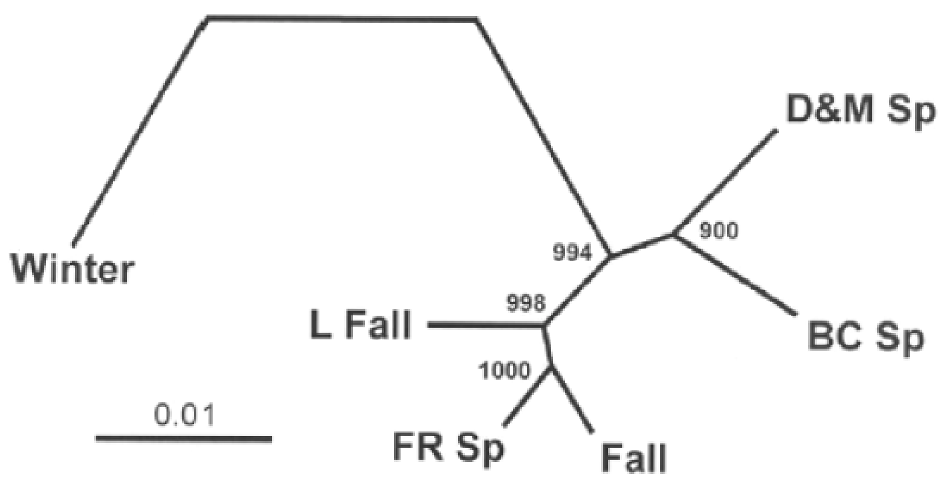

Figure 2-62. Genetic distance among Central Valley Chinook runs. L Fall = late fall, D&M Sp =Deer and Mill Creek springs, BC Sp = Butte Creek springs, FR Sp = Feather River Springs., from Hedgecock (2002)

These stressors are expected to adversely affect the population until the measures of the Lower Feather River Habitat Improvement Program are implemented. The program is designed to address these specific stressors on the spring-run Chinook salmon population and will include numerous actions that will improve the population's response to the proposed future operation of the Oroville Facilities. Incremental implementation of the actions tied to the program will result in improved conditions that will increase the production, abundance, and life history and genetic diversity of the Feather River spring-run Chinook salmon population. By year 5, gravel augmentation will have recharged approximately 15 significant spawning locations and will increase the quality and quantity of spawning habitat. This increased space for spawning and improved gravel size should increase production and abundance of the population by increasing the carrying capacity of spawning habitat.

By year 12 of the license, the fish segregation weir will separate the fall-and spring-run Chinook salmon spawners thereby increasing egg survival and fry abundance. The weir also will reduce the level of interbreeding between spring- and fall-run Chinook salmon which will stabilize and begin to improve the genotype of Feather River spring-run Chinook salmon. This will improve the viability of the Feather River population by increasing abundance and improving genetic diversity. This will also improve the spatial structure of the population by creating conditions where they are geographically isolated from fall-run Chinook salmon.

The temperature targets and criteria that have been established for the new license are designed to meet life history requirements of migrating, holding, spawning, and rearing Chinook salmon in the LFC. The temperature model simulations demonstrate that in most years, index values that optimize life stage fitness will be met. However, temperature-related stressors may adversely affect individuals during certain conditions that are expected to correlate with dry and critically dry years.

Based on the information provided by DWR, simulated average monthly water temperatures during the adult CV spring-run Chinook salmon migration period are generally below the index values of 64°F that could stop migration, and never reach 68°F, which can cause both sublethal and lethal effects. The sublethal affects from elevated water temperatures can result in no loss of adults, but can result in loss of egg viability. The exception to the temperature values is during dry and critically dry years, or from 5 to 10 percent of years, where temperatures may exceed 64°F in July and August at the downstream end of the LFC at Robinson Riffle.

Until the segregation weir is operational, effects the proposed action that will continue include:

- Interbreeding between fall-run Chinook salmon and CV spring-run Chinook salmon, and
- Superimposition of fall-run Chinook salmon redds on top of CV spring-run Chinook salmon redds.

The segregation weir is not likely to address interbreeding between wild and hatchery CV spring-run Chinook salmon. It is likely that interbreeding of the wild and hatchery CV spring-run Chinook salmon in LFC is reducing the fitness and survival of the offspring of the wild CV spring-run Chinook salmon. This is an effect that carries through from the eggs, to the fry, juveniles, smolts, immature fish, and adults, and can affect survival at all of these life stages. This effect will persist until modified hatchery practices can address the domestication of wild CV spring-run Chinook salmon.

2.4.5.3.7 CV Spring-run Chinook Salmon Embryo Incubation Stressors and Exposure

Instream flows in the LFC generally will be a constant 800 cfs during egg incubation. Flows during the egg incubation period may be periodically increased above 800 cfs during December and January during high water events. These high flows occur in approximately 3 percent of years in December and 10 percent of years in January. Flows that exceed 10,000 cfs may mobilize gravels up to 1 inch in diameter, while larger materials such as cobbles are mobilized at 25,000 cfs. When the substrate is mobilized, the eggs in redds are dislodged and this is fatal. Exposure of the salmonid eggs to turbulence, or light, can kill them. Additionally, exposure of the eggs makes them easy for predators to eat.

The frequency and magnitude of channel forming flows has changed habitat dramatically and had effects to habitat availability. Bankfull flow events are the flows that normally occur every 1 to 2 years (Rosgen and Silvey 1996). They are defined as the flows that begin to inundate floodplains (Dunne and Leopold 1978), and are responsible for the formation and maintenance of channel characteristics, and in turn form and maintain the habitats that are used by anadromous fish in the Feather River (Buer *et al.*, 2004). The pre-dam bankfull discharge (2-year flow event) for the Feather River at Oroville gage was about 65,000 cfs. The post-dam 2-year recurrence interval event for the low flow reach is about 2,000 cfs, a much smaller event that is not capable of transporting significant quantities of bedload or eroding river banks. The 65,000-cfs flow now occurs at a lower frequency level of about every 10 years. The high flow reach now has a 2 year discharge of 26,000 cfs, also significantly smaller than the pre-project event of 65,000 cfs. Flood frequency calculations show that the pre- and post-project flood frequency curves have changed. The 2-year recurrence interval decreased an order of magnitude, from 65,000 to 3,000. The 10-year recurrence event decreased from 160,000 to 75,000. The 50-year event decreased from 240,000 to 180,000 cfs (Buer *et al.*, 2004).

Water temperatures for egg incubation in the LFC are generally favorable for CV spring-run Chinook salmon, but reach levels that increase egg abnormalities and mortality near the Feather River Hatchery in up to 10 percent of years, and at Robinson Riffle during about 25 percent of the years. However, the effect is expected to be small, because 99 percent of the spawning occurs within the upper mile of the LFC, near the FRFH.

2.4.5.3.8 CV Spring-run Chinook Salmon Embryo Incubation Response

Short duration, high flow events can scour salmon redds and result in the injury and mortality of incubating eggs. Redd dewatering can occur when river flows are reduced during or after the spawning period and also will result in injury and mortality of incubating eggs. While DWR does not provide specific data on redd scouring, we expect that based on bed mobilization rates, flows between 5,000 and 25,000 cfs, or in about 10 percent of years, are capable of mobilizing and scouring spawning gravel. Scouring would be deepest and affect the most eggs at the high end of the flow curve. Redd exposure to these flows will cause scour and result in reduced egg survival and fry abundance.

The coarsening of the river bed has reduced the quality and quantity of gravel in the LFC. Sommer et al. (2001b) also showed that coarsening of spawning gravels and large number of fall-run Chinook salmon in the LFC has increased competition for spawning habitat, increased redd superimposition, and reduced spawning success and egg survival. Gravel augmentation projects will incrementally increase the quantity and quality of spawning habitat for CV spring-run Chinook salmon over a 5-year period, and then will be maintained over the 50-year period of the license. This is expected to reduce redd superimposition and improve spawning success and egg survival. After 12 years, the installation of a segregation weir will separate fall- and CV spring-run Chinook salmon spawning. This action will reduce competition for spawning habitat, reduce redd superimposition, and further increase egg survival and spawning success, which ultimately will increase juvenile population abundance from year 12 through year 50 of the license. Over the next 12 years, however, or until such time that the populations are separated, we expect the adverse effects related to superimposition will continue to reduce juvenile abundance.

Water temperatures for egg incubation in the LFC are generally favorable for CV spring-run Chinook salmon, but reach levels that increase egg abnormalities and mortality near the Feather River Hatchery in up to 10 percent of years, and at Robinson Riffle during about 25 percent of the years. These egg abnormalities and mortalities can reduce the abundance of the fry population. Because this environmental stressor is only expected in dry years and a majority of the spawning population reproduces upstream in the area close to the Feather River Hatchery, the effect is expected to be small, because 99 percent of the spawning occurs within the upper mile of the LFC, near the FRFH.

The proposed action includes *A108, Instream Flow and Water Temperature Requirements for Anadromous Fish*, which requires completing a reconnaissance study of potential facilities modifications to address water temperature/habitat needs for anadromous fish in the LFC and HFC.

Following this reconnaissance study, a feasibility study and implementation plan is to be completed within three years of license issuance. It is anticipated that facilities modifications—combined with the proposed immediate increases in minimum instream flow and decreased maximum water temperature targets—will provide greater stability and flexibility for water temperature management in the Feather River, which will improve the ability to meet water temperature criteria in the LFC and HFC. While the measures will improve the ability to meet temperature requirements more frequently, when the effects of climate change (more frequent dry years) over the next 50 years are included, we expect that the frequency of dry water year conditions will increase, resulting in conference years more frequently. This will likely result in increased water temperatures during the early part of spawning and incubation in some conference years.

Proposed temperature criteria will be an improvement over the past temperature conditions. The proposed segregation weir will also likely restrict spring-run Chinook salmon to cooler sections of the river. The water temperature criteria for the Feather River covered by the proposed action are not expected to change during the term of the license, except that initial temperature targets are expected to become requirements after completion of facilities modifications. Because CV spring-run Chinook salmon spawn and their eggs incubate in the upper part of the LFC, we do not expect negative effects on incubation due to water temperatures.

2.4.5.3.9 CV Spring-run Chinook Salmon Juvenile Rearing Stressors and Exposure

Blockage of the river channel has changed the flow regime, sediment mobility, and geomorphic characteristic of the Feather River below Oroville Dam (Brown 2001, Buer et al. 2004), affecting instream and floodplain habitat availability. The current flow regime in the Feather River downstream of Oroville dam is different from pre-dam conditions, particularly in the LFC reach (Figure 2-63).

The primary function of the dam is to store winter and spring runoff for release into the Feather River as necessary for project purposes. This results in an altered hydrologic regime that includes changes to the yearly, monthly, and daily stream flow distributions; bankfull discharge, flow exceedance, peak flow, and other hydraulic characteristics (Buer 2004). The most significant effect may be that minimum instream flows in the LFC and the HFC are substantially reduced when compared to pre-dam average monthly flow conditions (Figure 2-63). The current flow patterns in the Feather River downstream from Oroville dam are different than pre-dam conditions, particularly in the LFC reach. The proposed action results in the continuation of an impaired hydrograph in the LFC and HFC.

LFC flows measured at the Oroville gage (USGS 11407000, located immediately upstream of the Fish Barrier Dam) show a reduction in flows from pre- to post-dam (Buer et al. 2004). The hydrology of the river has been considerably altered by the operation of the Oroville complex.

One of the major changes is that flow that historically passed through the LFC is now diverted into the Thermalito Complex. Mean monthly flows through the LFC are now 5 to 38 percent of pre-dam levels. Mean total flow is presently lower than historical levels during February through June, but higher during July through January. Mean total flow in the HFC is presently lower than historical levels during April and May, but higher from June through March. Average monthly flows in the HFC are now at least 23 percent lower in April and 33 percent lower in May than pre-dam flows.

Figure 2-63 depicts the average monthly flows in the Feather River pre-dam (1902-1967) and post-Oroville Dam (1968-1993), taken from Sommer et al. (2001b).

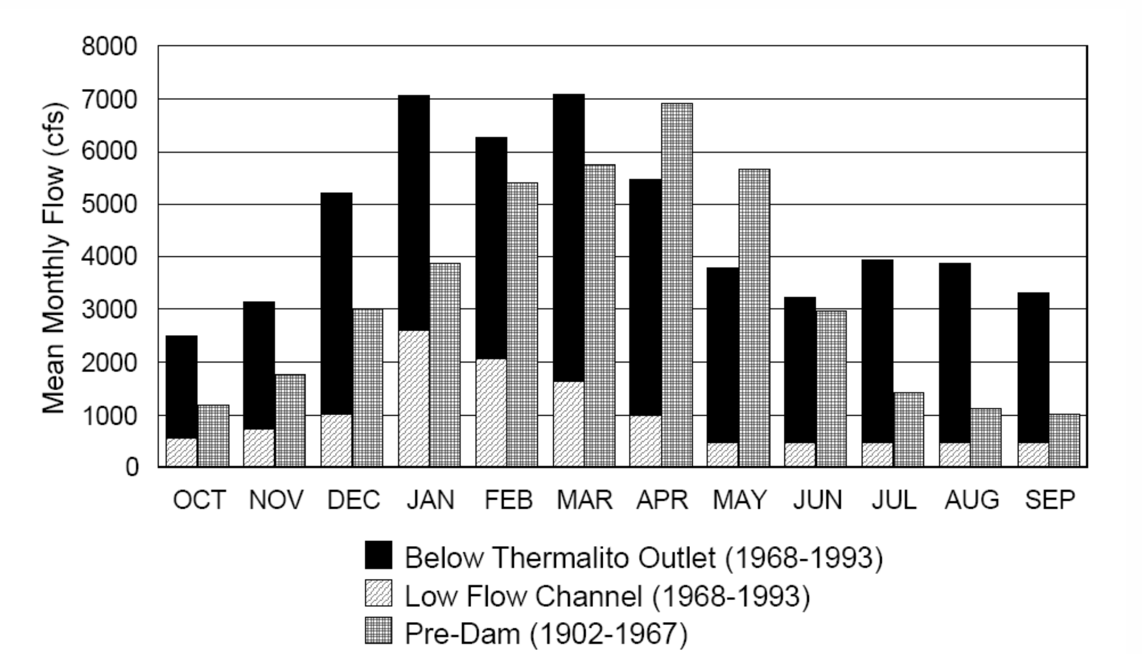

Figure 2-63. Average Monthly Flows, Feather River Pre- (1902-1967) and Post Oroville Dam (1968-1993)

The frequency and magnitude of channel forming flows has changed dramatically. Bankfull flow events are the flows that normally occur every 1 to 2 years (Rosgen and Silvey 1996). They are defined as the flows that begin to inundate floodplains (Dunne and Leopold 1978) and are responsible for the formation and maintenance of channel characteristics. They in turn form and maintain the habitats that are used by anadromous fish in the Feather River (Buer et al. 2004).

The pre-dam bankfull discharge (two-year flow event) for the Feather River at Oroville gage was about 65,000 cfs. The post-dam two-year recurrence interval event for the low flow reach is about 2,000 cfs, a much smaller event that is not capable of transporting significant quantities of bedload or eroding river banks. The 65,000- cfs flow now occurs at a lower frequency level of about every 10 years. The high flow reach now has a two-year discharge of 26,000 cfs, also significantly smaller than the pre-project event of 65,000 cfs.

Flood frequency calculations show that the pre- and post-project flood frequency curves have changed. The two-year recurrence interval decreased an order of magnitude, from 65,000 to

3,000. The 10-year recurrence event decreased from 160,000 to 75,000. The 50-year event decreased from 240,000 to 180,000 cfs (Buer et al. 2004).

The presence and operation of the Oroville Facilities has eliminated the contribution of bed material from the upper watershed. Regulated flows from Oroville Dam have dampened the magnitude and frequency of low and high flow events downstream (Buer et al. 2004). A reduction in overbank flooding, combined with the elimination of upstream bed material, halts natural sedimentation processes and contributes to channel degradation. These changes to the river hydrology and sedimentation patterns have, in turn, altered channel morphology, including habitat quantity and quality, as well as changes to the channel shape, stability, and capacity.

Currently, sediment from the upstream watershed is reduced by an estimated 97 percent downstream of Lake Oroville, resulting in sediment deprivation downstream. Only silt, clay, and a very small amount of sand—and no gravel or cobble-sized substrates—are currently discharged to the Feather River downstream of Oroville Dam. The resulting substrate in the Lower Feather River is armored by cobbles and boulders, mainly due to the lack of gravel recruitment to riffles since the 1960s when Oroville Dam was completed. Wolman Pebble Counts show that spawning gravel in the LFC has become progressively larger and more armored over the past 16 years (Sommer et al. 2001a). The changes affect the amount of habitat available for adult spawning, which in turn affects reproductive success. Changes in the amount of habitat for fry and juvenile rearing may affect growth and survival.

Several conservation measures have been developed to address the ecological effects associated with blocking the river channel with Oroville Dam and other facilities. These measures were described in detail in section *1.3 Proposed Action* of this Opinion. These measures include the Lower Feather River Habitat Improvement Plan, Gravel Supplementation and Improvement Program, Channel Improvement Program, Structural Habitat Supplementation and Improvement Program, and the Riparian and Floodplain Improvement Program. These measures are expected to improve the CV spring-run Chinook salmon rearing habitat and reduce the negative effects of exposure to the present conditions.

Another significant alteration is that flow that historically passed through the LFC is now diverted into the Thermalito complex. Average monthly flows through the LFC are now 5 to 38 percent of pre-dam levels. Mean total flow in the LFC is presently lower than historical levels during February through June, but higher during July through January (Sommer et al. 2001b). Figure 2-64 shows that median monthly flows are significantly modified, with major changes in the average monthly flows in winter and spring months.

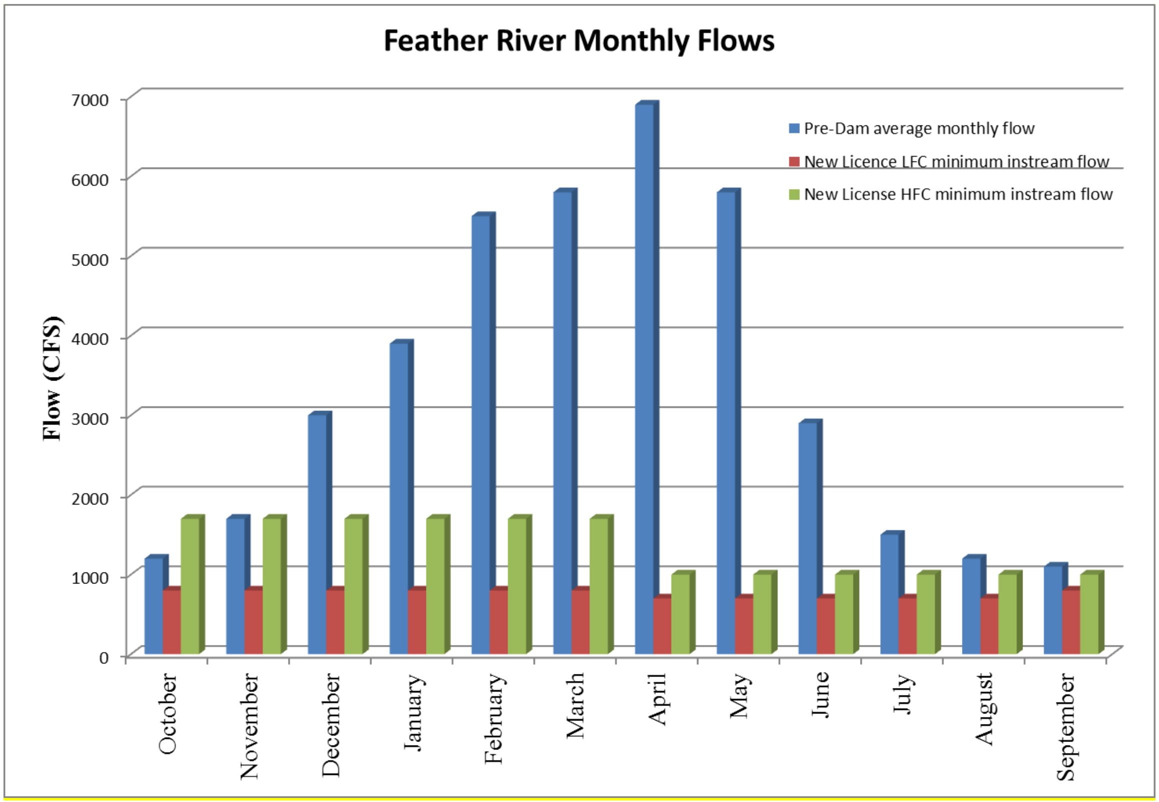

Figure 2-64. Comparison of Pre-dam Feather River flows to proposed minimum instream flows in the LFC and the HFC illustrating that there has been a seasonal shift of peak flow events from late winter and spring months

Figure 2-65 shows modeled average monthly flows proposed for the Feather River LFC. OCAP 7.0 represents current operations, 7.1 represents near future operations, and 8.0 represents future operations (U.S. Bureau of Reclamation 2008c).

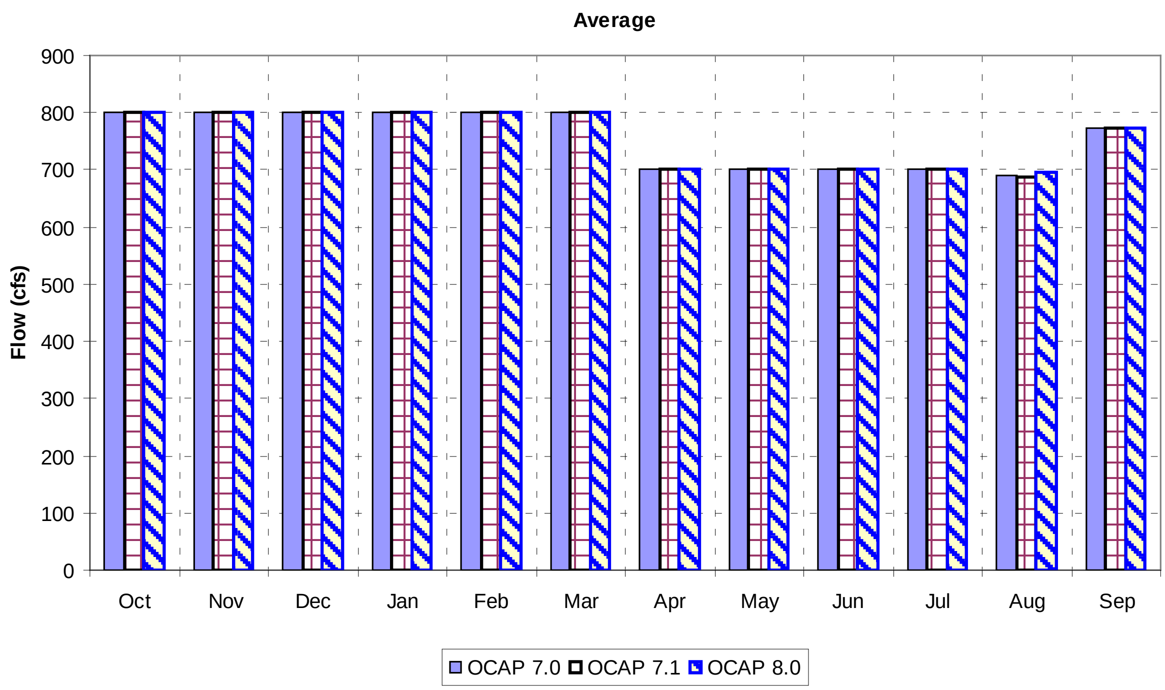

Figure 2-65. Modeled Average Monthly Flows Proposed for the Feather River LFC

In the HFC, minimum instream flows (measured at the Thermalito Afterbay Outlet to the Feather River) are 1,000 to 1,700 cfs (October through March) and 1,000 cfs (April through September), although they can be much higher depending on water year type and other operational considerations. Figure 2-65 and Figure 2-75 illustrate average monthly flow conditions during normal and dry water years. Projected average monthly flows in the HFC during CV spring-run Chinook and CCV steelhead migration ranges from 1,500 cfs during dry years to 12,300 cfs during wet years (National Marine Fisheries Service 2011b).

Figure 2-66 shows modeled average monthly flows in Feather River HFC for all water years combined.

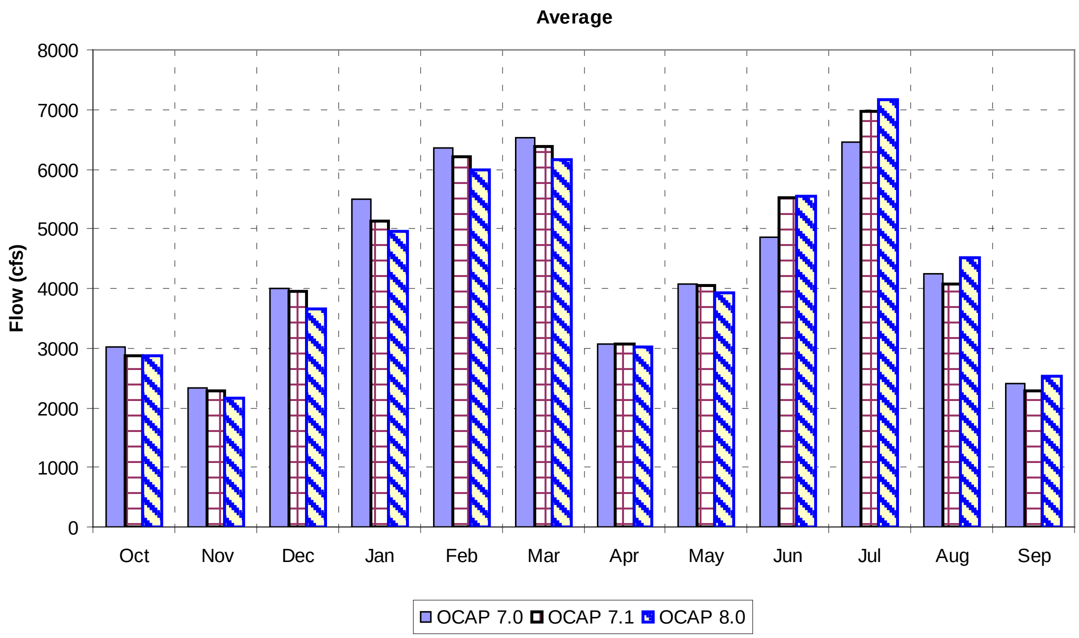

Figure 2-66. Modeled Average Monthly Flows, Feather River HFC, All Water Years Combined

Figure 2-67 shows modeled average monthly flows in Feather River HFC during 1976-1977, a critically dry water year.

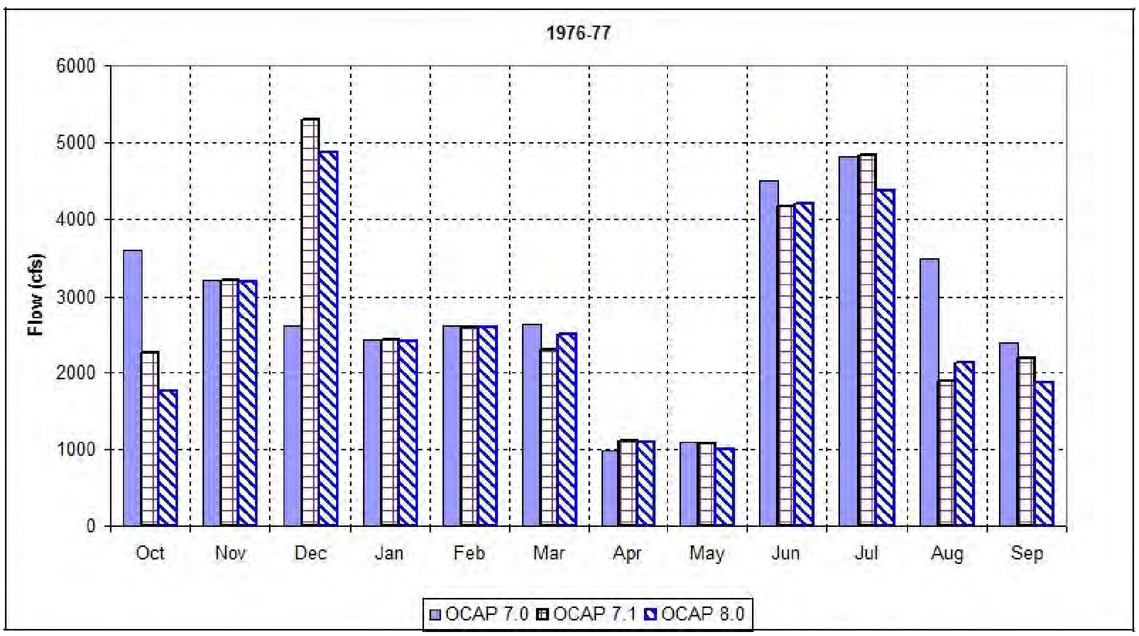

Figure 2-67. Modeled Average Monthly Flows in Feather River HFC, 1976-1977

Flow-related habitat suitability was evaluated at a variety of flow conditions using a weighted useable area (WUA) index (also known as the relative suitability index [RSI]) generated by the Physical Habitat Simulation (PHABSIM) model (Payne 2003).

Past flow fluctuations for flood control or dam safety inspections have resulted in fry and juvenile Chinook salmon being stranded in side channels of the LFC. From 1980 to 2009, such conditions occurred 16 times in the January through June rearing season. The significance of these stranding losses is unknown because many of the dead fish are lost to predation or under rocks and are not visible. Also, it is difficult to truly distinguish the difference between fall-run and CV spring-run Chinook salmon due to the extensive overlap in spawning timing and distribution and because many fish follow receding flows and avoid being trapped. Stranding is mostly a concern where inundated areas have been impacted through gravel extraction or other activities that degrade and isolate floodplains. Numerous studies have shown that inundation of natural floodplains is more beneficial than harmful. Sommer et al. (2001b)_ENREF_283 described that grading of the Yolo Bypass and relatively gradual water stage reductions likely helps promote successful emigration of young salmon. Although some individuals will be killed from stranding, it is likely that more individuals actually benefit from these events. Jeffres et al. (2008)_ENREF_142 demonstrated increased growth of juvenile Chinook salmon on floodplains and off-channel rearing habitats in the Cosumnes River, and Sommer et al. (2001b)_ENREF_283 also showed higher growth rates in fish using the flooded Yolo Bypass versus the Sacramento River.

2.4.5.3.10 CV Spring-run Chinook Salmon Juvenile Rearing Responses

Results of juvenile salmonid instream flow studies on the Lower Feather River provide some insight on the effect of forecasted flows on Chinook salmon fry and juvenile rearing (Payne and Allen 2005). Chinook salmon fry (*i.e.,* <50mm) WUA/RSI increases from 400 to 3,000 cfs. For Chinook salmon juveniles (*i.e.,* >50mm) WUA/RSI values vary depending upon how cover affects habitat suitability, but generally increases with more flow between 500 and 3,000 cfs. With cover included the WUA/RSI values are maximized at 100 cfs, and drop from 100 to 500 cfs. The proposed action includes minimum flows of 800 cfs during CV spring-run Chinook salmon fry rearing. This flow represents about 75 percent of the maximum modeled (Payne and Allen 2005) WUA/RSI value. For juvenile Chinook salmon, in the LFC with no cover, the amount of habitat increases from 100 to 3,000 cfs. With cover the maximum WUA/RSI is at the lowest flow, 100 cfs, and decreases as flows increase up to 1,500 cfs. The minimum flows of 700 and 800 cfs represent approximately 67 percent of the maximum WUA/RSI value with cover, and approximately 63 percent of the maximum WUA/RSI value for no cover.

Results of juvenile salmonid instream flow studies in the HFC are shown below in Figure 2-68 and Figure 2-69 and demonstrate the effect of flows on Chinook salmon fry and juvenile rearing habitat availability for both the low-value no cover and the zero-value no cover suitability options (Payne and Allen 2005).

In the HFC, Chinook salmon fry (*i.e.,* <50mm) WUA/RSI climbs steadily from 500 to 7,000 cfs. For Chinook salmon juveniles (*i.e.,* >50mm) WUA/RSI values vary depending upon how cover affects habitat suitability. With no cover the WUA/RSI for juvenile Chinook increases from 500 cfs to 7,000 cfs. With some cover, the maximum WUA/RSI value is at the lowest flow modeled (500 cfs) and decreases as flow increase to about 3,000 cfs. For the minimum flows of 1,000 to 1,700 cfs in the HFC the WUA/SRI for Chinook salmon fry will range from approximately 40 percent to 70 percent of the maximum WUA/SRI value modeled. For the minimum flows in the HFC the WUA/SRI for Chinook salmon juveniles will range from approximately 30 percent to

70 percent of the maximum WUA/SRI value modeled. These values have wide ranges depending on whether cover is available and the range of the minimum flows.

The modeling of the WUA/RSI identifies that cover is an important aspect of habitat. The modeling also shows greater WUA/RSI values for juvenile Chinook salmon compared to Chinook salmon fry. This reflects the better swimming ability of juvenile Chinook salmon. Because spawning of CV spring-run Chinook salmon will occur in the upper areas of the LFC, it is expect that most of the fry rearing will occur in the LFC. Juvenile CV spring-run Chinook salmon are also expected to do much of their rearing in the LFC, and as they grow they will move into the HFC to migrate downstream. While the proposed action minimum flows do not provide the maximum WUA/RSI values for CV spring-run Chinook salmon fry and juveniles, the minimum flows do provide a good amount of habitat. The minimum flows also represent balancing for other species

Figure 2-68 shows weighted usable area curves for Chinook salmon fry in the HFC of the project area (Payne and Allen 2005).

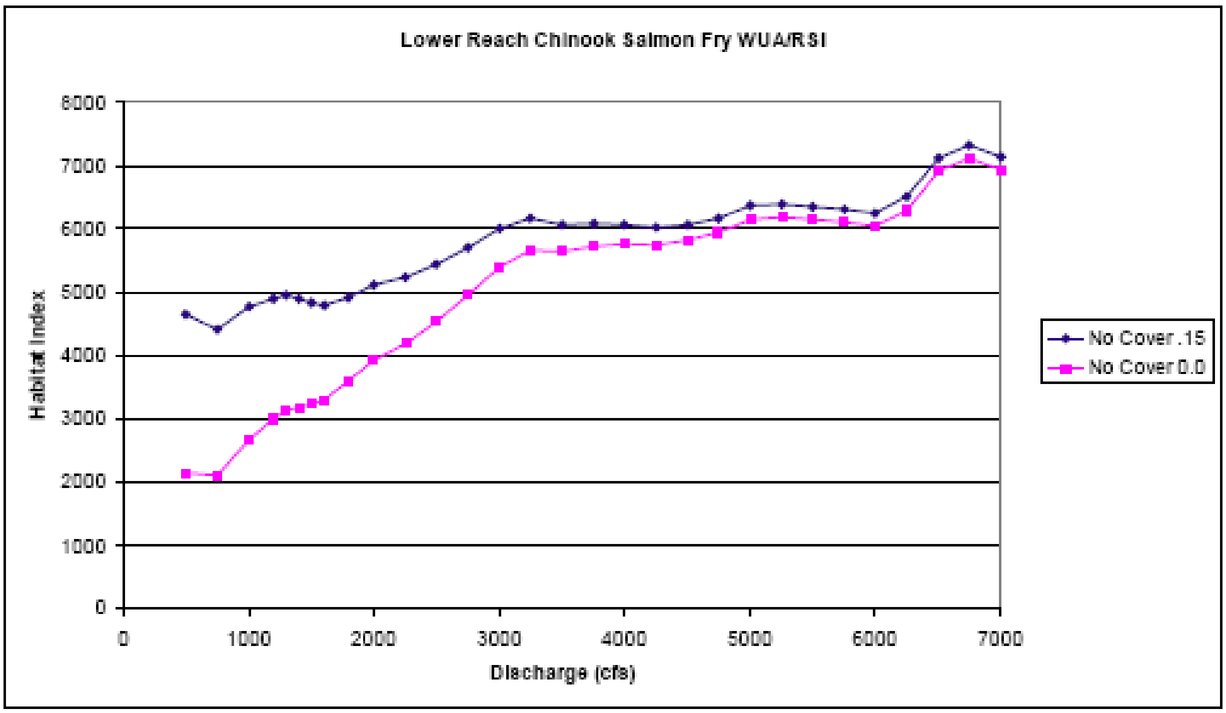

Figure 2-68. Weighted Usable Area Curves for Chinook Salmon Fry in the HFC of the Project Area

Figure 2-69 shows weighted usable area curves for Chinook salmon juveniles in the HFC of the project area.

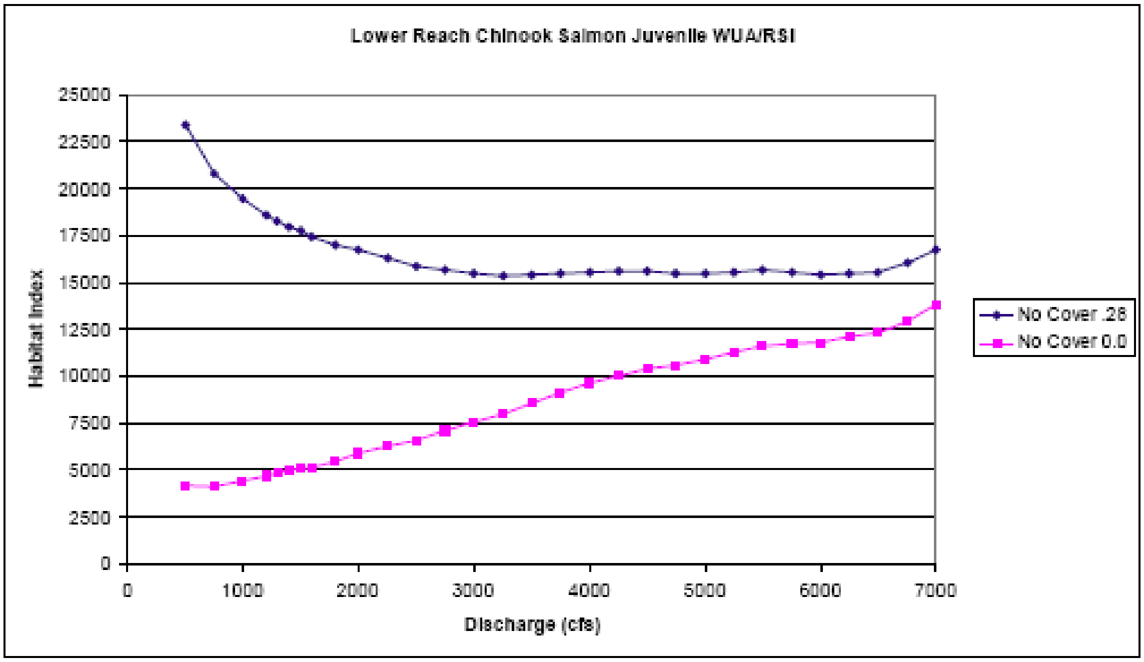

Figure 2-69. Weighted Usable Area Curves for Chinook Salmon Juveniles in the HFC of the Project Area

Flood control operations above 5,000 cfs may result in rapid and large flow fluctuations within the Lower Feather River. Flow may exceed 25,000 cfs in December and January under the three to five percent exceedance forecast. Depending on the magnitude or duration of these flow fluctuations, there is a potential for fry and juvenile Chinook salmon to become stranded. The proposed ramping rate is designed to minimize impacts to CV spring-run Chinook salmon juveniles from stranding in the LFC. While the ramping rates in the LFC will carry through to the HFC, the actual ramping rates in the HFC will also be affected by the operation of the Thermalito Afterbay Outlet.

Past flow fluctuations for flood control or dam safety inspections have resulted in fry and juvenile Chinook salmon being stranded in the HFC. Kindopp (2003)_ENREF_148 reports that rearing juveniles are susceptible to stranding in the HFC when flows decrease by more than one-half over a seven day period when flows fluctuate between 8,000 and 1,000 cfs. The magnitude of these stranding losses is unknown because it is difficult to truly distinguish the difference between effects to CV spring-run Chinook salmon and fall-run Chinook salmon due to the extensive overlap in spawning timing and distribution, and co-occurrence of juveniles rearing in the HFC.

Section *1.3 Proposed Action* includes ramping rates for the LFC and the HFC. Ramping rates for the HFC were identified in the 1983 Agreement. No ramping rates are proposed during flood management operations. Down ramping rates implemented in the LFC will continue and attenuate into the HFC. Down ramping in the HFC will also be affected by changes in releases from the Thermalito Afterbay Outlet as well as the LFC. The LFC and HFC minimum flows are identified in Table 2-18 and Table 2-19, and ramping rates are in Table 2-21.

Table 2-21. LFC and HFC Ramping Rates

LFC Down Ramping Rates	
Feather River LFC Releases (cfs)	**Rate of Decrease (cfs)**
3,500–5,000	1,000 per 24 hours
2,500–3,500	500 per 24 hours
< 2,500	300 per 24 hours
HFC Down Ramping Rates	
Feather River LFC Releases (cfs)	**Rate of Decrease (cfs)**
< 2,500	200 per 24 hours

In our ramping rate analysis we looked at rating tables for the Feather River near Gridley gage. While we considered the information in the U.S. Geological Survey December 16, 1997, rating table, we relied on the CDEC January 2, 2006 rating table because the CDEC rating table is more recent. No information was provided regarding the implementation of the down ramping. The rates were identified as a change in flows in a 24-hour period. For the ramping rates identified in Table 2-21, NMFS found that as an instantaneous change in flows this could result in stage elevation changes at the gage near Gridley of 1.56 to 10.32 inches. The Washington Department of Fisheries has identified that absent river reach specific ramping studies, ramping rates to protect juvenile salmon and CCV steelhead should be as identified in Table 2-22 (Hunter 1992). This information was develop based on the results of a number of studies looking at juvenile salmonid stranding due to down ramping associated with the operations of hydropower projects.

Table 2-22. Down Ramping Rates (Hunter 1992)

Season	Daylight Rates [3]	Night Rates
February 16 to June 15 [1]	No ramping	2 inches/hour
June 16 to October 31 [2]	1 inch/hour	1 inch/hour
November 1 to February 15	2 inches/hour	2 inches/hour

1 Salmon fry are present

2 Steelhead fry are present

3 Daylight is defined as one hour before sunrise to one hour after sunset

If the Oroville Project ramping rate changes in flows were implement over the complete 24-hour period (broken into 24 equal flow changes) the change in stage elevation would not reach

1 inch/hour (the range was 0.065 to 0.43 inches/hour for flow changes analyzed). It is NMFS's understanding that there are difficulties in implementing small flow changes. Based on Hunter (1992) and the stage changes at the gage near Gridley, most of the time if the identified ramping rates were implemented instantaneously we would expect stranding of juvenile salmonids. Juvenile CV spring-run Chinook salmon would be expected to be susceptible to river stage changes during rearing and migration. In the Feather River this is estimated to be November through May. NMFS looked at 12 years of daily flow information for the Near Gridley gage (2001-2012 inclusive). We used this to identify flow frequency changes and changes of large magnitude. We then examined several examples of rapid flow changes.

Figure 2-70 shows the flows for water year 2004.

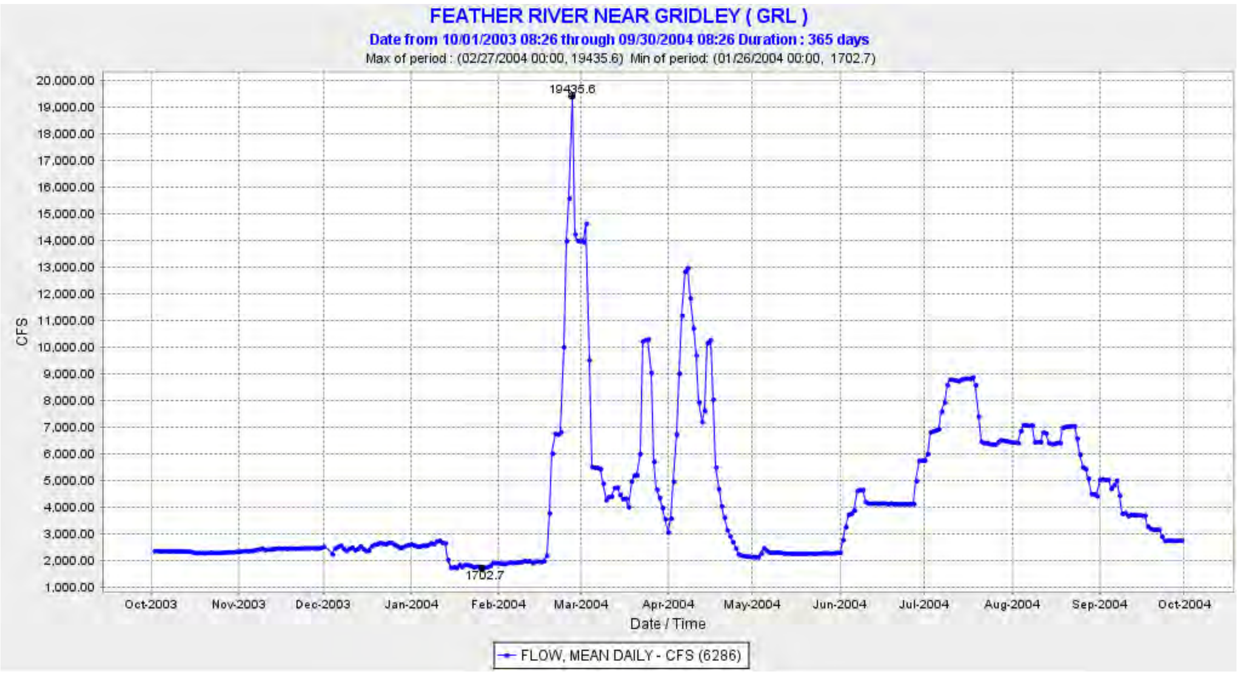

Figure 2-70. Near Gridley Gage Flows October 2003-September 2004

It appears there was significant change in flows in early March of 2004. Figure 2-71 shows the stage change for that event.

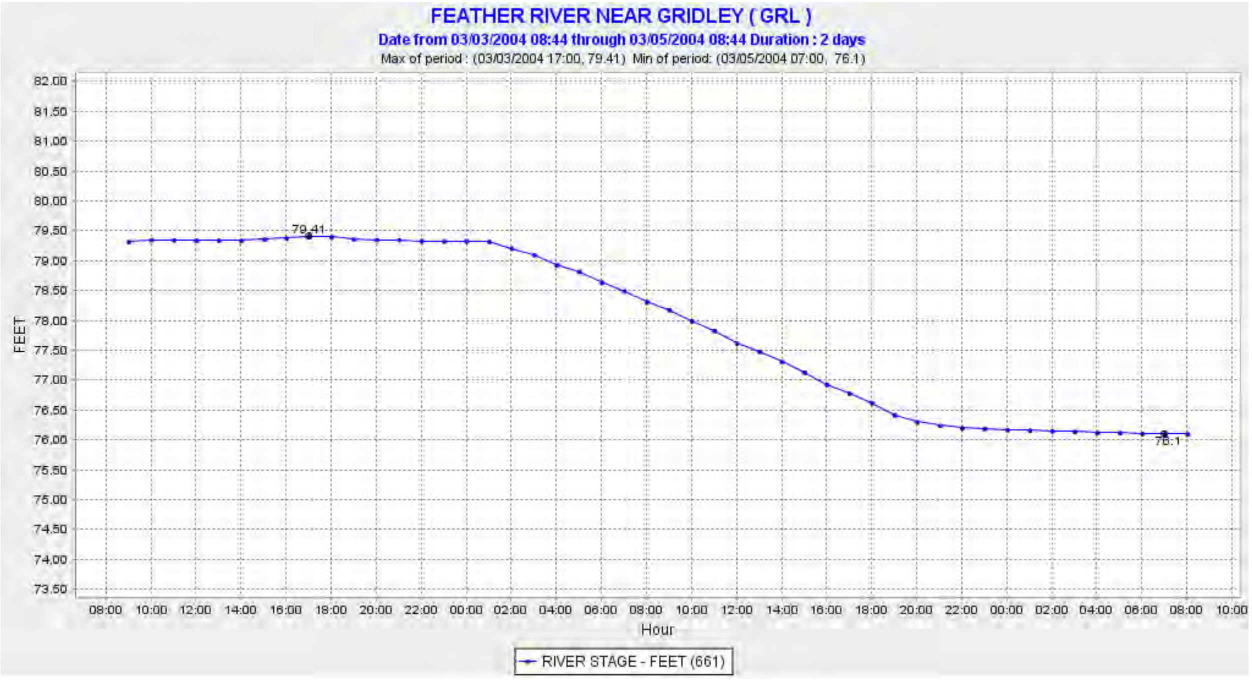

Figure 2-71. Near Gridley Gage Stage Change on March 4, 2004

Examination of this information shows a steady reduction in flows, not an abrupt change. The water stage change from 0400 March 4, 2014 to 1800 hours showed about a 2.5-foot decrease in elevation. Over this 14-hour period, the stage change equates to an average stage change of 2.14 inches per hour. While this could have resulted in some stranding of juvenile salmon and CCV steelhead, this particular event was likely associated with a storm event (Feb. 25–Mar 02). Storm events may result in unregulated flows and flow changes. Ramping rates are not necessarily applied with flood management operations. The observed ramping rates at this gage are likely attenuated from the flow changes that occurred upstream.

The rating table for the Near Gridley gage provides information regarding how flow changes in the HFC may affect changes in water elevations in the HFC. Available data at the Near Gridley gage provides information about flow events in the HFC.

While instantaneous implementation of the project ramping rates could result in significant stranding of juvenile salmonids, including CV spring-run Chinook salmon, it appears that DWR’s actual implementation of down ramping is usually much more gradual and not likely to cause significant stranding.

The potential for stranding CV spring-run Chinook salmon could further be reduced by reducing or eliminating down ramping during daylight hours when CV spring-run Chinook salmon fry are present.

While ramping rates can address potential losses of salmonids associated with stranding on gravel bars, ramping rates do not address losses of salmonids associated with pothole stranding. Pothole stranding is where fish become stranded in a pool of water that becomes isolated from the flowing stream. While fish may survive in a pothole that retains water, often the pothole pools drain or water temperatures rise until a point where fish die. Losses can also occur with bird predation. The only way to avoid stranding in potholes is to avoid all down ramping that isolates these pools. We do not currently have information regarding the amount of potential pothole habitat is in the Feather River. However, in disturbed areas (such as where gold mining has occurred) pothole habitat would be expected to occur. The modifications of the stream channel are most pronounced in the LFC. It is our understanding that flow fluctuations in the LFC are less frequent than in the HFC. Minimal flow reduction frequency and magnitude during salmonid fry rearing periods will reduce the potential losses of CV spring-run Chinook salmon associated with pothole stranding.

Because no changes are proposed in the ramping rates for the proposed action it is expected that there will be little change in the amount of stranding of juvenile CV spring-run Chinook salmon from present conditions. Some loss of juvenile CV spring-run Chinook salmon is expected during down ramping events. Flood operations of the Oroville Facilities will reduce the frequency and magnitude of storm related flows and down ramping events. Because the frequency of down ramping events is expected to be associated with the frequency of storm events, and we do not have data regarding the exposure to pothole stranding, and because the losses will be dependent on CV spring-run Chinook population sizes, it is not possible to estimate the number of CV spring-run Chinook that will be adversely affected by down ramping.

By year 15 of the license, the floodplain improvement plan will be partially implemented, and by year 25, the floodplain improvement plan will be fully implemented and will include habitat restoration measures and pulse flows that will inundate certain floodplain areas to increase juvenile outmigrant growth and survival. This will affect the Feather River population by improving juvenile growth, survival and abundance.

The proposed temperatures for the LFC are not expected to cause stressful conditions for rearing juvenile CV spring-run Chinook salmon. The HFC is primarily a migration corridor for adult and pre-smolt CV spring-run Chinook salmon, so water temperatures in the HFC are not expected to be an issue of rearing juvenile CV spring-run Chinook salmon.

2.4.5.3.11 CV Spring-run Chinook Salmon Smolt Emigration Stressors and Exposure

CV spring run Chinook salmon fry emerge from redds from December through January. Results from Feather River Chinook salmon emigration studies indicate virtually all CV spring run Chinook salmon juveniles in the Feather River exit as sub-yearlings. Emigration begins immediately following emergence in late November, peaks in January and February, and continues into the early spring (DWR 1999a, b, c). DWR observations from rotary screw trap captures in the LFC found that there does not appear to be a relationship between flow and juvenile Chinook salmon outmigration rates (Kindopp 2003, Department of Water Resources 2004b). Similarly, at the Live Oak rotary screw trap in the HFC, where there is considerable flow fluctuation, outmigration rates do not correlate with flow increases. However, many researchers have found that high spring flows are likely to increase the growth and survival of emigrants (Moyle and Yoshiyama 1997, Jager and Rose 2003). The primary reasons often given for increased survival from high flows include reduced temperature related mortality and reduced predation (Jager and Rose 2003).

S. P. Cramer Fish Sciences (2000)_ENREF_265 examined relationships between changes in environmental conditions and Chinook salmon movement on the Stanislaus River. They found that peak fry outmigration coincided with increases in river flow in January, but not in February when peak passage occurred during periods of increased and decreased flows. Fry outmigration dropped quickly in mid-March when flows declined from over 4,000 to less than 2,000 cfs. Flows in the river remained more stable from March through June when most smolt and parr outmigration occurred. The study concluded that flow increases probably encourage fry migration, but have less of an impact on smolts.

Another study on the Stanislaus (Demko and Cramer 1998) observed that outmigration peaked for only 1-4 days, when flows in the Stanislaus River increased from 400 to 1,400 cfs. The pattern of daily outmigrant abundance recorded before, during, and after the sustained pulse flow events suggested that the stimulant effect of flow on Chinook migration lasted only a few days and that sustained high flows "flush" juvenile Chinook out of the river. Demko and Cramer (1998)_ENREF_64, however, also concluded that smolt size Chinook will emigrate from the Stanislaus River in the spring, even in the absence of flow increases. Therefore, it appears reasonably likely that the proposed constant low flows reduce the ability for juveniles to respond to natural flow related migration cues and likely increase their downstream migration time, resulting in reduced outmigrant survival.

2.4.5.3.12 CV Spring-run Chinook Salmon Smolt Emigration Responses

High spring flows that inundate floodplains were historically present, but are now dampened by the storage of water behind Oroville Dam. Sommer et al. (2001b)_ENREF_283 reported that juvenile Chinook salmon grew faster on a large Central Valley floodplain (Yolo Bypass) than in the adjacent river channel, a likely result of increased invertebrate prey base and consumption. Jeffres et al. (2008)_ENREF_142 found significant differences in juvenile Chinook salmon growth rates between salmon rearing in floodplain and river sites along the lower Cosumnes River and suggested that if more off-channel floodplain habitat were available to juvenile Chinook during downstream migration, fish would be larger when they reached estuarine and marine waters, which has been found to increase overall survivorship (Unwin and Glova 1997, Galat and Zweimüller 2001). Seesholtz et al. (2004)_ENREF_271 also concluded that if high spring flows can inundate floodplains, creating beneficial growth conditions, some increase in survival to the estuary will be realized. CV spring-run response to the reduction in spring flows and floodplain inundation resulting from the proposed action operations would therefore be a reduction in survival of juveniles in the estuarine and marine environments.

Based on rotary screw trap captures, DWR concluded that there does not appear to be a relationship between flow and juvenile Chinook salmon outmigration rates (Department of Water Resources 2002b). Past investigations by DWR show that fry passage at the rotary screw trap in the LFC varies considerably over time while flows remain constant at 600 cfs. Similar patterns are expected under the proposed action, although flows will be moderately higher (compared to previous minimum flows). However, variations in migration patterns during consistently low flows (compared to unregulated flows) does not necessarily indicate that there is no relationship between flows and migration, but does suggest that other factors may have an influence on migration timing when flows are held at low levels. Several studies have clearly demonstrated that juvenile fish migrations are triggered by increased flows. Snider and Titus (2000) reported that peak movement of juvenile salmon in the Sacramento River occurs during high flow periods. Exposure to consistent low flows (compared to unregulated flows) is likely to disconnect juvenile outmigrants from natural flow cues, delay migration timing, and reduce survival of some individuals.

The HFC is primarily used for adult migration and as a juvenile migration and rearing corridor. Mean total flow is presently lower than historical levels during April and May, but higher from June through March. Average monthly flows are now at least 23 percent lower in April and 33 percent lower in May than pre-dam flows.

Instream flows in the HFC will be a minimum of 1,200 to 1,700 cfs from October through February, 1,000 to 1,700 cfs in March, and 1,000 cfs from April through September, but average monthly flows can range from 1,500 cfs during dry years to 12,300 cfs during wet years. Based on SA Article A108(b), if the April 1 runoff forecast in a given water year indicates that, under normal operation of the project, Oroville Reservoir will be drawn to 733 feet in elevation, minimum flows in the HFC may be diminished on a monthly average basis in the same proportion as the respective monthly deficiencies imposed upon deliveries for agricultural use from the project. In no case, however, shall the minimum flows be reduced by more than 25 percent. Due to flood management and water storage operations flows are not expected to be as variable as unregulated flows. This will mean fewer down ramping events, which will mean less stranding due to down ramping events compared to unregulated flows. However, there will be fewer high flow events. This will result in increased travel time to the Delta, and likely increased mortality during downstream migration, compared to unregulated conditions.

Ramping criteria for the Feather River that were established in a 1983 agreement between DWR and DFG will continue under the proposed action. This agreement requires that when flows downstream of the Thermalito Afterbay are less than 2,500 cfs, flows are to be reduced by no more than 200 cfs during any 24-hour period, except for flood control. Downramping rates could also strand emigrating CV spring-run Chinook. In our analysis above for juvenile rearing CV spring-run Chinook salmon, we found that there have been some stranding events. These events could have stranded emigrating salmonids as well as rearing salmonids. Reduction of exposure to potential stranding of emigrating salmonids could be obtained by modification of ramping rates to require more gradual ramping and adopting the Washington Department of Fisheries default ramping rates (Hunter 1992).

2.4.5.4 Feather River Fish Hatchery Effects

The production of hatchery salmonids has the potential to affect other populations of CV spring-run Chinook salmon outside the Feather River. Hatcheries are often concerned about the amount of fish that do not return to the hatchery or the river upon which the hatchery is located. This is usually expressed as the percent of fish of the total return that end up in other rivers (the stray rate). To analyze the potential effects of the FRFH operations it is also important to look at the percentage that FRFH fish make up of other spawning populations.

CDFG used mark and recapture data (coded wire recoveries) in the ocean fisheries, Central Valley streams, and hatcheries to reconstruct the 1998 fall Chinook cohort from the FRFH (Palmer-Zwahlen et al. 2004). One of the products of this analysis was an estimate of the rate at which fish released in the estuary return to the Feather River and to other streams (the stray rate). DFG staff estimated that of the adult fall and spring FRFH Chinook that returned to the Central Valley, about 90 percent returned to the Feather River (including the FRFH), and about 10 percent strayed outside the Feather River basin. By comparison about 6 percent of the in-basin releases strayed to streams other than the Feather River. It is quite likely that the 1998 cohort analysis significantly underestimated the straying rate, mainly due to lack of consistent tag recovery efforts on the major Chinook salmon spawning streams. At this time we are unable to determine the extent of this underestimate. The findings from the cohort analysis are in line with those from tag recoveries in Central Valley hatcheries and streams. Although tags from FRFH fish were collected in most Central Valley streams sampled, about 96 percent of the 12,438 tags recovered during the 1997–2002 period were collected in the Feather River or at the hatchery. Compared to Bay releases, a lower percentage of in-basin releases survived to reenter the estuary as adults (0.3 vs. 0.9 percent); however, these fish returned to the Feather River with greater fidelity (around 95 as compared to around 90 percent for Bay releases). Although the straying rate from Bay releases is less than might be expected based on earlier studies, it is still higher than natural straying rates.

One has to be careful interpreting the data. First, the cohort analysis was only for one brood year. Second, and perhaps most importantly, tagging and tag recovery efforts on all Central Valley streams do not provide statistically robust data on the proportion of tagged fish in the spawning populations. Third, there is a significant inland sports fishery in most Central Valley salmon streams and in recent years sampling this fishery, and collecting tags, has been inconsistent. The CVP Improvement Act's Comprehensive Assessment and Monitoring Program (CAMP) sponsored this valley-wide fishery sampling effort for two years, but the program was largely eliminated due to budget shortfalls. Estimates in recent years of strays from California Central Valley hatcheries has been possible due to coded wire tagging of hatchery fish. Most of the non-FRFH strays observed at the Feather River Hatchery and in the Feather River came from either experimental releases (Merced Hatchery fall Chinook releases in Delta studies or Coleman late fall Chinook releases, also in Delta studies) or from Bay releases of fall Chinook from the Mokelumne Hatchery.

Infrared and videographic sampling on both ladders at Daguerre Point Dam since 2003 has detected adipose fin clips on some of these fish, and since all Feather River CV spring-run Chinook salmon are adipose fin clipped, this is a strong indication that that Feather River Hatchery CV spring-run Chinook salmon are straying into the Yuba and spawning with the Yuba CV spring-run population.

Williams et al. (2011) identified that for strays from within a diversity group, stray rates exceeding 10 percent over three or more generations represents a high risk of extinction. From Lindley et al. (2007) as cited by Williams et al. (2011).

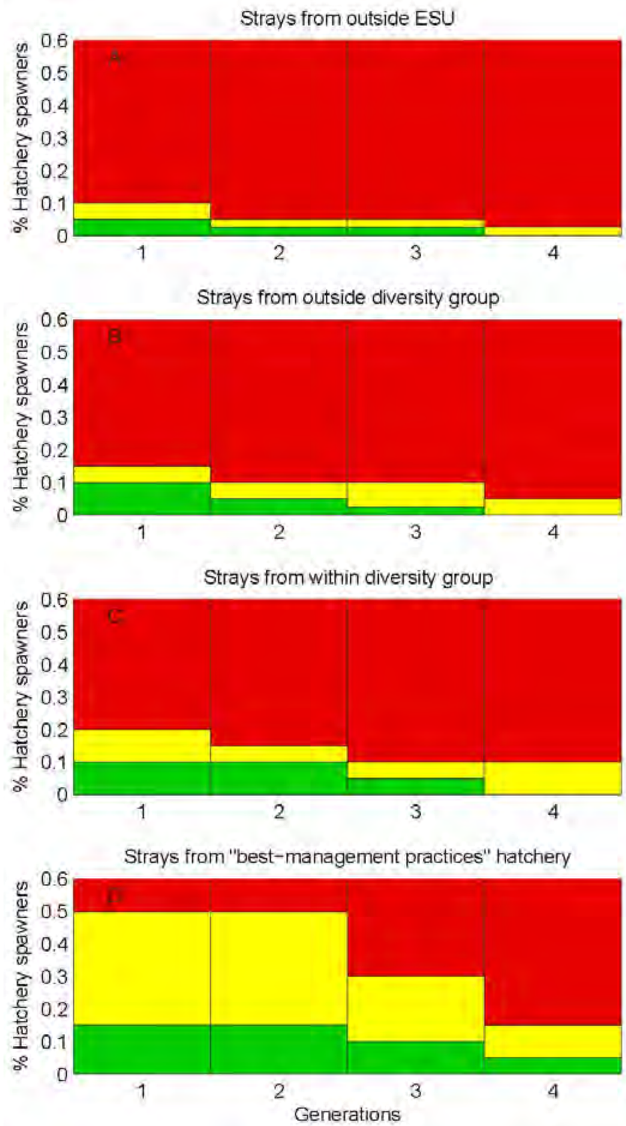

Figure 2-72. Extinction Risk Levels Corresponding to Different Amount, Duration, and Source of Hatchery Strays

From Figure 2-72 it can be seen that the hatchery stray rate should be 5 percent or less to minimize the risk of extinction.

The history of the Yuba River CV spring-run Chinook salmon must also be considered. It is likely that due to extensive gold mining in the Yuba River watershed and significant modifications of river flows and temperatures, CV spring-run Chinook salmon in the Yuba River were reduced to non-viable numbers.

More recent favorable changes have allowed CV spring-run Chinook salmon to return to the Yuba River. Yuba River CV spring-run Chinook salmon are genetically very similar to Feather River Chinook salmon. The source of recent returns of Yuba River CV spring-run Chinook salmon is likely strays from the Feather River, including FRFH CV spring-run Chinook salmon. While the Feather River CV spring-run Chinook salmon are close relatives to the Yuba River CV spring-run Chinook salmon, continued straying of FRFH CV spring-run Chinook into the Yuba

River could represent a significant risk to the establishment of an independent population of CV spring-run Chinook salmon in the Yuba River.

In the NMFS 2005 status review we identified that the Deer Creek, Mill Creek, and Butte Creek CV spring-run Chinook population are not closely related to the FRFH CV spring-run Chinook and that FRFH strays were not a concern. The NMFS 2011 status review did not identify any new risk from FRFH strays. The NMFS 2016 status review did identify that a significant number of FRFH CV spring-run Chinook salmon strays have been observed at the Keswick Dam fish trap (114 in 2015). That review identified a need for more information on the incidence of FRFH CV spring-run Chinook salmon straying. Researchers (Kormos et al. 2012, Palmer-Zwahlen and Kormos 2013) identified the percent of FRFH CV spring-run Chinook salmon in Butte Creek and Clear Creek were less than one percent of the returning CV spring-run Chinook salmon spawners in those systems in 2010 and 2011. From available information it appears that, other than the Yuba River, the percent of CV spring-run Chinook salmon strays from the FRFH is very low and not currently an area of concern. As of 2015, all FRFH CV spring-run Chinook salmon releases are being made in the Feather River, and the releases to San Pablo Bay have been discontinued. This is expected to reduce straying of FRFH spring-run Chinook salmon outside the Feather River watershed.

Figure 2-72 shows extinction risk levels corresponding to different amount, duration, and source of hatchery strays. Green bars indicate the range of low risk, yellow bars moderate risk, and red areas indicate high risk. Which chart to use depends on the relationship between the source and recipient populations.

A—Hatchery strays are from a different ESU than the wild population.

B—Hatchery strays are from the same ESU but from a different diversity group within the ESU.

C—Hatchery strays are from the same ESU and diversity group, but the hatchery does not employ “best management practices”.

D—Hatchery strays are from the same ESU and diversity group, and the hatchery employs “best management practices”.

Table 2-23 shows the estimated numbers of Chinook salmon, ad-clipped and non ad-clipped, phenotypic CV Spring-run Chinook salmon that passed upstream of Daguerre Point Dam annually from 2004 through 2014. (Lower Yuba River Accord River Management Team 2013). For the 11 years of data, the average percent of hatchery CV spring-run Chinook salmon passing upstream of Daguerre Point Dam has been 19 percent. The range has been 3 to 61 percent. In 7 of the 11 years the percentage was 10 percent or higher. From the criteria in Figure 2-72 it would appear that at times the strays from the FRFH into the Yuba River may significantly increase the risk of extinction.

Improvement of hatchery operations has reduced and is expected to continue to reduce the risk to Yuba River CV spring-run Chinook salmon. The risk could further be reduced by improving our understanding of how the combined water operations of the Feather River and Yuba River influence straying of FRFH CV spring-run Chinook into the Yuba River and then operating to minimize straying.

It is also important to have information about the numbers fall-run Chinook salmon in the harvest and in the rivers to understand how FRFH operations affect straying of fall-run Chinook salmon. Marking and tagging make it possible to identify FRFH fall-run Chinook salmon in the harvest and on the spawning grounds. Without marking of fall-run Chinook salmon, evaluation of the potential effects of the FRFH fall-run Chinook salmon program on spring-run Chinook salmon would not be possible. The current marking and tagging rate of 25 percent of fall-run Chinook salmon is considered by NMFS to be the minimum that should be marked for making estimates of FRFH fall-run Chinook salmon on the spawning grounds and for reconstructing run sizes. Increases in this marking and tagging rate would improve monitoring and evaluation efforts. It is NMFS' understanding that the marking rate for FRFH fall-run Chinook salmon will be further addressed through HGMPs.

Table 2-23. Chinook Salmon Passage Upstream of Daguerre Point Dam, 2004-2014

Year	Demarcation Date	Chinook Salmon Passage Upstream of Daguerre Point Dam				
		All Chinook Salmon	Spring-run Chinook Salmon			
			Total	ad-clipped	Not ad-clipped	% ad-clipped
2004	8/1/04	5,927	738	72	666	10
2005	8/24/05	11,374	3,592	676	2,916	19
2006	9/6/06	5,203	1,326	81	1,245	6
2007	9/4/07	1,394	372	38	334	10
2008	8/10/08	2,533	521	15	506	3
2009	7/9/09	5,378	723	213	510	29
2010	7/6/10	6,469	2,886	1,774	1,112	61
2011	9/7/11	7,785	1,159	323	836	28
2012	9/15/12	6,251	1,046	297	749	28
2013	8/20/13	11,394	3,130	137	2,993	4
2014	9/14/14	9,424	2,336	218	2,118	9

2.4.5.5 Proposed Conservation Measures

The proposed action will also expose CV spring-run Chinook salmon to actions related to the Lower Feather River Habitat Improvement Program (A101). The program will include actions that affect CV spring-run Chinook salmon and CCV steelhead in both the LFC and the HFC, the sub-programs are described here and include:

- **Gravel Supplementation and Improvement Program (A102)**—To counter the effects of bedload depletion from Oroville Dam, DWR will, within two years of license issuance, develop a gravel improvement plan and, within five years of license issuance, DWR will place a minimum of 8,300 cubic yards of suitable CV spring-run Chinook salmon and CCV steelhead spawning gravel at approximately 15 sites and will continue gravel augmentation every five years, or as needed to meet the habitat needs of anadromous fish. Most sites will be in the upper few miles of the Lower Feather River that are used by spawning CV spring-run Chinook salmon.

  - By year five, DWR will submit a Gravel Management Plan to FERC that will include a gravel budget and plan for augmenting gravels to support spawning habitat. The plan will ensure that gravel supplies and conditions will be sustained for CV spring-run Chinook salmon for the remainder of the license term. Spawning salmon will initially be exposed to the current stress regime of coarsening gravel size in the LFC, but habitat conditions will incrementally improve in both quality and quantity as the gravel program is initially implemented over a five-year period and maintained over the period of the license.

- **Channel Improvement Program (A103)**—Within one year of license issuance, DWR will develop a channel improvement plan to improve two existing side channels at the upstream end of the LFC by modifying these channels to provide suitable discharge, velocity, depth, substrate, cover and riparian vegetation to support salmonid spawning and rearing. Within four years of license issuance, the DWR will develop a channel construction plan to identify and construct, within ten years of license issuance, five additional side channel riffle/glide complexes of not less than a cumulative total of 2,460 feet in length of new habitat. These side channels shall be located and designed to maximize quantity and quality of suitable salmonid habitat attributes (depth, velocity, substrate, cover, and vegetation) while minimizing the potential for warming, stranding, and predation problems. This program is expected to increase the amount of spawning and rearing habitat in the LFC.
- **Structural Habitat Supplementation and Improvement (SHSI) Program (A104)**—Within two years of license issuance, DWR will develop a SHSI plan to provide additional or improved salmonid rearing habitat in the Lower Feather River. Structural elements such as LWM and boulders placed in the Feather River as part of this program are expected to increase channel complexity and create additional cover, slow- or edge-water habitats, and pool habitats important to listed salmonids. Upon implementation, the program is anticipated to provide substrate for algae and macroinvertebrates important as a food source for juvenile salmon and CCV steelhead along with creating pools, increasing channel complexity, and providing additional salmonid spawning habitat. Increased habitat complexity created through implementation of this program is expected to increase the carrying capacity of the Lower Feather River for juvenile salmon and CCV steelhead. Studies have shown that higher fish densities are often associated with LWM (Federal Energy Regulatory Commission 2007) and channel complexity.
- **Fish Weir Program (A105)**—Within one year of the license issuance, DWR will begin a multi-phased fish weir program that will study CV spring-run Chinook salmon run timing and distribution in the LFC, and will develop a plan within eight years for creating spatial separation of naturally spawning CV spring-run Chinook salmon in the Feather River. We expect that the ultimate installation of the segregation weir would significantly

reduce interbreeding between CV spring-run and fall-run Chinook salmon spawning in the river, along with reducing redd superimposition and pre-spawning mortality. The weir location is uncertain, however, and it could be at least 12 years before the weir is installed, so the overall effectiveness of this program on the conservation of Feather River CV spring-run Chinook salmon is delayed for that period. Under Settlement Agreement Article A105, this stressor would be expected to continue for at least 12 years, resulting in reduced abundance and loss of genetic diversity until Phase 2 of the Fish Weir Program is implemented. Under SWRCB Order WQ 2010-016 Special Condition S5, DWR will use a monitoring weir, or an additional separate interim weir, to segregate adult CV spring-run Chinook salmon and fall-run Chinook salmon within 5 years, which is expected to reduce the duration of this stressor and resulting effects.

- **Riparian and Floodplain Improvement Program (A106)**—Within six months of license issuance, DWR will develop a plan for a phased program to enhance riparian and other floodplain habitats for associated terrestrial and aquatic species. The plan will address connection of portions of the Feather River to its floodplain within the OWA.

  The Riparian and Floodplain Improvement Program set forth in the plan will be implemented in four phases by DWR in consultation with the EC and resource agencies.

  - Phase 1 will occur within one year of license issuance and consists of a screening level analysis of potential projects and identification of the recommended alternative. In the screening level analysis, higher priority will be given to those projects that maximize benefits for all species and habitats, including restoring riparian vegetation and the riparian corridor, restoring habitat for terrestrial species, reconnecting the river to its floodplain, and restoring and enhancing riparian and channel habitat for fish and other aquatic species.
  - Phase 2 will begin within four years of license issuance, will be completed within 15 years of license issuance, and consists of implementing the Phase 1 recommended alternative.
  - Phase 3 will occur within 15 years of license issuance and will reevaluate other potential feasible projects, including those considered under Phase 1, and will identify a Phase 3 alternative.
  - Phase 4 will occur within 25 years of license issuance and consists of implementing the Phase 3 alternative.
  - The overall effectiveness of this program on the conservation of listed anadromous fish species in the HFC cannot be determined until the final program plan is developed and approved by FERC. Some benefits are expected after completion of the Phase 1 recommended alternative within 15 years of license issuance and the full benefits are not expected until at least after year 25 of the new license, meaning that some existing stressors will adversely affect five to eight generations, for at least half of the license period.

- **Feather River Fish Hatchery Improvement Program (A107)**

  The objective of this program is to continue to operate the FRFH to mitigate for lost Chinook salmon and CCV steelhead production resulting from blocked passage to historical habitat upstream as a result of the construction of the Oroville Facilities. In addition, elements of this proposed program are designed to address current hatchery facilities and management issues (*i.e.* fish production, management protocols, hatchery water temperatures, fish genetics, disease management, straying, *etc.*).

Under the proposed action, the FRFH will continue to be operated as it is currently operated for the production of CV spring-run and fall-run Chinook salmon, CCV steelhead, and other salmonids from license issuance until completion and implementation a plan for the Feather River Hatchery Management Program. The plan is scheduled to be completed within two years of license issuance and implementation of the plan is scheduled to begin within three years of license issuance.

FRFH operations have adversely affected Chinook salmon within the Feather River watershed, through genetic mixing of CV spring-run and fall-run Chinook salmon stocks, altered run timing, and the creation of high spawning densities downstream of the Fish Barrier Dam. DFG estimates that 30 to 50 percent of the Feather River runs are fish produced by the hatchery (Federal Energy Regulatory Commission 2007). Currently, 2,000 CCV steelhead are artificially spawned in the FRFH each year, producing 400,000 CCV steelhead annually. These fish are released into the Feather River as young-of-the-year smolts (Chinook) or yearlings (CCV steelhead) or are transported and released into Lake Oroville or other California reservoirs, the Sacramento River, and San Pablo Bay near San Francisco Bay (Federal Energy Regulatory Commission 2007). As mentioned above, it is anticipated that the FRFH will continue to operate as it is currently operated until implementation of the plan for the Feather River Fish Hatchery Management Program, scheduled to begin within three years of license issuance.

Therefore, for purposes of this analysis, it is anticipated that the FRFH will continue to operate as it has been and will continue to adversely affect listed salmonids through genetic mixing, altered run timing, and high spawning densities on limited available habitat downstream of the Fish Barrier Dam, as described above, until completion and implementation of the plan. With development of the plan, we expect most of the HSRG recommendations to be incorporated into the plan. With implementation of the plan the effects of the FRFH on CV spring-run Chinook salmon are expected to be decreased. Some of the measures that are expected to be incorporated into the plan have recently been implemented. This includes making only in river releases. This started in 2015 and is expected to reduce straying of FRFH CV spring-run Chinook salmon into the upper areas of the Sacramento River. Measures have also been recently implemented to reduce the production of crosses between fall-run and CV spring-run Chinook salmon.

- **Instream Flow and Water Temperature Requirements for Anadromous Fish (A108)**--In section *1.3.3 Proposed Conservation Measures* proposed minimum flows and temperature criteria are identified. The effects of these minimum flows and temperature criteria are discussed above in this section.

2.4.5.5.1 Construction Related Activities

No additional project facilities are proposed for construction; however, Appendix A and Appendix F of the Settlement Agreement include several articles that will include construction of new facilities required to improve habitat conditions in the Feather River as part of the Lower Feather River Habitat Improvement Plan, or in the Sacramento River Basin as part of the HEA. Many of these activities require further study and will be implemented at various times throughout the term of the license, and detailed descriptions of these construction activities are not known at this time. Once studies are complete and necessary facility modifications are described, separate consultations may be required depending on the locations of the activities and effects on listed species and may be tiered to this Opinion. The general actions are described below in subsections *2.4.5.5.2 Construction Related Activities Related to the Lower Feather River Habitat Improvement Program* and *2.4.5.5.3 Construction Activities Related to the Habitat Expansion Agreement*.

2.4.5.5.2 Construction Related Activities Related to the Lower Feather River Habitat Improvement Program

Gravel Supplementation and Improvement Program (A102)—This action will place a minimum of 8,300 cubic yards of suitable CV spring-run Chinook salmon and CCV steelhead spawning gravel at approximately 15 as yet undisclosed sites over a period of 5 years and maintain the gravel with future placements at intervals of every 5 years. Placement will occur during summer months to avoid direct effects to spawning fish. The placement of the gravel may temporarily displace rearing fish, especially juvenile CCV steelhead, but is not expected to injure or kill any individuals.

Channel Improvement Program (A103)—This program will include instream construction in two existing side-channels (Moe's Ditch and Hatchery Ditch) and the development of at least five additional side-channels, totaling approximately 2,460 linear feet within the Lower Feather River and probably in the LFC. Potential adverse effects during implementation of this conservation measure are related to temporary increased sedimentation, turbidity, and possibly contamination from fuel spills during construction. Although plans must still be developed for these actions, implementation of best management practices to protect fish and aquatic habitats would minimize these stressors, and construction during summer months would avoid direct effects to spawning fish. The actions may temporarily displace rearing fish, especially juvenile CCV steelhead, but are not expected to injure or kill any individuals.

Structural Habitat Supplementation and Improvement (SHSI) Program (A104)—This program is anticipated to place structural elements into the river channels such as LWM and boulders. Potential adverse effects during implementation of this conservation measure are related to temporarily increased sedimentation, turbidity, and possibly contamination from fuel spills during construction. Although plans must still be developed for these actions, BMPs would minimize these stressors, and construction during summer months would avoid direct effects to spawning fish. The actions may temporarily displace rearing fish, especially juvenile CCV steelhead, but are not expected to injure or kill any individuals.

Fish Weir Program (A105)—Construction of monitoring and segregation weirs will require instream work in the LFC. Potential construction-related adverse effects include temporarily increased sedimentation, turbidity, and possibly contamination from fuel spills during construction. Although plans must still be developed for these actions, BMPs would minimize these stressors, and construction during summer months would avoid direct effects to spawning fish. The actions may temporarily displace rearing fish, especially juvenile CCV steelhead, but are not expected to injure or kill any individuals.

Riparian and Floodplain Improvement Program (A106)—This program will require floodplain improvement projects along the Lower Feather River, and most likely within the LFC and HFC within the Oroville Wildlife Area. Potential adverse effects during implementation of this conservation measure are related to temporarily increased sedimentation, turbidity, and possibly contamination from fuel spills during construction. Although plans must still be developed for these actions, BMPs would minimize these stressors, and construction during summer months would avoid direct effects to spawning fish. The actions may temporarily displace rearing fish, especially juvenile CCV steelhead, but are not expected to injure or kill any individuals.

Instream Flow and Water Temperature requirements for Anadromous Fish (A108)—This article could require construction related activities in the project area that have potential to result in temporarily increased sedimentation, turbidity, and possibly contamination from fuel spills during construction. Although plans must still be developed for these actions, BMPs would minimize these stressors, and construction during summer months would avoid direct effects to spawning fish. The actions may temporarily displace rearing fish, especially juvenile CCV steelhead, but are not expected to injure or kill any individuals.

2.4.5.5.3 Construction Activities Related to the Habitat Expansion Agreement

The HEA is likely to include instream construction activities in one or more tributaries to the Sacramento River Basin. Similar to the activities that will occur as part of the Lower Feather River Plan, instream construction for fish passage facilities, dam removal, or other work may result in temporarily increased sedimentation, turbidity, and possibly contamination from fuel spills during construction. Although plans must still be developed for these actions, BMPs would minimize these stressors, and construction during summer months would avoid direct effects to spawning fish. The actions may temporarily displace rearing fish, especially juvenile CCV steelhead, but are not expected to injure or kill any individuals. Any construction action related to the HEA will undergo separate ESA Section 7 consultation if warranted. The HEA is not part of the proposed action.

2.4.5.6 Other Measures under the Proposed Action that May Affect CV Spring-run Chinook Salmon

2.4.5.6.1 Lake Oroville Warm Water Fishery Improvement Program (A110)

Within one year of license issuance, a plan for the Lake Oroville Warm Water Fishery Improvement Program will be developed that will include the construction, operation, and maintenance of projects designed to improve warm water fishery habitat within Lake Oroville and the fluctuation zone.

This program has the potential to increase the number of warm water fish species (*e.g.,* largemouth bass) in Lake Oroville and some of the increased production may pass to the Feather River downstream of Oroville Dam. Warm water fish species might compete with juvenile salmonids for space and prey on juvenile salmonids rearing and migrating in the Feather River downstream of Oroville Dam. The potential also exists that warm water fish species introduced into the Feather River from Lake Oroville could spread diseases to wild, native salmonids downstream.

Because specific program plans and implementation elements have yet to be developed, a more complete assessment of the anticipated effects of this program on CV spring-run Chinook salmon cannot be made at this time. Although the interaction between warm water fish species from upstream of Oroville Dam and listed species in the Feather River downstream of Oroville Dam is considered minimal, without additional program information, it is anticipated that some potential exists for negative effects on ESA listed anadromous fish species downstream of Oroville Dam in the Feather River. Due to mortalities associated with passage in spill through Oroville Dam, or passage through the hydropower turbines, any increase in the population of warm water fish by fish coming from upstream of Oroville Dam is expected to be small.

2.4.5.6.2 Lake Oroville Cold Water Fishery Improvement Program (A111)

Within one year of license issuance, a plan for the Lake Oroville Cold Water Fishery Habitat Improvement Program will be developed that will provide for stocking approximately 170,000 yearling salmon, or equivalents, annually into Lake Oroville (this is consistent with current practices). The initial plan will focus on the first 10 years after licensing and will be revised every 10 years.

Coho salmon have typically been used for this program although Chinook salmon are also used on occasion. Fingerling coho have escaped over the Oroville dam spillway during high spring flows. A more aggressive species than Chinook, coho may dominate in competitive interactions, although the potential for interaction with other fishes in the Feather River is considered minimal by FERC (Federal Energy Regulatory Commission 2007). We believe this potential stressor needs additional study.

Prior to 2013, triploid coho salmon were used for this program. CDFW pathologists collected blood samples from 64 brood year 2011 triploid coho salmon at the FRFH. The samples were submitted to Washington State University to test for triploidy. Of the 61 fish sampled, 53 (87%) were triploid. This was below CDFW's accepted threshold for triploidy of 95 to 98%. To both ensure protection of native coho salmon and to protect the integrity of CDFW's recovery program, use of coho salmon in Lake Oroville was discontinued. Since 2013, fall-run Chinook salmon have been planted each year. The potential exists that the Lake Oroville coldwater fish stocking program could spread diseases to wild, native salmonids downstream. As a precaution, the Lake Oroville Cold Water Fishery Improvement Program plan shall provide for, among other things, an analysis of the feasibility of providing a disinfection system for hatchery water resources.

Fall-run Chinook salmon currently occupy the LFC. In the future, the segregation weir is expected to preclude fall-run Chinook salmon from the upper portion of the LFC. Fall-run Chinook salmon entering the upper portion of the LFC from upstream of Oroville Dam could compete with spring-run Chinook salmon and prey on spring-run Chinook salmon in the LFC. Due to mortalities associated with passage of fall-run Chinook salmon in spill through Oroville Dam, or passage through the hydropower turbines, the increase in the population of fall-run Chinook salmon in the LFC from fish coming from upstream of Oroville Dam is expected to be small. Because specific program plans and implementation elements have yet to be developed, a more complete assessment of the anticipated effects of this program cannot be made at this time.

2.4.5.7 Summary of Effects on Spring-run Chinook Salmon

The most significant stressors affecting CV spring-run Chinook salmon population abundance and diversity in the Lower Feather River are primarily related to the loss of access to historic habitat and restriction to highly altered habitat, loss of spawning gravel in the LFC, the co-occurrence with fall-run Chinook during the spawning season, the FRFH, and the impaired hydrograph. These stressors are affecting behavior, growth, and survival of individuals and the abundance and life history and genetic diversity of the population. Loss of flow related migration cues in the Lower Feather River is another stressor that could be affecting abundance and life history diversity. The egg mortality and production loss related to redd superimposition affects population abundance for fry and juveniles and possibly later life stages. Loss of flow-related migration cues delays migration of individuals and requires that they respond to other migration cues such as water temperature changes. This is expected to result in a higher number of fry outmigrating during low water periods, when they are exposed to higher rates of predation and increased water temperatures, resulting in reduced survival and emigrant population abundance.

Most significantly, hybridization with fall-run Chinook salmon is threatening the genetic diversity of CV spring-run Chinook salmon in the Feather River through genetic homogenization. Lindley et al. (2004)_ENREF_165 reported that Feather River CV spring-run Chinook salmon were most similar to fall-run Chinook salmon (Figure 2-76) and concluded that while the phenotype for early entrance into freshwater still persists in the Feather River, the mixing of gametes of these fish with fall run fish led to homogenization of these runs. However, (Hedgecock et al. 2001) found small but statistically significant allele frequency differences between Feather River CV spring-run Chinook salmon and fall-run Chinook salmon and suggested there has been a minimal exchange between these groups in recent years. This is somewhat surprising considering the extent of hybridization that has occurred over the past 40 years and suggests that through segregation, this genotype can be preserved.

Lindley *et al.*, (2004) reports that:

> *The genetic results from Hedgecock (2002), the existence of springtime freshwater entry, and the possible segregational natural spawning of spring-run fish in the Feather River system suggest that rescue of a spring run in the Feather may be possible, even though there has been extensive introgression of the fall run gene pool into that of the spring run. Further, the capacity of salmonid fishes to rapidly establish different run timings may make reestablishing discrete temporal runs possible if separate spawning habitats can be made available. It is doubtful that this phenotype will persist without immediate and direct intervention to preserve the genetic basis of spring run timing.*

CV spring-run Chinook salmon captured in the river formed a homogeneous group with CV spring-run Chinook salmon captured in the hatchery, which suggests that the naturally spawning population is not independent from the Federally listed hatchery spawners.

Figure 2-73 depicts the genetic distance among Central Valley Chinook runs. L Fall = late fall, D&M Sp = Deer and Mill Creek springs, BC Sp = Butte Creek springs, FR Sp = Feather River Springs., from Hedgecock (2002).

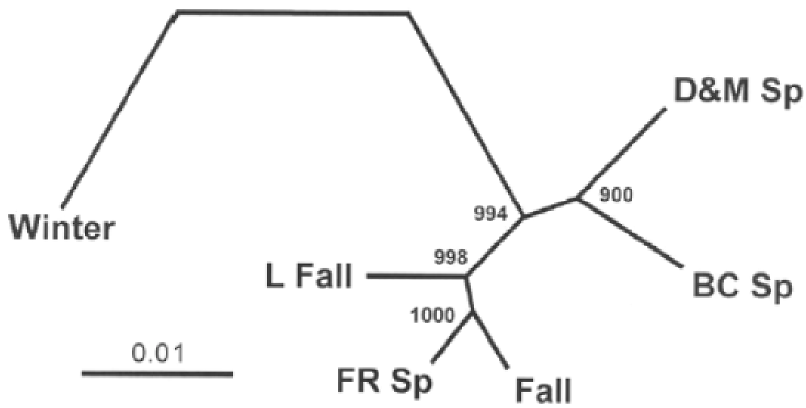

Figure 2-73. Genetic Distance Among Central Valley Chinook Runs

These stressors are expected to adversely affect the population until the measures of the Lower Feather River Habitat Improvement Program are implemented. The program is designed to address these specific stressors on the CV spring-run Chinook salmon population and will include numerous actions that will improve the population's response to the proposed future operation of the Oroville Facilities. Incremental implementation of the actions tied to the program will result in improved conditions that will increase the production, abundance, and life history and genetic diversity of the Feather River CV spring-run Chinook salmon population. By year five, gravel augmentation will have recharged approximately 15 significant spawning locations and will increase the quality and quantity of spawning habitat. This increased space for spawning and improved gravel size should increase production and abundance of the population by increasing the carrying capacity of spawning habitat.

By year 12 of the license, the fish segregation weir will separate the fall- and CV spring-run Chinook salmon spawners thereby increasing egg survival and fry abundance. The weir also will reduce the level of interbreeding between spring- and fall-run Chinook salmon, which will stabilize and begin to improve the genotype of Feather River CV spring-run Chinook salmon. This will improve the viability of the Feather River population by increasing abundance and improving genetic diversity. This will also improve the spatial structure of the population by creating conditions where they are geographically isolated from fall-run Chinook salmon.

By year 15, the floodplain improvement plan will be partially implemented. By year 25, the floodplain improvement plan will be fully implemented and will include habitat restoration measures and pulse flows that will inundate certain floodplain areas to increase juvenile outmigrant growth and survival. This will affect the Feather River population by improving juvenile growth, survival, and abundance.

2.4.5.7.1 Abundance and Production

The FRFH has raised two runs of Chinook salmon (spring and fall) since its inception.

By comparison, in the decade prior to the construction of Oroville Dam the runs averaged 1,700 spring-run and 39,000 fall-run Chinook salmon (Painter et al. 1977). Based on studies that showed survival to the ocean fishery was 2 to 3 times higher if the fish were released in the estuary instead of near the hatchery, beginning in the 1970s hatchery staff trucked the juvenile salmon to San Pablo Bay for release. In addition, several hundred thousand juvenile fall-run Chinook salmon are used annually in various studies and released off site. Figure 2-74 shows the number of CV spring-run Chinook salmon that have returned to the FRFH since 1975. The number of adult CV spring-run Chinook salmon returning to the hatchery has ranged from 198 to 8,662 fish and averaged 2,462. (CDFW 2016). The methodology for counting FRFH CV spring-run Chinook salmon changed in 2005.

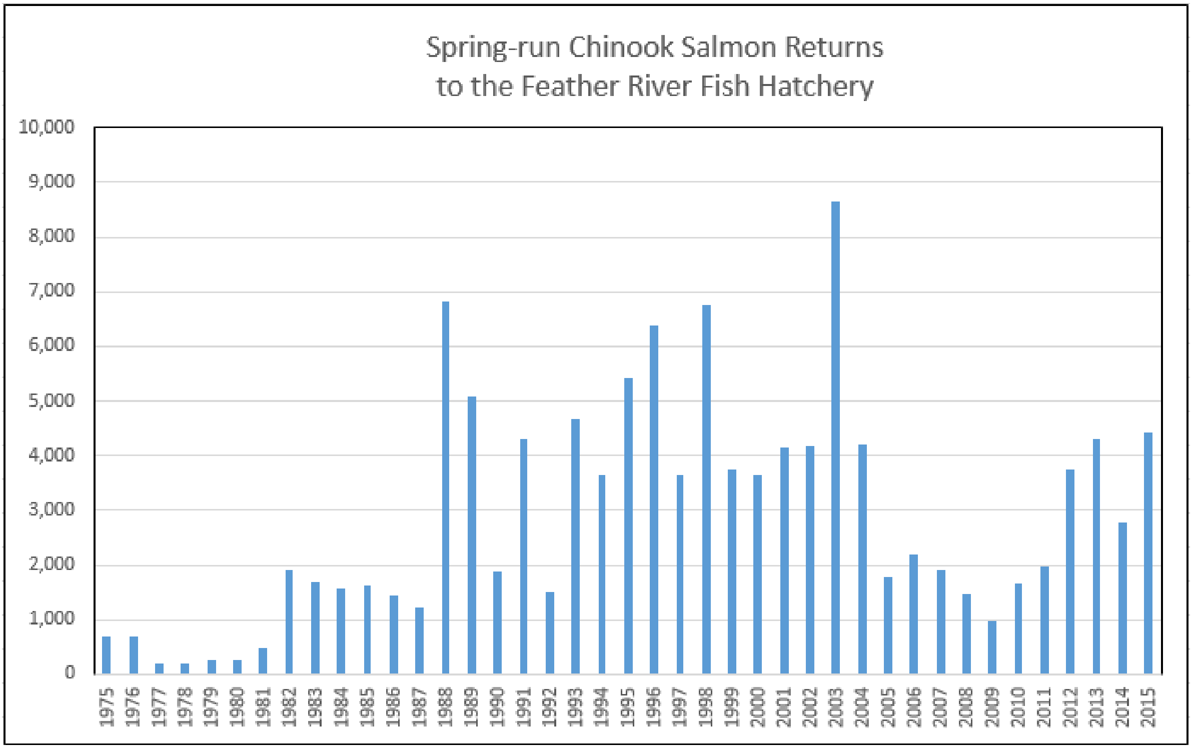

Figure 2-74. Number of CV Spring-run Chinook Salmon That Have Returned to the FRFH Since 1970

The proposed conservation measures are expected to improve the production and abundance of both FRFH and wild spawning CV spring-run Chinook salmon. The increased abundance is expected due to improved hatchery practices and improved habitat.

2.4.5.7.2 CV Spring-run Chinook Life History Diversity and Genetics

There are several concerns about how hatcheries may affect naturally spawning salmonids including hybridization between runs on the same stream, spawning with salmonids from other streams, and changing the genetic structure of a population as a result of fish culture practices.

One of the key questions about Feather River Chinook salmon involves the genetic and phenotypic existence of a spring-run and the potential effects of the FRFH on this run. The Feather River phenotypic spring run is currently part of the CV spring-run Chinook salmon ESU and is thus listed as threatened. The phenotypic spring and fall runs on the Feather River are genetically similar and most closely related to Central Valley fall Chinook. However, a significant phenotypic spring run arrives in Feather River in April, May, and June. From 2005 to 2015 the FRFH CV spring-run Chinook numbers have ranged from 989 to 4,440. Over that time this run has averaged 2,473. Genetically, the Feather River fall-run Chinook salmon and the Feather River spring-run Chinook salmon are very similar. Phenotypically there is a component of the Chinook salmon returning to the Feather River that exhibits adult CV spring-run Chinook salmon timing. There does not appear to be distinct stream and hatchery components to the run, meaning that the naturally spawning population is supported by the hatchery.

The following is a qualitative summary of the expected effects of FRFH operation on Central Valley Chinook salmon taken from (Brown et al. 2004). The summary is based on the observed genetic structure, the life history of individual races, and FRFH operations themselves. The general approach is to look at the probabilities of inter-breeding of FRFH fish and those from the other runs. A low probability indicates a low chance of adverse impacts.

> *There is more of a possibility that FRH operations have affected the genetic structure of this run. The FR spring Chinook propagated at the FRH are released off site and thus stray more than wild population albeit at rates that appear to be significantly lower than expected. A few nominal FRH spring Chinook have been collected on spring Chinook tributaries and in Battle Creek and the CNFH. (Battle Creek is the site of an extensive restoration program, one of the goals of which is to provide habitat necessary to establish a spring Chinook run.) The FRH spring run fish have only been recovered in the lower, fall run spawning sections of Deer, Mill, and Butte creeks, perhaps in part due to low total numbers in the higher reaches and sampling problems in these areas. The genetic structure of spring Chinook runs to Mill, Deer and Butte creeks indicates that to date, FRH operations have not affected this run - i.e. the structures are genetically quite different from that of the FRH and FR spring runs.*

It is clear that the FRFH has had an impact on the genetics and diversity of spring-run Chinook salmon in the Feather River. The FRFH has made modifications in recent years that have addressed some of these impacts. However, many of these impacts are expected to continue until the HSRG recommendations are implemented and the segregation weir is in operation. The negative effects of the FRFH spring-run Chinook salmon spawning in the Feather River are expected to continue as long as significant proportion of the fish spawning in the river are hatchery fish.

2.4.5.8 Effects of the Proposed Action on CV Spring-run Chinook Salmon Designated Critical Habitat

Critical habitat for CV spring-run Chinook salmon in the Feather River is designated in river reaches downstream from the Fish Barrier Dam. This assessment will analyze potential effects of the proposed action on the condition and value of critical habitat in these river reaches focusing on the migratory corridors and spawning and rearing habitat PBFs.

2.4.5.8.1.1 Spawning Habitat

The proposed action will impact spawning habitat through its influence on water temperature, flow-related habitat availability, and bed load supply and transport characteristics. The proposed action includes several measures designed to incrementally improve this PBF. Spawning habitat within the geographic scope of designated critical habitat will increase in quantity and quality through implementation of the Gravel Supplementation and Improvement Program.

Some short-term adverse effects to critical habitat PBFs are likely to occur during implementation of the proposed action. Although the action area's water quality has some potential to be negatively impacted, implementation of BMPs make this very unlikely to occur. Gravel augmentation, floodplain and side channel enhancement, and placement of instream habitat structures may cause a temporary increase in turbidity and may redistribute and deposit silt or sand downstream of project sites in the Feather River, which could temporarily degrade current spawning gravel. BMPs will be employed during implementation of the proposed action so that any negative effects to spawning gravel will be minimized. Implementation of these BMPs is expected to ensure these potential effects are insignificant, and these potential effects are not expected to reduce the value of designated critical habitat for the conservation of the species. A segregation weir to prevent fall-run Chinook salmon from disturbing habitat in which spring-run Chinook salmon have spawned is also included in the proposed action.

The proposed action will continue to confine CV spring-run Chinook salmon to spawning habitat downstream of the Fish Barrier Dam. The proposed action includes activities to address the adverse effects from the Oroville Facilities to the spawning habitat downstream of the Fish Barrier Dam. Activities in the proposed action addressing the adverse effects on spawning habitat downstream of the Fish Barrier Dam include gravel supplementation; placement of wood; increases in minimum flows, which will increase habitat and decrease water temperatures; temperature management; and a segregation weir. DWR began implementation of the gravel supplementation in 2014. These improvements will have a positive effect on the value of this PBF for the conservation of CV spring-run Chinook salmon and will support the recovery of the species in the action area.

2.4.5.8.1.2 Adult Migratory Corridors

The Oroville Facilities proposed action will impact the adult migratory corridor for CV spring-run Chinook salmon through altered flows and water temperatures. During implementation of some of the habitat enhancement measures (e.g. gravel supplementation) some adults may experience disturbance to the migration corridor due to construction activities, but passage routes will be present. The current biological value of adult migration corridors downstream of the Fish Barrier Dam will be improved over the existing conditions as result of the Lower Feather River Habitat Improvement Program. The program will be implemented through the period of the license and will incrementally improve migration corridors through improved temperature management and flow conditions that will facilitate and support adult upstream migration cues.

2.4.5.8.1.3 Rearing Habitat and Juvenile Migratory Corridors

The Oroville Facilities proposed action will impact the juvenile rearing habitat and juvenile migratory corridors for CV spring-run Chinook salmon through altered flows and water temperatures. There may be long-term temporary loss (two to five years to fully regrow) of some riparian habitat as a result of creating temporary access points to the river and covering vegetation with gravel, as well as removal for floodplain and side channel enhancement. Gravel augmentation methods, floodplain and side channel enhancement, and placement of instream habitat structure may impact riparian vegetation along the channel margin. Overall, some of the riparian vegetation that will be lost from access roads and restoration activities for an extended period. Loss of riparian vegetation may reduce food availability for fish (from reduced leaf and insect input to the aquatic habitat) until it is restored. In addition, physical disturbance to rearing habitat will occur, and be unavailable for use during implementation of gravel augmentation, floodplain and side channel enhancement, or instream habitat structure placement, but this will be temporary and adjacent suitable habitat is available.

The Oroville Facilities will impact rearing habitat and juvenile migratory corridors through its influence on water temperature, flow-related habitat availability, and bed load supply and transport characteristics. Although impaired by past operations of the Oroville Facilities, which will continue until conservation measures are implemented as described above, the biological value of juvenile rearing corridors in the Lower Feather River will be incrementally improved over existing conditions through the Lower Feather River Habitat Improvement Program. This plan includes gravel supplementation, side channel habitat improvements, placement of large woody material, increased minimum flows, and improvements in water temperatures. Through these measures the program will address the impaired biological value of juvenile rearing habitat and migration corridors in the Feather River downstream of the Fish Barrier Dam and will support the recovery of the species in the Feather River.

2.4.6 California Central Valley Steelhead

Many of the stressors and responses of the proposed action on CCV steelhead are similar to the stressors and responses of CV spring-run Chinook salmon. Where they are the same we refer to the Effects of the Actions section for CV spring-run Chinook salmon. Information specific to CCV steelhead is presented below. The proposed action has the same proposed flows and temperatures for CCV steelhead as for CV spring-run Chinook salmon.

The effects of water temperature on steelhead have been extensively analyzed and reviewed. The water temperature requirements of CCV steelhead life stages were described in section 2.3 *Environmental Baseline* of the Opinion. They are also described in great detail in the *Biological Assessment for Federally Listed Anadromous Fishes: Oroville Facilities Relicensing* (Department of Water Resources 2007) and the *Final Report Evaluation of Oroville Facilities Operations on Water Temperature Related Effects on Pre-Spawning Adult Chinook Salmon and Characterization of Holding Habitat, Appendix F* (Bratovich et al. 2004b).

Similar to what was previously described for Chinook salmon, individual and population-level responses to water temperatures are highly variable and often related to a number of influencing factors that cannot be uniformly applied to all situations. The EPA developed guidance for Pacific northwest state and tribal temperature water quality standards in 2003 (U.S. Environmental Protection Agency 2003). This guidance specifically addresses water temperatures and salmonids. Agencies and researchers have used a variety of temperature measurement criteria. Some of the criteria that have been used included constant temperatures, daily average temperatures (DAT), maximum weekly average temperature (MWAT), 7-day moving average of maximum daily temperatures (7DMAVG), and maximum 7-day average of the daily maxima (7DADM). The U.S. Environmental Protection Agency (2003)_ENREF_297 recommended the use of 7DADM as the water temperature metric for numeric criteria that is applied to specific species and lifestages of salmonids.

For the purpose of evaluating water-temperature stressors, however, we considered the wide range of available information and identified more specific water temperature index values, in great part from Appendix F (Department of Water Resources 2004a) for each life stage and evaluated potential fish responses to those temperatures (Table 2-25 and Table 2-26).

These index values are useful to establish as screening tools for identifying potential conditions that are suitable, optimal, stressful, or lethal to anadromous fish. They are not meant to be considered as absolute thresholds.

Table 2-24. Steelhead Temperature Tolerances

steelhead - Feather River

values in degrees Fahrenheit

eggs/embryos																																																
October-November	no eggs present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
December	eggs present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
January-March	peak egg presence	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
April-May	eggs present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
June-September	no eggs present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
Juveniles																																																
October-September	year round presence	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
Parr/smolt transformation																																																
October-September	possible year round	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
adult migration/holding																																																
October	peak migration	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
November-June	possible adult migration or holding	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
July-August	adult migration	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
September	peak migration	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
spawning																																																
October-November	no spawning	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
December	spawning	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
January-February	peak spawning	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
March	spawning	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
April-September	no spawning	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81

Green=optimal yellow=acceptable orange=impaired fitness red=likely lethal black=lethal

Table 2-25. CCV Steelhead Water Temperature Index Values That Are Used as Technical Analytical Guidelines for this Opinion

Life Stage	Period	EPA 2003 Water Temperature Criteria (7DADM)	Water Temperature Index Values	Rationale
Spawning LFC Only	December–March Peak: January and February	55°F	52° F	Optimum water temperature range of 46.0°F to 52.0°F for steelhead spawning in the Central Valley (U.S. Fish and Wildlife Service 1995). Optimum water temperature range of 46.0°F to 52.1°F for steelhead spawning and 48.0°F to 52.1°F for steelhead egg incubation (Hymanson et al. 1999). Upper limit of preferred water temperature of 52.0°F for steelhead spawning and egg incubation (State Water Resources Control Board 2003).
Immigration and Holding	July–May Peak: September and October	61°F	52-68°F	Preferred range for adult steelhead immigration of 46.0°F to 52.0°F (NMFS 2002; State Water Resources Control Board 2003); optimum range for adult steelhead immigration of 46.0°F to 52.1°F (U. S. Bureau of Reclamation 2008). Recommended adult steelhead immigration temperature range is 46.0°F to 52.0°F (Hannon et al. 2003). Temperatures in the 60s are tolerable during immigration, but long-term (holding) exposure to temperatures greater than 65 can reduce adult fecundity (Hallock et al. 1957).
Immigration and Holding Migration Barrier	July–May Peak: September and October	Not applicable	69°F	Creates migration barriers (McCullough et al. 2001). Migration barriers have frequently been reported for Pacific salmonids when water temperatures reach 69.8°F to 71.6°F (McCullough et al. 2001); Snake River adult steelhead immigration was blocked when water temperatures reached 69.8 [Strickland 1967 as cited in McCullough et al. (2001)].

Life Stage	Period	EPA 2003 Water Temperature Criteria (7DADM)	Water Temperature Index Values	Rationale
Egg Incubation	December–May	55ºF	52ºF	Optimum water temperature range of 46.0°F to 52.0°F for steelhead spawning in the Central Valley (U.S. Fish and Wildlife Service 1995); Optimum water temperature range of 46.0°F to 52.1°F for steelhead spawning and 48.0°F to 52.1°F for steelhead egg incubation (U. S. Bureau of Reclamation 2008); Upper limit of preferred water temperature of 52.0°F for steelhead spawning and egg incubation (State Water Resources Control Board 2003). Survival of rainbow trout eggs declined at water temperatures between 52.0 and 59.4°F (Humpesch 1985). The optimal constant incubation water temperature for steelhead occurs below 53.6°F (McCullough et al. 2001)
Juvenile Rearing	Year-round in the LFC and HFC: December-August, peak January through May	61ºF	65º F	Upper limit of 65°F preferred for growth and development of Sacramento River and American River juvenile steelhead (National Marine Fisheries Service 2002). Nimbus juvenile steelhead growth showed an increasing trend with water temperature to 66.2°F, irrespective of ration level or rearing temperature (Cech and Myrick 1999). The final preferred water temperature for rainbow fingerlings was between 66.2 and 68°F (Cherry et al. 1975). Nimbus juvenile steelhead preferred water temperatures between 62.6°F and 68.0°F (Cech and Myrick 1999). Rainbow trout fingerlings preferred or selected water temperatures in the 62.6°F to 68.0°F range (McCauley and Pond 1971). (Myrick and Cech 2002) identified that FRFH CCV steelhead exhibited a temperature preference between 17 and 20°C (62.6–68.0°F).

Life Stage	Period	EPA 2003 Water Temperature Criteria (7DADM)	Water Temperature Index Values	Rationale
Smoltification	HFC: January through May	57ºF	52º F	Steelhead successfully smolt at water temperatures in the 43.7°F to 52.3°F range (Myrick and Cech 2001). Steelhead undergo the smolt transformation when reared in water temperatures below 52.3°F, but not at higher water temperatures (Adams et al. 1975). Optimum water temperature range for successful smoltification in young steelhead is 44.0°F to 52.3°F (Rich 1987).

2.4.6.1 California Central Valley Steelhead Stressors and Exposures

Below is a table summarizing CCV steelhead stressors, exposures, and responses, which does not include expected responses to proposed action conservation measures.

Table 2-26. Exposure and Summary of Responses of Feather River CCV Steelhead to the Proposed Action

Life Stage/ Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
Adult Migration				
The Feather River from the confluence with the Sacramento River, upstream to the PG&E Poe Hydroelectric Project	Feather River Fish Barrier Dam Oroville Dam	September - March	September - March	Blocked access to historical habitat upstream from Oroville Dam (by blocking upstream migration of adults, all other life stages that would have used this habitat also are affected).

Life Stage/ Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
Spawning				
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Oroville releases—flow fluctuations associated with flood events	December-March	December-March	Redd dewatering and isolation prohibiting successful completion of spawning. Scour occurs in some years, but the proposed action reduces the number of scour events. These events are associated with high reservoir conditions. Reduced reproductive success.
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Feather River Hatchery—natural-origin steelhead spawning with hatchery *O. mykiss*	December-March	December-March	Biosimplification related to genetic hybridization. Reduced reproductive success and reduced survival of offspring produced.
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Low and Declining Habitat Availability	December-March	December-March	Reduced spawning habitat availability. Reduced reproductive success.

Life Stage/ Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
Feather River Fish Hatchery	Hatchery Operations	December-March	December-March	Reduced genetic diversity. Reduced reproductive success, reduced survival of post-spawn adults.
Embryo Incubation				
In-river riffle habitat between the Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Oroville spillway releases—redd scour	December-May	December-May	Egg and alevin mortality. Reduced survival. Scour occurs in some years, but the proposed action reduces the number of scour events. These events are associated with high reservoir conditions.
Juvenile Rearing				
Fish Barrier Dam downstream to the confluence with the Thermalito Afterbay Outlet pool	Oroville releases—flow fluctuations; low flows	Year-round	Year-round	Fry stranding and juvenile isolation; low flows limiting the availability of quality rearing habitat including predator refuge habitat. Reduced survival.

Life Stage/ Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
Feather River downstream from Thermalito Afterbay Outlet HFC	Water temperatures warmer than life stage requirements	All year	June–September	Physiological effects—reduced ability to successfully complete the smoltification process, increased susceptibility to predation. Reduced growth. Reduced survival.

2.4.6.1.1 California Central Valley Steelhead Stressors and Exposures During Adult Migration

As with CV spring-run Chinook salmon, CCV steelhead do not have access to historic habitats upstream of the Fish Barrier Dam. No CCV steelhead fish passage provisions are included in the proposed action. The timing of this stressor is from September through March for CCV steelhead.

Instream flows in the LFC will range from 700 to 800 cfs during the adult upstream migration, spawning, egg incubation, and juvenile outmigration. During the early part of the upstream migration from July through early September, flows will be 700 cfs and will increase during the peak adult upstream and spawning period to 800 cfs. Flows during the latter part of the spawning and egg incubation period will decrease to 700 cfs.

Near the Feather River Hatchery, water temperatures during the adult migration period exceed 52°F from July through December in approximately 75 percent of the years, but are below 52°F from January through March. Temperatures of 52°F may also be exceeded in April and May during 5 percent of years. During the peak adult migration period temperatures are always well below a level that would block migration or reduce fecundity. Further downstream at Robinson Riffle, water temperatures during the adult migration period exceed 52°F from July through December in all years (never exceeding 60°F), but are below 52°F from January through March.

At the downstream end of the project boundary, approximately one mile downstream from the Thermalito Afterbay Outlet, water temperatures during adult CCV steelhead migration exceed 52°F in all months except January and February. Temperatures are highest during the early part of the migration, but never exceed levels that would delay or block migration. Water temperatures generally become warmer moving downstream from this point. Near the mouth of the Yuba River and at Verona 52°F is exceeded in normal and dry years during all migration months except December through February, reaching as high as 72°F and 80°F from August through mid-September, the peak migration period.

2.4.6.1.2 California Central Valley Steelhead Responses During Adult Migration

Loss of access to historic habitat upstream of the Fish Barrier Dam is likely somewhat greater for CCV steelhead, than for CV spring-run Chinook salmon. This is because CCV steelhead may have migrated further upstream. Historical abundance of CCV steelhead was summarized by Brown (Brown et al. 2004). Adult CCV steelhead were counted in a trap at the mouth of the river bypass outlet for three years during the construction of Oroville Dam. The trapping yielded 813 fish in 1964, 383 fish in 1965, and 607 fish in 1966 (Brown et al. 2004). The post-dam abundance of CCV steelhead is similar or higher compared to available pre-dam information (Sommer et al. 2001b, Brown et al. 2004, California Department of Fish and Game 2012).

Instream flows in the LFC will range from 700 to 800 cfs during the adult upstream migration, spawning, egg incubation, and juvenile outmigration. During the early part of the upstream migration from July through early September, minimum flows will be 700 cfs and will increase during the peak adult upstream and spawning period to 800 cfs. Flows during the latter part of the spawning and egg incubation period will decrease to 700 cfs.

Extensive evaluations of critical riffles have not revealed any passage limitations for CCV steelhead in the HFC under the proposed flows. Because of this the proposed flows are expected to provide adequate depths and velocities for upstream migration.

In the LFC, the maximum optimal water temperature for adult CCV steelhead upstream migration is exceeded during the majority of the migration period, including the peak period during September and October, with temperatures as high as 56 to 58ºF from September through December. Exposure to water temperatures between 52°F and 68°F may slow upstream migration (July - May, peak September and October) and possibly increase an individual fish's susceptibility to disease, but is not expected to result in blocked migration or mortality of adult CCV steelhead. In most years, temperatures do not reach or exceed 69ºF, where migration would be blocked. In dry years, however, when water temperatures exceed 68°F and reach as high as 75°F, migration is likely to be substantially delayed or blocked from the vicinity of the Yuba River downstream to the confluence with the Sacramento River. Chronically exposed individuals would probably die at these temperatures. In September and October, during the peak of the migration, temperatures are lower. In 2014, a dry year, peak water temperatures recorded near Gridley were less than 67°F from mid-August to about September 10, then were less than 65°F from September 10 into October.

Water temperatures during the peak upstream migration of adult CCV steelhead appear to be significant enough to delay or block upstream migration in normal and dry years. In normal years, the temperature levels are likely to cause minor delays that could last for a few hours or several weeks. Diurnal, seasonal, or flow-related water temperatures could support upstream migration for limited periods. In dry years, migration may be more significantly delayed or blocked at lower reaches. These dry year delays or blockages during peak migration periods could cause migrating adults to seek out new migratory pathways and stray into other Sacramento River tributaries or increase the population's overall susceptibility to disease, predation, and exposure-related mortality, resulting in reductions in abundance of the Feather

River population. However, current information regarding Feather River Hatchery CCV steelhead indicates straying is low.

2.4.6.1.3 California Central Valley Steelhead Stressors and Exposures During Spawning

The presence of CCV steelhead and their use of habitat within the LFC are described in detail in section *2.3 Environmental Baseline* of this biological opinion. In summary, adult CCV steelhead migrate into the LFC between July and May, peaking in September and October. They spawn in only about three small, braided side channels from December through March, peaking in January and February. Juvenile incubation lasts from December to May, juvenile rearing can occur year-round, and outmigration occurs from January through May.

As with migration, CCV steelhead do not have access to historic spawning habitats upstream of the Fish Barrier Dam. The exposure time is December through March.

Due to their spawning timing being during the winter, when storms and uncontrolled flows occur, steelhead may spawn at high elevations during high flow events. Some of these redds may be dewatered or isolated due to decreases in the water elevation levels.

Figure 2-75 shows weighted usable area for Chinook salmon and CCV steelhead spawning in the LFC (DWR 2004F).

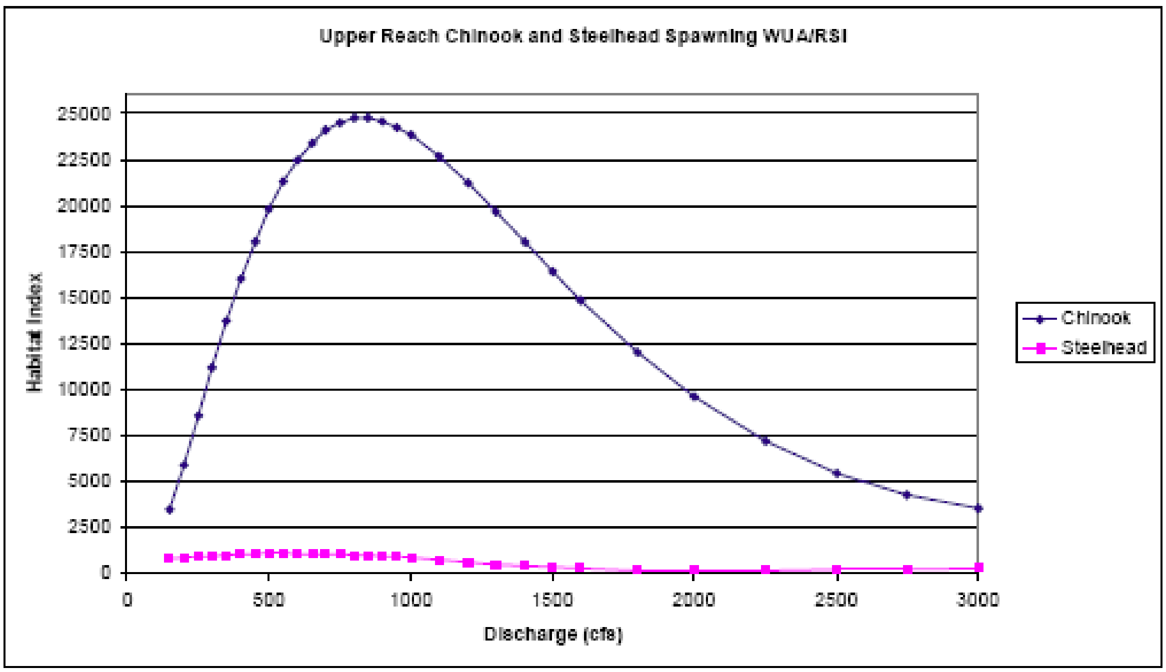

Figure 2-75. Weighted Usable Area for Chinook Salmon and CCV Steelhead Spawning in the LFC

Flow/habitat availability curves (Figure 2-75) show instream flow and the corresponding spawning habitat WUA for CCV steelhead. Evaluation of the WUA for the adult spawning life stage of CCV steelhead indicates that the maximum amount of spawning area in the LFC, given the current channel configuration, would occur at flows between 800 and 1,000 cfs.

Figure 2-76 shows weighted usable area curves for CCV steelhead spawning in the HFC.

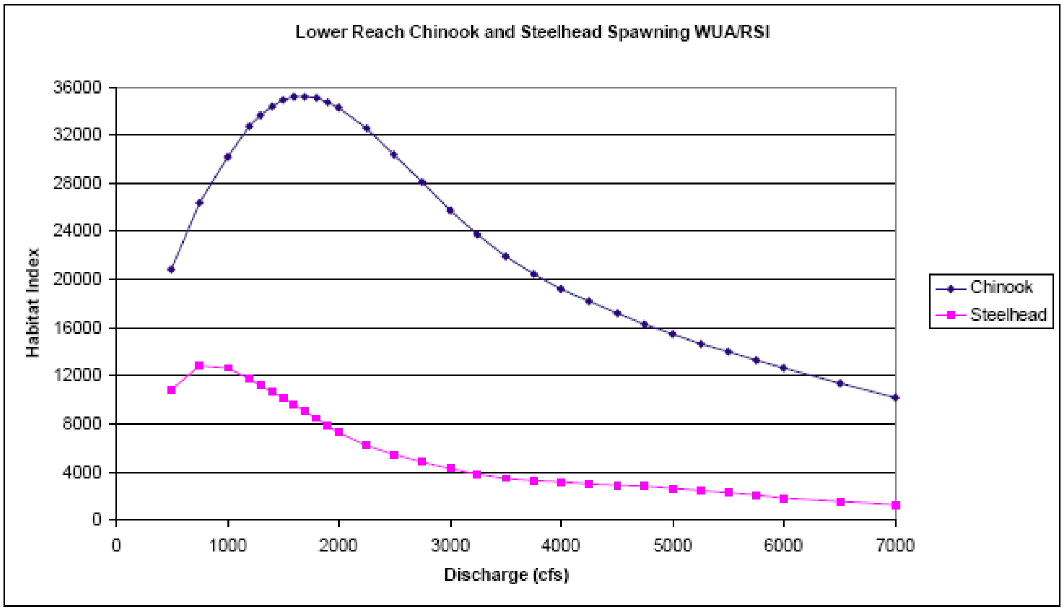

Figure 2-76. Weighted Usable Area Curves for CCV Steelhead Spawning in the HFC

Similar to what was described for CV spring-run Chinook salmon, existing spawning habitat is now limited to river reaches downstream from Oroville and the Fish Barrier Dam. Due to the preference of CCV steelhead to use small side channels for spawning, there is even less area available than for Chinook salmon. Spawning areas are limited to Moe's Ditch and the Hatchery Ditch, located in the Feather River adjacent to the FRFH, the Auditorium Riffle, located upstream from State Route 70, and the upper Eye Riffle, located near the downstream end of the LFC. Some spawning may also occur in the HFC, but the majority occurs in the LFC. Spawning substrate in the Lower Feather River is armored by cobbles and boulders, mainly due to the lack of gravel recruitment to riffles since the 1960s, when Oroville Dam was completed. Substrate evaluations using Wolman Pebble Counts show that spawning gravel in the LFC has become progressively armored over the past 16 years (Sommer et al. 2001b), and it is assumed that this trend is likely to continue without intervention.

The presence of CCV steelhead and their use of habitat within the HFC are described in detail in section *2.3 Environmental Baseline* of this biological opinion. In summary, The HFC is primarily used as an adult migration corridor and a juvenile migration and rearing corridor; however, limited adult spawning also has been documented. Adult CCV steelhead migrate into the HFC between July and May, peaking in September and October. They spawn in small, braided side channels from December through March, peaking in January and February.

Instream flows in the HFC are the same as those previously described for CV spring-run Chinook salmon as are exposure to instream flows, the hydrograph, and habitat availability in the HFC. Minimum flows will be 1,000 cfs during the first month of the adult migration period, and minimum flows will be between 1,200-1,700 cfs during the remainder of the adult migration, spawning, and egg incubation period. Average monthly flows are likely to be much higher on average water year types.

During spawning and egg incubation, temperatures exceeding 52°F at the FRFH occur through late December, and again in March and April, but remain below that level during the peak spawning and egg incubation period in January and February. During the spawning period, temperatures are never more than 56°F in the upper LFC. Further downstream at Robinson Riffle, spawning temperatures of 52°F are exceeded through late December, and again in March and April, but remain below that level during the peak spawning and egg incubation period in January and February. During the spawning period, temperatures are never more than 58°F.

As with CV spring-run Chinook salmon, there is intermixing of hatchery and wild CCV steelhead on the spawning grounds. This results in reduced fitness of the wild CCV steelhead.

2.4.6.1.4 California Central Valley Steelhead Responses During Spawning

As with CV spring-run Chinook, CCV steelhead do not have access to historic spawning habitat upstream of the Fish Barrier Dam. This has reduced the amount of spawning and rearing habitat available to CCV steelhead. Without intervention, the low amount of spawning and rearing sites in the LFC, combined with the coarsening of the spawning gravel in the LFC, is expected to reduce the quantity and quality of habitat available to individuals. As spawning gravel is reduced in supply, competition for spawning habitat will increase, resulting in increased levels of redd superimposition and reduced levels of spawning success and egg survival.

The minimum instream flows of 1,200 to 1,700 cfs during the spawning period are marginally lower than the maximum WUA/RSI that is achieved at flows between 1,500 and 2,000 cfs. However, minimum instream flows are more likely to occur in dry and critically dry years. During average water year types, the monthly flows can be much greater. Because of the low number of fish that spawn in this reach (Cavallo et al. 2004), habitat availability is probably not limited at these flows and is unlikely to adversely affect individual fish. DWR concluded that the flow fluctuations permitted during the CCV steelhead spawning period in the HFC have not affected this life stage of CCV steelhead.

Spawning during high flows can result in redd dewatering when flows are reduced after the high flow event. While the magnitude and frequency of high flow events are both reduced due to the Oroville Facilities’ flood management operations, those operations can increase the duration of high flow events. Increased duration of high flow events can encourage CCV steelhead to spawn in areas where flow cannot be maintained throughout the incubation period.

High flow events can also result in the loss of eggs, through scour. High flows can result in bedload movement that results in the loss of CCV steelhead eggs.

Preferred water temperatures generally are met during the peak spawning period of January and February, but will be exceeded by up to 5°F in late December and again in March and April, causing increased levels of egg mortality. This reduces the number of juveniles entering the population and also may have an effect on population abundance and life history diversity if one portion of the population is affected more regularly than another.

The water temperature improvement actions for the proposed action are intended to improve and stabilize water temperature regimes in the Lower Feather River. With climate change, the frequency of conference years and duration of droughts may increase. This will result in higher water temperatures. Because steelhead spawn in the winter, the increases in winter temperatures are not expected to increase to a level that would impact spawning steelhead.

With hatchery CCV steelhead spawning in the same areas as wild CCV steelhead, there are losses of wild CCV steelhead due to competition for the best spawning locations. Interbreeding between hatchery and wild CCV steelhead reduces the genetic diversity of the wild CCV steelhead and reduces the fitness of the wild CCV steelhead.

While the habitat expansion threshold under the HEA does not specifically address CCV steelhead, actions implemented under the HEA are expected to be beneficial to spawning CCV steelhead based on habitat needs similar to CV spring-run Chinook salmon. NMFS reserves its authority under FPA Section 18 to prescribe the construction, operation, and maintenance of fishways for the Oroville Facilities and other hydroelectric projects in the Feather River basin during the terms of the licenses as provided in the HEA. If the HEP does not meet the requirements of the agreement and there is no agreement on an alternative habitat expansion plan that would meet the requirements of the HEA, the HEA would be terminated, and NMFS is expected to prescribe fishways based on previous fishway prescriptions for hydroelectric projects in the Feather River basin. The HEA is not part of the proposed action analyzed in this Opinion, but it is an interrelated action.

2.4.6.1.5 California Central Valley Steelhead Stressors and Exposures During Embryo Incubation

CCV steelhead egg incubation lasts from December to May.

Instream flows in the LFC will range from 700 to 800 cfs during the adult upstream migration, spawning, egg incubation, and juvenile outmigration. During the early part of the upstream migration from July through early September, flows will be 700 cfs and will increase during the peak adult upstream and spawning period to 800 cfs. Flows during the latter part of the spawning and egg incubation period will decrease to 700 cfs.

Short-duration, high-flow events can scour CCV steelhead redds and result in injury and mortality of incubating eggs. Redd dewatering can occur when river flows are reduced during or after the spawning period and also can result in injury and mortality of incubating eggs. While DWR does not provide specific data on redd scouring, we expect that based on bed mobilization rates, flows between 5,000 and 25,000 cfs are likely to scour redds and result in reduced redd production and fry abundance in only about 10 percent of years.

During egg incubation, temperatures exceeding 52°F at the FRFH occur through late December, and again in March and April, but remain below that level during the peak egg incubation period in January and February. Egg incubation temperatures are exceeded in December in about 50 percent of years, and in April and May in about 25 percent of the years. Further downstream at Robinson Riffle, incubation temperatures of 52°F also are exceeded through late December, and again in March and April, but remain below that level during the peak egg incubation period in January and February. Egg incubation temperatures are exceeded in December in about 50 percent of the years and from March through May in about 25 percent of the years. However, the effect is expected to be small, because 99 percent of the spawning occurs within the upper mile of the LFC, near the FRFH, during January and February.

Egg incubation temperatures also may exceed 52ºF at the FRFH and Robinson Riffle in December of about 50 percent of the years, but are below that level during peak incubation in January and February.

2.4.6.1.6 California Central Valley Steelhead Responses During Embryo Incubation

Redd scour and redd dewatering can result in the loss of CCV steelhead eggs. The operation of the proposed action is expected to reduce the number of high flow events, compared to natural conditions. The proposed action is not likely to result in more redd scour or redd dewatering events than what is currently occurring.

Habitat modeling identified that for the LFC and the HFC the minimum flows will nearly maximize spawning habitat for CCV steelhead.

Water temperatures for spawning and egg incubation in the LFC generally are favorable for CCV steelhead, but during early and latter parts of the spawning period may result in some egg mortality. This reduces the number of juveniles entering the population and also may have an effect on population abundance and life history diversity if one portion of the population is affected more regularly than another.

2.4.6.1.7 California Central Valley Steelhead Stressors and Exposures During Juvenile Rearing

CCV steelhead juvenile rearing can occur year-round.

Past flow fluctuations for flood control or dam safety inspections have resulted in fry and juvenile Chinook salmon and CCV steelhead being stranded in the LFC; this is expected in up to 10 percent of years when flood flows recede and fish become stranded in side channels.

For steelhead fry, WUA/RSI (Figure 2-77) initially declines between 150 and 300 cfs before increasing with flows up to approximately 1,000 cfs.

Figure 2-77 depicts weighted usable area curves for CCV steelhead fry in the HFC.
(DWR 2004F).

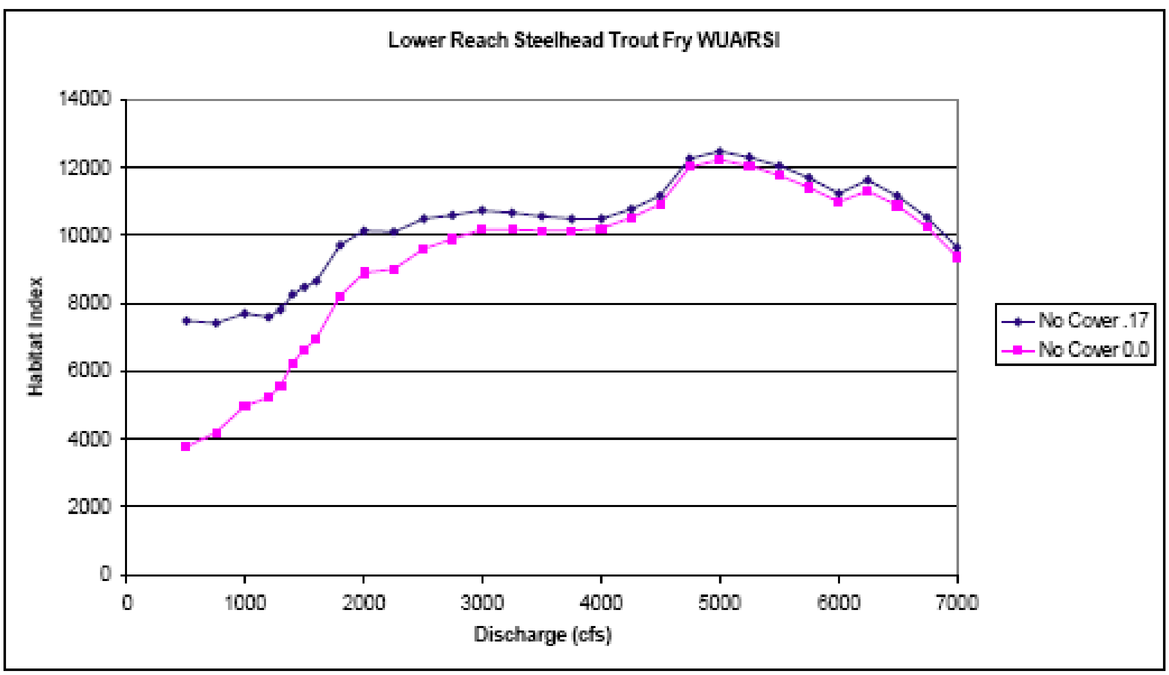

Figure 2-77. Weighted Usable Area Curves for CCV Steelhead Fry in the HFC

For steelhead juveniles (*i.e.*, >50mm), WUA/RSI values (Figure 2-42) vary depending upon how cover affects habitat suitability, but generally increases with more flow between 150 and 3,000 cfs. Generally, habitat indices reach maximum usable areas at 1,000 cfs with small incremental improvements between 1,000 and 3,000 cfs (Payne and Allen 2005). Minor variations in the indices within the total flow range are a result of variability in channel margin areas and are not believed to be significant (Department of Water Resources 2005b).

Figure 2-78 shows weighted usable area curves for CCV steelhead juveniles in the HFC.

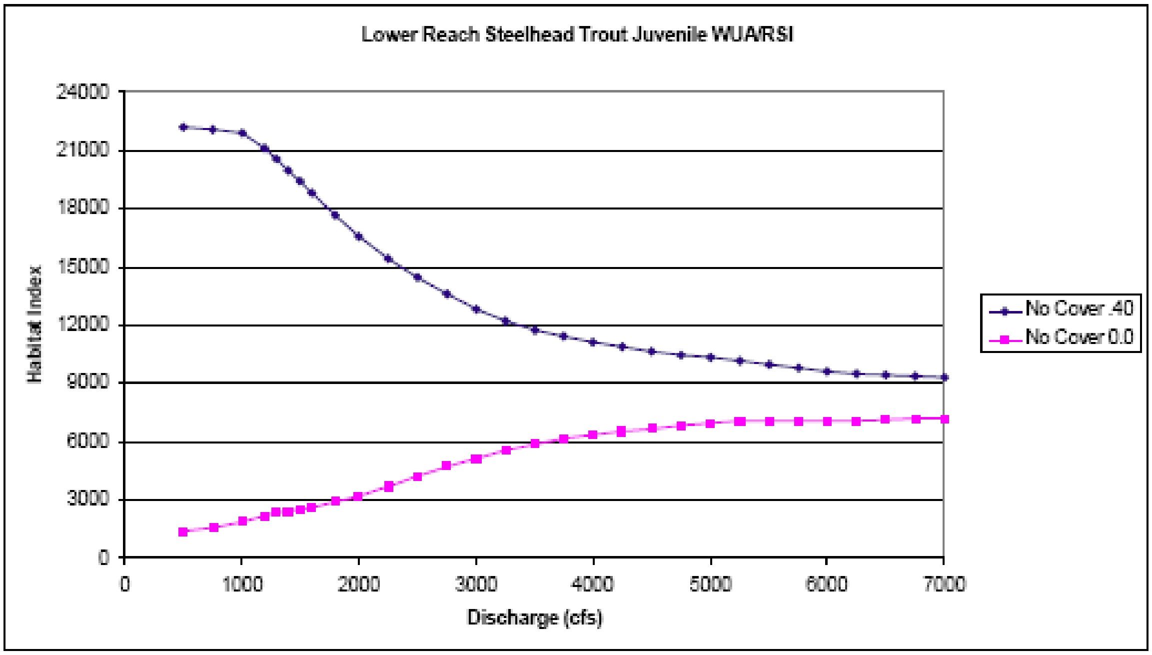

Figure 2-78. Weighted Usable Area Curves for CCV Steelhead Juveniles in the HFC

In all cases, forecasted project flows do not maximize WUA/RSI, but are near maximum limits. Additionally only a few riffles support CCV steelhead spawning and rearing. Increasing river flows will increase WUA values, but not necessarily enough to increase the number of individuals that may use the habitat, especially for spawning. Additional riffle sites would be needed to support more spawning individuals.

Most CCV steelhead spawning and early rearing appears to occur in the LFC in habitats associated with well vegetated side channels (Seesholtz et al. 2003). Recent CCV steelhead redd surveys (Cavallo et al. 2004) found that nearly half of all redds were constructed in the one mile immediately below the Fish Barrier Dam, and recent snorkel surveys by DWR show that most newly emerged CCV steelhead fry are rearing in the uppermost portions of the LFC (Seesholtz et al. 2003). The remaining spawning and rearing primarily occurs in one additional side-channel riffle complex toward the downstream end of the LFC. In 2003, a minimum population of less than 200 adults was estimated to have spawned in the Feather River. Both spawning and rearing habitats are uncommon in the Lower Feather River. This lack of available spawning and rearing habitat is likely limiting natural CCV steelhead production and juvenile rearing success and ultimately the viability of the natural spawning population.

We expect naturally spawning CCV steelhead populations to remain below viable levels because of the lack of spawning and rearing habitat for at least 10 years after license issuance until the

Gravel Supplementation and Improvement Program and the Channel Improvement Program are fully implemented. These programs are expected to incrementally increase the quality, complexity, and quantity of spawning and rearing habitat for CCV steelhead within 3 to 10 years of license issuance. Planned improvements in two existing side-channels (Moe's Ditch and Hatchery Ditch) combined with the development of five additional side-channels is expected to increase available habitat spawning and rearing habitat by 3,260 linear feet within the action area. More suitable substrate and abundant instream and overhead cover generally associated with side-channels is expected to provide better juvenile CCV steelhead rearing habitat than that found in the main channel of the Feather River. Also, improved or additional side-channels are expected to provide additional spawning and juvenile rearing habitat for CV spring-run Chinook salmon. It is not yet known, however, how many CCV steelhead the improved habitat will support.

As with CV spring-run Chinook salmon, down ramping can result in gravel bar stranding and pothole stranding of juvenile CCV steelhead. Down ramping from high flow events, or due to maintenance operations can result in both types of stranding. Gravel bar stranding can be minimized by down ramping slowly enough to allow juvenile salmonids to follow the receding water elevation. Pothole stranding can only be reduced through limiting down ramping events that connect pothole type habitats.

In the LFC, good rearing temperatures are never exceeded. Rearing and outmigration temperatures at the downstream end of the project boundary are below 65ºF and generally are between 52ºF and 62ºF. Further downstream, suitable juvenile migration temperatures are not exceeded until June, when few if any outmigrating CCV steelhead would be present. Temperatures necessary to facilitate smoltification are exceeded from March through May during normal and dry years.

2.4.6.1.8 California Central Valley Steelhead Responses During Juvenile Rearing

The HFC minimum instream flows during the juvenile rearing period are substantially lower than the maximum WUA/RSI of 12,000 cfs for fry and 21,000 cfs for juveniles greater than 50 mm. This is largely the result of managed river releases limiting floodplain inundation and activation and probably results in lower growth rates and survival. We expect this separation from floodplains to reduce the growth and survival of rearing and migrating juvenile CCV steelhead.

Depending on the magnitude or duration of flow fluctuations for flood control or dam safety, there is a potential for fry and juvenile CCV steelhead to become stranded. As identified above for CV spring-run Chinook salmon, the 1983 ramping rate agreement between DWR and DFG and the ramping rates included in section *1.3 Proposed Action* are expected to minimize impacts to juvenile CCV steelhead from stranding in the LFC and HFC.

Past flow fluctuations for flood control or dam safety inspections have resulted in fry and juvenile CCV steelhead being stranded. Gravel bar and pothole stranding is expected to be similar to that for CV spring-run Chinook salmon. However, past studies (Hunter 1992) have identified that down ramping rates at which juvenile CCV steelhead are protected are slightly higher than those for Chinook salmon. DWR assumes that rearing juveniles are susceptible to stranding in the HFC when flows decrease by more than one-half over a 7-day period when flows fluctuate between 8,000 and 1,000 cfs.

Between 1980 and 2009, such conditions have occurred 16 times in the January through June rearing season. The significance of these stranding losses is unknown because very little is known about CCV steelhead abundance and migration trends in the Feather River. However, as with CV spring-run Chinook salmon, we do expect mortality of stranded fish.

Many fish follow receding flows, however, and avoid being trapped and demonstrate greater rates of growth from rearing in off-channel habitats. Sommer et al. (2001b) described that flooding of the Yolo Bypass and relatively gradual water stage reductions likely helps promote successful emigration of young salmon. Jeffres et al. (2008) clearly demonstrated increased growth of juvenile Chinook salmon on floodplains and off-channel rearing habitats in the Cosumnes River. Sommer et al. (2001b) also showed higher growth rates in fish using the flooded Yolo Bypass versus the Sacramento River.

The Riparian and Floodplain Improvement Program would develop a phased program plan within 6 months of license issuance, with the objective of enhancing riparian and floodplain habitats on the Lower Feather River to improve growth and survival conditions for juvenile salmonids. Specific project designs and implementation of program elements will be completed within 15 (phases 1 and 2 for one set of projects) and 25 years (phases 3 and 4 for a second set of projects) of issuance of the new license. Ultimately, this program is expected to create pulse flows capable of inundating floodplains and increasing growth and survival of individuals and will improve the viability of the Feather River population.

Temperatures for rearing conditions in the LFC are within preferred temperature ranges year-round and adverse effects to rearing juveniles are not expected in this area.

The water temperature improvement actions for the proposed action are intended to improve and stabilize water temperature regimes in the Lower Feather River. With climate change, the frequency of conference years and duration of droughts may increase. This will result in higher water temperatures. This may impact rearing steelhead. With the proposed action’s temperature criteria for the LFC, it is likely that the frequency of adverse water temperatures will be infrequent. Adverse water temperatures will occur more frequently in the lower part of the HFC, where ambient conditions will have more of an effect on water temperatures. The proposed action’s temperature criteria will provide an area of the Feather River with good water temperatures that would not exist in this area of the Feather River under natural conditions.

2.4.6.1.9 California Central Valley Steelhead Stressors and Exposures During Emigration

Outmigration temperatures at the downstream end of the project boundary are below 65°F and generally are between 52°F and 62°F. Further downstream, suitable juvenile migration temperatures are not exceeded until June, when few if any outmigrating CCV steelhead would be present. Temperatures necessary to facilitate smoltification are exceeded from March through May during normal and dry years.

2.4.6.1.10 California Central Valley Steelhead Responses During Emigration

There is currently insufficient information to specifically assess the effects of flow on CCV steelhead outmigration. Very few steelhead are captured in the rotary screw traps in the HFC and the LFC. Because of their larger size, CCV steelhead are able to avoid capture by the RSTs (Kindopp 2003). Based on the information currently available we expect that CCV steelhead will likely respond similarly to Chinook salmon and are missing natural flow cues that may result in fish responding to other migration stimulants such as water temperature, with more fish migrating during low-flow conditions and being exposed to warmer water temperatures and higher rates of predation.

Project-related flow regimes do not appear to have an effect on the timing of juvenile outmigration. Based on the extensive amount of literature regarding the importance of high spring flow events, however, the currently reduced spring hydrograph and the infrequency of high pulse flow events that inundate floodplains, we expect that juvenile survival and population abundance is reduced by project operations.

Based on the thermal requirements for CCV steelhead smolts described above, however, smolt transformation is likely inhibited from March through May, during the latter part of the migration period. Steelhead appear to be more sensitive to temperatures at this stage than Chinook salmon and also are more sensitive compared to their greater resistance to high temperatures during other juvenile stages (McCullough et al. 2001). High temperatures during the smolt transformation phase can result in outright lethality, premature smolting, blockage of seaward migration, desmoltification, shifts in emigration timing, resulting in decreased survival in the marine environment or other stresses detrimental to fitness (McCullough et al. 2001).

Water temperatures that prohibit smoltification likely have a population-level response. To provide a thermal regime protective of smoltification, temperature should follow a natural seasonal pattern (Wedemeyer et al. 1980). Varying temperatures are common in the natural environment, and fluctuating temperatures are more stimulating to CCV steelhead smoltification than constant temperatures (Zaugg and Wagner 1973, Wagner 1974).

During the CCV steelhead downstream migration period, the proposed action’s temperature criteria will represent an improvement over water temperatures during recent years. Due to the utilization of the coldwater in Lake Oroville, the proposed action also likely represents cooler temperatures than natural conditions. While these temperatures are higher than ideal for smoltification, steelhead turn into smolts in the Delta, downstream of the Feather River. Water quality in the Delta is affected by many other influences.

2.4.6.2 Feather River Fish Hatchery Effects

The FRFH has raised CCV steelhead since its inception. Over the years the hatchery has released 10 million CCV steelhead juveniles. Recent spawning escapements to the Feather River have averaged about 1,800 CCV steelhead (hatchery only). By comparison, in the decade prior to the construction of Oroville Dam the runs averaged a few hundred CCV steelhead (Painter et al. 1977).

It is not possible with the available data to determine if the hatchery system has reduced the fitness (overall survivability) of CCV steelhead. The literature, particularly for steelhead, suggests that such a reduction in fitness is highly likely due to changes in individual growth, survival, and reproductive success over time (Brown et al. 2004).

2.4.6.3 Proposed Conservation Measures

The effects of the conservation measures described under CV spring-run Chinook salmon will be similar for CCV steelhead.

2.4.6.4 Summary of Effects on CCV Steelhead

The most significant stressors affecting CCV steelhead population abundance and diversity in the Lower Feather River are primarily related to loss of access to historic habitat and restriction to highly altered habitat, limited spawning habitat in the LFC, the co-occurrence with hatchery CCV steelhead during the spawning season, and the impaired hydrograph. These stressors are affecting behavior, growth, and survival of individuals and the abundance and life history and genetic diversity of the population.

2.4.6.5 Effects of the Proposed Action on Steelhead Critical Habitat

The proposed action includes a number of measures to improve the PBF of this degraded habitat. The proposed action includes SA Article A108, *Instream Flow and Water Temperature Requirements for Anadromous Fish*, which requires a reconnaissance study. The reconnaissance study will evaluate the potential facilities modifications to address water temperature and habitat needs for anadromous fish in the LFC and HFC. Following this reconnaissance study, a feasibility study and implementation plan is to be completed within three years of license issuance. It is anticipated that facilities modifications, combined with the proposed immediate increases in minimum instream flow and decreased maximum water temperature targets will provide greater stability and flexibility for water temperature management in the Feather River, which will improve the ability of the Oroville Facilities to meet water temperature criteria in the LFC and HFC. The measures will improve the ability to meet the new temperature requirements. While the measures will improve the ability to meet temperature requirements more frequently, when the effects of climate change over the next 50 years are applied to these temperature regimes, we assume that the frequency of dry water year conditions will incrementally increase. This means that the modifications will improve water temperatures over the term of the license, but that the frequency of conference years will increase. The new minimum flows and habitat improvement measures will increase the amount of available spawning and rearing habitat.

2.4.6.5.1 Adult Migratory Corridors

The Oroville Facilities proposed action will impact the adult migratory corridor for CCV steelhead through altered flows and water temperatures. During implementation of some of the habitat enhancement measures (e.g. gravel supplementation) some adults may experience disturbance to the migration corridor due to construction activities, but passage routes will be present. The current biological value of adult migration corridors downstream of the Fish Barrier Dam will be improved over the existing conditions as result of the Lower Feather River Habitat Improvement Program. The program will be implemented through the period of the license and will incrementally improve migration corridors through improved temperature management and flow conditions that will facilitate and support adult upstream migration cues.

2.4.6.5.2 Spawning Habitat

The proposed action will impact spawning habitat through its influence on water temperature, flow-related habitat availability, and bed load supply and transport characteristics. The proposed action includes several measures designed to incrementally improve this PBF. Spawning habitat within the geographic scope of designated critical habitat will increase in quantity and quality through implementation of the Gravel Supplementation and Improvement Program.

Some short-term adverse effects to critical habitat PBFs are likely to occur during implementation of the proposed action. Although the action area's water quality has some potential to be negatively impacted, implementation of BMPs make this very unlikely to occur. Gravel augmentation, floodplain and side channel enhancement, and placement of instream habitat structures may cause a temporary increase in turbidity and may redistribute and deposit silt or sand downstream of project sites in the Feather River, which could temporarily degrade current spawning gravel. BMPs will be employed during implementation of the proposed action so that any effects to spawning gravel will be minimized. Implementation of these BMPs is expected to ensure these potential effects are insignificant, and these potential effects are not expected to reduce the value of designated critical habitat for the conservation of the species.

The proposed action will continue to confine CCV steelhead to spawning habitat downstream of the Fish Barrier Dam. The proposed action includes activities to address the adverse effects from the Oroville Facilities to the spawning habitat downstream of the Fish Barrier Dam. Activities in the proposed action addressing the adverse effects on spawning habitat downstream of the Fish Barrier Dam include gravel supplementation; placement of wood; increases in minimum flows, which will increase habitat and decrease water temperatures; temperature management; and a segregation weir. DWR began implementation of the gravel supplementation in 2014. These improvements will have a positive effect on the value of this PBF for the conservation of CCV steelhead and will support the recovery of the species in the action area.

2.4.6.5.3 Rearing Habitat and Juvenile Migratory Corridors

The Oroville Facilities proposed action will impact the juvenile rearing habitat and juvenile migratory corridors for CCV steelhead through altered flows and water temperatures. There may be long-term temporary loss (two to five years to fully regrow) of some riparian habitat as a result of creating temporary access points to the river and covering vegetation with gravel, as well as removal for floodplain and side channel enhancement. Gravel augmentation methods, floodplain and side channel enhancement, and placement of instream habitat structure may impact riparian vegetation along the channel margin. Overall, some of the riparian vegetation that will be lost from access roads and restoration activities will be for an extended time. Loss of riparian vegetation may reduce food availability for fish (from reduced leaf and insect input to the aquatic habitat) until it is restored. In addition, physical disturbance to rearing habitat will occur, and be unavailable for use during implementation of gravel augmentation, floodplain and side channel enhancement, or instream habitat structure placement, but this will be temporary and adjacent suitable habitat is available.

The Oroville Facilities will impact rearing habitat and juvenile migratory corridors through its influence on water temperature, flow-related habitat availability, and bed load supply and transport characteristics. Although impaired by past operations of the Oroville Facilities, which will continue until conservation measures are implemented as described above, the biological value of juvenile rearing corridors in the Lower Feather River will be incrementally improved over existing conditions through the Lower Feather River Habitat Improvement Program. This plan includes gravel supplementation, side channel habitat improvements, placement of large woody material, increased minimum flows, and improvements in water temperatures. Through these measures the program will address the impaired biological value of juvenile rearing habitat and migration corridors in the Feather River downstream of the Fish Barrier Dam and will support the recovery of the species in the Feather River.

2.4.7 Green Sturgeon

Southern DPS Green sturgeon are also expected to be exposed to effects of the proposed action in the Feather River, although the details about their presence, utilization, and status are not as clear as with salmon and CCV steelhead.

Based on data from acoustic tags (Heublein et al. 2008), adult sDPS green sturgeon leave the ocean and enter San Francisco Bay between January and early May. Migration through the bay/Delta takes about one week and progress upstream is fairly rapid to their spawning sites (Heublein et al. 2008). Adult sDPS green sturgeon may be present through the following January (Heublein et al. 2008). This includes the migration, spawning, and post-spawn holding life stages. Spawning, egg incubation, larval development, and early larval rearing occur from April through mid-June (Poytress et al. 2013b). These stages are considered to be the most sensitive to temperature exceedances outside of optimal ranges. Juvenile and sub-adult life stages may be present year-round, but are not particularly sensitive to temperatures below the lethal level of 73.5°F.

Water temperature modeling data were available for numerous locations in the Feather River, including the Thermalito Afterbay Outlet pool and the downstream end of the project boundary. Modeling data were not specifically available for the Gridley Bridge, but data from Honcut Creek (located approximately 6 miles downstream from Gridley) were reviewed to infer trends in temperature change progressing downstream from the project boundary. Honcut Creek also may provide representative information for early larval and juvenile rearing. These life stages drift downstream from spawning sites and are also sensitive to similar temperatures indices as spawning and egg development.

Considerable lab research has determined the temperature preferences for various life stages and this information has a high degree of certainty with few limitations (Israel 2009). The water temperature analysis of this biological opinion evaluates the known temperature responses and thresholds of green sturgeon during the adult migration and spawning period based on simulated water temperatures using water temperature indices for different life stages.

The water temperature requirements of green sturgeon were described in section *2.2 Rangewide Status of the Species and Critical Habitat* of this Opinion, and baseline water temperatures were discussed in section *2.3 Environmental Baseline* of the Opinion. Similar to the application of these temperatures for salmon and steelhead, these index values are useful to establish as screening tools for identifying potential conditions that are suitable, optimal, stressful, or lethal to anadromous fish. They are not meant to be considered as absolute thresholds.

Table 2-27. Green Sturgeon Water Temperature Index Values That Are Used as Technical Analytical Guidelines for This Biological Opinion

Life Stage	Period	Water Temperature Index Values	Rationale
Adult Immigration and Holding	March–November	< 73.5°F	Recent tagging studies on the Sacramento River. Adult migration and holding life stages are not considered to be particularly sensitive to water temperature. The upper limit is the most important for survival.
Spawning and Egg Incubation	April–June Peak: April–May	57–64°F	Temperatures greater than 63°F are suboptimal (Pacific States Marine Fisheries Commission 1992). Laboratory studies concluded that 63-64°F are upper limit of thermal optima (Van Eenennaam et al. 2005). Temperatures greater than 68°F are lethal to eggs (Cech Jr et al. 2002).
Juvenile Rearing	Year Round	65–75°F	Optimal for juvenile growth (Allen et al. 2006).

Table 2-28. Green Sturgeon Temperature Tolerances

green sturgeon - Feather River																																																
values in degrees Fahrenheit																																																
eggs/larvae																																																
October-April	no eggs present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
May-July	eggs possibly present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
August-September	no eggs present	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
Juveniles																																																
October-September	juveniles possibly pres	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
adults																																																
October-April	holding or absent	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
May	possible spawning	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
June	peak spawning	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
July	possible spawning	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
August-September	holding or absent	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81

Green=optimal yellow=acceptable orange=impaired fitness red=likely lethal black=lethal

2.4.7.1 Green Sturgeon Stressors, Exposure, and Responses

Below is a table summarizing sDPS green sturgeon stressors, exposures, and responses, which does not include expected responses to proposed action conservation measures.

Table 2-29. Exposure and Summary of Responses of sDPS Green Sturgeon to the Proposed Action

Life Stage/ Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
Adult Migration and Holding				
The Feather River from the confluence with the Sacramento River to and from historic habitat above Oroville Dam	Blockage of the Feather River Migratory Corridor by Fish Barrier Dam, Oroville Dam	March-October (upstream and downstream migration included)	March-October	Blocked access to historical habitat upstream from Oroville Dam (by blocking upstream migration of adults, all other life stages that would have used this habitat also are affected). Reduced availability of holding habitat. Reduced reproductive success, reduced abundance.
Lower Feather River from the confluence with the Sacramento River, upstream to the Thermalito Afterbay Outlet	Blockage of the Migratory Corridor from low flows at Sunset Pumps (RM 38.5)	March-June upstream passage only	Peak exposure: March-May	Blocked access to spawning habitat in the Lower Feather River. Migration delays, reduced reproductive success, reduced abundance.
Deep pools between The Fish Barrier Dam Outlet (RM 67) and the Gridley Bridge (RM 50)	Water Temperatures	March-June	May - June	Affects spawning habitat selection, egg and larvae development and survival, abundance.

Life Stage/ Location	Stressor	Life Stage Timing	Period of Anticipated Potential Exposure to Stressors	Response to Exposure
Juvenile Rearing				
Thermalito Afterbay Outlet pool downstream to the Sacramento River	Predation	Year-round	Year-round	Survival and abundance

Given the scarce, but recently developing data on sturgeon in the Feather River, the discussion of specific effects of water temperature on green sturgeon is based on supportable assumptions and recent confirmed information that green sturgeon are spawning and reproducing within the action area. Considerable lab research has determined the temperature preferences for various life stages and this information has a high degree of certainty with few limitations (Israel 2009). The water temperature analysis of this Opinion evaluates the known temperature responses and thresholds of green sturgeon during the adult migration and spawning period based on simulated water temperatures using water temperature indices for different life stages.

Based on observations of sDPS green sturgeon in the Feather River, and the size of the channel above the Thermalito Afterbay Outlet pool, we have assumed that the potential for spawning is limited to deep pools in the HFC from the Thermalito Afterbay Outlet pool (RM 59) downstream to the vicinity of the Gridley Bridge (RM 50). Confirmed green sturgeon information from 2011 shows that individuals were present at the upstream extent of the LFC during spawning months. We have interpreted this presence, and the presence of green sturgeon in the LFC in previous years, as evidence that green sturgeon are migrating upstream into the LFC as part of their normal migration behavior to seek out suitable spawning habitat for reproduction.

Water temperature modeling data were available for numerous locations in the Feather River, including the Thermalito Afterbay Outlet pool and the downstream end of the project boundary. Modeling data were not specifically available for the Gridley Bridge, but data from Honcut Creek (located approximately 6 miles downstream from Gridley) were reviewed to infer trends in temperature change progressing downstream from the project boundary. Honcut Creek also may provide representative information for early larval and juvenile rearing. These life stages drift downstream from spawning sites and are also sensitive to similar temperature indices as spawning and egg development.

Adult green sturgeon are expected to be present in the Feather River between March and November. This includes the migration, spawning, and post-spawn holding life stages. Spawning, egg incubation, larval development, and early larval rearing occur from April through July. These stages are considered to be the most sensitive to temperature exceedances outside of optimal ranges. Juvenile and sub-adult life stages may be present year-round, but are not particularly sensitive to temperatures below the lethal level of 73.5°F. The peak spawning period is probably April and May with spawning occurring later in the year into June. Early larval development and juvenile rearing stages are present into July.

2.4.7.1.1 Adult sDPS Green Sturgeon Migration and Holding Stressors and Exposure

Adult sDPS green sturgeon may migrate upstream to spawn from March through June, with peak migration occurring from March through May. The peak spawning period is probably April and May with spawning occurring later in the year into June. Larval development and juvenile recruitment continue into July, followed by juvenile rearing and a slow outmigration to the lower river that may occur over a year's time.

This analysis reviews the exposure of sDPS green sturgeon in the Feather River to the proposed flow regime and habitat conditions based on the best available information from the Feather and Sacramento Rivers. Green sturgeon spawning occurs in deep pools in large, turbulent river mainstreams (Moyle et al. 1992). Observations of sDPS green sturgeon in the Feather River have occurred from RM 67 in the LFC downstream to near the confluence with the Sacramento River in the HFC. Most observations are at the Thermalito Afterbay Outlet, which has turbulent hydraulic conditions and deep pools that attract sDPS green sturgeon for holding and spawning. Holding, spawning, and early rearing is expected to occur in the LFC and the HFC, but the exact downstream extent of spawning is not known.

Successful migration of adult green sturgeon to and from spawning grounds is dependent on sufficient water flow and spawning success is associated with water flow and water temperature compared to other variables (NMFS 2009). As described in the *Status of the Species* section of this biological opinion, spawning in the Sacramento River is believed to be triggered by increases in water flow to about 14,000 cfs (Brown 2007). Post-spawning downstream migrations are triggered by increased flows, ranging from 6,150-14,725 cfs in the late summer (Vogel 2005) to greater than 3,550 cfs in the winter (Erickson *et al.* 2002, Benson *et al.* 2007). The current suitability of these flow requirements is almost entirely dependent on releases from Shasta Dam. High winter flows associated with the natural hydrograph do not occur within the section of the river utilized by green sturgeon with the frequency and duration that was seen in pre-dam conditions. A similar situation is expected in the Feather River because the green sturgeon in the Feather River presumably would have the same life history needs and migration cues as in the Sacramento River.

Mora et al. (2009)_ENREF_188 conducted modeling comparing green sturgeon usage of nearby rivers based on a small number of habitat elements (flow, gradient, and air temperature) that gives some indication that historically, without impassable dams and altered hydrographs, sDPS green sturgeon would have utilized portions of the lower Feather River. Mora's modeling further estimates that approximately 16 ± 4 km (10 ± 2.5 miles) of habitat may have been blocked or inundated by Oroville Dam. As a result, sDPS green sturgeon are now limited to the lower Feather River, downstream of the Fish Barrier Dam. Southern DPS green sturgeon spawning has been documented only at the Thermalito Afterbay Outlet pool (RM 59) (Seesholtz et al. 2015). The amount of available habitat can vary depending on season and water temperature.

Due to Oroville Facilities operations, high winter flows associated with the natural hydrograph no longer occur within the section of the river utilized by green sturgeon with the frequency and duration that was seen in pre-dam conditions. Minimum instream flows during the upstream migration period will continue to be reduced by 86, 90, 88 and 76 percent of average pre-dam monthly flow for March, April, May and June, respectively, in the LFC, and 71, 85, 83 and 66 percent in the HFC for the same months.

The USFWS working paper on restoration needs, volume 3 (1995b) described that good sDPS sturgeon recruitment, as measured in the Delta fish salvage facilities, occurred during years when mean monthly flow ranged from 3,488 to 20,505 cfs at Gridley (RM 50, approximately 4 miles downstream from the Project Boundary), and 7,028 to 35,234 at Nicolaus. They recommended providing mean monthly February through May flows of at least 7,000 cfs at Gridley and at least 11,500 cfs at Nicolaus during above normal and wet water years. These flows were recommendations based on salvage in the Delta and are not based on production estimates from the Feather River.

As summarized in the *Final Assessment of Potential Sturgeon Passage Impediments*, (Niggemyer and Duster 2003), there were three potential physical upstream migration barriers for sturgeon in the Feather River. They were identified and field evaluated during representative low flow (November 2002, approximately 2,074 cfs) and high flow (July 2003, approximately 9,998 cfs) conditions by a team of selected sturgeon passage experts. The three potential physical upstream migration barriers included Shanghai Bench (RM 25), Sunset Pumps (RM 38.5), and Steep Riffle (located two miles upstream of the Thermalito Afterbay Outlet) (U.S. Fish and Wildlife Service 1995). After a site visit by agency biologists, Steep Riffle was subsequently removed from the list of potential impediments and is no longer considered to present a passage problem. Shanghai Bench was altered in 2011 and is no longer a potential fish passage barrier. The evaluations at these sites are preliminary. A definitive evaluation of the passage constraints at each of the potential passage barriers in the lower Feather River is not possible without a greater understanding of sturgeon migration patterns and physiologic limitations (Niggemyer and Duster 2003).

A team of experts examined flows over Sunset Pumps weir at approximately 2,074 cfs and 9,998 cfs (Niggemyer and Duster 2003). The conclusion was that at the low flows the weir at Sunset Pumps is a likely sturgeon passage barrier due to the height of the falls and water velocities. DWR green sturgeon scientists have reviewed passage flows in the lower Feather River and have determined that flow ranging from 2,500 to 3,000 cfs would be needed for sDPS adult green sturgeon passage at Sunset Pumps. At Sunset Pumps, the existing hydrologic record from 1968 through 2008 shows that 2,500 cfs flows lasting for two or more days between the months of March and May occurred during 72 to 76 percent of years, with the average number of days when the flows exceeded these levels ranging from 18 to 24 days per month. Based on these flow frequencies and the observations of sDPS green sturgeon in the Feather River during a broad range of water year types, it appears that although suitable passage conditions occur during most years, low flows during dry or critically dry water year types may block or delay migration. Observations of sDPS green sturgeon above Sunset Pumps during dry and critically dry years, however, suggests that passage is not completely blocked.

Regardless of the passage flows that are needed to facilitate upstream movement past impediments and barriers, sturgeon upstream migrations appear to coincide with high river flow conditions during the spring.

On February 4, 2008 a tagged adult green sturgeon entered the Feather River and was detected at Beer Can Beach (below Shanghai) for 5 hours, then left and headed up the Sacramento River. Flow at Shanghai was slightly less than 2,000 cfs. On May 15, 2010, a tagged adult green sturgeon entered the Feather River and was detected at Star Bend (below Shanghai). It appears that this fish went further upstream, but not above Shanghai Bench before returning downstream passing Star Bend on May 17, and then back into the Sacramento to head up to spawn. Feather River flow at Shanghai was around 2,400 cfs.

In 2006, it appears that there was a run of green sturgeon in the Feather River. A single fisherman reportedly caught 24 adult green sturgeon at the Thermalito Outlet. The fishery lasted primarily from May through June. Green sturgeon were also observed below Daguerre Point Dam on the Yuba River. In 2011, green sturgeon were caught and seen jumping at the Thermalito Outlet on April 5 to 6. On April 9, a DIDSON was used to record about a dozen sturgeon at the Thermalito Outlet and one sturgeon was detected at Fish Barrier Dam, located at the upstream end of the low flow channel. As shown in Figure 2-79, Feather River flows were in the tens of thousands of CFS during these years.

Based on this information, flows similar to what occurred in 2008 and 2010 are restrictive and do not support green sturgeon attraction to and production in the Feather River. Flows more similar to the 2006 and 2011 water years are needed to attract, hold, and provide adequate conditions for successful spawning and rearing of green sturgeon in the Feather River. Of course sufficient data are not available to specifically determine where the line could be drawn regarding flow needed to attract, hold, and provide adequate conditions for successful spawning and rearing of green sturgeon in the Feather River, but 7,000 cfs at Gridley does not appear to be enough.

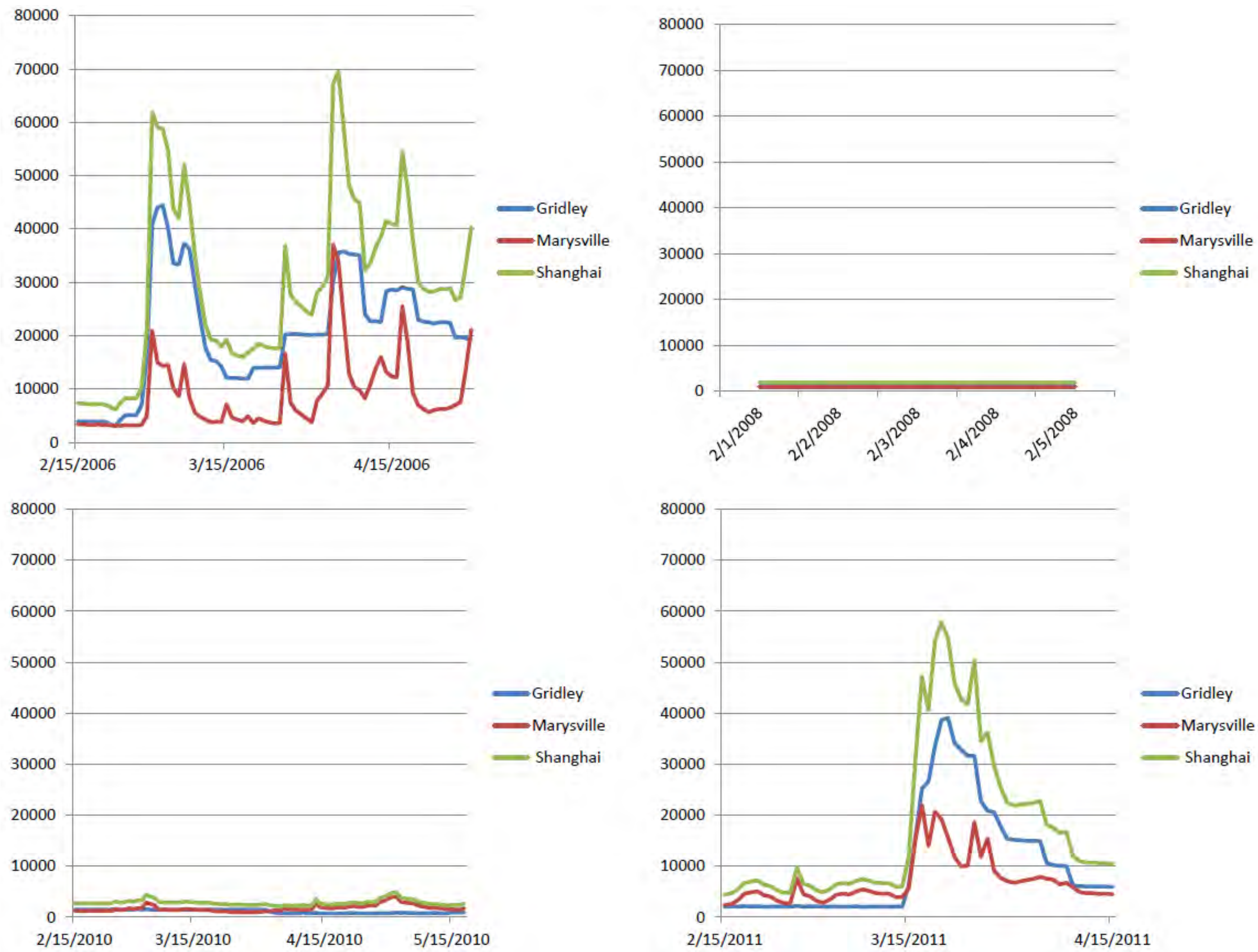

Figure 2-79. Flow distribution comparison of water years when adult green sturgeon were present in greatest known abundance (2006 and 2011) and years when green sturgeon abandoned upstream migration into the Feather River (2008 and 2010).

2.4.7.1.2 SDPS Green Sturgeon Spawning Stressors and Exposure

WUA curves and other carrying capacity or production models are not available for green sturgeon, so we do not have any data to review the flow and spawning habitat relationships for this species. Similarly, there currently is insufficient information to conclusively determine how the continued bedload depletion associated with the presence and operation of Oroville Dam will affect the spawning habitat. Although bedload size and coarseness is increasing in the LFC, Sommer et al. (2001b)_ENREF_283 reported that surface and subsurface bed particle surveys in the HFC have not shown a measurable change in size since the construction of the Oroville Facilities.

As described in section *2.3 Environmental Baseline*, during March and April water temperatures can support spawning from RM 67 downstream to RM 39, but in May and June, water temperatures are only suitable for sDPS green sturgeon spawning downstream to an area between RM 51 and RM 54.

2.4.7.1.3 SDPS Green Sturgeon Spawning Responses

Green sturgeon have been observed in the LFC during spawning and pre-spawning periods. Water temperature exceedance distributions are shown in Figure 2-80, Figure 2-81, and Figure 2-82. Water temperatures are generally below 64°F, except for 5 to 10 percent of years (dry water years) when temperatures may be exceeded at the downstream end of the LFC at Robinson Riffle. Egg mortalities are possible in July of dry years in approximately two miles of the LFC from Robinson Riffle downstream to the Thermalito Afterbay Outlet pool.

At this time, it does not appear that the project is having an adverse effect on spawning habitat substrate. There is survey data and information available from DWR that shows the amount and extent of sDPS green sturgeon spawning habitat that is present in the LFC and the HFC (Bratovich 2004). DWR estimates that that there are up to 12 deep holes across 13 miles of habitat from the Fish Barrier Dam at RM 67 downstream to RM 54, with characteristics capable of attracting and supporting sDPS green sturgeon spawning. Seven of these holes are greater than 5 meters deep, and five of the pools are between 3 and 5 meters. The total area of the pools is greater than 164,500 m^2.

2.4.7.1.4 Adult sDPS Green Sturgeon Migration and Holding Responses

Based on observations of sDPS green sturgeon in the Feather River, and the size of the channel above the Thermalito Afterbay Outlet pool, we have concluded that the potential for spawning is limited to deep pools in the HFC from the Thermalito Afterbay Outlet pool (RM 59) downstream to the vicinity of the Gridley Bridge (RM 50). Confirmed green sturgeon information from 2011 shows that individuals were present at the upstream extent of the LFC during spawning months. We have interpreted this presence, and the presence of green sturgeon in the LFC in previous years, as evidence that green sturgeon are migrating upstream into the LFC as part of their normal migration behavior to seek out suitable spawning habitat for reproduction.

The proposed action includes water temperature targets and criteria at the downstream end of the project boundary (approximately five miles downstream from the Thermalito Afterbay Outlet) that range from 56°F to 64°F and are within the optimal range for adult migration and holding, spawning and egg incubation. Optimal conditions are expected to be met within the Project Area Boundary from March through May, with exceedance of 63°F occurring in only 2 percent of days in May at the downstream project boundary.

2.4.7.1.5 Juvenile Rearing sDPS Green Sturgeon Stressors and Exposure

Spawning, egg incubation, larval development, and early larval rearing occur from April through July. These stages are considered to be the most sensitive to temperature exceedances outside of optimal ranges. Juvenile and sub-adult life stages may be present year-round, but are not particularly sensitive to temperatures below the lethal level of 73.5°F. Early larval development and juvenile rearing stages are present into July.

Water temperature modeling data were available for numerous locations in the Feather River, including the Thermalito Afterbay Outlet pool and the downstream end of the project boundary. Modeling data were not specifically available for the Gridley Bridge, but data from Honcut Creek (located approximately 6 miles downstream from Gridley) were reviewed to infer trends in temperature change progressing downstream from the project boundary. Honcut Creek also may provide representative information for early larval and juvenile rearing. These life stages drift downstream from spawning sites and are also sensitive to similar temperatures indices as spawning and egg development.

Early larval development and juvenile rearing stages are present into June and in some cases July (Table 2-8 in Allen et al. 2006). Water temperature values for locations within the HFC are shown in numerous figures above and in Figure 2-80 to Figure 2-82 below. These figures show temperature ranges and exceedances that would occur without implementation of operational or facility modifications as proposed in Article 108 of the Settlement Agreement. These ranges and exceedance values are expected to occur for the first 10 years of the license until modifications are in place that would reduce water temperature peaks and exceedance values.

Figure 2-80 depicts daily mean temperature exceedance curves for April.

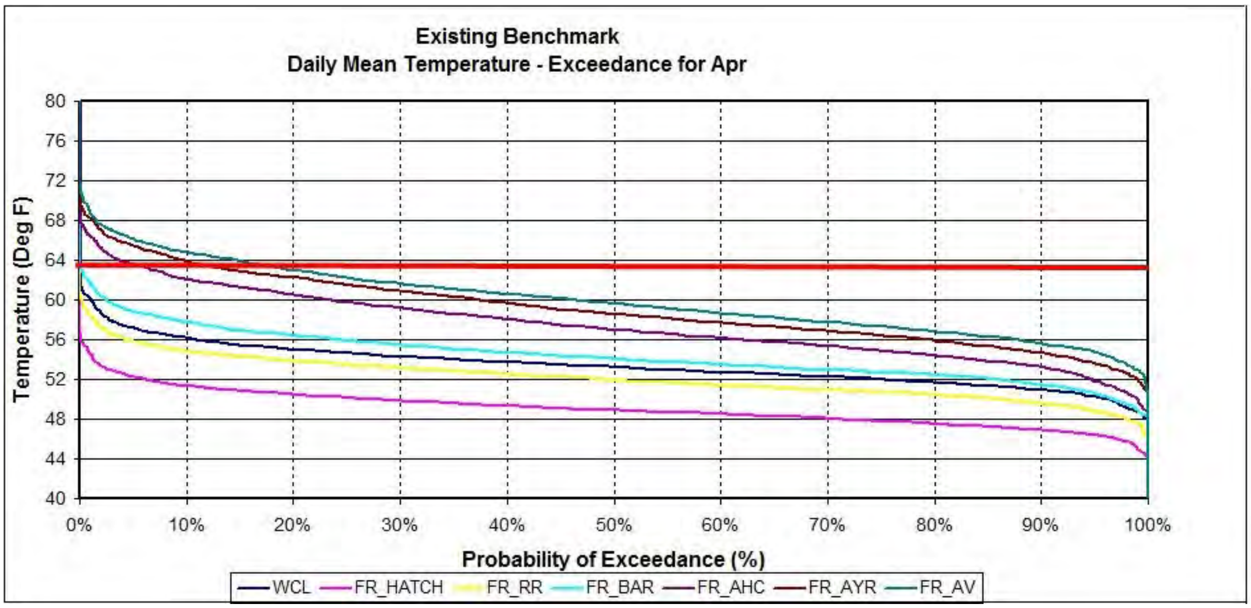

Figure 2-80. Daily Mean Temperature Exceedance Curves for April

WCL=Western Canal, FR_Hatch=Feather River Hatchery, FR_RR is Feather River at Robinson Riffle, FR_BAR=Feather River at Thermalito outlet, FR AHC= Feather River at Honcut Creek, FR_AYR=Feather River above Yuba River, and FR_AV=Feather River and Verona (near the confluence with the Sacramento River). The red line depicts the spawning, egg and larvae development, and early juvenile rearing index value.

Figure 2-81shows daily mean temperature exceedance curves for May.

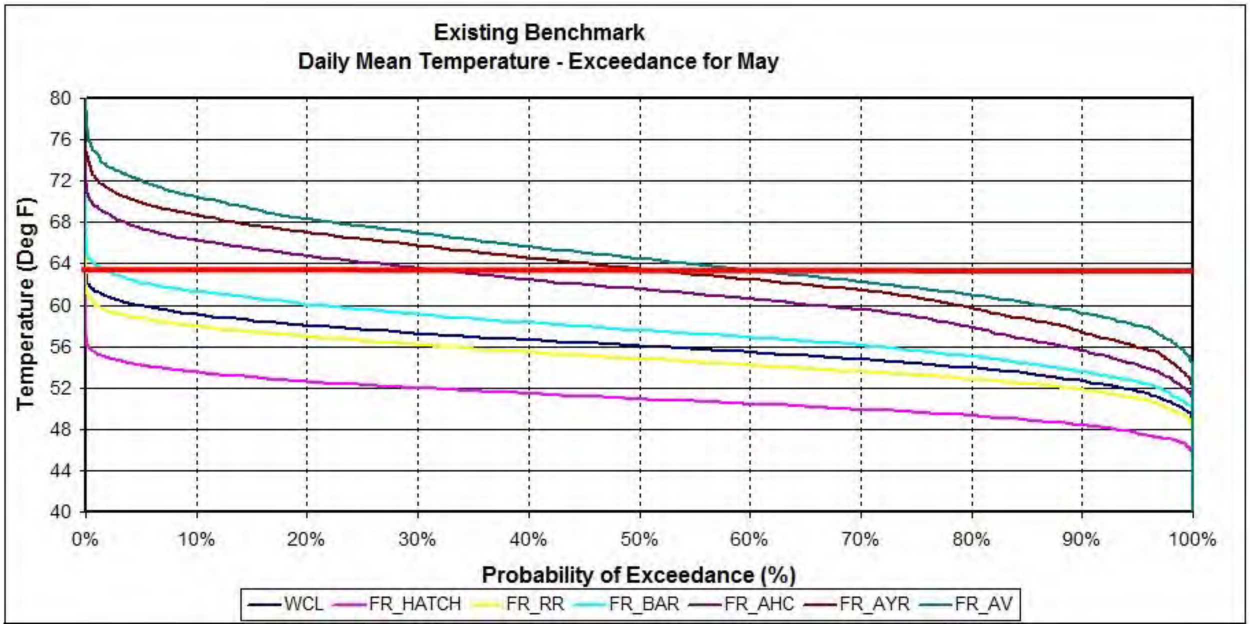

Figure 2-81. Daily Mean Temperature Exceedance Curves for May

WCL=Western Canal, FR_Hatch=Feather River Hatchery, FR_RR is Feather River at Robinson Riffle, FR_BAR=Feather River at Thermalito outlet, FR AHC= Feather River at Honcut Creek, FR_AYR=Feather River above Yuba River, and FR_AV=Feather River and Verona (near the confluence with the Sacramento River). The red line depicts the spawning, egg and larvae development, and early juvenile rearing index value.

Figure 2-82 shows daily mean temperature exceedance curves for June.

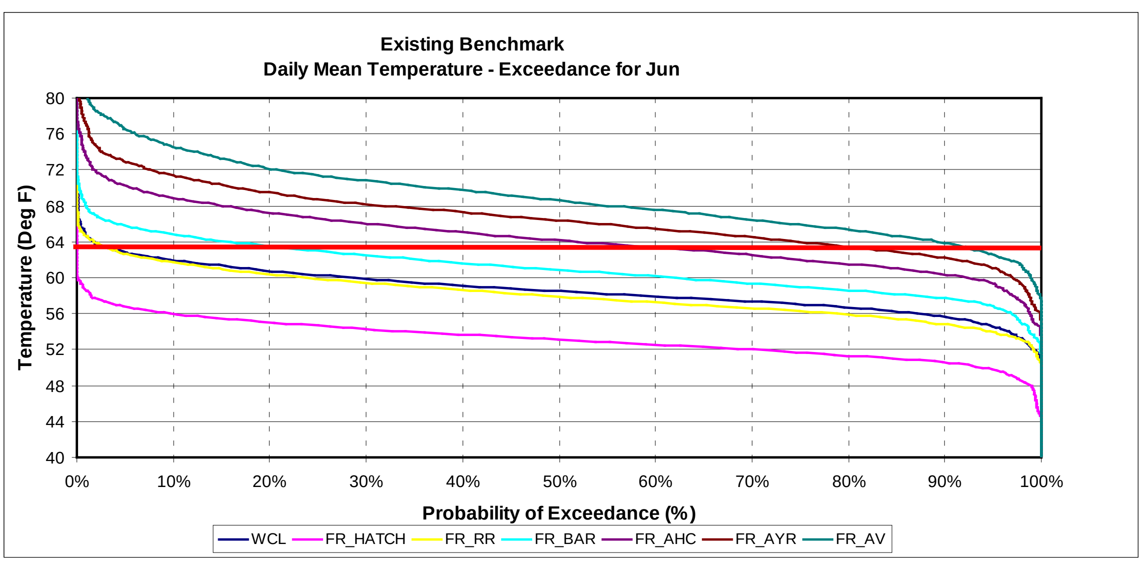

Figure 2-82. Daily Mean Temperature Exceedance Curves for June

WCL=Western Canal, FR_Hatch=Feather River Hatchery, FR_RR is Feather River at Robinson Riffle, FR_BAR=Feather River at Thermalito outlet, FR AHC= Feather River at Honcut Creek, FR_AYR=Feather River above Yuba River, and FR_AV=Feather River and Verona (near the confluence with the Sacramento River). The red line depicts the spawning, egg and larvae development, and early juvenile rearing index value.

The proposed action includes operational and facility modifications that will be used to manage water temperatures within the targets as described in Article A108 of the Settlement Agreement. Facility modifications are expected to reduce the frequency of temperatures that exceed optimal levels for sDPS green sturgeon spawning, especially in June. Preliminary modeling of potential facility modifications such as a canal around the Thermalito Afterbay or valve improvements would reduce June exceedances to only 9 to 12 percent of days. These improvements are expected to benefit sDPS green sturgeon starting at year 10 of the new license and will create spawning conditions that are expected to result in higher levels of sDPS green sturgeon production.

2.4.7.1.6 Juvenile Rearing sDPS Green Sturgeon Responses

Egg incubation, larval development, and early larval rearing occur from April through July. These stages are considered to be the most sensitive to temperature exceedances outside of optimal ranges. Juvenile and subadult life stages may be present year-round, but are not particularly sensitive to temperatures below the lethal level of 73.5°F (Table 2-9 in Allen et al. 2006).

The National Marine Fisheries Service (2008a)_ENREF_211 reported sDPS green sturgeon subadults are found in the lower Sacramento River and the Delta during summer months, suggesting that they have a wide range of temperature tolerances. Although summer temperatures may reach high levels in the lower Feather River during summer months (Figure 2-81 and Figure 2-82), due to the wide range of subadult temperature tolerances, and the observation that simulated water temperatures in the Feather River that are warmer than 73.5°F only occur after the peak of upstream migration, we do not expect any adverse water-temperature effects for migrating and holding adults or rearing juveniles.

June exceedances are more common and can occur in 22 percent of days at the downstream project boundary (as simulated over the period of record from 1964 to 1994). Most exceedances are expected to occur in dry or critically dry years, are concentrated during periods of extreme hot weather events, and occur during the second half of June, after the peak of spawning and early larval development. These conditions are expected to last for the first 10 years of the new license until facility modifications are constructed.

Project-related temperature exceedances are expected to cause an increased number of embryo abnormalities, reduced hatching success, abnormal early larval development, and death during June of dry and critically dry years, or during extreme heat events during other water year types when water temperature management is strongly influenced by external forces.

2.4.7.2 Summary

Water temperatures in the Lower Feather River from RM 67 downstream to RM 54 at the downstream project boundary are generally within optimal ranges capable of supporting all freshwater life stages of sDPS green sturgeon, but are exceeded during some years in the HFC in

May and June, and in the LFC in July. HFC exceedances are highest during the second half of June during dry and critically dry years or during extreme heat events of other water year types. This is mostly expected to affect early larval and juvenile rearing life stages during the latter half of June. Spawning habitat suitability is reduced downstream from this point with late spring and early summer water temperatures that can cause egg abnormalities and reduce hatching success.

The water temperatures appear suitable for spawning adults, and the water temperatures are suitable to support spawning during most of the spawning season, especially in above normal and wet water year types.

With facility modifications after year 10, spawning temperatures will improve, especially during June at the downstream project boundary. These improvements are expected to benefit the survival of sDPS green sturgeon and will create spawning conditions that are expected to result in higher levels of sDPS green sturgeon production.

2.4.7.3 Green Sturgeon Critical Habitat

2.4.7.3.1 Food Resources

Within freshwater riverine systems, this PBF includes abundant prey items for larval, juvenile, subadult, and adult life stages. There is insufficient information available to fully understand how the proposed action will affect the food resources of sDPS green sturgeon. However, due to the presence of macroinvertebrate and other benthic prey that green sturgeon are known to feed on, NMFS concludes that the existing biomass of aquatic invertebrates in the Lower Feather River provide adequate nutritional resources for green sturgeon rearing in the river. Because the proposed action will generally continue conditions that result in the existing biomass of aquatic invertebrates in the Lower Feather River, NMFS anticipates that the effects of the proposed action will continue to result in adequate nutritional resources for sDPS green sturgeon rearing in the river.

2.4.7.3.2 Substrate Type or Size

This PBF includes substrates suitable for egg deposition and development (*e.g.*, bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to "collect" eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (*e.g.*, substrates with interstices or voids providing refuge from predators and from high flow conditions), and subadults and adults (*e.g.*, substrates for holding and spawning). _ENREF_312Although Sommer et al. (2001a) found that substrate was becoming more coarse in the LFC, substrate size in the HFC where sDPS green sturgeon are expected to spawn has not changed in size since the construction of Oroville Dam. Therefore, the proposed action is not expected to have an adverse effect on this PBF.

2.4.7.3.3 Water Flow

As described in the *Environmental Baseline* section of this Opinion, the current suitability of flows for green sturgeon in the Feather River is almost entirely dependent on releases from Oroville Dam and the Thermalito Afterbay. High spring flows associated with the natural hydrograph do not occur within the section of the river utilized by green sturgeon with the frequency and duration that was seen in pre-dam conditions, but sufficient flow conditions exist to allow green sturgeon to migrate upstream even in dry water year types, as evidenced by the observation of adult green sturgeon in the upper river reaches below Oroville and the Fish Barrier Dams. A certain flow regime (*i.e*., magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) is necessary for normal behavior, growth, and survival of all life stages in rivers that are occupied by green sturgeon.

However, there is insufficient information available to provide a more complete analysis of the project-related effects on the Feather River's flow regime and the flow regime necessary for green sturgeon.

2.4.7.3.4 Migratory Corridors

There is one potential physical upstream migration barrier for sturgeon in the lower Feather River: Sunset Pumps (Niggemyer and Duster 2003). At low flows, Sunset Pumps are likely sturgeon passage impediments because of the height of their waterfalls, water velocities of the mid-channel chute, or lack of attraction flow within the potentially passable side channel.

2.4.7.3.5 Water Quality

PBFs for sDPS green sturgeon critical habitat in freshwater riverine systems include water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures, salinities, and dissolved oxygen levels are discussed in detail in section *2.2.1.4.32.2.1.4.3 Green Sturgeon Life History.*

Comparative analyses of historic and contemporary thermal regimes indicate that habitat in the lower Feather River is different than before the Oroville Facilities were constructed. It is less clear what affect the change has had on green sturgeon. Under laboratory conditions, Mayfield and Cech (2004) reported optimal bio-energetic performance of age 0 and age 1 Northern DPS green sturgeon from 15 to 19°C.

Contaminants in fish is another concern. Mercury, polynuclear aromatic hydrocarbons, and polychlorinated biphenyls have been detected in other species of fish in the Feather River. It is unknown what levels of these chemicals occur in green sturgeon in the Feather River, nor what levels of these chemicals may affect green sturgeon. It is not expected that the proposed action will increase the exposure of green sturgeon to these chemicals.

There is insufficient information available to provide a more complete analysis of the project-related effects on the Feather River's water quality.

2.4.7.3.6 Depth

PBFs for sDPS green sturgeon critical habitat in freshwater riverine systems include deep (≥5m) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow to maintain the physiological needs of holding adult or subadult fish. Deep pools of five-meter or more depth are critical for adult sDPS green sturgeon spawning and for summer holding. Adult green sturgeon in the Klamath and Rogue rivers occupy deep holding pools for extended periods of time, presumably for feeding, energy conservation, or refuge from high water temperatures (Erickson et al. 2002, Benson et al. 2007).

There is insufficient information available to provide an analysis of the Oroville Facilities effects on water depths in the Feather River.

2.4.7.3.7 Sediment quality

PBFs for sDPS green sturgeon critical habitat in estuarine habitats include sediment quality (*i.e.*, chemical characteristics) necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of contaminants (*e.g.*, elevated levels of selenium, PAHs, and organochlorine pesticides) that can cause negative effects on all life stages of sDPS green sturgeon (see description of *sediment quality* for riverine habitats in section *2.2.1.4.6.7 Sediment Quality*.

There is insufficient information available to provide an analysis of the Oroville Facilities effects on sediment quality for green sturgeon.

2.5 Cumulative Effects

Cumulative effects are those effects of future state or private activities not involving Federal activities, which are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR § 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA.

Non-Federal actions that that are reasonably certain to occur in the action area include: (1) angling subject to State regulations; (2) non-Federal hatchery practices; (3) continued agricultural practices; (4) water withdrawals, diversions, and transfers; (5) mining activities; (6) population growth and urbanization; (7) exposure to contaminants; (8) non-Federal bank stabilization projects; and (9) climate change.

Changes in State angling regulations have generally led to stronger protections for listed fish species. However, angling subject to State regulations still adversely affects listed fish species, and these effects are expected to continue, because there are no proposed revisions that are reasonably certain to occur at this time. For example, in 2008 the California Fish and Game Commission established a 0 bag limit for Chinook salmon on the Sacramento River system, including the Feather River, due to extremely low returns of adult fall-run Chinook salmon in 2007. However, some angling regulations persist that allow the harvest of wild trout in waters such as the upper Sacramento River. Currently, harvest of wild trout and steelhead is not allowed in the Feather River during the spawning season (catch and release is allowed). In-river losses of both CV spring-run Chinook salmon and CCV steelhead are expected to continue due to incidental hooking mortality in the inland sport fishery. Lindsay et al. (2004)_ENREF_167 found 3.2 percent of CV spring-run Chinook salmon died because of hooking mortality in Oregon. California rivers are expected to have higher rates due to generally warmer water temperatures, which can diminish the recovery rate of fish exposed to incidental hooking (National Marine Fisheries Service 2015c).

Agricultural practices within the action area are expected to continue and may degrade PBFs of critical habitat (*e.g.*, cover, water quality) through the cumulative loss of riparian habitat due to bank stabilization projects, uncontrolled run-off, or the discharge of return flows with poor water quality.

Future non-Federal water withdrawals, diversions, and transfers within the action area may affect listed fish species by entraining, injuring, or killing individual fish at unscreened, improperly screened, or poorly maintained diversions. In addition, these actions may result in depleted river flows in the lower reaches of the Feather River downstream of the Thermalito Afterbay Outlet, adversely affecting migration of adult Chinook salmon and possibly rearing of juveniles.

Depleted flows due to future non-Federal water withdrawals and diversions may also adversely affect sDPS green sturgeon occupying the lower reaches of the Feather River by limiting adult migration, holding, spawning, and rearing habitat for this species. Although most of the largest diversions within the action area have been screened to meet NMFS standards to protect salmon, a number of smaller diversions remain unscreened, largely on private lands, and may have a significant cumulative effect to listed fish species.

Future mining activities will likely include the extraction of gravel by local mining companies from dredger spoil piles left along the Lower Feather River floodplain by past dredging activities on the river. This continued mining is expected to affect water quality, riparian habitat function, and aquatic habitat productivity in the Feather River through introduction of sediment and the disturbance or destruction of riparian vegetation and other habitat features important to listed fish species.

Future population growth, urbanization, and agricultural development may adversely affect lower Feather River aquatic habitat through encroachment, point and non-point source contaminant discharges, non-Federal bank stabilization or flood control projects, and increased recreational use of the river corridor. Encroachment, bank stabilization, and flood control projects are anticipated to reduce or confine the riparian corridor along the lower Feather River and limit river channel migration, altering stream bank and channel morphology and reducing fish habitat quality and quantity. Urban and agricultural run-off is expected to introduce contaminants such as herbicides, pesticides, petroleum products and other contaminants into the river.

The world is about 1.3°F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may rise by two or more degrees in the 21st century (Houghton et al. 2001). Much of that increase likely will occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes et al. 1998). Using objectively analyzed data, (Huang and Liu 2001) estimated a warming of about 0.9°F per century in the Northern Pacific Ocean.

Sea levels are expected to rise by 0.5 m to 1.0 m along the Pacific coast in the next century, mainly due to warmer ocean temperatures, which lead to thermal expansion much the same way that hot air expands. This will cause increased sedimentation, erosion, coastal flooding, and permanent inundation of low-lying natural ecosystems (*e.g.*, estuarine, riverine, mud flats), affecting salmonid PBFs. Increased winter precipitation, decreased snow pack, permafrost degradation, and glacier retreat due to warmer temperatures will cause landslides in unstable mountainous regions, and destroy fish and wildlife habitat, including salmon-spawning streams. Glacier reduction could affect the flow and temperature of rivers and streams that depend on glacier water, with negative impacts on fish populations and the habitat that supports them.

Droughts along the West Coast and in the interior Central Valley of California are already occurring and likely to increase with climate change. This means decreased groundwater storage and stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. Warmer stream temperatures will allow for more invasive species to overtake native fish species and impact predator-prey relationships (Petersen and Kitchell 2001, Stachowicz et al. 2002).

In light of the predicted impacts of global warming, the Central Valley has been modeled to have an increase of between 2°C and 7°C (3.6°F and 12.6°F) by the year 2100 (Dettinger et al. 2004, Hayhoe et al. 2004, Vanrheenen et al. 2004, Dettinger 2005, U.S. Bureau of Reclamation 2008c) with a drier hydrology predominated by precipitation rather than snowfall. The Sierra Nevada snow pack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled. This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. Summer temperatures and flow levels will likely become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This will likely truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold water pool from melting snow pack filling behind reservoirs in the spring and early summer, water temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids that must spawn below dams over the summer and fall periods.

From 2012–2015, California experienced one of the worst droughts in the last 83 years. Salmon, steelhead, and green sturgeon populations have experienced lower egg and juvenile survival due to poor freshwater conditions (*e.g.*, low flows, higher temperatures) caused by the drought. Adult abundance of listed salmonids and green sturgeon is expected to decline significantly after 2015, given the poor conditions since 2012.

2.6 Integration and Synthesis

This *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (section *2.4 Effects of the Action*), environmental baseline (section *2.3 Environmental Baseline*), cumulative effects (section *2.5 Cumulative Effects*), taking into account rangewide status of the species and critical habitat (section *2.3.6 Rangewide Status of the Species and Critical Habitat*) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species.

The criteria recommended for low risk of extinction (Table 2-30) for Pacific salmonids are intended to represent a species and populations that are able to respond to environmental changes and withstand adverse environmental conditions. Thus, when our assessments indicate that a species or population has a moderate or high likelihood of extinction, we also understand that future adverse environmental changes could have significant consequences on the ability of the species to survive and recover.

Table 2-30. Criteria for assessing the level of risk of extinction for populations of Pacific salmonids (reproduced from Lindley et al. 2007)

	Risk of Extinction		
Criterion	High	Moderate	Low
Extinction risk from PVA	> 20% within 20 years	> 5% within 100 years	< 5% within 100 years
	– or any ONE of –	– or any ONE of –	– or ALL of –
Population size[a]	$N_e \leq 50$	$50 < N_e \leq 500$	$N_e > 500$
	–or–	–or–	–or–
	$N \leq 250$	$250 < N \leq 2500$	$N > 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	not apparent
Hatchery influence[f]	High	Moderate	Low

[a] Census size N can be used if direct estimates of effective size N_e are not available, assuming $N_e/N = 0.2$.
[b] Decline within last two generations to annual run size $\leq$ 500 spawners, or run size > 500 but declining at $\geq$ 10% per year. Historically small but stable population not included.
[c] Run size has declined to $\leq$ 500, but now stable.
[d] Catastrophes occuring within the last 10 years.
[e] Decline < 90% but biologically significant.
[f] See Figure 1 for assessing hatchery impacts.

It is also important to note that an assessment of a species having a moderate or high likelihood of extinction does not mean that the species has little or no chance to survive and recover, but that the species faces moderate to high risks from various processes that can drive a species to extinction.

With this understanding of both the current likelihood of extinction of the species and the potential future consequences for species survival and recovery, NMFS will analyze whether the effects of the proposed action are likely to appreciably reduce the species viability, and therefore the likelihood of both survival and recovery of an ESA listed ESU or DPS.

In designating critical habitat, NMFS identifies the physical and biological features (PBFs) within the designated areas that are essential to the conservation of the species and that may require special management considerations or protection. The basis of the "destruction or adverse modification" analysis is to evaluate whether the proposed action results in a direct or indirect alteration that appreciably diminishes the value of designated critical habitat for the conservation of the species. Such alterations may include, but are not limited to, those that alter the PBFs essential to the conservation of a species or that preclude or significantly delay development of such features.

2.6.1 Sacramento River Winter-run Chinook Salmon

2.6.1.1 Summary of the Status and Viability of the Species

Historically, the distribution of winter-run spawning and rearing occurred in the upper Sacramento River and its tributaries, where spring-fed streams provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963, Yoshiyama et al. 1998). The construction of Shasta Dam in 1943 blocked access to all these waters except Battle Creek, which has its own impediments to upstream migration (*i.e.*, the fish weir at Coleman and other small hydroelectric facilities situated upstream of the weir) (Moyle et al. 1989, National Marine Fisheries Service 2014a).

Section 2.2 *Rangewide Status of the Species and Critical Habitat* of this biological opinion establishes that the Sacramento River winter-run Chinook salmon ESU faces a moderate extinction risk according to PVA, and is at a low risk according to other criteria (i.e., population size, population decline, and the risk of wide ranging catastrophe). Lindley et al. (2007)_ENREF_166 states that the winter-run ESU fails the "representation and redundancy rule" because it has only one population, and that population spawns outside of the ecoregion in which it evolved. In order to satisfy the "representation and redundancy rule," at least two populations of winter-run would have to be re-established in the basalt- and porous-lava region of its origin. An ESU represented by only one spawning population at moderate risk of extinction is at a high risk of extinction over an extended period of time (Lindley et al. 2007). During the recent drought (2012-2016) two of the three cohorts of Sacramento River winter-run Chinook salmon spawning in the Sacramento River experience extremely high incubation mortality rates due to drought conditions.

2.6.1.2 Summary of the Effects of the Proposed Action on Sacramento River Winter-run Chinook Salmon

Sacramento River winter-run Chinook salmon spawn in the upper Sacramento River and are not expected to reside in the Feather River. The effects of the integrated operations of the CVP and SWP, including the Oroville Facilities, in the Sacramento River and Sacramento-San Joaquin River Delta were analyzed in the NMFS CVP/SWP Biological Opinion (National Marine Fisheries Service 2009, 2011d). It is expected that the proposed action will not result in additional adverse effects to ESA listed anadromous fish species downstream of the mouth of the Feather River beyond the effects of coordinated operations of the CVP and SWP analyzed in the CVP/SWP Biological Opinion.

Genetic analysis of Central Valley Chinook salmon indicates that winter-run Chinook salmon remain isolated from the other runs (i.e. fall, late-fall, and spring). Operation of the FRFH has not affected (and is not expected to affect) the winter-run Chinook salmon genome. This conclusion is based on the winter run's unique May through July spawning timing and the location of spawning in the Sacramento River between Keswick Dam and Redding. Any spring-run Chinook salmon strays from the FRFH hatchery population would not arrive on the spawning grounds mature enough to spawn with spawning winter-run Chinook salmon.

2.6.1.3 Summary of the Effects of the Proposed Action on the Sacramento River winter-run Chinook salmon ESU

The Feather River is not within the historic ecoregion of spawning for winter-run Chinook salmon. Based on our analysis of available evidence, NMFS concludes that the proposed action is not expected to appreciably reduce the viability, or the likelihood of both the survival and recovery of the Sacramento River winter-run Chinook salmon ESU.

2.6.1.4 Summary Effects of the Proposed Action on Winter-run Chinook Salmon Critical Habitat

The Feather River does is not included within critical habitat designated for Sacramento winter-run Chinook salmon. Spawning habitat will not be affected by the proposed action. The effects of the coordinated operations of the CVP and SWP, including the Oroville Facilities, in the Sacramento River and Sacramento-San Joaquin River Delta were analyzed in the NMFS CVP/SWP Biological Opinion, as amended in 2011 (National Marine Fisheries Service 2009, 2011d). The proposed Oroville Facilities flow and temperature management represents an improvement over the operations of the Oroville Facilities at the time of the CVP/SWP Biological Opinion. The proposed action is not likely to produce stressors that adversely affect the critical habitat of winter-run Chinook salmon. Therefore, it is expected that the proposed action will not result in additional adverse effects to designated winter-run Chinook salmon critical habitat downstream of the mouth of the Feather River beyond the effects of coordinated operations of the CVP and SWP analyzed in the CVP/SWP Biological Opinion.

2.6.1.5 Adult Migratory Corridors

The migratory corridor for adult Sacramento River winter-run Chinook salmon does not include the Feather River. The effects of the coordinated operations of the CVP and SWP, including the Oroville Facilities, in the Sacramento River and Sacramento-San Joaquin River Delta were analyzed in the NMFS CVP/SWP Biological Opinion, as amended in 2011 (National Marine Fisheries Service 2009, 2011d). The proposed Oroville Facilities flow and temperature management represents an improvement over the operations of the Oroville Facilities at the time of the CVP/SWP Biological Opinion.

Therefore, it is expected that the proposed action will not result in additional adverse effects to migrating Sacramento River winter-run Chinook salmon downstream of the mouth of the Feather River beyond the effects of coordinated operations of the CVP and SWP analyzed in the CVP/SWP Biological Opinion. The proposed action is not expected to measurably reduce the conservation value of adult migratory corridors.

2.6.1.6 Spawning Habitat

Spawning habitat will not be affected by the proposed action, and its value for the conservation of the species is not expected to change.

2.6.1.7 Rearing Habitat and Juvenile Migratory Corridors

The effects of the coordinated operations of the CVP and SWP, including the Oroville Facilities, on juvenile rearing corridors from the confluence with the Feather River downstream through the lower Sacramento River and the Delta were analyzed in the CVP/SWP Biological Opinion. The proposed Oroville Facilities flow and temperature management represents an improvement over the operations of the Oroville Facilities at the time of the CVP/SWP Biological Opinion. Therefore, it is expected that the proposed action will not result in additional adverse effects to migrating Sacramento River winter-run Chinook salmon downstream of the mouth of the Feather River beyond the effects of coordinated operations of the CVP and SWP analyzed in the CVP/SWP Biological Opinion.

2.6.1.8 Summary of the Risk to the Value of Sacramento River Winter-run Chinook Salmon Critical Habitat for the Conservation of the Species

Many of the physical and biological features that are essential for the conservation of Sacramento River winter-run Chinook salmon are currently degraded. The proposed Oroville Facilities flow and temperature management represents an improvement over the operations of the Oroville Facilities at the time of the CVP/SWP Biological Opinion. Therefore, it is expected that the proposed action will not result in additional adverse effects physical and biological features of Sacramento River winter-run Chinook salmon beyond the effects of coordinated operations of the CVP and SWP analyzedin the CVP/SWP Biological Opinion. Based on the analysis of available evidence, the proposed action is not likely to appreciably diminish the value of critical habitat for the conservation of Sacramento River winter-run Chinook salmon.

2.6.2 Central Valley Spring-run Chinook Salmon

2.6.2.1 Summary of the Status and Viability of the Species

Historically, the majority of CV spring-run Chinook salmon in the Central Valley were produced in the Southern Sierra Nevada Diversity Group, which contains the San Joaquin River and its tributaries. All CV spring-run Chinook salmon populations in the Southern Sierra Nevada diversity group have been extirpated (Lindley et al. 2007).

The Central Valley Technical Recovery Team delineated 18 or 19 historic independent populations of CV spring-run Chinook salmon, and a number of smaller dependent populations, that are distributed among four diversity groups (Lindley et al. 2004). Of these independent populations, only three are extant (Mill, Deer, and Butte creeks) and they represent only the Northern Sierra Nevada diversity group. The three extant populations passed through prolonged periods of low abundance before increasing in abundance moderately (Mill, Deer creeks) or robustly (Butte Creek) in the 1990s. All independent populations in the Basalt and Porous Lava group and the Southern Sierra Nevada group were extirpated, and only a few dependent populations persist in the Northwestern California group (National Marine Fisheries Service 2016b).

With a few exceptions, CV spring-run Chinook salmon populations have increased through 2014 returns since the 2010/2011 status review, which has moved the Mill and Deer creek populations from the high extinction risk category, to moderate, and Butte Creek has remained in the low risk of extinction category. Additionally, the Battle Creek and Clear Creek populations have continued to show stable or increasing numbers the last five years, putting them at moderate risk of extinction based on abundance. Overall, the Southwest Fisheries Science Center (SWFSC) concluded in their viability report that the status of CV spring-run Chinook salmon (through 2014) has probably improved since the 2010/2011 status review and that the ESU's extinction risk may have decreased; however, the ESU is still facing significant extinction risk, and that risk is likely to increase over at least the next few years as the full effects of the recent drought are realized (Williams et al. 2016).

Past and present impacts within the Sacramento River basin have caused significant loss of habitat. Populations have declined drastically over the last century, and many subpopulations have been extirpated. The construction of dams has limited access to a large and significant portion of historical spawning and rearing. Dam operations have changed downstream flow patterns, affecting stream dynamics (*i.e.*, geomorphology, habitat configuration, *etc*.), and affected available habitat through changes in water temperature characteristics, limiting gravel recruitment to available spawning reaches and limiting the introduction of LWM which contributes to habitat diversity. Gold mining has occurred in the Feather River, and there are dams (of which Oroville Dam is one of the largest in California), water diversions, and levees.

Despite the impaired genetic status of the Feather River population, and the substantial reduction in habitat availability and suitability since the construction of the Oroville Facilities, the value of the lower Feather River basin as a migratory corridor, its location as the southern-most extant population of CV spring-run Chinook salmon, and its suitability as spawning and rearing habitat make the river an important node of habitat for the survival and recovery of the species.

2.6.2.2 Summary of the Effects of the Proposed Action on Central Valley Spring-run Chinook salmon in the Feather River

Population viability is determined by four parameters: spatial structure, diversity, abundance, and productivity (growth rate). Both population spatial structure and diversity (behavioral and genetic) provide the foundation for populations to achieve abundance levels at or near potential carrying capacity and to achieve stable or increasing growth rates. Spatial structure on a watershed scale is determined by the availability, diversity, and utilization of properly functioning habitats and the connections between such habitats.

Oroville Dam and the Fish Barrier Dam just downstream will continue to block passage of Chinook salmon to historical spawning and rearing habitat upstream. This confines CV spring-run Chinook salmon to river reaches below Oroville Dam, and facilities at the FRFH. Natural spawning is limited to approximately 5 miles of habitat downstream from the Fish Barrier Dam. This reduces the spatial structure, life history, and genetic diversity of CV spring-run Chinook salmon in the Feather River. The restriction of CV spring-run Chinook salmon to the lower Feather River reduces the geographic extent of the species, reduces the amount of available spawning and rearing habitat, and results in significant domestication effects due to hatchery influences.

The proposed action includes water temperature targets and criteria that will provide conditions for the successful migration, holding, spawning, rearing and outmigration of juvenile CV spring-run Chinook salmon within the project area boundary. The temperatures are expected to be met when the OTMI is less than 1.25 MAF. CALSIM modeling indicates that this will be met or exceeded in about 90 percent of years. Conference years will be declared when the OTMI cannot be met and Conference Actions (section 1.3.3.9.4) will be implemented through a strategic plan that conserves the cold water storage pool and provides cold water for fish.

Year-round flows of 700 to 800 cfs in the LFC of the Feather River will maintain approximately five miles of habitat with habitat features and water temperatures necessary for holding, spawning, and rearing CV spring-run Chinook salmon. Water temperatures within the LFC generally are conducive to holding, spawning, egg incubation, and rearing. During dry or critically dry years, the temperatures at Robinson Riffle downstream to the Oroville Afterbay Outlet may approach levels during August and September that can reduce adult fecundity, or cause increased egg mortality. These conditions are expected to affect relatively few individuals and have a marginal effect on population abundance because most of the adult population uses the upper reaches of the LFC for summer holding, where average daily temperatures can be as much as 5^{o} F cooler. Additionally, DWR will make operational changes that include reduced pump-back operations and flow increases to maintain the target temperatures for approximately 10 years until facility modifications can be implemented to ensure that appropriate temperatures can be maintained as criteria. Climate change is expected to make water temperature management more difficult, meaning that extensive facility modifications may be necessary. Although there is some reduction in the amount of suitable spawning habitat in dry years near the downstream end of the LFC, sufficient habitat is present in the upper reaches to support thousands of holding and spawning CV spring-run Chinook salmon.

Spawning habitat availability is maximized at the proposed flows of 800 cfs, but the increasing size and armoring of spawning gravel related to the loss of sediment recruitment behind Oroville Dam could continue to reduce the quantity and quality of habitat, and could limit population production and abundance. The Gravel Supplementation and Improvement Program will, within 5 years, augment existing gravels and reduce the gravel size to accommodate sizes selected by CV spring-run Chinook salmon, and will continue as needed to maintain appropriately sized gravel to counter the effects of bedload depletion from Oroville Dam. Therefore, we expect spawning gravel quantity or quality downstream of the Fish Barrier Dam will not limit the abundance, production, or viability of CV spring-run Chinook salmon in the lower Feather River.

Oroville Facilities operations also will maintain flow and temperature conditions that allow spring- and fall-run Chinook salmon populations to co-occur within the LFC. This compression of spawning habitat, combined with overlap in spawning period, contributes to significant levels of superimposition and hybridization between fall-run Chinook salmon and CV spring-run Chinook salmon. Redd superimposition can reduce egg survival, juvenile production, and population abundance. Hybridization with fall-run Chinook salmon reduces genetic diversity, and individual and population fitness, which reduces viability.

The Fish Weir Program is designed specifically to study and abate the stressors of superimposition and hybridization. Under Settlement Agreement Article A105, DWR will begin evaluating Feather River Chinook salmon run timing immediately after the issuance of the FERC license, and will submit a plan within 8 years to provide spatial separation for the spawning of CV spring-run Chinook salmon and fall-run Chinook salmon. Within 12 years, there will be complete separation between spring- and fall-run Chinook salmon in the Feather River and at the FRFH. Until the separation weir is in place, superimposition and hybridization will continue to affect egg survival and genetic diversity for the next three to four generations. Under SWRCB Order WQ 2010-016 Special Condition S5, DWR will use a monitoring weir, or an additional separate interim weir, to segregate adult CV spring-run Chinook salmon and fall-run Chinook salmon within 5 years, which is expected to reduce the duration of these effects.

Outmigration conditions for juvenile spring-run Chinook salmon in the Lower Feather River will continue to be affected. The most significant stressor appears to be related to hydrograph reduction and stabilization during April and May. The stabilization of the hydrograph has reduced the occurrence of high flow peaks that inundate floodplains and make them accessible to rearing juveniles in the HFC. This likely decreases juvenile growth, survival and eventually, population abundance. Life history diversity may also be constrained to favoring early season migration, reducing the resiliency of the population. The Lower Feather River Habitat Improvement Program will develop and implement floodplain and riparian habitat improvement projects and the potential for creating pulse flows that will inundate floodplain habitats. These actions will ultimately improve the growth and survival of juvenile salmon migrating through the Lower Feather River. Adverse effects to individuals and population abundance and life history diversity will persist to some degree for up to 25 years, but we expect some incremental improvements will occur as restoration projects are implemented on an incremental basis.

The FRFH will continue to produce CV spring-run Chinook salmon. This will contribute positively to abundance and production parameters, but will impair populations and life history diversity. The proposed action will implement additional programs, including the fish weir, that seek to improve spatial and genetic integrity by segregating CV spring-run Chinook spawners in the Feather River and improve the population's viability and capacity to respond and adapt to environmental changes. Development of a HGMP and implementation of the measures in the HGMP should also improve the population's genetic integrity and viability. Recent and ongoing efforts at the FRFH to separate CV spring-run Chinook salmon from fall-run Chinook salmon and to integrate best management practices into the operation of the hatchery will maintain a cultured population that should provide protection to the ESU from catastrophic events that could affect the in-river population.

Because of these factors, the project will continue to perpetuate some of these adverse effects. However, because of the implementation of the numerous conservation measures (Lower Feather River Habitat Improvement Program; and the HEA, or fish passage) over the course of the license we expect improvements in the abundance of naturally spawning CV spring-run Chinook salmon, creation of spatial segregation from fall-run Chinook salmon, and improvement in the genetic integrity and security of the unique life history traits of the population. Therefore, we conclude that although the proposed action will continue to affect CV spring-run Chinook salmon by blocking access to historic upstream habitat, improvements to habitat below the dam can support an abundant population that will improve in terms of genetic and life history diversity through the implementation of the conservation measures in the proposed action, which will improve the viability of the Feather River population of CV spring-run Chinook salmon in both the hatchery and the wild.

2.6.2.3 Summary of the Effects of the Proposed Action on the Central Valley Spring-run Chinook Salmon ESU

The CV spring-run Chinook salmon ESU is currently at low to moderate risk of extinction within the foreseeable future. However, there are only three independent populations in one diversity group; habitat elimination and modification throughout the Central Valley have drastically altered the ESU's abundance, spatial structure and diversity. In addition, the ESU has a risk associated with catastrophes, especially considering the remaining independent population's proximity to Mt. Lassen and the probability of a large scale wild fire occurring throughout these closely spaced watersheds that support the three independent CV spring-run Chinook populations. The ESU is still facing significant extinction risk, and that risk is likely to increase over at least the next few years as the full effects of the recent drought are realized.

Operation of the Oroville Facilities including the FRFH has affected the genetic and life history diversity of CV spring-run Chinook salmon in the Feather River. Based on the low occurrence of FRFH CV spring-run Chinook salmon strays in other CV spring-run Chinook salmon tributaries and the significant genetic differences between Feather River CV spring-run Chinook salmon and other CV spring-run Chinook salmon populations in upstream tributaries of the Sacramento River, FRFH operations do not appear to be negatively affecting other populations in the ESU (Department of Water Resources 2007). As discussed in the previous section, the Feather River population of CV spring-run Chinook salmon is not currently viable, but the proposed action includes numerous conservation measures that are intended to secure the existing population and improve its long-term prospects to become an independent, viable population.

The information available to date suggests that although there is a risk of hatchery fish interacting with wild populations of CV spring-run Chinook salmon, with the exception of the Feather and Yuba River, hatchery effects do not appear to have adversely affected the abundance, production, spatial structure, or genetic and life history diversity of other naturally spawning populations of CV spring-run Chinook salmon in the ESU.

The HEA activities are interrelated to the proposed action, and this agreement was developed to address the blockage by several hydroelectric projects on the Feather River, including the Oroville Facilities, of fish passage to historical habitat. The HEA was finalized in August 2007 with the specific goal of expanding habitat, within the Sacramento River basin, sufficiently to accommodate an increase of approximately 2,000 to 3,000 spawning CV spring-run Chinook salmon. Potential actions include, but are not limited to, dam removal, dam reoperation, flow and water temperature improvements, fish passage, and physical habitat improvements. . In November 2010, DWR and PG&E submitted a final HEP to NMFS. The final HEP was a proposal for habitat improvements in the Yuba River watershed. In NMFS' review of the HEP, NMFS determined that it did not meet several of the NMFS Approval Criteria in the Amended HEA (2011). However, NMFS noted that its determination was subject to additional procedures described in the Amended HEA. NMFS and DWR are discussing how to implement the HEA. Although the exact locations have not been finally determined, the long-term implementation of the HEA would increase the spatial distribution and abundance of CV spring-run Chinook salmon, and reduce the risks to the ESU related to catastrophic events. NMFS reserves its authority under FPA Section 18 to prescribe the construction, operation, and maintenance of fishways for the Oroville Facilities and other hydroelectric projects in the Feather River basin during the terms of the licenses as provided in the HEA. If the HEP does not meet the requirements of the agreement and there is no agreement on an alternative habitat expansion plan that would meet the requirements of the HEA, the HEA would be terminated, and NMFS is expected to prescribe fishways based on previous fishway prescriptions for hydroelectric projects in the Feather River basin.

The extensive conservation measures included in the Lower Feather River Habitat Improvement Program, which include improvements to fish habitat and hatchery management, will increase the genetic and life history diversity, natural production and spatial diversity of the Feather River population of CV spring-run Chinook salmon. Hatchery management will be addressed through the development and implementation of an HGMP.

The Northern Sierra Nevada Diversity Group, to which the Feather River population belongs, currently meets the representation and redundancy rule (Lindley et al. 2007) for viability by having at least three viable independent populations even without the Feather River population.

The abundance and spatial structure of the ESU is eventually expected to be increased above current conditions through the implementation of the HEA or exercise of NMFS' authority to prescribe fishways under FPA Section 18 if the HEA is not implemented. This will provide additional protection and resiliency to the ESU from exposure to catastrophic events, and will either increase the representation and redundancy of populations in the Northern Sierra Nevada Diversity Group or other diversity groups in the Sacramento River Basin.

The proposed action is expected to secure the existing Feather River population by taking steps to increase the abundance, improve the genetic integrity, and secure the unique life history traits of the naturally spawning population by providing for the spatial separation between spring- and fall-run Chinook salmon, and improving management of the FRFH through the development and implementation of improved hatchery practices and the HGMP.

Although CV spring-run Chinook salmon have been separated from their historic habitat where they were geographically separated from other Chinook salmon, and forced to relocate to downstream reaches that have been co-occupied by fall-run Chinook salmon for the past 40 years, the proposed action will take steps to separate the two stocks and re-establish a degree of geographic isolation that is essential for completing their freshwater life history processes. Separation and isolation of the Feather River population of CV spring-run Chinook salmon from the fall-run population will improve the spatial structure of the Northern Sierra Nevada Diversity Group by creating the conditions where an independent population of Feather River CV spring-run Chinook salmon unimpaired by hybridization can re-establish.

Based on our analysis of available evidence, NMFS concludes that the proposed action is not expected to appreciably reduce the likelihood of both the survival and recovery of the CV spring-run Chinook salmon ESU.

2.6.2.4 Summary of Effects of the Proposed Action on CV Spring-run Chinook Salmon Critical Habitat

Critical habitat for CV spring-run Chinook salmon is designated in river reaches downstream from the Fish Barrier Dam. This section will summarize the biological value of available migratory corridors and spawning and rearing habitat and effects of the proposed action on those PBFs.

2.6.2.5 Adult Migratory Corridors

The adult migratory corridors for CV spring-run Chinook salmon have been highly altered. Modifications include levees and dikes to protect property; dams which modify the hydrograph, water temperatures, and preclude access to historic habitat; unscreened diversions; and channel alterations due to gold mining.

In the Feather River, the hydrograph may delay migration timing of spring-run Chinook salmon adults through reductions in flow related stimuli, but is not expected to prevent them from accessing upstream spawning areas in the lower Feather River. With the proposed action, CV spring-run Chinook will continue to be excluded from historic migratory corridors upstream of the Fish Barrier Dam, and be confined to the degraded habitat downstream of the Fish Barrier Dam. Measures in the proposed action will address aspects of the degraded habitat downstream of the Fish Barrier Dam. This is primarily a result of implementation of the Lower Feather River Habitat Improvement Program, and cooler water temperatures that result from improved temperature management including facility modifications.

2.6.2.6 Spawning Habitat

The Oroville Facilities adversely impact spawning habitat through its influence on water temperature, flow-related habitat availability, and bed load supply and transport characteristics. Although impaired by past operations of the Oroville Facilities, which will continue until conservation measures are implemented, the proposed action includes several measures designed to incrementally address the degraded habitat conditions downstream of the Fish Barrier Dam. It is anticipated that facilities modifications, combined with the proposed immediate increases in minimum instream flow and decreased maximum water temperature targets, will provide greater stability and flexibility for water temperature management in the Feather River. This will improve the ability to meet water temperature criteria for fish in the LFC and HFC. While the measures will improve the ability to meet temperature requirements more frequently, when the effects of climate change over the next 50 years are applied to these temperature regimes, the frequency of dry water year conditions are expected to increase. This means that the modifications will address degraded water temperatures conditions for the first few decades of the license but will essentially maintain them similar to existing conditions toward the end of the license term. Spawning habitat will increase in quantity and quality through implementation of the Gravel Supplementation and Improvement Program. The proposed action will increase flows during the spawning period, which will address impacted habitat conditions downstream of the Fish Barrier Dam.

2.6.2.7 Rearing Habitat and Juvenile Migratory Corridors

The effects of coordinated operations of the CVP and SWP, including the Oroville Facilities, in the Sacramento River and Sacramento-San Joaquin River Delta were considered in the NMFS CVP/SWP Biological Opinion, as amended in 2011 (National Marine Fisheries Service 2009, 2011d). The proposed Oroville Facilities flow and temperature management addresses effects of the proposed action downstream of the Fish Barrier Dam. It is expected that the proposed action will not result in additional adverse effects to juvenile CV spring-run Chinook salmon habitat downstream of the mouth of the Feather River beyond the effects of coordinated operations of the CVP and SWP analyzedin the CVP/SWP Biological Opinion.

Water temperature and fish habitat improvements related to the Lower Feather River Habitat Improvement Program will incrementally add to the biological value of juvenile rearing habitat and migration corridors in the lower Feather River through the license period. Flood management will continue to limit access to rearing habitat on inundated floodplains. During the term of the license, climate change may increase the frequency of drought and result in more conference years, which could result in reduced suitable habitat.

2.6.2.8 Summary of the Risk to the Value of CV Spring-run Chinook Salmon Critical Habitat for the Conservation of the Species

Many of the PBFs that are essential for the conservation of CV spring-run Chinook salmon designated critical habitat in the Feather River are currently degraded. The proposed action will improve the condition of some of the PBFs, and is not expect to cause further degrading of the other PBFs. Based on the analysis of available evidence, the proposed action is not likely to appreciably diminish the value of critical habitat for the conservation of CV spring-run Chinook salmon.

2.6.3 California Central Valley Steelhead

2.6.3.1 Summary of the Status and Viability of the Species

O. mykiss have long been recognized as having one of the most complex and diverse life histories among all the salmonids. Populations may be entirely anadromous, partly anadromous, or entirely resident, and levels of anadromy can vary by age and sex. One of the difficulties in assessing any steelhead data in the Central Valley is the possibility that some individuals may actually be resident fish, as it is nearly impossible to visually distinguish the two life history forms when they are juveniles.

CCV steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby et al. 1996) and were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern River systems, and in both east- and west-side Sacramento River tributaries (Yoshiyama et al. 2001). Lindley et al. (2006) estimated that historically there were at least 81 independant CCV steelhead populations distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin Rivers. This distribution has been greatly affected by dams (McEwan and Jackson 1996). Presently, impassable dams block access to 80 percent of historically available habitat, and block access to all historical spawning habitat for about 38 percent of historical populations (Lindley et al. 2006).

Most of the steelhead populations in the Central Valley have a high hatchery component, including Battle Creek (adult intercepted at the Coleman NFH weir), the American River, Feather River, and Mokelumne River. Assessing steelhead abundance is confounded by the fact that most of the dedicated monitoring programs in the Central Valley occur on rivers that are annually stocked.

Existing wild CCV steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in Big Chico and Butte creeks and a few wild CCV steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996). Recent snorkel surveys (1999 to 2002) indicate that CCV steelhead are present in Clear Creek [J. Newton, USFWS, pers. comm. 2002, as reported in _ENREF_122Good et al. (2005)]. Because of the large resident *O. mykiss* population in Clear Creek, CCV steelhead spawner abundance has not been estimated.

Spatial structure for CCV steelhead is fragmented and reduced by elimination or significant reduction of the major core populations (*i.e.*, Sacramento River, Feather River, American River) that provided a source for the numerous smaller tributary and intermittent stream populations like Dry Creek, Auburn Ravine, Yuba River, Deer Creek, Mill Creek, and Antelope Creek. Tributary populations can likely never achieve the size and variability of the core populations in the long-term, generally due to the size and available resources of the tributaries.

Despite the substantial reduction in habitat availability and suitability since the construction of the Oroville Facilities, the value of the lower Feather River basin as a migratory corridor and the presence of spawning and rearing habitat make it an important node of habitat for the survival and recovery of the species.

Lindley et al. (2007) indicated that prior population census estimates completed in the 1990s found the CCV steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good et al. (2005) indicated the decline was continuing as evidenced by new information. CCV steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates. Although there is limited data concerning the status of CCV steelhead, Lindley et al. (2007) concluded that there is sufficient evidence to suggest that the DPS is at moderate to high risk of extinction.

2.6.3.2 Summary of the Effects of the Proposed Action on CCV Steelhead in the Feather River

The construction of Oroville dam has forced the naturally spawning population to relocate to the Lower Feather River, where they are subject to flow and geomorphic effects of the proposed action on spawning and rearing habitat availability. In addition, the abundance of the Feather River CCV steelhead population is now strongly influenced by the FRFH operations.

Decades of uniform hatchery practices have reduced the genetic and life history diversity of the Feather River CCV steelhead population. Genetic diversity and life history will continue to be impaired by the ongoing and future operation of the FRFH. Currently, influence of the FRFH on the naturally-spawning population fails the TRT's fourth generational hatchery introgression criteria for achieving low and moderate viability by allowing more than 5 and 10 percent of the naturally spawning fish to be of hatchery origin. However, the FRFH is implementing measures to improve the management of Feather River CCV steelhead and is preparing an HGMP that will be implemented to improve the genetic and life history diversity of the population.

Year-round flows of 700 to 800 cfs in the LFC of the Feather River will continue to maintain approximately five miles of habitat with preferred water temperatures for holding, spawning, and rearing CCV steelhead. The LFC likely supports the majority of the naturally-spawning CCV steelhead, although some spawning has been observed in the HFC. Water temperatures within the LFC generally are conducive to CCV steelhead spawning, egg incubation, and rearing. Although temperatures during spawning can be warm enough to cause low levels of egg mortality during December, temperatures are within optimal ranges during the peak of the spawning period. DWR proposes to make operational changes that include reduced pump-back operations and flow increases to maintain the target water temperatures for approximately 10 years until facility modifications can be implemented to ensure that the temperatures can be met. Climate change is expected to make water temperature management more difficult throughout the term of the license and may increase the frequency that criteria cannot be met.

Spawning habitat availability is maximized at the proposed flows of 800 cfs, but the increasing size and armoring of spawning gravel related to the loss of sediment recruitment behind Oroville Dam could continue to reduce the quantity and quality of habitat. The Gravel Supplementation and Improvement Program will, over the first 5 years of the license, augment existing gravels, will reduce the gravel size to accommodate sizes selected by CCV steelhead, and will continue as needed to maintain appropriately sized gravel and counter the effects of bedload depletion from Oroville Dam. NMFS expects this action will improve abundance and survival of CCV steelhead in the Feather River.

CCV steelhead redd and juvenile rearing surveys in the Feather River [(DWR 2003b, (Seesholtz et al. 2003)] indicate that spawning and rearing habitat is limited and primarily exists at only two locations; one at the upstream end, and one at the downstream extent of the LFC. This limited amount of available habitat is likely to limit juvenile production and the carrying capacity for CCV steelhead fry and juvenile rearing. We expect the naturally spawning Feather River CCV steelhead population to remain below viable levels due to the lack of spawning and rearing habitat for at least the next 10 years until the Gravel Supplementation and Improvement Program and the Channel Improvement Program are fully implemented. These programs are expected to incrementally increase the quality, complexity, and quantity of spawning and rearing habitat for CCV steelhead within 3 to 10 years of license issuance. Planned improvements in two existing side-channels (Moe's Ditch and Hatchery Ditch) combined with the development of five additional side-channels is expected to increase available spawning habitat and rearing habitat by 3,260 linear feet within the action area. More suitable substrate and abundant instream and overhead cover generally associated with side-channels is expected to provide better juvenile CCV steelhead rearing habitat than that found in the main channel of the Feather River. In addition, improved or additional side-channels are expected to provide additional spawning and juvenile rearing habitat for CV spring-run Chinook salmon.

Juvenile survival and population abundance is reduced by project operations. The project-related flow regimes in the HFC do not seem to have an effect on the timing of juvenile outmigration, but we expect that based on the extensive amount of literature regarding the importance of high spring flow events, the currently reduced spring hydrograph and the infrequency of high pulse flow events that inundate floodplains. The Riparian and Floodplain Improvement Program would develop a phased program plan, within 6 months of license issuance, with the objective of enhancing riparian and floodplain habitats on the Lower Feather River to improve growth and survival conditions for juvenile salmonids. Specific project designs and implementation of program elements will be completed within 15 (phases 1 and 2 for one set of projects) and 25 years (phases 3 and 4 for a second set of projects) of new license issuance. Ultimately this program is expected to create pulse flows capable of inundating floodplains and increasing growth and survival of individuals, and will improve the survival, abundance and life history diversity of the Feather River population.

Because of these factors, the Oroville Facilities will perpetuate some of the adverse effects related to existing baseline conditions, but over the course of the license the proposed action with its numerous conservation measures (Lower Feather River Habitat Improvement Program) and the interrelated HEA will be expected to improve the abundance of naturally spawning CCV steelhead, and improve the genetic and life history diversity of the population. Therefore, we conclude that the proposed action will secure the existing population and will improve the survival, abundance and life history diversity of the Feather River population of CCV steelhead in both the hatchery and the wild.

2.6.3.3 Summary of the Effects of the Proposed Action on the Central Valley Steelhead DPS

The previous sections discussed how the Feather River population of CCV steelhead currently is not viable, but the Lower Feather River Improvement Program includes a substantial number of measures that are intended to secure the existing population and improve its long-term management and prospects for becoming viable.

Additionally, the interrelated HEA, which was developed to address the blockage by several hydroelectric projects on the Feather River, including the Oroville Facilities, is expected to expand habitat availability. The HEA was finalized in August 2007 with the specific goal of expanding habitat, within the Sacramento River basin, sufficiently to accommodate an increase of approximately 2,000 to 3,000 spawning CV spring-run Chinook salmon (which is also expected to accommodate some amount of habitat for spawning CCV steelhead). Potential actions include, but are not limited to, dam removal, dam reoperation, flow and water temperature improvements, fish passage, and physical habitat improvements. In November 2010, DWR and PG&E submitted a final HEP to NMFS. The final HEP was a proposal for habitat improvements in the Yuba River watershed. In NMFS' review of the HEP, NMFS determined that it did not meet several of the NMFS Approval Criteria in the Amended HEA (2011). However, NMFS noted that its determination was subject to additional procedures described in the Amended HEA. DWR and NMFS are discussing how to implement the HEA. Although the exact locations have not been finally determined, the long-term implementation of the HEA would increase the spatial distribution and abundance of CCV steelhead, and reduce the risks to the DPS related to catastrophic events. NMFS reserves its authority under FPA Section 18 to prescribe the construction, operation, and maintenance of fishways for the Oroville Facilities and other hydroelectric projects in the Feather River basin during the terms of the licenses as provided in the HEA. If the HEP does not meet the requirements of the agreement and there is no agreement on an alternative habitat expansion plan that would meet the requirements of the HEA, the HEA would be terminated, and NMFS is expected to prescribe fishways based on previous fishway prescriptions for hydroelectric projects in the Feather River basin.

Operation and hatchery effects do not appear to have had adversely affected the abundance, production, spatial structure, or genetic and life history diversity of other naturally spawning populations of CCV steelhead in the DPS.

NMFS concludes that the proposed action will not appreciably reduce the likelihood of recovering the DPS because of the following.

- The abundance and spatial structure of the DPS will be increased through the implementation of the Habitat Expansion Agreement or fishway prescriptions if the Habitat Expansion Agreement is not implemented. This will provide additional protection and resiliency to the DPS from exposure to catastrophic events and will either increase the representation and redundancy of populations in the Northern Sierra Diversity Group or other diversity groups in the Sacramento River Basin.
- The proposed action will secure the existing Feather River population by taking steps to increase the abundance and improve the genetic and life history diversity of the naturally spawning population by increasing the quantity and quality of spawning and rearing habitat in the LFC and improving management of the FRFH through development and implementation of improved hatchery practices.

Based on our analysis of available evidence, NMFS concludes that the proposed action is not expected to appreciably reduce the likelihood of both the survival and recovery of the CCV steelhead DPS.

2.6.4 Effects of the Proposed Action on CCV Steelhead Critical Habitat

Critical habitat for CCV steelhead is designated in the Feather River reaches downstream from the Fish Barrier Dam. This assessment will summarize the biological value of available migratory corridors and spawning and rearing habitat and effects of the proposed action on those PBFs.

2.6.4.1 Adult Migratory Corridors

The adult migratory corridors for CCV steelhead have been highly altered. Modifications include levees and dikes to protect property; dams which modify the hydrograph, water temperatures, and preclude access to historic habitat; unscreened diversions; and channel alterations due to gold mining.

In the Feather River the hydrograph may delay migration timing of adults through reductions in flow related stimuli, but is not expected to prevent them from accessing upstream spawning areas in the LFC. The value of adult migration corridors within the Feather River will incrementally improve as result of the proposed action. This is primarily a result of implementation of the Lower Feather River Habitat Improvement Program, and cooler water temperatures that result from improved temperature management including facility modifications.

2.6.4.2 Spawning Habitat

The Oroville Facilities impact spawning habitat through its influence on water temperature, flow-related habitat availability, and bed load supply and transport characteristics. Although impaired by past operations of the Oroville Facilities, which will continue until conservation measures are implemented, the proposed action includes several measures designed to improve this PBF. Spawning habitat will increase in quantity and quality through implementation of the Gravel Augmentation and Improvement Program and the Channel Improvement Program. The proposed action will increase flows during the spawning period, which will increase the amount of habitat available to steelhead and decrease water temperatures for most of the license period.

2.6.4.3 Rearing Habitat and Juvenile Migratory Corridors

As with adult migratory corridors, CCV steelhead juvenile rearing and migratory corridors have been highly altered.

The effects of from the coordinated operations of the CVP and SWP, including the Oroville Facilities, in the Sacramento River and Sacramento-San Joaquin River Delta were considered in the NMFS CVP/SWP Biological Opinion, as amended in 2011 (National Marine Fisheries Service 2009, 2011d). The proposed Oroville Facilities flow and temperature management represents an improvement over the operations of the Oroville Facilities at the time of the CVP/SWP Biological Opinion. Therefore, it is expected that the proposed action will not result in additional adverse effects to juvenile CCV steelhead habitat downstream of the mouth of the Feather River beyond the effects of coordinated operations of the CVP and SWP analyzed in the CVP/SWP Biological Opinion.

Water temperature and fish habitat improvements related to the Lower Feather River Habitat Improvement Program will incrementally improve the biological value of juvenile rearing habitat and migration corridors in the lower Feather River through the license period. Flood management will continue to limit access to rearing habitat on inundated floodplains. During the term of the license, climate change may increase the frequency of drought and result in more conference years, which could result in reduced suitable habitat.

2.6.4.4 Summary of the Risk to CCV Steelhead Critical Habitat

Many of the physical and biological features that are essential for the conservation of CCV steelhead are currently degraded. As a result of implementing the proposed action, some of those physical and biological features, such as floodplain inundation, will likely continue to be adversely impacted by project operations.

The proposed action, however, includes a substantial number of measures that are designed to improve the biological value of critical habitat. The Lower Feather River Habitat Improvement Program will improve water temperatures throughout much of the license period and will increase habitat complexity through construction of side channels, placement of LWM, gravel augmentation, and implementation of floodplain restoration projects. Toward the end of the license period, water temperature management may become more difficult, as dry years are expected to become more common based on climate change scenarios, and water temperatures may become more similar to existing conditions by the end of the proposed 50-year license period.

Based on the analysis of available evidence, NMFS concludes that the proposed action is not likely to appreciably diminish the value of the critical habitat for the conservation of CCV steelhead. This is mainly due to the extensive conservation measures that will be implemented to increase spawning and rearing habitat quantity and quality to support a larger in-river population, the water temperature management actions that will ensure cold water supplies for all freshwater life stages, and the proposed downstream floodplain restoration and inundation actions that will be fully implemented by mid-way through the license.

2.6.5 Southern DPS of Green Sturgeon

2.6.5.1 Summary of the Status and Viability of the Species

Southern DPS green sturgeon currently appear limited to only one spawning population in the Sacramento River. The 70 FR 37160 (June 28, 2005) concluded that a significant population no longer exists in the Feather River. They also concluded that the blockage of sDPS green sturgeon from historic spawning areas above Shasta Dam along with the accompanying decrease in spawning area resulting from the loss of spawning area in other rivers, such as the Feather River, make North American green sturgeon in the Southern DPS at risk of extinction in the foreseeable future.

Currently, there are no reliable data on population size of the sDPS of North American green sturgeon. It is clear, however, that the amount and quality of accessible habitat for this species has been greatly reduced.

There is insufficient information to evaluate the productivity of sDPS green sturgeon. Southern DPS green sturgeon genetic analyses shows strong differentiation between northern and southern populations, and, therefore, the species was divided into a northern and southern DPS. However, the genetic diversity of the sDPS is not well understood.

The principal threat to green sturgeon in the sDPS is the reduction of available spawning habitat due to the construction of barriers on Central Valley rivers. Other threats are insufficient flow rates, increased water temperatures, water diversion, non-native species, poaching, pesticide and heavy metal contamination, and harvest (71 FR 17757; April 7, 2006).

The majority of the NMFS BRT (70 FR 37160 June 28, 2005) felt that the blockage of sDPS green sturgeon spawning from their historic spawning areas above Shasta Dam and the accompanying decrease in spawning habitat associated with dam construction on other rivers (such as the Feather River), made the sDPS likely to become endangered in the foreseeable future throughout a significant portion of its range. Due to substantial habitat loss, the decline in abundance observed at water pumping facilities and the occurrence of only one breeding population, the Southern DPS of North American green sturgeon remains at a moderate to high risk of extinction.

2.6.5.2 Summary of the Effects of the Proposed Action on Green Sturgeon in the Feather River

The effects of the proposed action on the sDPS green sturgeon are difficult to determine given the paucity of empirical evidence. Based on the best available information, however, it is very likely that an sDPS green sturgeon population historically used the Feather River. Approximately 10 miles of spawning habitat loss is associated with the construction and presence of Oroville Dam. Lost access to this habitat will continue as a result of the proposed action. However, sDPS green sturgeon appear to have relocated to habitats downstream of the Fish Barrier Dam. Specific spawning locations for sDPS green sturgeon in the Feather River are unknown, but are probably limited to the area from Thermalito Afterbay Outlet, downstream to near the Gridley Bridge .(U.S. Fish and Wildlife Service 1995, Seesholtz 2003). More recent investigations of suitable deep pools indicate that that there are up to 12 deep holes over 13 miles of habitat from the Fish Barrier Dam at RM 67 downstream to RM 54, with characteristics capable of supporting sDPS green sturgeon spawning. Seven of these holes are greater than 5 meters deep, and five of the pools are between 3 and 5 meters. The total area of the pools is greater than 164,500 m^2. There are numerous accounts of sturgeon being captured or observed by anglers and DWR fisheries scientists throughout the Lower Feather River, including the LFC and the HFC. Based on the available information, NMFS concludes that a Feather River population of sDPS green sturgeon has persisted since the construction of the Oroville Facilities.

Water temperatures during the spawning and early juvenile development period, river flows during the upstream migration period, and limited spawning habitat availability are the most significant stressors affecting sDPS green sturgeon individuals in the Lower Feather River.

Water temperatures within potential spawning areas are within optimal ranges during a majority of the spawning and early rearing period from March through May, but are warmer in June, exceeding optimal levels that may result in egg and early juvenile mortalities or abnormalities. Water temperatures within the optimal range for spawning and early rearing can extend downstream for 28 miles during March and April, 16 miles during May, and approximately 13 miles during June, although optimal conditions are exceeded during certain times. June temperatures can exceed optimal ranges at the downstream project boundary for 22 percent of days for the first 10 years of the license, and could be reduced down to 9 to 12 days of exceedance once long-term facility modifications are in place. Exceedances are expected to occur in dry and critically dry years or in 10 percent of years when extreme heat events occur. Temperatures are not expected to reach levels that could result in adult mortalities.

Therefore, although the range of optimal water temperatures varies depending on month and water year type, there appears to be at least as much suitable spawning habitat as pre-dam conditions. Given the continued detection of sDPS green sturgeon under a wide variety of water year types, the water temperatures appear adequate to support reproduction, especially in important wet and above normal water years when sturgeon production is known to be highest.

NMFS also reviewed information for flow-related habitat availability and found that adult upstream migrants are exposed to a simplified hydrograph that curtails flow for reservoir storage during spring months. High spring flows associated with the natural hydrograph do not occur within the section of the river used by sDPS green sturgeon with the frequency and duration that was seen in pre-dam conditions. However, sufficient flow conditions exist to create migration conditions that allow sDPS green sturgeon to migrate upstream even in dry water year types, as evidenced by the observation of adult sDPS green sturgeon in the upper river reaches below Oroville and the Fish Barrier Dams.

DWR green sturgeon scientists have recently reviewed passage flows in the Lower Feather River and have determined that flow ranging from 2,500 to 3,000 cfs would be needed for adult sDPS green sturgeon passage at Sunset Pumps. The higher flow at this location is a conservative (or most protective) value.

At Sunset Pumps, the existing hydrologic record from 1968 through 2008 shows that 2,500 cfs flows lasting for two or more days between March and May occurred during 72 to 76 percent of years, with the average number of days where the flows exceeded these levels ranging from 18 to 24 days per month.

Based on these frequencies and the observations of sturgeon in the Feather River during a broad range of water year types, it appears that although passage conditions occur during most years, low flows during dry or critically dry water year types may delay or block migration to some extent. However, observations of sturgeon above these impediments during dry and critically dry years suggests that passage is not completely blocked and sturgeon are likely to reach spawning grounds upstream although in low flow years their migration may be delayed, resulting in egg absorption.

Proposed flows and water temperatures appear suitable for attracting spawning adults into the Feather River, and the water temperatures are suitable to support spawning during most of the spawning season, especially in above normal and wet water year types. With facility modifications after year 10, spawning temperatures will improve, especially during June at the downstream project boundary. These improvements are expected to benefit sDPS green sturgeon and will create spawning conditions that are expected to result in higher levels of sDPS green sturgeon production.

2.6.5.3 Summary of the Effects of the Proposed Action on the Green Sturgeon DPS

The temperature and habitat analysis in section *2.6.5.2 Summary of the Effects of the Proposed Action on Green Sturgeon in the Feather River* of this biological opinion concludes that there are between 12 and 28 miles of suitable spawning habitat below Oroville Dam. Although there are flow-related passage and water temperature stressors that may delay upstream passage and restrict the window of the spawning period, especially in June; the water temperature measures in Article A108 of the Settlement Agreement will reduce the frequency in which optimal water temperatures are exceeded. These measures will also improve spawning success and production of sDPS green sturgeon in the Lower Feather River.

This analysis, which includes consideration for water temperature improvements over the next 10 years and over the period of the license, leads NMFS to conclude that conditions in the Feather River are expected to be suitable for the production of sDPS green sturgeon. Because the best available information recognizes that the Sacramento River currently supports the only spawning population of sDPS green sturgeon within the DPS, the proposed action, with its water temperature and habitat improvement actions, is likely to create conditions in the Lower Feather River capable of supporting a second spawning population.

From the perspective of species viability, a species (or DPS) with low abundance and only one spawning population faces a higher risk from catastrophic events and is at a high risk of extinction. The presence of a second spawning population in the Feather River could reduce the exposure of the DPS from catastrophic events in the Sacramento River and increase the abundance of the DPS throughout its range.

Therefore, we conclude that the proposed action, through the continued 50-year operation of the facilities in a manner that maintains and increases the quantity and quality of spawning habitat in the Lower Feather River, is not expected to appreciably reduce the likelihood of both the survival and recovery of the DPS.

2.6.5.4 Summary of the Effects of the Proposed Action on SDPS Green Sturgeon Critical Habitat

Critical habitat for sDPS green sturgeon is designated in Feather River reaches downstream from the Fish Barrier Dam. This section will summarize the biological value of available migratory corridors and spawning and rearing habitat and effects of the proposed action on the PBFs.

2.6.5.4.1 Food Resources

Within freshwater riverine systems, this PBF includes abundant prey items for larval, juvenile, subadult, and adult life stages. There is insufficient information available to fully understand how the proposed action will affect the food resources of sDPS green sturgeon. However, due to the presence of macroinvertebrate and other benthic prey that green sturgeon are known to feed on, NMFS concludes that the existing biomass of aquatic invertebrates in the Lower Feather River provide adequate nutritional resources for green sturgeon rearing in the river. Because the proposed action will generally continue conditions that result in the existing biomass of aquatic invertebrates in the Lower Feather River, NMFS anticipates that the effects of the proposed action will continue to result in adequate nutritional resources for sDPS green sturgeon rearing in the river.

2.6.5.4.2 Substrate Type or Size

This PBF includes substrate suitable for egg deposition and development (*e.g.*, bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to collect eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (*e.g.*, substrates with interstices or voids providing refuge from predators and from high flow conditions), and subadults and adults (*e.g.*, substrates for holding and spawning). _ENREF_314Although Sommer et al. (2001b) found that substrate was becoming more coarse in the LFC, substrate size in the HFC where sDPS green sturgeon are expected to spawn has not changed in size since the construction of Oroville Dam. Therefore, the proposed action is not expected to have an adverse effect on this PBF.

2.6.5.4.3 Water Flow

There is insufficient information available to provide a complete analysis of the project-related effects on the Feather River's flow regime. Although high spring flows associated with the natural hydrograph do not occur within the section of the river utilized by sDPS green sturgeon with the frequency and duration that was seen in pre-dam conditions, sufficient flow conditions exist that create migration conditions that allow sDPS green sturgeon to migrate upstream even in dry water year types, as evidenced by the observation of adult sDPS green sturgeon in the upper river reaches below Oroville and the Fish Barrier Dams.

2.6.5.4.4 Migratory Corridors

Sunset Pumps is a potential physical upstream migration barrier for sturgeon in the lower Feather River (USFWS 1995; DWR 2003c). At low flows, Sunset Pumps is a likely adult sturgeon passage impediment because of the height of its waterfalls, water velocities of the mid-channel chute, or lack of attraction flow within the potentially passable side channel. However, sufficient flow conditions that allow sDPS green sturgeon to pass this area occur during the migration period as evidenced by the observation of adult sDPS green sturgeon in the upper river reaches below Oroville and the Fish Barrier Dams in different water year types, including dry years.

2.6.5.4.5 Summary of the Risk to SDPS Green Sturgeon Critical Habitat

Based on the analysis of available evidence, the proposed action maintains the PBFs for sDPS green sturgeon that support their migration, spawning, and production in the Lower Feather River. The action includes numerous water temperature and habitat improvement actions that will substantially improve the value of critical habitat for the conservation of sDPS green sturgeon after the first 10 years of the license and throughout the remainder of the license period. Therefore, NMFS concludes that the proposed action is not likely to appreciably diminish the value of critical habitat for the conservation of sDPS green sturgeon.

2.7 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CCV steelhead, or Southern DPS of North American green sturgeon or destroy or adversely modify designated critical habitat for these listed species.

2.8 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. “Harm” is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR § 402.02). Section 7(b)(4) and Section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

2.8.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take would occur as follows:

NMFS anticipates incidental take of CCV steelhead, CV spring-run Chinook salmon, and the Southern DPS of North American green sturgeon from impacts related to the proposed action. Take is expected to be limited to migrating, holding, and spawning adults; migrating, rearing and smolting fry and juveniles; and incubating eggs.

As described in the biological opinion, effects, including incidental take, of coordinated operations of the CVP and SWP, including the Oroville Facilities, in the Sacramento River and Sacramento-San Joaquin River Delta were analyzed in the CVP/SWP biological opinion and are not part of the proposed action analyzed in this Opinion. Therefore, such incidental take is not covered in this incidental take statement.

As described in the Opinion, NMFS does not anticipate take of Sacramento River winter-run Chinook salmon from impacts related to the proposed action. Sacramento River winter-run Chinook salmon are not expected to use the Feather River; therefore, effects of the proposed action on winter-run Chinook salmon in the Feather River, except for effects of the FRFH, are discountable. Effects of the FRFH are discountable due the separate spawning timings of Sacramento winter-run Chinook salmon and the fish (CV spring-run Chinook salmon, and CCV steelhead) produced by the FRFH.

The expected effects of the proposed action in the Feather River basin will result in potential death, injury, or harm to the freshwater life stages of CV spring-run Chinook salmon, CCV steelhead, and North American Southern DPS of green sturgeon in the Feather River. These effects of the proposed action are expected to include: (1) blocked upstream migration of anadromous fish in the Feather River resulting in the compression of spawning and rearing to reaches of the Feather River below Oroville Facilities (*i.e.*, the Fish Barrier Dam, Thermalito Diversion Dam and Oroville Dam); (2) generally limited habitat availability for Chinook salmon and CCV steelhead on the currently accessible portion of the Feather River, due to being restricted to impaired habitat downstream of the Fish Barrier Dam, and due to the highly modified flows; (3) continued hybridization, through competition for limited spawning space and straying, between CV spring-run Chinook salmon and fall-run Chinook salmon due to FRFH practices and the effects described above; (4) potential stranding of redds, eggs, and juvenile CV spring-run Chinook salmon and CCV steelhead during low flow periods; and (5) potential reduced egg viability in holding adults and death or injury to juveniles due to elevated water temperatures in the HFC during periods of low flows. These effects are anticipated to be reduced by adjustments made in the proposed action through operation of temperature control strategies, minimum instream flows, and implementation of the protection, mitigation, and enhancement measures (PM&Es). Based on the effects of the proposed action that are listed above, the types of incidental take, the life stages to be taken, and how the take would occur are:

Take in the form of harm to CV spring-run Chinook salmon, CCV steelhead, and the Southern DPS of North American green sturgeon in the Feather River from the continued blockage of upstream migration at the Oroville Facilities (*i.e.* the Fish Barrier Dam, Thermalito Diversion Dam, and Oroville Dam) resulting in being restricted from historic habitat and confined to highly altered habitat. This type of take includes:

- Harm through the impairment of rearing and feeding by juvenile CCV steelhead as a result of a shortage of available small side channels that are suitable for in-river spawning and rearing habitat available to CCV steelhead for ten years, or until the Channel Improvement Program (SA Article A103) projects are fully implemented.
- Harm of spawning adult and rearing juvenile CV spring-run Chinook salmon through competition for space with more numerous fall-run Chinook salmon impairing spawning, rearing, feeding and sheltering behavior as a result of habitat compression below the Oroville Facilities (*i.e.* the Fish Barrier Dam, Thermalito Diversion Dam and Oroville Dam) for 12 years or until CV spring-run Chinook salmon are segregated from fall-run Chinook salmon in the LFC.
- Injury and death to incubating CV spring-run Chinook salmon eggs in the LFC from superimposition with natural and hatchery-origin fall-run Chinook salmon during September through November for up to 12 years or until the CV spring-run Chinook salmon are segregated from fall-run Chinook salmon in the LFC.
- Injury and death to all life stages of CV spring-run Chinook salmon in the LFC from reduced fitness related to genetic impacts from hybridization for 12 years or until CV spring-run Chinook salmon are segregated from fall-run Chinook salmon in the LFC.

Take in the form of harm to spawning adult CV spring-run Chinook salmon and CCV steelhead in the LFC and the HFC from reduced spawning habitat availability related to the gravel depletion caused by the presence and continued operation of Oroville Dam. In the LFC the take will be for a period of five years following issuance of the new license, or until gravel projects described in the project description are fully implemented (8,300 cubic yards of spawning gravel are placed as described in SA Article A102). Harm will be due to impaired breeding.

Take in the form of harm to rearing CV spring-run Chinook salmon and CCV steelhead in the LFC and HFC from reduced transport of large woody material from upstream of Oroville Dam for four years or until the Structural Habitat Supplementation and Improvement Program Plan (SA Article A104) is implemented. Harm will occur due to impaired rearing, sheltering, and feeding behavior.

Take will occur due to increased water temperatures. This type of take includes:

> Take in the form of injury and death to adult CV spring-run Chinook salmon from increased susceptibility to disease, pre-spawning mortality, reduced fecundity, and reduced reproductive success from exposure to water temperatures greater than 64° F in

the LFC in July and August in 5 percent of years (expected to be dry or critically dry years), for 10 years after license issuance, or until long-term operational or facility modifications are in place.

Take in the form of harm to adult CCV steelhead from delayed migration from exposure to water temperatures between 58° and 68° F in the LFC and the HFC to the downstream project boundary from July through December of all water year types. Harm will occur due to impaired migration behavior.

Take in the form of injury and death to juvenile and smolt CCV steelhead in the HFC from the downstream project boundary to the confluence with the Yuba River from the physiological effects, increased susceptibility to predation, and reduced migration rates related to high water temperatures in late May and June.

Take in the form of injury and death to holding adult CV spring-run Chinook salmon from increased susceptibility to disease, pre-spawning mortality, reduced fecundity, and reduced reproductive success from exposure to water temperatures greater than 64° F in the HFC in May and June in 5 to 10 percent of years (expected to be dry or critically dry years) for 10 years or until long-term operational or facility modifications are in place.

Take in the form of injury and death to incubating eggs and post emergent larvae and fry CV spring-run Chinook salmon from abnormalities and mortalities from exposure to water temperatures greater than 56°F (DAT) in the LFC near the FRFH in 10 percent of years and at Robinson Riffle in 25 percent of years between mid-September and November for approximately 10 years or until long-term operational or facility modifications are in place.

Take in the form of injury and death to incubating eggs and post emergent larvae and fry CCV steelhead from abnormalities and mortalities from exposure to water temperatures greater than 52°F in the LFC near the FRFH and at Robinson Riffle in late-December in 50 percent of years, and in March and April in 25 percent of years for approximately 10 years or until long-term operational or facility modifications are in place.

Take in the form of injury and death to juvenile CV spring-run Chinook salmon fry and smolts in the HFC from the downstream project boundary to the confluence with the Yuba River from the physiological effects, increased susceptibility to predation, and reduced migration rates related to water temperatures in excess of 64° F in 10 percent of years during the months of April and June.

Take in the form of injury and death related to reduced adult fecundity, egg mortality and abnormalities, and early larval and juvenile rearing of sDPS green sturgeon during May and June, with May exceedance of 63°F occurring in 2 percent of days at the downstream project boundary; and June exceedances in 22 percent of days at the downstream project boundary in dry or critically dry years, or during extreme heat events which occur in 10 percent of years. These conditions are expected to last for the first 10 years of the new license until facility modifications are constructed, upon which time June exceedances will occur in 9 to 12 percent of days of years described above.

Take in the form of death, injury and harm to juvenile and adult CV spring-run Chinook salmon and CCV steelhead is anticipated due to reservoir and facility operations that are expected to alter natural flow patterns in the Feather River downstream of Oroville Facilities (*i.e.* the Fish

Barrier Dam, Thermalito Diversion Dam and Oroville Dam). Death and injury are expected to occur to downstream migrating juvenile salmonids due to reduced flows, increased travel time, and increased predation. Harm is expected to occur due to modified (delayed) migration behavior of adult and juvenile salmonids.

Take in the form of harm related to flow-related effects that delay upstream migration of adult sDPS green sturgeon at Sunset Pumps from March through May at flows less than 2,500 cfs at Sunset Pumps. Harm will occur through modification of migration behavior and possibly spawning behavior.

Take in the form of death and injury to juvenile CV spring-run Chinook salmon and juvenile CCV steelhead is expected due to stranding from down ramping events that results in death due to suffocation, desiccation and increased predation. Harm to juvenile CV spring-run Chinook salmon and juvenile CCV steelhead is also expected due to down ramping due to impaired feeding, rearing, and sheltering for salmonids that are stranded, but do not die.

Take in the form of injury and death to all life stages of CV spring-run Chinook salmon and CCV steelhead in the LFC from reduced fitness related to genetic impacts from hybridization as a result of the FRFH CV spring-run Chinook salmon and CCV steelhead production programs for 2 years or until HGMPs are approved by NMFS and implemented by DWR.

Take due to handling, behavior modification, and capture, will result in potential harm, injury, or death associated with annual installation and removal of the monitoring weir and segregation weir is expected to be insignificant. The potential effects to designated critical habitat from installation of the weirs is expected to be insignificant.

Take from handling, behavior modification, and capture, may result in potential harm, injury, or death to juvenile federally listed anadromous fish species associated with annual juvenile studies. This take is expected to be insignificant.

Take associated with monitoring and evaluation in the form of mortalities, harm, and harassment, which includes:

- Lower Feather River Monitoring Weir(s) in the LFC, annually:

Species	Listing Unit/Stock	Production /Origin	Life Stage	Sex	Expected Take	Indirect Mort	Take Action	Observe /Collect Method
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	1000	0	Observe/Harass	Observations at weirs, fish ladders, dams where no trapping occurs
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	3000	0	Observe/Harass	Observations at weirs, fish ladders, dams where no trapping occurs
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	500	0	Observe/Harass	Observations at weirs, fish ladders, dams where no trapping occurs
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	2000	0	Observe/Harass	Observations at weirs, fish ladders, dams where no trapping occurs
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Adult	Male and Female	1	0	Observe/Harass	Observations at weirs, fish ladders, dams where no trapping occurs

- Low Flow Channel Segregation Weir(s), annually:

Species	Listing Unit/Stock	Production/ Origin	Life Stage	Sex	Expected Take	Indirect Mortality	Take Action	Observe/ Collect Method
Salmon, Chinook	CV spring-run (NMFS Threatened)	Natural	Adult	Male and Female	100	5	Observe/ Harass/ Capture	Weir will be placed prior to fall-run Chinook arrival on spawning grounds.
Steelhead	CCV (NMFS Threatened	Natural	Adult	Male and Female	10	1	Harass	Weir will be removed at the end of fall-run Chinook spawning and prior to steelhead spawning.

- Lower Feather River CV Spring-run Chinook and CCV Steelhead Redd Surveys, annually:

Species	Listing Unit/Stock	Production /Origin	Life Stage	Sex	Expected Take	Indirect Mort	Take Action	Observe /Collect Method
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	500	0	Observe/Harass	Spawning surveys
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	750	0	Observe/Harass	Spawning surveys
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	200	0	Observe/Harass	Spawning surveys
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	50	0	Observe/Harass	Spawning surveys

- Feather River Juvenile Salmonid Monitoring/Community Surveys, annually:

Species	Listing Unit/Stock	Production /Origin	Life Stage	Sex	Expected Take	Indirect Mort	Take Action	Observe /Collect Method
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	1000	0	Observe/Harass	Snorkel/Dive surveys
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	500	0	Observe/Harass	Snorkel/Dive surveys
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	250	0	Observe/Harass	Snorkel/Dive surveys
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	500	0	Observe/Harass	Snorkel/Dive surveys
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	7500	0	Observe/Harass	Snorkel/Dive surveys
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	300	0	Observe/Harass	Snorkel/Dive surveys
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	1000	0	Observe/Harass	Snorkel/Dive surveys
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	300	0	Observe/Harass	Snorkel/Dive surveys
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	500	5	Capture/Handle/Release Fish	Seine, Beach
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	950	4	Capture/Handle/Release Fish	Seine, Beach
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	300	2	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Seine, Beach
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	50	0	Capture/Handle/Release Fish	Seine, Beach

Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	500	5	Capture/Handle/Release Fish	Electrofishing, Backpack
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	500	5	Capture/Handle/Release Fish	Electrofishing, Backpack
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	1000	5	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Electrofishing, Backpack
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	200	2	Capture/Handle/Release Fish	Electrofishing, Backpack
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Juvenile	Male and Female	50	0	Intentional (Directed) Mortality	Seine, Beach

- Feather River Spring-run Chinook Salmon Telemetry Study, annually:

Species	Listing Unit/Stock	Production /Origin	Life Stage	Sex	Expected Take	Indirect Mort	Take Action	Observe /Collect Method
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	15	0	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Hook and line/angler/rod and reel
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	30	0	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Hook and line/angler/rod and reel
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	10	0	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Fish Ladder (only if associated with fish handling)
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	10	0	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Fish Ladder (only if associated with fish handling)
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	5	0	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Net, Fyke
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	5	0	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Net, Fyke

- Feather River Juvenile Salmonid Emigration Monitoring, annually:

Species	Listing Unit/Stock	Production /Origin	Life Stage	Sex	Expected Take	Indirect Mort	Take Action	Observe /Collect Method
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	20	0	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Trap, Screw
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	500	10	Capture/Handle/Release Fish	Trap, Screw
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	250	2	Capture/Handle/Release Fish	Trap, Screw
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Smolt	Male and Female	500	10	Capture/Handle/Release Fish	Trap, Screw
Steelhead	California Central Valley (NMFS Threatened)	Natural	Smolt	Male and Female	50	2	Capture/Handle/Release Fish	Trap, Screw
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Smolt	Male and Female	5000	50	Capture/Handle/Release Fish	Trap, Screw
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Smolt	Male and Female	500	5	Capture/Handle/Release Fish	Trap, Screw
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	2	0	Capture/Handle/Release Fish	Trap, Screw
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	3	0	Capture/Handle/Release Fish	Trap, Screw
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Fry	Male and Female	12000	240	Capture/Handle/Release Fish	Trap, Screw
Steelhead	California Central Valley (NMFS Threatened)	Natural	Fry	Male and Female	1750	10	Capture/Handle/Release Fish	Trap, Screw

- Feather River Chinook Escapement Survey, annually:

Species	Listing Unit/Stock	Production /Origin	Life Stage	Sex	Expected Take	Indirect Mort	Take Action	Observe /Collect Method
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Spawned Adult/ Carcass	Male and Female	2830	0	Observe/Sample Tissue Dead Animal	Gaff
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Spawned Adult/ Carcass	Male and Female	6770	0	Observe/Sample Tissue Dead Animal	Gaff
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Spawned Adult/ Carcass	Male and Female	170	0	Observe/Sample Tissue Dead Animal	Gaff
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Spawned Adult/ Carcass	Male and Female	230	0	Observe/Sample Tissue Dead Animal	Gaff

- FRFH Spatial and Temporal Patterns of Naturally Spawning Hatchery CV Spring-run Chinook Salmon, annually:

Species	Listing Unit/Stock	Production /Origin	Life Stage	Sex	Expected Take	Indirect Mort	Take Action	Observe /Collect Method
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	25000	200	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Fish Ladder (only if associated with fish handling)
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	2500	50	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Fish Ladder (only if associated with fish handling)

- Passage, Abundance, Distribution, and Potential Spawning of Green Sturgeon in the Lower Feather River, annually:

Species	Listing Unit/Stock	Production /Origin	Life Stage	Sex	Expected Take	Indirect Mort	Take Action	Observe /Collect Method
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Adult	Male and Female	1000	0	Observe/Harass	Fish or a stream survey (where fish information is collected)
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	3000	0	Observe/Harass	Fish or a stream survey (where fish information is collected)
Steelhead	California Central Valley (NMFS Threatened)	Natural	Adult	Male and Female	25	0	Observe/Harass	Fish or a stream survey (where fish information is collected)
Steelhead	California Central Valley (NMFS Threatened)	Listed Hatchery Adipose Clip	Adult	Male and Female	50	0	Observe/Harass	Fish or a stream survey (where fish information is collected)
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Adult	Male and Female	5	0	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Hook and line/angler/rod and reel
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Adult	Male and Female	3	0	Capture/Handle/Release Fish	Hook and line/angler/rod and reel
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Adult	Male and Female	5	0	Capture/Mark, Tag, Sample Tissue/Release Live Animal	Hook and line/angler/rod and reel
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Adult	Male and Female	200	0	Observe/Harass	Fish or a stream survey (where fish information is collected)

- Lower Feather River Green Sturgeon Spawning Survey, annually:

Species	Listing Unit/Stock	Production /Origin	Life Stage	Sex	Expected Take	Indirect Mort	Take Action
Salmon, Chinook	Central Valley spring-run (NMFS Threatened)	Natural	Juvenile	Male and Female	50	1	Capture/Handle/Release Fish
Details: Benthic D-Nets will be used.							
Steelhead	California Central Valley (NMFS Threatened)	Natural	Juvenile	Male and Female	10	0	Capture/Handle/Release Fish
Details: Benthic D-Nets will be used.							
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Egg	Unknown	10	0	Intentional (Directed) Mortality
Details: Benthic D-Nets will be used.							
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Egg	Unknown	50	0	Intentional (Directed) Mortality
Details: Egg Mats will be used.							
Sturgeon, green	Southern DPS (NMFS Threatened)	Natural	Larvae	Male and Female	60	15	Capture/Handle/Release Fish
Details: Benthic D-Nets will be used.							

Beyond the take quantified above, NMFS cannot, using the best available information, quantify the anticipated incidental take of individual CV spring-run Chinook salmon, CCV steelhead, and the Southern DPS of North American green sturgeon because of the variability and uncertainty associated with the population size of each species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the project area. In addition, detection of killed or injured individuals is unlikely to occur or be effective without extensive impracticable river monitoring efforts. In such cases, this ITS will use ecological surrogates to describe the expected extent of take due to the proposed action when direct quantification of take for individuals is not possible. Surrogates are used for this ITS since it is nearly impossible to quantify the number of individuals of listed species exposed to the proposed action, but it is reasonably certain that those individuals that are exposed will incur some level of adverse response to the exposure resulting in take as defined under the ESA. In the ITS, NMFS will explain the causal link between the surrogate and the expected response from the exposed listed species; the reason why quantifying the amount of individuals exposed to the action (*i.e.*, take) is impractical to measure; and finally, establish a clear standard as to when take is exceeded (the surrogate parameter).

Accordingly, NMFS is expressing the amount or extent of anticipated incidental take of CV spring-run Chinook salmon, CCV steelhead, and the Southern DPS of North American green sturgeon according to the following ecological surrogates.

Take of CV spring-run Chinook salmon and CCV steelhead and sDPS green sturgeon associated with the continued blockage of access to historic habitat will occur due to harm experienced by adults and juveniles spawning, incubating, and rearing in altered habitat downstream of the Fish Barrier Dam. For these three species the area in which they are now restricted has regulated flows, which have reduced frequency of channel forming flows. Further, for CV spring-run Chinook salmon and for CCV steelhead, by being restricted to this area there is harm associated with reduced fitness associated with interbreeding with FRFH fish. For CV spring-run Chinook salmon there is harm associated with interbreeding with fall-run Chinook salmon and loss of CV spring-run Chinook salmon from superimposition by fall-run Chinook salmon. It is not possible to enumerate the take in the form of harm associated with spawning, incubating, and rearing in the area of altered habitat to which these species are restricted. For example, outside of a controlled setting, with superimposition of a fall-run Chinook salmon redd on top of a CV spring-run Chinook salmon redd, it is not possible to enumerate the number of eggs that were killed when the fall-run Chinook salmon digs its redd in the same location. Variables include the amount of overlap of the two redds, the stage of development of the CV spring-run Chinook salmon eggs, the relative depths of the two redds, and how the flow of water and oxygen to the CV spring-run Chinook salmon eggs is affected.

Due to the difficulty in quantifying the actual take with these species being restricted to altered habitat, we have identified minimum flows as a surrogate for take in the form of harm. The quantity of flow is directly related to the amount of habitat available and harm due to spawning, incubating, and rearing in the area of altered habitat to which these species are restricted. The minimum flows are identified in Table 2-32 and Table 2-33. Deviation of flows less than the minimum flows less than three times a year, of less than or equal to 10 percent reduction from the minimum flow; or for less than a total of 24 hours in a year are to be considered consistent with this surrogate, but any deviations outside of these parameters are to be considered inconsistent with this surrogate. Flow reductions of equal to or less than this magnitude and frequency are expected to have insignificant effects.

Operation of the Oroville Facilities is expected to alter water temperatures in the LFC and HFC. Increases in water temperatures are expected to result in the take of juvenile CV spring-run Chinook salmon and juvenile CCV steelhead. Increased water temperatures is also expected to result in take associated with reduced egg viability for both of these species. Because eggs are below the bottom of the stream, and juvenile fish use the spaces between rock for cover, and predators quickly remove dead fish, it is difficult to enumerate the losses of eggs and juvenile salmonids. As a surrogate to loss of eggs and fish we use the proposed action’s temperature targets and criteria (Table 2-31). These maximum daily average temperatures are targets that must be achieved to the extent possible until facilities modification are completed or within 10 years of license issuance (including a testing period). Upon completion of facility modification but not more than 10 years after license issuance, the temperatures in Table 2-31 become criteria.

Due to the difficulty in quantifying the actual take of these species associated with death, injury, and harm from warm water temperatures, we have identified the temperature targets and criteria as a surrogate for take associated with water temperatures downstream of the Fish Barrier Dam. Temperature deviations in excess of the temperature targets, except for conference years (see below), for less than 5 days per calendar year and for no more than 3 °F are to be considered consistent with this surrogate, but any deviations outside of these parameters are to be considered inconsistent with this surrogate. The effects of occasional inadvertent deviations due to equipment failure, or operations errors within these limits are expected to be insignificant.

In some years due to precipitation conditions, it will not be possible to meet the temperature targets or criteria. When specific conditions occur, these will be identified as conference years. In conference years specific plans will be developed to address that year's situation. The plans will be developed to minimize the effects of the Oroville Facilities on listed anadromous fish species. In conference years, implementation of the temperature plans for that year, as approved by NMFS, will be considered the surrogate for that conference year. As long as there is no deviation from the conference year temperature plan, any take that occurs associated with water temperatures will be considered consistent with this surrogate.

Table 2-31. Temperature Objectives.

Temperature Objectives (ºF)			
Maximum Daily Mean Water Temperature for the LFC (measured at Robinson Riffle, RM 61.6)		**Maximum Daily Mean Water Temperature for the HFC (measured at the downstream project boundary[1])**	
Period	**Temperature**	**Period**	**Temperature**
January 1–March 31	56	January 1–March 31	56
April 1–30	56	April 1–30	61
May 1–15	56–63*	May 1–15	64
May 16–31	63	May 16–31	64
June 1–August 31	63	June 1–August 31	64
September 1–8	63 -58*	September 1–8	61
September 9–30	58	September 9 - 30	61
October 1–31	56	October 1-31	60
November 1–December 31	56	November 1–December 31	56

Changes in flow, outside of flood management conditions, may result in the take of juvenile CV spring-run Chinook salmon and/or juvenile CCV steelhead through stranding. Rearing salmonids may be lost due to increased predation, desiccation, or suffocation when, due to operations of the Oroville Facilities, the water elevation in the Feather River decreases. Fish may become stranded on the dewatered shore, or trapped in pools that are disconnected from the river. Enumeration of stranding is difficult because it involves fish that are beneath the bed of the river, and birds remove stranded fish quickly at daylight. NMFS has identified the maximum ramping rates as a surrogate for this type of take. The maximum ramping rates outside of flood operations are identified in Table 2-34. Outside of flood operations, exceeding the maximum ramping rates up to three times in one calendar year is to be considered consistent with this surrogate, but any deviations outside of these parameters is to be considered inconsistent with this surrogate. The effects from occasional unplanned ramping rate deviations within the limits identified are expected to be insignificant.

Table 2-32. Low Flow Channel Minimum Instream Flows

Low Flow Channel Minimum Instream Flows	
Months	**Flow**
April 1–September 8	700 cfs
September 9–March 31	800 cfs

Table 2-33. High Flow Channel Minimum Instream Flow

High Flow Channel Minimum Instream Flow			
Percent of Normal Runoff *	**Oct–Feb (cfs)**	**March (cfs)**	**April–Sept (cfs)**
≥55%	1,700	1,700	1,000
<55%	1,200	1,000	1,000

Table 2-34. LFC Ramping Rates

LFC Ramping Rates	
Feather River LFC Releases (cfs)	**Rate of Decrease (cfs)**
3,500–5,000	1,000 per 24 hours
2,500–3,500	500 per 24 hours
< 2,500	300 per 24 hours
HFC Ramping Rates	
Feather River HFC Releases (cfs)	**Rate of Decrease (cfs)**
< 2,500	200 per 24 hours

Hatchery-influenced selection (often called domestication) occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with hatchery-origin fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program. Hatchery-influenced selection can range from relaxation of selection (that would normally occur in nature) to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999). Take of natural spawning and rearing CV spring-run Chinook salmon, and CCV steelhead can occur in the form of harm during all life stages due to reduced fitness due to interbreeding of hatchery fish with naturally spawning fish. Reduced fitness due to interbreeding can result in take through death or harm of wild spawning salmonids. This type of take can occur in the Feather River and other streams.

Currently, it would not be possible to accurately measure any genetic effects on listed CV spring-run Chinook salmon or CCV steelhead solely assignable to the hatchery actions in a manner that would allow for the accurate quantification of take, because discrete genetic diversity or fitness effects resulting only from implementation of the hatchery programs cannot be detected in a comprehensive, reliable manner.

Therefore, in the Feather River NMFS will rely on a surrogate take indicator that relates to the productivity of the listed population – a primary factor in determining genetic diversity and fitness reduction effects. For the FRFH effects in the Yuba River we will use another surrogate. It should be noted that the productivity goals may go unmet for a variety of factors apart from hatchery-related genetic effects (most notably, the degraded state of habitat), but the selected indicators would trigger further analysis to determine the causes of low productivity, with effects attributed to the hatchery program considered commensurately with other factors (e.g., habitat-related conditions and harvest-related effects).

With implementation of the monitoring weir and segregation weir, it will be possible to enumerate the number of CV spring-run Chinook salmon and make estimates of hatchery and natural origin CV spring-run Chinook salmon. Over time the cohort replacement rate for naturally spawning CV spring-run Chinook salmon can be calculated. After 7 years of weir operation a five-year running average of the cohort replacement rate can be calculated. If the five year moving average cohort replacement rate falls below a value of one (1.0), further analysis will be conducted to determine the causes of low productivity, with effects attributed to the hatchery program considered commensurately with other factors (e.g., habitat-related conditions and harvest-related effects). A five year moving cohort replacement rate is used to take into consideration the natural variation in survival. If the five year cohort replacement rate falls below 1.0, it is an indicator that the population is in decline (less than 1 adult offspring per adult parent). If the five year cohort replacement is less than 1.0, an analysis is necessary to determine if the low cohort replacement value is due to FRFH effects, or other causes. The additional analysis should include comparison with other populations in the Sacramento River watershed. The comparison analysis will help identify whether the low cohort replacement value is specific to the Feather River or a larger region. The surrogate take indicator will be exceeded if the cohort replacement value is less than 1.0 and the analysis attributes an annual 10 percent or greather decline in the population to the FRFH. Lindley et al. (2007) identified that annual declines of greather than or equal to 10 percent represent a high risk of extinction. If the monitoring weir can be used to collect similar information for steelhead, the same analysis should be conducted for steelhead.

Based on recent data, it appears that the only other stream with fish that may be significantly affected by the FRFH is the Yuba River, where FRFH spring-run Chinook salmon have been up to 60 percent of the CV spring-run Chinook salmon moving upstream of Daguerre Point Dam. NMFS has identified a surrogate for take in the Yuba River as under five percent of a year's in-river spawning population being composed of FRFH CV spring-run Chinook salmon and FRFH CCV steelhead. Straying of more than five percent from a "best-management practices" hatchery has been identified as having a moderate risk of extinction (Figure 2-72) (Lindley et al. 2007). This surrogate will be measured based on video information from Daguerre Point Dam fishways or surveys. If FRFH spring-run Chinook salmon are used for reintroduction efforts in the Yuba River watershed, this metric may need to be revised.

The proposed action provides a framework for facilities modifications described in SA Article 108 that will be selected and implemented at a later time. At this time, the specific details of potential facilities modifications that would be selected and implemented under SA Article 108 are not available in enough specificity to make estimates of the amount of take that may result. Once studies are completed and necessary facility modifications are proposed, a separate consultation may be required depending on the details of those activities and potential effects on ESA listed anadromous fish species.

Future actions that may be enacted to address the absence of fish passage at the Oroville Facilities include implementation of the HEA with an approved HEP, or if the HEA is not implemented, fishways prescribed for CV spring-run Chinook salmon and CCV steelhead at or around this and other hydroelectric projects in the Feather River basin. The FPA licensing process and the HEA provide frameworks for these activities that will be determined and implemented at a later time. At this time, the specifics for either of these options are not available in enough detail to estimate take. When a choice to implement either of these options is made, and the details are developed, a separate consultation may be required depending on the details of those activities and potential effects on ESA listed anadromous fish species.

2.8.2 Effect of the Take

In the Opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.8.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR § 402.02).

NMFS believes that the following reasonable and prudent measures are necessary and appropriate to minimize the effect of incidental take of CV spring-run Chinook salmon, CCV steelhead, and sDPS North American green sturgeon resulting from the proposed action:

1. Measures shall be taken consistent with NMFS' authority under Federal Power Act Section 18 to prescribe the construction, operation, and maintenance of fishways at the Oroville Facilities.

Biological Goal: The goal is to address the loss of access to historic holding, spawning, incubation, and rearing habitat; and the loss of productivity for CV spring-run Chinook salmon and CCV steelhead.

2. Measures shall be taken to further minimize the adverse effects of hybridization, superimposition, and egg mortality associated with the spatial and temporal co-existence of fall-run Chinook salmon and CV spring-run Chinook salmon in the LFC, and of wild and hatchery CV spring-run Chinook salmon and wild and hatchery CCV steelhead in the LFC.

   Biological Goal: The goal is to reduce temporal and spatial overlap of spawning CV spring-run Chinook salmon with fall-run Chinook salmon; spatial overlap of spawning hatchery and wild CV spring-run Chinook in the LFC; and spatial overlap of spawning wild and hatchery CCV steelhead in the LFC, while balancing the needs of spring-run and fall-run Chinook salmon and CCV steelhead with available habitat.

3. In accordance with Settlement Agreement Article A103, measures shall be taken to construct a sufficient amount of CCV steelhead spawning and rearing habitat in the LFC to minimize the effects of take associated with the restriction from historic spawning and rearing habitat, and confinement to degraded habitat.

   Biological Goal: The goal is to increase steelhead spawning and rearing habitat in the Feather River by constructing spawning habitat for adult CCV steelhead and rearing habitat for juvenile CCV steelhead to meet the needs of CCV steelhead spawning and rearing in the LFC.

4. Measures shall be taken to minimize temperature related effects to CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon in the Lower Feather River.

   Biological Goal: The goal is to ensure that facilities modifications and/or operational changes are made that will improve water temperatures and minimize the take of listed salmon, steelhead and green sturgeon.

5. Measures shall be taken to further avoid or minimize take associated with the operational impacts associated with the implementation of the proposed action, and to improve the survival and growth of adult and juvenile CV spring-run Chinook salmon, CCV steelhead, and Southern DPS of North American green sturgeon.

   Biological Goal: The goal is to minimize take associated with the proposed action through initiating work on the LFRHIP as soon as possible and to maximize opportunities to restore habitat and increase fish production.

6. Measures shall be taken to implement immediate actions to minimize adverse effects associated with the operation of the FRFH.

   Biological Goal: The goal is to improve management of the FRFH to minimize adverse effects on local listed salmon and steelhead genetics, and to reduce straying to other watersheds and creating offsite genetic consequences that reduce the fitness of those populations.

7. Measures shall be taken to implement a comprehensive research, monitoring, and evaluation program for sDPS green sturgeon in the Feather River (Green Sturgeon Research and Monitoring and Evaluation Program).

   Biological Goal: Improve the understanding of green sturgeon use of the Feather River including movements, distribution, abundance, productivity and genetic characteristics; and how green sturgeon respond to variations in flows in the Feather River as a result of the proposed action.

8. Measures shall be taken to develop a Green Sturgeon Management Plan as part of the Lower Feather River Habitat Improvement Program in order to minimize take associated with the proposed action.

   Biological Goal: The overall goal is to ensure that a management program exists for the duration of the license that minimizes take associated with the proposed action of sDPS green sturgeon in the Feather River.

9. Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the term of the license to ensure their effectiveness.

   Biological Goal: The goal is to ensure sufficient monitoring and reporting of project effects and conservation measures in order to monitor the impacts of the incidental take that is described in this biological opinion.

10. Prepare and provide NMFS with plans and reports describing how federally listed anadromous fish species in the action area are and will be protected and monitored and to document the effects of the action on listed species in the action area.

    Biological Goal: The goal is to ensure that NMFS receives timely information to ensure the proposed action and measures of the biological opinion are carried out as described and prescribed.

2.8.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and FERC or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). FERC or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. **The following terms and conditions implement reasonable and prudent measure 1 (*Measures shall be taken consistent with NMFS' authority under Federal Power Act Section 18 to prescribe the construction, operation, and maintenance of fishways at the Oroville Facilities.*):**

   a) FERC shall incorporate in the license for the Oroville Facilities NMFS' reservation of authority to prescribe fishways under Section 18 of the Federal Power Act, which provides:

      > Authority is reserved for the National Marine Fisheries Service to prescribe the construction, operation, and maintenance of fishways at the project, including

measures to determine, ensure, or improve the effectiveness of such prescribed fishways, pursuant to Section 18 of the Federal Power Act, as amended, during the term of the project license, as provided in the Habitat Expansion Agreement (2007).

b) In the event that the Habitat Expansion Agreement is terminated before its implementation is complete and NMFS exercises its reserved authority to prescribe fishways at the Oroville Facilities, FERC shall incorporate in the license for the Oroville Facilities any modified prescription of fishways at the Oroville Facilities, including any schedules therein, that NMFS files with FERC under Section 18 of the Federal Power Act.

2. The following terms and conditions implement reasonable and prudent measure 2 (*Measures shall be taken to further minimize the adverse effects of hybridization, superimposition, and egg mortality associated with the spatial and temporal co-existence of fall-run Chinook salmon and CV spring-run Chinook salmon in the LFC, and of wild and hatchery CV spring-run Chinook salmon and wild and hatchery CCV steelhead in the LFC.*):

a) FERC shall require DWR, in consultation with NMFS and CDFW, to take the steps described in this term and condition consistent with SWRCB Order WQ 2010-016 Special Condition S5 to count and separate adult spring-run and fall-run Chinook salmon in the Lower Feather River. FERC shall require DWR to install and operate a monitoring weir in the vicinity upstream of the Thermalito Afterbay Outlet within three years of license issuance and to use the monitoring weir, or an additional separate interim weir, to segregate adult spring-run and fall-run Chinook salmon within five years of license issuance.

DWR, in consultation with NMFS and the EC (established pursuant to Article A100 of the Settlement Agreement for the Licensing of the Oroville Facilities), shall determine the best location for the operation of both weirs. DWR may install and operate an interim weir until a long-term segregation weir is installed and operated consistent with Article A105 of the Settlement Agreement. The goal and activities of the weir operation shall be consistent with Article A105 of the Settlement Agreement. The segregation weir may be installed seasonally if consistent with recommendations by the Feather River Fishery Technical Team (FRTT) and the EC. FERC shall require DWR to seek NMFS concurrence with the location and operational procedures of the monitoring and segregation weir.

b) FERC shall require DWR to install fish or egg collection facilities at the segregation weir and operate the collection facility upon installation of the segregation weir. The fish or egg collection facilities are necessary for the operation of the FRFH. Without a fish or egg collection facility the FRFH could not perform its function, because the segregation weir is downstream of the hatchery fish ladder. If an interim segregation weir is installed and operated by DWR, collection facilities will be required to be installed for that weir while a long-term solution is developed and implemented. FERC shall require DWR to seek NMFS concurrence with the location and operational procedures of the fish or egg collection facilities.

c) FERC shall require that the placement of any long-term segregation weir create sufficient space to support a naturally producing CV spring-run Chinook salmon population of sufficient size and distribution so as to allow for the appropriate levels of abundance, production, and genetic and life history diversity to be considered self-sustaining and viable in the Feather River. FERC shall require DWR to seek NMFS concurrence that the segregation weir location is sufficient to allow for a naturally-producing, self-sustaining and viable population of CV spring-run Chinook salmon in the Feather River.

d) FERC shall require that in the event that DWR determines it will be unable to meet the five-year timeline to install the segregation weir due to circumstances beyond its control, that DWR shall develop an alternative schedule for installation of the fish segregation weir. In the event that DWR determines it will be unable to meet the five-year timeline to install the segregation weir due to circumstances beyond its control, DWR shall consult with the EC and provide written notification to NMFS of such delay as soon as it becomes clear that the five-year timeline will not be met. If NMFS determines that good cause exists for such delay, DWR shall develop, in consultation with the EC, an alternative schedule for installing the segregation weir by the earliest date feasibly possible. The schedule will be provided to NMFS for approval and modification if necessary. Circumstances that may be considered good cause for an extension may include, but not be limited to, the inability of DWR to acquire necessary regulatory permits, water rights, easements, or purchase real property required for construction and operation of the segregation weir, fish collection, or egg collection facilities. In such a case, DWR will provide NMFS notification of these reasons in writing with as much advance notice as feasible. Failure to install the segregation weir within the five-year timeline due to circumstances beyond DWR's control will not be considered a violation of the terms and conditions of this Opinion as long as NMFS determines that DWR showed that it was acting reasonably to meet the five-year time frame for installing the weir.

3. **The following terms and conditions implement reasonable and prudent measure 3 *(In accordance with Settlement Agreement Article A103, measures shall be taken to construct a sufficient amount of CCV steelhead spawning and rearing habitat in the LFC to minimize the effects of take associated with the restriction from historic spawning and rearing habitat, and confinement to degraded habitat.)*:**

   a) FERC shall require DWR to use established, peer reviewed carrying capacity or production models to maximize the design (e.g., flow-related habitat availability, habitat carrying capacity and population viability) of spawning and rearing habitat projects, including those recommended by the FRTT, to optimize the designs and evaluation of future habitat enhancements such as side channel construction and other habitat improvements as described in Settlement Agreement Article A103.

4. **The following terms and conditions implement reasonable and prudent measure 4 (*Measures shall be taken to minimize temperature related effects to CV spring run Chinook salmon, CCV steelhead, and sDPS green sturgeon in the Lower Feather River.*):**

   a) FERC shall require that the feasibility analysis for evaluating potential facility modifications in accordance with Settlement Agreement Article A108 will incorporate modeling scenarios for climate change and shall use the climate change forecasts for the duration of the license for selecting modification alternatives. For temperature improvements in the HFC, priority shall be given to facility or operation improvements to reduce thermal loading.

b) In relation to the facilities modification(s) testing period report described in Settlement Agreement Article 108.5:

   (i) FERC shall require DWR to submit the draft testing period report to NMFS within six months of completion of the 5-year testing period.

   (ii) FERC shall require DWR to indicate in the final testing period report whether NMFS concurred in any alterations to the table for HFC temperatures listed in Settlement Agreement Article A108.4, Table 2.

   (iii) FERC shall require DWR to submit the final testing report to NMFS for review and concurrence of any alterations to the table for HFC temperatures listed in Settlement Agreement Article A108.4, Table 2.

c) FERC shall require DWR in the event of a conference year to consult with NMFS regarding development of a strategic plan for managing the coldwater pool and water temperatures in the LFC and HFC as described in Settlement Agreement A108.6 and submit the strategic plan to NMFS for review and concurrence.

d) FERC shall require DWR to develop and apply a temperature egg and fry survival model for juvenile production of CV spring-run Chinook salmon and CCV steelhead in the Feather River. FERC shall require that DWR submit to NMFS for review and concurrence a targeted research, monitoring and modelling plan to further reduce uncertainties related to temperature dependent mortalities.

e) FERC shall require that DWR in coordination with the EC and with NMFS' concurrence, develop an evaluation and report of water temperature criteria for the LFC and HFC. The evaluation will consider climate change, facilities modifications, adaptive management, and the feasibility of using the EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (2003) recommendations, including the use of 7DADM. The evaluation will include emerging science and application of the 7DADM criteria in other rivers of the Central Valley. The report will include recommendations to the EC regarding the findings and suitability of applying 7DADM to the Feather River. The evaluation report will be provided to the EC and NMFS consistent with the timing in Settlement Agreement Article A108.5.

5. The following terms and conditions implement reasonable and prudent measure 5 (*Measures shall be taken to further avoid or minimize operational impacts associated with the implementation of the Oroville Facilities, and to improve the survival and growth of adult and juvenile CV spring-run Chinook salmon, CCV steelhead, and Southern DPS of North American green sturgeon.*):

a) FERC shall require DWR to continue to chair the FRTT. Meetings will be held at least quarterly if not more often and DWR will record and distribute meeting notes from each meeting. DWR will seek the advice and guidance of the FRTT on ways to implement the Settlement Agreement and this Opinion. The FRTT will be composed of at least DWR, NMFS, USFWS, and CDFW.

i) FERC shall require DWR to use the FRTT for advice and guidance, in consultation with the EC, for implementation of Article A106 of the Settlement Agreement (Riparian and Floodplain Improvement Plan) to improve floodplain habitat.

ii) DWR shall use the FRTT for advice and guidance to use DWR's programs and authorities to protect, enhance, and restore riparian and floodplain habitats within the HFC at locations outside the Oroville Wildlife Area in order to minimize the effects of the project's flows on federally listed anadromous fish interactions with floodplain habitats in these areas. Within two years of license issuance, DWR shall submit a plan to NMFS for review and concurrence describing potential partners, actions, and a conceptual implementation strategy to minimize the effects of the project's flows on federally listed anadromous fish interactions with floodplain habitats within the HFC at locations outside the Oroville Wildlife Area.

iii) DWR shall be responsible for taking FRTT meeting notes, and shall submit an annual report to NMFS regarding FRTT activities. Draft FRTT meeting notes will be distributed within two working days of the FRTT meetings. The FRTT shall meet as determined by its members, but is expected to meet at least quarterly. The FRTT shall establish a regular meeting schedule at the beginning of each year, based on the anticipated need for review and discussion of projects. DWR may reschedule a meeting, or call a special meeting with three days' notice to the FRTT members, or on request of NMFS or any two or more FRTT members.

b) FERC shall require DWR to create the Feather River Operations Group (FROG) to provide recommendations for coordination of Feather River flows, flows with fish releases, flows for green sturgeon, and to provide input on research to identify effects of flow management on fish migrations. This research shall include, but is not limited to, the effects of flows and temperatures on fish migration. DWR and the FROG shall consider how to coordinate Feather River flows with Yuba River flows to minimize straying and benefit Federal ESA listed anadromous fish species. The FROG shall be composed of representatives of at least DWR, NMFS, USFWS, and CDFW.

The FROG will have the responsibility to gather and analyze information and make recommendations regarding adjustments to water operations within the range of flexibility prescribed in the Oroville Facilities license and the Terms and Conditions of this Opinion.

i) The FROG will provide recommendations to DWR that affect HFC flows, on management of flows in the HFC to benefit fish resources (upstream and downstream migration, water temperatures, flows, habitat, pulse flows, and survival of adult and juvenile salmonids and green sturgeon).

ii) FERC shall require DWR to provide to the FROG participants information about operations and reservoir conditions, and forecasted operations and reservoir conditions, including water deliveries, at least 2 working days prior to FROG meetings. The forecasts shall include, at a minimum, current and projected reservoir levels, flows, water temperatures, cold water pool volume, and water transfers.

iii) DWR shall be responsible for taking FROG meeting notes, and shall submit an annual report to NMFS regarding FROG activities. Draft FROG meeting notes will be distributed within two working days of the FROG meetings. The FROG shall meet as determined by its members, but is expected to meet at least monthly. The FROG shall establish a regular meeting schedule at the beginning of each year, based on the anticipated need for adjustment to operations. DWR may reschedule a meeting, or call a special meeting with three days' notice to the FROG members, or on request of NMFS or any two or more FROG members.

iv) FERC shall require DWR to inform NMFS, California Central Valley Office, CDFW, and the FROG prior to Dam safety inspections that involve the need to fluctuate flows in the LFC to ensure the inspections are conducted at a time or in a manner that minimizes the potential for adverse effects to spawning or rearing CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon.

v) FERC shall require DWR to convene the FROG to meet at least every two weeks, or as needed during conference years as defined in Settlement Agreement Article A108.6, to review reservoir storage, status of the coldwater pool, coldwater pool carry over, and coldwater management plans, and to consider and recommend actions for DWR to take in order to meet the water temperature criteria while meeting its water supply and other legal obligations. The FROG will work in consultation with the EC.

vi) FERC shall require DWR to contribute information about Oroville conditions, operations and forecasts to the Water Operations Management Team (WOMT) at all WOMT meetings.

vii) FERC shall require that when the Real Time Drought Operations and Management Team (RTDOT), or similar operations group, is convened to respond to drought conditions, for DWR to contribute information about Oroville conditions, operations and forecasts and participate in all RTDOT meetings.

viii) FERC shall require DWR to provide annual reports of FROG activities and accomplishments to the fish resource agencies. The draft report is to be provided by September 10th of each year, with a 3-week comment period. The annual report is to be finalized by November 1st.

c) If DWR proposes to change the ramping rates or conditions associated with rates, FERC shall require DWR to submit proposed changes to NMFS and the FROG for review and comment, and obtain concurrence from NMFS regarding any modifications to the down ramping rates.

d) FERC shall require DWR through the FRTT to monitor redds for egg survival, and evaluate juvenile survival in the Feather River. FERC shall require DWR to provide NMFS, FROG, and FRTT annual reports on these activities.

6. The following terms and conditions implement reasonable and prudent measure 6 (*Measures shall be taken to take immediate actions to minimize adverse effects associated with the operation of the FRFH.*):

a) FERC shall require DWR to work with the California Department of Fish and Wildlife to complete Hatchery and Genetic Management Plans (HGMPs) within two years of license issuance for all anadromous fish populations at the FRFH, as provided in Settlment Agreement Article A107.3.

b) FERC shall require DWR to implement fisheries monitoring programs to examine predation and hybridization effects associated with the Oroville Facilities, including FRFH practices, until HGMPs and such long-term programs developed under the HGMPs are implemented. Studies shall be developed and implemented that evaluate the survival of hatchery and wild fish through the Feather River, and that evaluate the genetic status of hatchery and naturally spawned salmon and CCV steelhead in the Feather River.

c) FERC shall require DWR to annually mark and CWT 100 percent of all CV spring-run Chinook salmon produced at the FRFH. DWR shall annually mark and CWT fall-run Chinook salmon per the HGMPs. Until HGMPs are finalized and approved by NMFS, at least 25% percent of all fall-run Chinook salmon produced at the FRFH shall be marked and CWT. Over time this percentage will be increased to be consistent with other CV fall-run Chinook marking and tagging programs. Adaptive management changes to this marking strategy shall be made in coordination with and with concurrence by NMFS and CDFW and be incorporated into the most current FRFH CV spring-run Chinook salmon HGMP. All CCV steelhead produced at the FRFH shall be marked with an adipose fin clip or other mark standard for Central Valley hatcheries until HGMPs and such long-term programs developed under the HGMPs are implemented. DWR shall implement marking and tagging of steelhead produced at the FRFH as identified in HGMPs.

d) FERC shall require DWR to develop and implement an annual monitoring program documenting the amount and extent of straying of Chinook salmon and CCV steelhead produced by the FRFH, using CWT data produced by existing monitoring programs in the Central Valley or genetic marking techniques, until long term marking and tagging programs are established through HGMPs and such long-term programs developed under the HGMPs are implemented. DWR shall submit annual straying reports to NMFS by March 1 of each year. The annual straying reports will include information about, at a minimum, the numbers and percent of FRFH fish that strayed to areas outside the Feather River, and the percent the FRFH origin fish compose of the populations in the streams where they stray.

7. **The following terms and conditions implement reasonable and prudent measure 6 (*Measures shall be taken to implement a comprehensive research, monitoring, and evaluation program for green sturgeon in the Feather River (Green Sturgeon Research and Monitoring and Evaluation Program*)):**

   a) FERC shall require DWR to develop and implement a comprehensive research, monitoring, and evaluation program for sDPS green sturgeon in the Feather River (Green Sturgeon Research and Monitoring and Evaluation Program), including the following objectives: 1) Describe and quantify green sturgeon use of the Feather River including movements, distribution, abundance, productivity and genetic characteristics; 2) Evaluate the effects of normal variation in river discharge on green sturgeon use of the Feather River; and 3) characterize Green Sturgeon holding, spawning and rearing habitats in the Feather River.

   b) FERC shall require DWR to incorporate in the Green Sturgeon Research and Monitoring and Evaluation Program the following eight research, monitoring and evaluation strategies:

i) Immediately begin steps to implement a comprehensive, long-term research, monitoring and evaluation program of green sturgeon in the Feather River.

ii) Monitor all sturgeon life stages including adult migration and residence, spawning, incubation, larval dispersal, and juvenile rearing.

iii) Employ a basic annual sampling effort supplemented with additional sampling in years of high sturgeon abundance.

iv) Employ a phased approach: first evaluating current conditions to establish reference baseline conditions and empirically testable hypotheses, and later testing appropriate experimental measures identified based on initial evaluations.

v) Conduct initial evaluations of the effect of flow volume and duration on green sturgeon attraction, migration, and production based on normal variation in flow. The initial evaluation period will be for 10 years following DWR's acceptance of the new license and certain elements will be continued for a longer period based on recommendations of the Green Sturgeon Technical Sub-committee and concurrence by NMFS and the EC.

vi) Identify contingencies for implementing experimental flow levels in the event that normal water year variation does not provide a suitable range of test conditions over the course of a 10-year flow evaluation period.

vii) Include focused evaluations of sturgeon passage at Sunset Pumps.

viii) Design Feather River research, monitoring and evaluation efforts to complement other green sturgeon research and monitoring activities in progress or planned for the Sacramento and Feather Rivers by other agencies and parties including the California Department of Fish and Wildlife, U.S. Bureau of Reclamation, University of California at Davis, and the U.S. Fish and Wildlife Service.

c) FERC shall require DWR to carry out in the Green Sturgeon Monitoring, Research and Evaluation Program with the following objectives and tasks associated with each primary objective.

Objective 1. Describe and quantify the movements, distribution, abundance, productivity and diversity of green sturgeon in the Feather River.

Task 1.1. Identify spatial and temporal distribution, habitat use, and abundance of adult green sturgeon throughout the Feather River from its confluence with the Sacramento River to the fish barrier dam using high-resolution imaging sonar (Didson, blueview, or other technology).

Surveys of the entire river will be conducted by boat periodically throughout spring and summer. Sonars have proven to be very effective at locating and identifying sturgeon due to their large size. This method has currently been employed with great success in the Sacramento River. Recent tests in the Feather River have also confirmed its utility in those locations. Since the sonar is unable to distinguish white and green sturgeon, an underwater color video camera might also be used to assist with species identification when water clarity permits. Habitat characteristics and water quality will be identified at each site where sturgeon are observed.

Task 1.2. Collect adult surgeon by angling in areas of concentration in order to identify genetic characteristics and sexual maturity, and to tag with acoustic tags for subsequent tracking.

Genetic data from fin clips will be used to help determine whether the green sturgeon using the Feather River are the same or different from those in the Sacramento River. Maturity information will identify if the fish is an adult spawner. Acoustic tags will allow subsequent distribution and movements to be monitored. These tags will be particularly important for identifying the location of spawning if it occurs. Acoustic tags will be surgically implanted to minimize tag loss rates and allow for multi-year serviceability. Fish will also be PIT tagged for long-term identification in the event of recapture. Angling will be conducted at any time between February and October when concentrations of fish suitable for providing reasonable catch per effort are identified and water temperatures are suitable for fish handling.

Task 1.3. Monitor distribution and movements of acoustically tagged adult green sturgeon using a combination of active tracking and receiver arrays operated annually throughout the river for salmon and steelhead.

Over 30 fixed, automated receivers are currently distributed at intervals throughout the lower river. Acoustic tags are currently planted in several hundred green sturgeon from the southern DPS. The majority of these tags were placed on fish captured in the Sacramento-San Joaquin delta or in marine waters of bays along the coast. Adult green sturgeon are believed to undertake spawning migrations at 2 to 4 year intervals, and the vast majority of the acoustically-tagged fish are more likely to spawn in the Sacramento than the Feather River based on use patterns observed to date. Additional tags will be placed in green sturgeon captured in the Feather River.

Task 1.4. Use artificial substrates deployed in potential spawning locations to document the occurrence, timing and environmental or habitat conditions of spawning.

Artificial substrates are widely used with great success to collect sturgeon eggs, including those of green sturgeon in the Sacramento River. This method was effectively utilized in 2011 to sample eggs at a spawning site in the afterbay outlet. Potential spawning sites will be identified based on physical characteristics of green sturgeon spawning sites in other areas and observations of concentrated or prolonged fish occurrence at specific sites.

Task 1.5. Use a combination of D-ring nets, fyke nets, and a dedicated screw trap to sample for larvae and juveniles downstream from known or suspected spawning sites.

This sampling will help determine whether eggs incubate and hatch successfully in the Feather River. These gears have proven effective in other areas. Screw traps are currently operated in the Feather River to sample juvenile salmonids but sampling sites are not effective for green sturgeon. A dedicated screw trap located downstream from the afterbay outlet might prove to be a more effective sampling option.

Task 1.6. Evaluate the feasibility of using environmental DNA to evaluate the occurrence and distribution of green sturgeon and spawning sites.

The use of environmental DNA (eDNA) as a tool for detection of species has been demonstrated in freshwater environments. The presence of cryptic species is ascertained by using molecular genetic assays to detect within water samples DNA that has been shed into the aquatic environment. The eDNA protocols are generally used to expand capabilities for investigating the presence, distribution, or containment of species, and have been shown to be more sensitive than traditional survey approaches (e.g., electrofishing, netting). Although advancements are continually being made to this method, eDNA has not yet proven effective at quantifying abundances of targeted species in the field. Overall, this method provides a mechanism for rapid reconnaissance and statistically defensible trend analysis for a cryptic or invasive species.

Objective 2. Evaluate the effects of normal variation in river discharge on green sturgeon use of the Feather River.

Task 2.1. Evaluate current year effect of flow on distribution, movement and activity (including spawning) based on timing relative to low and high flow periods.

Comparisons will also consider other environmental factors (e.g. water temperatures, turbidity, passage blockages, food availability, tributary flows).

Task 2.2. Evaluate between year effect of flow (and other environmental factors, such as food availability, temperature, turbidity, passage blockages, and unscreened diversions) on abundance and productivity.

Numbers and productivity of green sturgeon in the Feather River are typically expected to reflect the net result of multiple factors operating concurrently on sturgeon over the course of a year.

Task 2.3. Evaluate effects of flow on passage at Sunset Pumps with dedicated sampling efforts over a range of flow conditions.

This work will involve focused sonar, telemetry, and angling efforts.

Objective 3. Characterize Green Sturgeon holding, spawning and rearing habitats in the Feather River.

*Task 3.1***.** *Use Acoustic Doppler Current Profiler (ADCP), or other technologies or models as recommended by the Green Sturgeon Technical Subcommittee, to create a cross channel vertical profile of current and temperature in potential holding, rearing and spawning areas.*

d) FERC shall require an independent peer review of the Green Sturgeon Monitoring, Research and Evaluation Program prior to finalization.

8. The following terms and conditions implement reasonable and prudent measure 8 (*Measures shall be taken to develop a Green Sturgeon Management Plan as part of the Lower Feather River Habitat Improvement Program in order to minimize take associated with the proposed action*.):

a) FERC shall require DWR to assemble a Green Sturgeon Technical Sub-committee of the FROG within six months of DWR's acceptance of the new license. The Green Sturgeon Technical Subcommittee will be chaired by DWR. The Subcommittee will be comprised of anadromous fish biologists from DWR, NMFS, USFWS, and CDFW, and at least one green sturgeon expert affiliated with a university. DWR shall work through the Green Sturgeon Technical Sub-committee to implement the Green Sturgeon Monitoring, Research and Evaluation Program and develop a Green Sturgeon Management Plan within 10 years of DWR's acceptance of the new license.

b) The Green Sturgeon Management Plan shall apply the information gathered from the Green Sturgeon Research Monitoring and Evaluation Program for the purpose of avoiding and minimizing short-and long-term impacts on the species.

c) FERC shall require DWR to obtain an independent peer review of the Green Sturgeon Management Plan and concurrence in the Plan by NMFS prior to finalization.

d) FERC shall require DWR to use the Green Sturgeon Technical Sub-committee to develop annual strategic plans for: (i) implementing interim actions to avoid and minimize adverse effects of the project based on outcomes of the Green Sturgeon Monitoring, Research and Evaluation Program; and (ii) implementing protective measures of the Green Sturgeon Management Plan. The strategic plans will be communicated to the FROG and the EC. FERC shall require DWR to submit the annual strategic plan to NMFS for review and concurrence.

e) The annual strategic plan will be developed in consultation with NMFS and CDFW by February 1 of each year. With NMFS concurrence, the strategic plan will recommend an adaptive management process that uses real-time sDPS green sturgeon monitoring or other relevant information conducted within the Feather River or applicable to the Feather River.

f) The Green Sturgeon Management Program to support survival of green sturgeon is intended to be consistent with Settlement Agreement Article A108 (Flow/Temperature to Support Anadromous Fish).

g) DWR shall consider and analyze green sturgeon spawning and rearing habitat requirements in developing the Feasibility Study and Implementation Plan for Facilities Modification(s) described in Settlement Agreement Article A108.4. The study shall clearly identify how potential operational and facility modifications will address green sturgeon water temperature requirements throughout their spawning habitat, downstream to the project boundary. The recommended alternative (per A108.4) shall take into account the temperature requirements for green sturgeon. In developing one or more modifications for implementation, DWR shall consult with the Green Sturgeon Technical Sub-committee to ensure that the modification(s) are beneficial to green sturgeon spawning and rearing habitat requirements. Similarly, at the end of the five-year testing period (Settlement Agreement Article A108.5) the testing period report shall describe and analyze monitoring data for temperature and habitat use by green sturgeon, operations, and whether temperatures resulting from the modification(s) have increased availability or suitability of the HFC habitat for green sturgeon.

h) If the Green Sturgeon Monitoring, Research and Evaluation Program reveals that existing physical impediments to passage within the lower Feather River are affecting fish passage, DWR shall identify operational and physical habitat modifications for those impediments, and identify responsible agencies and parties associated with those sites.

i) DWR shall use the results of the Green Sturgeon Monitoring, Research and Evaluation Program to recommend seasonal flow targets for attracting green sturgeon into the Feather River and providing passage at the Sunset Pumps weir. In recommending seasonal flow targets, DWR shall consult with the Green Sturgeon Technical Subcommittee to develop performance measures for evaluating the success of different flow regimes in attracting adult green sturgeon into the Feather River, providing unimpeded passage past structural impediments in the Feather River, and providing suitable flows for green sturgeon spawning and rearing. DWR in consultation with the Green Sturgeon Technical Subcommittee and the EC shall then identify seasonal target flows and describe how they can be achieved through operational changes. If the impediments to fish passage are removed, the seasonal target flows for adult green sturgeon fish passage will not be required, and attraction flows will be reevaluated and modified as appropriate. Upon successful implementation of physical modifications to the Sunset Pumps weir, or other physical impediments, the seasonal target flows will be reevaluated by DWR, in consultation with the Green Sturgeon Technical Subcommittee and upon approval by NMFS, modified as appropriate.

9. **The following terms and conditions implement reasonable and prudent measure 9 (Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the term of the license to ensure their effectiveness.):**

a) FERC shall require DWR to implement annual monitoring of anadromous fish (Chinook, steelhead and green sturgeon) populations in the Feather River. This monitoring shall include:

- Enumeration of anadromous fish in the Feather River. For Chinook salmon, methods shall be undertaken to make separate estimates of adult CV spring-run Chinook salmon and fall-run Chinook salmon.
- Prespawning mortality estimates,
- Estimates of salmonid straying to other watersheds in the CV,
- Estimates of incubation survival,
- Quantification of juvenile anadromous fish (Chinook, steelhead and green sturgeon) abundances and survival (no methods currently exist for juvenile green sturgeon),
- Evaluation of predation of anadromous fish (Chinook, steelhead and green sturgeon) in the Feather River,
- Coordination of water quality and flows monitoring with salmonid survival monitoring,
- Implementation of a tagging program to estimate the numbers of all hatchery salmonids, consistent with HGMPs when the HGMPs are approved, and
- Implementation of a steelhead monitoring plan to assess factors influencing anadromy.

b) FERC shall require DWR to develop and implement an adaptive management plan for managing water temperatures, flows, and hatchery operations. The adaptive management plan will be focused on addressing uncertainties in project effects associated with the survival and recovery of listed anadromous fish species. The adaptive management plan will be developed in consultation with the FROG and EC, and be submitted to NMFS for review and concurrence. The adaptive management plan shall conform with Settlement Agreement Article 101 and include adaptive management for effects on sDPS green sturgeon.

c) FERC shall require DWR to submit an annual report to NMFS on the implementation of conservation measures that affect anadromous fish resources, including, but not limited to: temperature compliance, flow compliance, ramping rate compliance, development of plans, and implementation of plans. In addition, the annual report shall include available information about anadromous fish escapement and migration in the Feather River, and FRFH releases. FERC shall require that adaptive management principles be incorporated into required plans, and the annual report shall include a discussion of how DWR is incorporating adaptive management into license activities that affect anadromous fish resources.

10. The following terms and conditions implement reasonable and prudent measure 10 (*Prepare and provide NMFS with plans and reports describing how federally listed anadromous fish species in the action area are and will be protected and monitored and to document the effects of the action on listed species in the action area.*):

a) FERC shall require DWR to submit reports on the status and implementation of plans, and activities of committees at least annually to NMFS. DWR shall submit reports to the National Marine Fisheries Service, California Central Valley Office, 650 Capitol Mall, Suite 5-100, Sacramento, California 95814.

b) Implementation of the monitoring and evaluation activities authorized under this biological opinion is contingent upon receipt of annual reports. FERC shall require DWR to submit annual reports online through the *Applications and Permits for Protected Species* website, **https://apps.nmfs.noaa.gov** by January 31st of each year. These monitoring requirements shall be reevaluated every 5 years and may be discontinued with the concurrence of NMFS. This applies to the reports for:

i. Lower Feather River Monitoring Weir(s) in the LFC,

ii. Low Flow Channel Segregation Weir(s),

iii. Lower Feather River CV Spring-run Chinook and CCV Steelhead Redd Surveys,

iv. Feather River Juvenile Salmonid Monitoring/Community Surveys,

v. Feather River Spring-run Chinook Salmon Telemetry Study,

vi. Feather River Juvenile Salmonid Emigration Monitoring,

vii. Feather River Chinook Escapement Survey,

viii. FRFH Spatial and Temporal Patterns of Naturally Spawning Hatchery CV Spring-run Chinook Salmon,

ix. Passage, Abundance, Distribution, and Potential Spawning of Green Sturgeon in the Lower Feather River, and

x. Lower Feather River Green Sturgeon Spawning Survey.

These reports shall include the following information:

- Describe any problems and/or any unforeseen effects and any steps taken (or proposed) to resolve such problems.
- Describe what measures were taken to minimize the permitted activities' effects on Federal ESA listed anadromous fish species and the effectiveness of these measures.

- If Federal ESA listed anadromous fish species were unintentionally injured or killed, describe the circumstances. Describe how they were disposed of if it wasn't in the way described in the authorization/permit.
- Describe the physical condition of Federal ESA listed anadromous fish species taken and used in the permitted activities.
- Describe the effects permitted activities had on Federal ESA listed anadromous fish species, including any unforeseen responses or effects.
- If applicable, describe the method used to estimate take if it differed from your proposed method.
- State what steps were taken to coordinate the permitted activities with other ESA Section 10 scientific research permit holders.
- If you do not have an electronic version logbook, please submit a hard copy to the address above (please include your permit number on all pages).
- Summarize any preliminary findings. Did you accomplish your project goals?
- List titles of reports, publications, etc. resulting from this reporting period.
- Provide any additional findings, results, or information you would like to report or comment on.

2.9 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR § 402.02).

1. FERC should encourage license applicants to implement resource actions, including fish passage, which will benefit federally listed species and their habitats to aid in their recovery.
2. FERC and DWR should continue to work cooperatively with other State and Federal agencies, private landowners, governments, and local watershed groups to identify opportunities for cooperative analysis and funding to support salmonid habitat restoration projects within the Feather River Basin, and the Lower Sacramento River system.
3. DWR should designate a hatchery liaison to collaborate with the FRFH manager and NMFS to incorporate new HGMP protocols, collect biometric and monitoring data, and investigate research questions specific to FRFH hatchery programs, in coordination with fisheries management research, and collaborate with geneticists on developing and implementing a spawning matrix for the FRFH CV spring-run Chinook salmon program.
4. FERC should investigate other FERC-licensed projects that have measurable adverse impacts on water temperatures in the Lower Feather River and propose corrective actions to minimize such effects.
5. FERC should require a Worker Environmental Awareness Training Program for construction personnel to be conducted by a NMFS-approved biologist for all construction workers prior to the commencement of construction activities conducted at FERC-licensed projects. The program should provide workers with information on their

responsibilities with regard to federally-listed fish, their critical habitat, an overview of the life-history of all the species, information on take prohibitions, protections under the ESA, and an explanation of any conservation requirements by FERC, or terms and conditions identified in any applicable NMFS biological opinion. Written documentation of the training should be submitted to NMFS within 30 days of the completion of training.

6. FERC should require a Worker Environmental Awareness Training Program for all Oroville Facilities staff and DWR staff working on implementation of the Oroville Facilities license conditions at least every two years. The training should include general biological and environmental information, and information specific to the environmental requirements of the Oroville Facilities license, and the ESA. The training should be conducted by a NMFS-approved biologist.

In order to be kept informed of actions that conserve listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

2.10 Reinitiation of Consultation

This concludes formal consultation for the relicensing of the Oroville Facilities.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) the amount or extent of incidental taking specified in the incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

2.11 "Not Likely to Adversely Affect" Determinations

2.11.1 Southern Resident Killer Whales

The Southern Resident killer whale DPS was listed as endangered under the ESA on November 18, 2005 (70 FR 69903).

Southern Residents are found throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as the Queen Charlotte Islands, British Columbia. There is limited information on the distribution and habitat use of Southern Residents along the outer Pacific Coast. Several potential factors identified in the final recovery plan for Southern Residents may have caused the decline or may be limiting recovery of the DPS, including: quantity and quality of prey; toxic chemicals, which accumulate in top predators; and disturbance from sound and vessel effects recovery plan (National Marine Fisheries Service 2008b). Oil spills are also a potential risk factor for this species. Research has yet to identify which threats are most significant to the survival and recovery of Southern Residents.

Southern Resident killer whales may be affected by the proposed action because whale populations depend on adequate prey levels, and, based on a long-term study of resident killer whale diet (Ford and Ellis 2006), Chinook salmon can comprise up to 72 percent of their prey consumed during spring, summer and fall. Because of the effects of the action on the Chinook fishery in the Feather River, there is a potential for the proposed action to affect killer whales. However, the level of these effects on the total ocean Chinook salmon population are not likely to be significant enough to have a discernable effect on Southern Resident killer whales. Furthermore, the prey based effects of the broad, coordinated operations of the SWP and the CVP on Southern Resident killer whales (due to effects on Central Valley Chinook salmon fisheries) are analyzed in the CVP/SWP Biological Opinion and are not part of the proposed action analyzed in this Opinion. Based on this analysis, the proposed action is not likely to adversely affect the Southern Resident killer whale DPS.

2.11.2 Central California Coast Steelhead

The Central California Coast (CCC) steelhead DPS (*O. mykiss*) is listed as threatened under the ESA (71 FR 834; January 5, 2006), and includes all naturally spawned steelhead populations below natural and manmade impassable barriers in California streams from the Russian River (inclusive) to Aptos Creek (inclusive), and the drainages of San Francisco and San Pablo Bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers. In addition, the DPS includes steelhead from two artificial propagation programs: the Don Clausen Fish Hatchery, and Kingfisher Flat Hatchery/Scott Creek (Monterey Bay Salmon and Trout Project).

CCC steelhead adults and smolts travel through the western portion of Suisun Marsh and Suisun Bay as they migrate between the ocean and these natal spawning streams. The Oroville Facilities are approximately 140 miles upstream of Suisun Marsh. It is unlikely that CCC steelhead will encounter effects of Oroville Facilities operations or project related stressors that are known to affect salmonids, because the focus area is outside of their known range.

Furthermore, the effects of the broad, coordinated operations of the SWP and the CVP on the CCC steelhead DPS are analyzed in the CVP/SWP Biological Opinion and are not part of the proposed action analyzed in this Opinion. Based on this analysis, the proposed action is not likely to adversely affect the CCC steelhead DPS.

2.11.3 California Central Coast Steelhead Designated Critical Habitat

CCC steelhead DPS critical habitat includes San Francisco Bay and San Pablo Bay, but does not extend eastward into Suisun Bay (September 2, 2005, 70 FR 52488). In summary, PBFs of designated critical habitat for CCC steelhead include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The PBFs for CCC steelhead DPS critical habitat are the same as PBFs for CCV steelhead, which are described in more detail in section 2.2.1.3.4 of this Opinion and the final rule for the critical habitat designation (September 2, 2005, 70 FR 52488). Due to the location of CCC steelhead critical habitat in San Pablo Bay and areas westward, and the unappreciable influence of the proposed action on the PBFs within this area, NMFS concludes that effects of the proposed action on CCC steelhead critical habitat are insignificant and discountable. Furthermore, the effects of the broad, coordinated operations of the SWP and the CVP on the CCC steelhead DPS critical habitat are analyzed in the CVP/SWP Biological Opinion and are not part of the proposed action analyzed in this Opinion. Based on this analysis, the proposed action is not likely to adversely affect CCC steelhead DPS critical habitat.

3 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (Section 3) defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by FERC and descriptions of EFH for Pacific coast salmon (PFMC 1999) contained in the fishery management plans developed by the Pacific Fishery Management Council and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

The action area for the Oroville Facilities proposed action has been identified to include EFH for Pacific coast salmon. Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), CV spring-run Chinook salmon (*O. tshawytscha*), and CV fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Pacific coast salmon fishery management plan that occur within the action area. The Endangered Species Act Section 7(a)(2) Opinion for the proposed action addresses effects of the action on ESA-listed Sacramento River winter-run and CV spring-run Chinook salmon (*O. tshawytscha*) and their critical habitat.

The broad, coordinated operations of the SWP and the CVP were considered in a separate, parallel consultation. On June 4, 2009, NMFS issued the CVP/SWP BO (National Marine Fisheries Service 2009). A Magnuson-Stevens Fishery Conservation and Management Act EFH Consultation on the Long-Term Operations of the Central Valley Project and State Water Project (CVP/SWP EFH consultation) was included as Enclosure 2 with the CVP/SWP BO. That CVP/SWP EFH consultation analyzes the effects related to the conveyance of SWP (including Oroville Facilities) water through the Sacramento River and the Delta to State and Federal water pumping facilities in the south Delta. Because of the separate CVP/SWP EFH consultation, this EFH consultation does not analyze the effects of Oroville Facilities water management operations on areas downstream of the mouth of the Feather River, this EFH consultation will concentrate on spring-run Chinook salmon and fall-run Chinook salmon (*O. tshawytscha*) EFH in the Feather River, and this EFH consultation will concentrate on the following designated Habitat Areas of Particular Concern (HAPC): (1) Complex Channels and Floodplain Habitats; (2) Thermal Refugia; and (3) Spawning Habitat substrate.

3.2 Adverse Effects on Essential Fish Habitat

We conclude that aspects of the proposed action would adversely affect EFH for Chinook salmon. We conclude that the following adverse effects on EFH designated for Pacific Salmon are reasonably certain to occur.

1. The creation of complex channels and inundation of floodplain habitats will be reduced. Due to water management for flood reduction and water supply, natural processes that form complex channels and inundate floodplain habitats will be reduced. Further, Oroville Dam and reservoir disrupt the movement of sediment and large woody material, which affects the formation of complex channels. Due to the conservation measures included in the proposed action, the adverse effects on complex channels and floodplain habitat will be reduced over time due to gravel supplementation, and enhancements of riparian floodplain habitat. The construction work to supplement gravel and enhance spawning and riparian floodplain habitat has the potential to adversely affect EFH, but in the long-term is expected to provide benefits.
2. Reservoir operations are expected to affect thermal conditions in the Feather River downstream of Oroville Dam. Measures included in the proposed action to improve temperature conditions will improve thermal refugia in the Feather River.
3. Recruitment of spawning habitat substrate has been impacted by Oroville Dam, and will continue to be impacted as long as the dam is in place. The proposed action includes conservation measures that will add spawning substrate to the LFC and HFC, and improve spawning habitat.

3.3 Essential Fish Habitat Conservation Recommendations

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in Section 3.2, above, approximately 242 acres of designated EFH for Pacific coast salmon.

1. For effect 1 listed above, in implementing the fish weir program and channel improvement program as described in the *Proposed Action* (section *1.3*) and *Terms and Conditions* (section *2.8.4*) that implement Reasonable and Prudent Measures 2 and 3, NMFS recommends that FERC require best management practices be used to be protective of EFH. This includes measures such as staging areas being set away from water bodies, and when necessary to use heavy equipment, such heavy equipment will be fueled away from streams and waterbodies connected to EFH, heavy equipment will be cleaned prior to arriving on site, and when possible biodegradable hydraulic fluid will be used.
2. For effect 2 listed above, NMFS does not have any conservation recommendations in addition to the temperature targets and criteria and facilities modification(s) conservation measures as described in the *Proposed Action* (section *1.3*) and *Terms and Conditions* (section *2.8.4*) that implement Reasonable and Prudent Measure 4.
3. For effect 3 listed above, NMFS does not have any conservation recommendations in addition to the Gravel Supplementation and Improvement Program conservation measures as described in the *Proposed Action* (section *1.3*) .

3.4 Statutory Response Requirement

As required by Section 305(b)(4)(B) of the MSA, FERC must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

FERC must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4 FISH AND WILDLIFE COORDINATION ACT

The purpose of the FWCA is to ensure that wildlife conservation receives equal consideration, and is coordinated with other aspects of water resources development (16 USC 661). The FWCA establishes a consultation requirement for Federal agencies that undertake any action to modify any stream or other body of water for any purpose, including navigation and drainage (16 USC 662(a)), regarding the impacts of their actions on fish and wildlife, and measures to mitigate those impacts. Consistent with this consultation requirement, NMFS provides recommendations and comments to Federal action agencies for the purpose of conserving fish and wildlife resources, and providing equal consideration for these resources. NMFS' recommendations are provided to conserve wildlife resources by preventing loss of and damage to such resources. The FWCA allows the opportunity to provide recommendations for the conservation of all species and habitats within NMFS' authority, not just those currently managed under the ESA and MSA.

The following recommendations apply to the proposed action:

FWCA Recommendation. At any project site within the Action Area that experiences foot traffic, FERC should require interpretive signs be posted describing the presence of listed fish or critical habitat as well as highlighting their ecological and cultural value.

The action agency must give these recommendations equal consideration with the other aspects of the proposed action so as to meet the purpose of the FWCA. This concludes the FWCA portion of this consultation.

5 DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

5.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are FERC. Other interested users could include USFWS, DWR, CDFW, State Water Contractors Association, Golden Gate Salmon Association, Friends of the River, and citizens of the affected areas. Individual copies of this opinion were provided to FERC. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

5.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

5.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section (*Bibliography*). The analyses in this opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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