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

Refer to NMFS No: WCRO-2019-02052

October 14, 2020

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 for the Oroville Dam Spillway Incident Emergency Response (FERC Project No. 2100-185)

Dear Secretary Bose:

Thank you for the Federal Energy Regulatory Commission's (FERC) letter of July 18, 2020, 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 Oroville Dam Spillway Incident Emergency Response. This consultation was conducted in accordance with the 2019 revised regulations that implement section 7 of the ESA (50 CFR 402, 84 FR 45016).

This document transmits NOAA's National Marine Fisheries Service's (NMFS) Biological Opinion (Enclosure 1) for the generally after-the-fact emergency consultation associated with the Oroville Dam Spillway Incident Emergency Response and the effects on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened California Central Valley steelhead (*O. mykiss*), the threatened Southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*), and their designated critical habitat in accordance with section 7(a)(2) of the ESA. The enclosed Biological Opinion is based on our review of the Federal Energy Regulatory Commission's (FERC) biological assessment (BA), comprised of both the May 31, 2019, biological evaluation prepared by the California Department of Water Resources (CDWR) (as modified by FERC staff) and the November 8, 2018, draft National Environmental Policy Act (NEPA) environmental assessment (EA) prepared for CDWR's request to amend its license. The enclosed Biological Opinion also incorporates new information provided by CDWR pursuant to 50 CFR § 402.14(d), (e), (f) and addresses comments received by FERC and CDWR during the 30-day review period associated with the draft Biological Opinion for the subject action.

During formal after-the-fact emergency consultation, the actual or estimated impacts and incidental take occurring from the emergency response actions are determined and are documented in this Biological Opinion for future inclusion in the species' environmental baseline. The incidental take statement in this emergency consultation does not include reasonable and prudent measures or terms and conditions to minimize take. Rather, the incidental take statement documents the recommendations that were given to minimize take during pre-consultation, the success in implementing those recommendations, and the ultimate effects of the action on the species and critical habitat.

The enclosed Biological Opinion concludes that the proposed action is not likely to jeopardize the continued existence of Central Valley spring-run Chinook salmon, California Central Valley steelhead and the Southern DPS of North American green sturgeon or destroy or adversely modify their designated critical habitat. NMFS concurs with FERC that the proposed action is not likely to adversely affect Sacramento River winter-run Chinook salmon. As noted by FERC, critical habitat designated for Sacramento winter-run Chinook salmon is outside the action area.

NMFS also reviewed the likely effects of the proposed action on essential fish habitat (EFH), pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)), and concluded that the action would adversely affect the EFH of Pacific Coast salmon. Therefore, we have included the results of that review in Section 3 of this document.

Please contact Amanda Cranford, NMFS California Central Valley Office, at Amanda.Cranford@noaa.gov, or (916) 930-3706 if you have any questions or if you require additional information.

Sincerely,

A. Catherine Marcinkevage

Cathy Marcinkevage
Assistant Regional Administrator
California Central Valley Office

Enclosure

cc: Copy to File No: 151422-WCR2019-SA00539

UNITED STATES DEPARTMENT OF COMMERCE
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Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Oroville Dam Spillway Incident Emergency Response

(**Project No. 2100-185**)

NMFS Consultation Number: WCRO-2019-02052

Action Agency: Federal Energy Regulatory Commission

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	Yes	No
California Central Valley steelhead (*O. mykiss*)	Threatened	Yes	No	Yes	No
Southern Distinct Population Segment of North American Green Sturgeon *(Acipenser medirostris)*	Threatened	Yes	No	Yes	No
Sacramento River winter-run Chinook salmon (*O. tshawytscha*)*	Endangered	No	N/A	N/A	N/A

* Please refer to Section 2.11 for the analysis of species that are not likely to be adversely affected. As noted by FERC, critical habitat designated for Sacramento winter-run Chinook salmon is outside the action area.

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	No

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

Issued By: A. Catherine Marcinkevage

Cathy Marcinkevage
Assistant Regional Administrator

Date: October 14, 2020

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1. Introduction

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3, below.

1.1. Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (Opinion) and incidental take statement (ITS) 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, as amended. 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.

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 (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the NMFS Central Valley Office in Sacramento, California.

1.2. Background on Events Leading to the Emergency

During February 2017, heavy precipitation and high flows in the Feather River basin resulted in extensive erosion and damage to the main Flood Control Spillway and Emergency Spillway area at the Feather River Hydroelectric Project's (Project) Oroville Dam in Butte County, California.

Inflows into Lake Oroville are released in one of four ways: through the Hyatt Pumping-Generating Plant (Hyatt Power Plant), through the gated main Flood Control Outlet Spillway, over the ungated Emergency Spillway, or through the low-level river outlet valve. Flows pass into the 320-acre Thermalito Diversion Pool, which is impounded by the 143-foot-high Thermalito Diversion Dam, located about four miles downstream (Figure 1).

The Federal Energy Regulatory Commission (FERC) licensee for the Project, the California Department of Water Resources (CDWR), first observed major damage to the main spillway on February 7, 2017, which included a large area of foundation erosion and concrete chute loss in the mid-section of the main Flood Control Outlet Spillway. Due to high inflows into Lake Oroville and reduced outflow capacity on the main Flood Control Outlet Spillway, Lake Oroville overtopped the adjacent Emergency Spillway on February 11, 2017, causing back-cutting erosion below the Emergency Spillway. The back-cutting erosion threatened the stability of the Emergency Spillway's crest structure. As such, CDWR increased operation of the damaged Flood Control Outlet Spillway to relieve pressure on the Emergency Spillway, which led to the loss of the lower portion of the main Flood Control Outlet Spillway chute. This caused significant erosion under and adjacent to the Flood Control Outlet Spillway. Impacts were most severe in the Thermalito Diversion Pool immediately below the spillways, but turbidity and fluctuating flows also impacted the Lower Feather River extensively downstream beyond the fish barrier dam and other project works (see Figure 1).

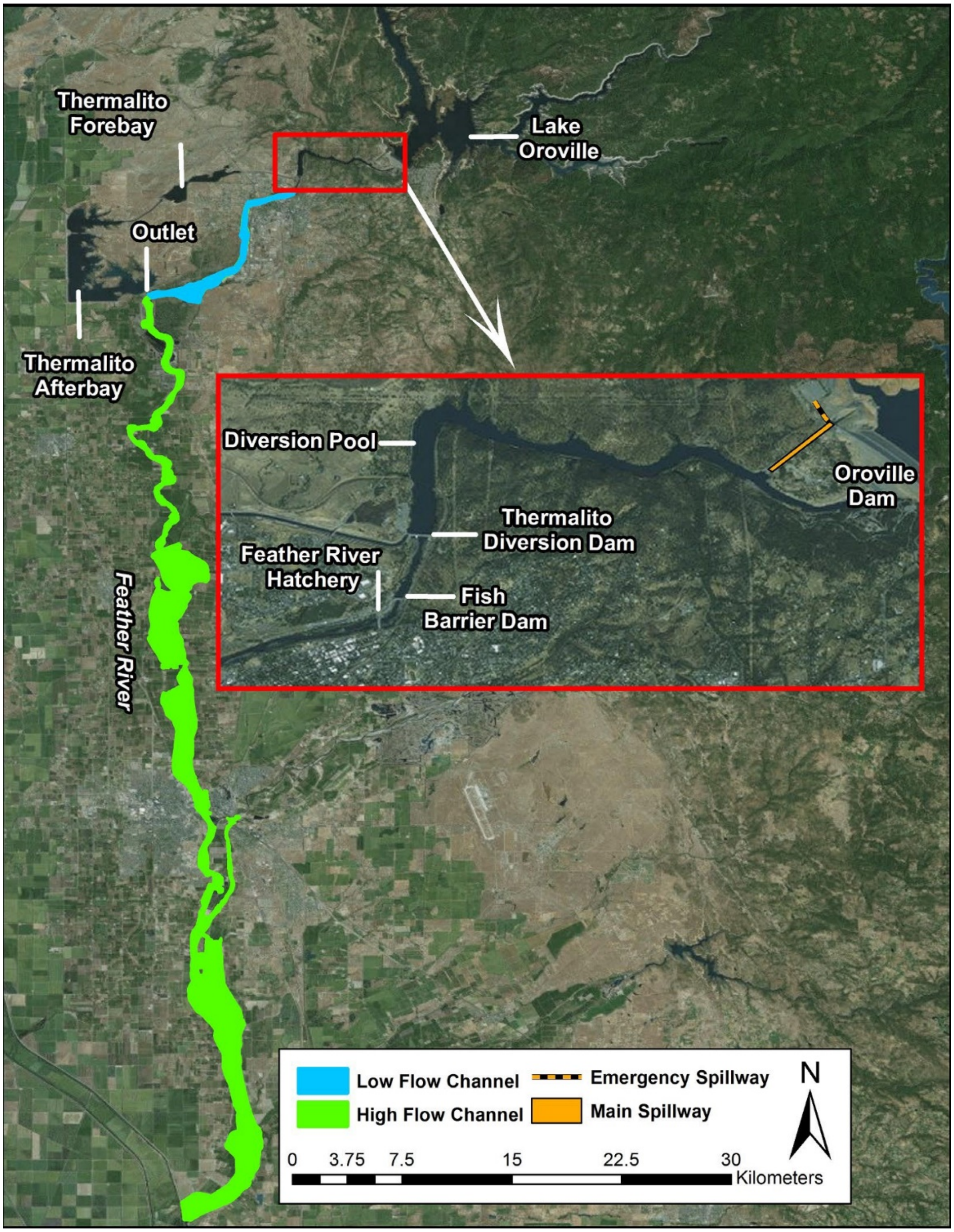

Figure 1. Location of the Action Area. Only the Feather River downstream to the confluence with the Sutter Bypass is shown on the map. The Feather River confluence with the Sacramento River is approximately eight miles downstream from where it meets the Sutter Bypass.

1.3. Consultation History

- February 7, 2017: CDWR first observed major damage to the main Flood Control Outlet Spillway, which included a large area of foundation erosion and concrete chute loss in the mid-section of the spillway.

- February 11, 2017: Due to high inflows into Lake Oroville (the project reservoir) and reduced outflow capacity on the Flood Control Outlet Spillway, Lake Oroville overtopped the adjacent Emergency Spillway, causing back-cutting erosion below the Emergency Spillway. The back-cutting erosion threatened the stability of the Emergency Spillway's crest structure. As such, CDWR increased operation of the damaged Flood Control Outlet Spillway to relieve pressure on the Emergency Spillway, which led to the loss of the lower portion of the main spillway chute and causing significant erosion under and adjacent to the Flood Control Outlet Spillway.

- February 24, 2017: In anticipation of dredging activities and flow fluctuations during CDWR's initial emergency response, NMFS sent a letter to FERC providing 12 recommendations to minimize potential effects on federally-listed threatened California Central Valley (CCV) steelhead, threatened Central Valley (CV) spring-run Chinook salmon, and threatened southern distinct population segment North American green sturgeon (sDPS green sturgeon) and their designated critical habitat below the fish barrier dam. The letter also recommended that FERC initiate emergency (formal) consultation with NMFS as soon as the emergency was under control.

- February 27, 2017: FERC staff discussed the February 24, 2017 recommendations with NMFS and CDWR. These included ramping rate recommendations, minimum flow maintenance, dredging guidance, water quality maintenance at the Feather River Hatchery (FRH), fish monitoring and rescues, water quality monitoring, water release recommendations, turbidity minimization measures, agency coordination, and data reporting. CDWR implemented some of the conditions; however, the ramping rate recommendations were not followed, due to measures CDWR took to maintain and observe the structural integrity of the remaining portion of the main spillway.

- March 31, 2017: FERC designated CDWR as its non-federal representative to conduct informal consultation with NMFS pursuant to section 7 of the ESA. Since that time, CDWR and FERC staff have regularly consulted on planned flow changes, monitoring, and construction activities, primarily through regular conference calls. In addition, CDWR informally consulted with NMFS and prepared a biological evaluation to assess the effects of the emergency response efforts on federally listed species under NMFS' jurisdiction, which it filed with FERC on June 29, 2018.

- July 5, 2018: FERC adopted the biological evaluation as its biological assessment (BA) and requested NMFS' concurrence that the actions taken likely adversely affected listed species, but had no effect on designated critical habitat or essential fish habitat (EFH).

- October 29, 2018: NMFS responded with a letter of non-concurrence with FERC's determinations, and requested additional information needed in order to analyze the effects of the action. Although NMFS addressed the letter to FERC staff, due in part to the U.S. Federal Government shutdown, NMFS did not electronically file this letter with

FERC until February 12, 2019. In ensuing teleconferences with CDWR, NMFS, and FERC staff, NMFS staff provided additional clarification and guidance pertaining to the additional information needed to initiate consultation.

- May 31, 2019: CDWR prepared and filed with FERC a revised biological evaluation that analyzed the effects of the emergency response efforts following the February 7, 2017, main spillway failure. The revised biological evaluation encompassed and analyzed the initial response period covering approximately February 2017 to November 2017, upon which repairs to the main spillway were completed.
- July 18, 2019: FERC adopted the revised biological evaluation as its BA and requested formal consultation with NMFS on the emergency response efforts associated with the 2017 failure of the Oroville Dam spillways.
- July 22, 2019: NMFS received the revised BA from FERC and commenced review of the submitted materials to determine whether sufficient to initiate consultation.
- August 1, 2019: NMFS completed its review of the revised BA and determined it was sufficient to initiate generally after-the-fact formal consultation under section 7 of the ESA for emergency actions.
- December 11, 2019: FERC and NMFS mutually agreed on an extension for a finalized opinion, on January 31, 2020
- January 29, 2020: FERC and NMFS mutually agreed on an extension for a finalized opinion, on February 28, 2020. Per that discussion, FERC notified NMFS that CDWR reached out to FERC to discuss their potential disagreement with the proposed determinations. However, FERC stated they did not anticipate any changes to the consultation determinations and therefore notified NMFS that no action was needed.
- February 6, 2020: CDWR reached out to NMFS requesting a meeting to discuss the changes FERC made to the BA and new information that CDWR was developing. CDWR also provided a copy of the letter they sent to FERC (dated November 18, 2019) stating their disagreement with the proposed determinations. The letter also requested that DWR be allowed to submit additional scientific data and other information for NMFS to analyze and consider, pursuant to 50 CFR § 14(d). NMFS agreed to meet with CDWR as requested and reached out to FERC to ensure they were included in the discussions.
- February 21, 2020: NMFS and FERC met with CDWR as requested. CDWR stated that the purpose of the meeting was to provide new data related to the emergency response to ensure the best available information was considered. CDWR introduced a new sediment transport model, developed by cbec eco engineering. They also discussed concerns with FERC's revised version of the BA.
- February 24, 2020: NMFS and FERC discussed the meeting with CDWR and agreed that additional time would be needed to complete the consultation. As FERC had stated previously, they did not anticipate that the additional information to be provided would change their determinations in the BA. FERC requested that NMFS continue to work on the opinion with the current information and agreed upon an extension date of April 1, 2020.

- March 4, 2020: CDWR notified NMFS via email that they would be drafting a letter requesting a time extension in order to finalize the cbec eco engineering sediment transport model and provide the new information for NMFS to consider as part of the opinion.
- March 31, 2020: NMFS and FERC mutually agreed upon a May 1, 2020, extension date for completion of the opinion.
- April 27, 2020: NMFS determined that CDWR's request for extension to provide additional information, dated March 10, 2020, was not considered. The letter was received by the Central Valley Office during the mandatory shelter-in-place orders, and therefore its receipt and consideration by NMFS was delayed.
- May 5, 2020: NMFS notified FERC of its receipt of CDWR's letter requesting that the formal consultation period be extended pursuant to 50 CFR § 402.14(e), (f) in order for NMFS to incorporate the cbec eco engineering sediment transport model, along with additional information from CDWR, in the development of the opinion. The letter was also addressed to FERC. NMFS informed FERC of its intent to place the consultation on hold as requested by CDWR and provided a copy of the letter from CDWR as supporting documentation.
- June 1, 2020: Leadership from NMFS and FERC met to discuss the current status of the consultation. FERC informed NMFS that their preference was for the consultation to proceed, due to a number of actions contingent upon completion of the opinion. NMFS agreed to discuss options internally.
- June 11, 2020: NMFS reached out to CDWR to request an update on the timing of the new information to be provided and whether the proposed timeframe of late-June identified in the March 10, 2020 letter would be met.
- June 15, 2020: FERC notified CDWR via letter (in response to CDWR's November 18, 2019 and March 10, 2020 letters) that they dismissed the requests to extend formal ESA consultation with NMFS. The letter also encourages NMFS to complete and file the biological opinion.
- June 24, 2020: NMFS informed FERC via email of the intent to proceed with the issuance of a draft biological opinion. Once the draft biological opinion has been issued, both FERC and CDWR would have 30 days to review and provide comments. After the 30-day review and comment period ends, NMFS would work to make any applicable updates and issue a final biological opinion. FERC replied via email and stated their concerns with the proposed issuance of a draft biological opinion. FERC suggested that NMFS file with FERC a letter to FERC's Secretary requesting extension of the formal consultation period to allow for the issuance of a draft biological opinion and to incorporate the information to be provided by CDWR.
- June 30, 2020: CDWR replied to NMFS (June 11, 2020 email) indicating that additional information related to the sediment transport model would be submitted to NMFS and FERC by July 15, 2020.

- July 2, 2020: Subsequent email correspondence between CDWR and NMFS provided additional resolution regarding the new information to be provided by CDWR and the proposed timeline for submittal of the information. CDWR stated that they would provide NMFS and FERC with the following by July 15, 2020:
    - An updated PowerPoint presentation showing the model outputs;
    - All of the data used for the model, including redd locations, *etc*.;
    - Two geographic information system (GIS) layers, one showing the redd locations and the other showing the sediment deposition locations;
    - A brief summary from the modeling consultant (cbec eco engineering) that includes the following information:
        - The type/name of the modeling program used, including the software that was used;
        - Information about the accuracy of the model when used for this purpose;
        - An explanation of the sources for the inputs;
        - A short explanation of what was done to corroborate or otherwise validate the outputs.

  CDWR also requested additional time to review and use the sediment transport model by applying it to existing data. CDWR stated its intent to have that analysis completed and provided to NMFS by the end of August.

- July 6, 2020: A call was held between FERC and NMFS to discuss the status of the consultation and the extension request from CDWR that was received by both agencies. FERC reiterated their previous request that NMFS file with FERC a letter to FERC's Secretary requesting extension of the formal consultation period to include consideration of the additional information provided by CDWR.

- July 15, 2020: CDWR sent NMFS via email a Technical Memorandum developed by their consultants (cbec eco engineering) which provided an overview of the development and application of the computer model developed to assess the potential impacts of the 2017 Oroville Dam Spillway Incident Response on the sediment regime in the Feather River. CDWR also reiterated that the information from the model, along with the additional information and analysis that CDWR intends to share with NMFS by the end of August, would provide a better scientific base for NMFS to formulate its biological opinion.

- July 17, 2020: NMFS filed with FERC a letter to FERC's Secretary requesting a 90-day extension of the formal consultation period in accordance with 50 CFR § 402.14(d), (e), and (f), to consider the additional information to be provided by CDWR. NMFS also provided, based on CDWR's request to NMFS to review a draft biological opinion that NMFS intended to issue a draft biological opinion in early August. NMFS also stated its intent to issue a final biological opinion by mid-October that considers the additional information expected to be provided by CDWR by the end of August. NMFS concluded that the proposed timeframe would be adequate to allow for consideration of the additional information provided by CDWR and incorporation of that information in the analysis of the final biological opinion.

- July 28, 2020: FERC filed a letter in response to NMFS' July 17, 2020 letter, accepting the 90-day extension of formal consultation requested by NMFS.

- August 4, 2020: NMFS transmitted its draft biological opinion to FERC and CDWR via email and through FERC's online eFiling system. Through transmission of the draft biological opinion, NMFS informed FERC and CDWR of a 30-day review and comment period on the draft biological opinion.

- August 27, 2020: FERC filed a letter with NMFS providing comments on the draft biological opinion.

- September 4, 2020: CDWR filed with FERC and NMFS a letter providing comments on the draft biological opinion. CDWR also included as an attachment to their letter a memorandum developed by cbec eco engineering titled, *An Assessment of Changes to Physical Habitat Resulting from the 2017 Spillway Incident: An Application of a 2D Sediment Transport Model to Characterize Potential Effects.* This memorandum serves as the additional information provided by CDWR for the purposes of informing the biological opinion.

1.4. Proposed Federal Action

Under the ESA, "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). Under the MSA, Federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910).

We considered, under the ESA, whether or not the proposed action would cause any other activities and determined that it would not.

The BA provided by FERC analyzes the effects of the emergency response efforts following the February 7, 2017, Oroville Dam Flood Control Outlet Spillway failure. The BA also examines potential effects to ESA-listed species, their designated critical habitat, and EFH from activities during the ensuing recovery period. During this time, which encompasses approximately November 2017 to the end of the calendar year 2019, project operations returned to normal and there was minimal construction work performed adjacent to or within the Thermalito Diversion Pool. Construction activities during the recovery period were primarily focused on the Flood Control Outlet and Emergency spillways. Finally, the BA provided by FERC incorporates some remaining prospective construction activities, including a proposal from CDWR to relocate a buried 13.8 kV power line and a buried fiber optic communication system, as well as to conduct some remaining site stabilization and demobilization activities. These Phase 1 Site Rehabilitation activities are directly related to the recommended Revegetation and Invasive Species Mitigation Plan described within the draft NEPA EA prepared for CDWR's request to amend its license. Similar to the recovery period construction activities, these prospective activities will take place upstream of the Fish Barrier Dam, an area that is currently inaccessible to ESA-listed species in the Feather River and is not designated as critical habitat (see Figure 1).

It is particularly important to note that the BA provided by FERC is not intended to assess effects resulting from the failure of the Oroville Dam Flood Control Outlet Spillway. It only describes and analyzes the effects associated with the emergency actions taken in response to the Oroville Dam Spillway Incident.

Four emergency actions taken in response to the Oroville Dam Spillway Incident that likely adversely affected ESA-listed species and their designated critical habitat include: (1) use of the damaged Flood Control Outlet Spillway and Emergency Spillway; (2) dredging and material removal from the damaged spillways and within the Thermalito Diversion Pool, including erosion repair activities; (3) four periods of rapid-flow increases and decreases from Flood Control Outlet Spillway operations and use of the Hyatt Power Plant; and (4) activities undertaken at the FRH. Table 1 below summarizes the emergency actions taken in chronological order.

Table 1. Emergency Actions Taken as a result of the Oroville Dam Spillway Incident

Emergency Action Date(s)	Emergency Action Category (1-4)	Description of Emergency Action
February 7, 2017	**(3)** Increase in flows (Flood Control Outlet Spillway)	Increased to 52,250 cubic feet per second (cfs) in anticipation of high inflows to the reservoir from predicted precipitation. Flood Control Outlet Spillway discharge was stopped for inspection and a large area of erosion of the concrete structure was observed.
February 8, 2017	**(1 & 3)** Short duration test flows (Flood Control Outlet Spillway)	Short duration test flows of 20,000 cfs were initiated and erosion patterns were monitored. Further erosion was observed from these test flows.
February 8-10, 2017	**(4)** Thermalito Annex Facility brought online to allow for the transfer of juvenile fish evacuated from the FRH	CDWR and CDFW worked to prepare the Thermalito Annex Facility by readying the raceways, turning on water, flushing raceways, *etc*. Approximately 2 million CV spring-run Chinook salmon and 2 million CV fall-run Chinook salmon were evacuated from the FRH and transferred to the Thermalito Annex.

Emergency Action Date(s)	Emergency Action Category (1-4)	Description of Emergency Action
February 9, 2017	**(3)** Increase in flows (Flood Control Outlet Spillway)	Erosion began to stabilize and Flood Control Outlet Spillway flows were increased to 35,000 cfs and again to 45,000 cfs.
February 9, 2017	**(3)** Hyatt Power Plant taken offline due to flooding	Flow from the Hyatt Power Plant was halted during this time as the debris entering the Thermalito Diversion Pool had raised water levels enough that the Hyatt Power Plant could not be operated safely.
February 9, 2017	**(2)** Debris cleared from Emergency Spillway in preparation for use	Preparations were made for use of the Emergency Spillway by clearing trees and debris from the hillside below the Emergency Spillway.
February 10, 2017	**(3)** Increase in flows (Flood Control Outlet Spillway)	Following peak inflow to the reservoir of > 190,000 cfs on February 9, the Flood Control Outlet Spillway discharge was increased to 55,000 cfs and then 65,000 cfs.
February 10, 2017	**(4)** Alternative water supply identified and utilized to improve water quality for incubating CCV steelhead eggs on-station at the FRH	In order to address the high turbidity levels in the incoming water, FRH staff used "domestic" water from a fire hydrant to dilute the water and reduce turbidity. However, chlorine levels in "domestic" water can be an issue for salmonids.
February 11, 2017	**(1)** Emergency Spillway used	Water began flowing over the Emergency Spillway for the first time since its construction.
February 11, 2017	**(4)** High-capacity charcoal filtration system installed at the FRH to improve water quality for incubating CCV steelhead eggs	FRH staff worked to install a high-capacity charcoal filter system. The system included 6-feet tall cylinders filled with charcoal. A system of pumps and pipes routed water through the filters before the water was pumped into egg stacks with incubating CCV steelhead.

Emergency Action Date(s)	Emergency Action Category (1-4)	Description of Emergency Action
February 12, 2017	**(1)** Erosion observed at the base of Emergency Spillway	Erosion at the base of the Emergency Spillway was observed to be progressing faster than expected.
February 12, 2017	**(3)** Increase in flows (Flood Control Outlet Spillway)	The Flood Control Outlet Spillway discharge was increased to 100,000 cfs to lower the elevation of the reservoir more rapidly and disengage the Emergency Spillway.
February 12, 2017	**(3)** Flows over Emergency Spillway ceased	Due to public health and safety concerns over the structural integrity of the Emergency Spillway (resulting from increased erosion) flows over the Emergency Spillway ceased.
February 13, 2017	**(2)** Erosion repair and fill (both the Flood Control Outlet Spillway and the Emergency Spillway)	Helicopters and heavy construction equipment began to move material into areas of erosion on the Flood Control Outlet Spillway and as reinforcement to the Emergency Spillway.
February 13, 2017	**(1 & 2)** Debris removal and dredging commenced within the Thermalito Diversion Pool	Significant amounts of debris entered the Thermalito Diversion Pool as flows from the Flood Control Outlet Spillway were sustained at 100,000 cfs. Equipment was staged to begin removing debris from the Thermalito Diversion Pool at the base of the damaged Flood Control Outlet Spillway.
February 16, 2017	**(3)** Reduction in flows (Flood Control Outlet Spillway)	Flows from the Flood Control Outlet Spillway were reduced to 80,000 cfs to allow debris removal in the Thermalito Diversion Pool but these efforts had limited effectiveness at the high flow levels.
February 16 – November 1, 2017	**(2)** Debris removal and dredging continued	Erosion control and debris removal activities continued as flows decreased. These activities continued intermittently until November 1, 2017.

Emergency Action Date(s)	Emergency Action Category (1-4)	Description of Emergency Action
February 17-27, 2017	**(3)** Both increases and reductions in flows (Flood Control Outlet Spillway)	Flows decreased to 70,000 cfs on February 17 and 55,000 cfs on February 18. Flows were then increased to 60,000 cfs due to storm predictions and were held at that level through February 23 as erosion control and debris removal efforts continued. On February 23, flows were reduced to 50,000 cfs.
February 27 - March 17, 2017	**(2 & 3)** Reduction in flows to 0 cfs (Flood Control Outlet Spillway)	Flows were decreased from 50,000 to 0 cfs to minimize potential erosion of the Flood Control Outlet Spillway and facilitate debris removal in the Thermalito Diversion Pool. The Flood Control Outlet Spillway discharge remained at 0 cfs through March 17 while debris removal efforts cleared the material that had been transported into the Thermalito Diversion Pool.
March 3, 2017	**(3)** Hyatt Power Plant brought back online	Flow into the Thermalito Diversion Pool resumed through the Hyatt Power Plant at a rate of 2,650 cfs when it was restarted.
March 4-5, 2017	**(3)** Hyatt Power Plant temporarily shut down and restarted	The Hyatt Power Plant was temporarily shut down again on March 4 and restarted again on March 5 at 1,720 cfs.
March 6-10, 2017	**(3)** Increase in flows (Hyatt Power Plant)	As more turbines came online, additional flow was released from the Hyatt Power Plant. Flows through Hyatt Power Plant increased to 3,550 cfs on March 6; 5,330 cfs on March 7; 8,800 cfs on March 9; and 12,900 cfs on March 10.

Emergency Action Date(s)	Emergency Action Category (1-4)	Description of Emergency Action
March 27, May 1, and May 19, 2017	**(3)** Three additional flow reductions (Flood Control Outlet Spillway)	CDWR exercised additional Flood Control Outlet Spillway outages from March 27-April 13, 2017 and May 1-9, 2017. During these outages, CDWR met minimum flow requirements using the Hyatt Power Plant. On May 19, 2017, the Flood Control Outlet Spillway was taken out of service for the remainder of the year. By using the turbines to control the reservoir level, the Flood Control Outlet Spillway would remain unused through completion of construction.

1.4.1. Summary of Emergency Actions Taken

1.4.2. Use of the Flood Control Outlet and Emergency Spillways

On February 7, 2017, discharge at the Flood Control Outlet Spillway had been ramped up to 52,250 cubic feet per second (cfs) in anticipation of high inflows to Lake Oroville from predicted precipitation. CDWR employees observed unusual flow patterns on the Flood Control Outlet Spillway. The Flood Control Outlet Spillway discharge was stopped for inspection and a large area of erosion of the concrete structure was observed. After determining the damage was too extensive to repair quickly, CDWR began consulting with FERC and the California Division of Safety of Dams (DSOD).

On February 11, 2017, increasing inflow to Lake Oroville caused reservoir levels to exceed the Emergency Spillway elevation and water began passing over the Emergency Spillway for the first time in project history. Flows passing over the Emergency Spillway caused significant erosion to the bare hillside below. This was coupled with ongoing erosion from the main Flood Control Outlet Spillway since the initial February 7, 2017, observation, thereby filling in portions of the Thermalito Diversion Pool with additional sediment. As a result of significant erosion and safety concerns, flow over the Emergency Spillway ceased on the evening of February 12, 2017.

The Hyatt Power Plant (one of four facilities utilized to release flows into the Feather River from Lake Oroville) ceased operations on February 9, 2017, due to backwater effects from debris accumulation below the main Flood Control Outlet Spillway in the Thermalito Diversion Pool. The Hyatt Power Plant returned to service on March 3, 2017, and was used in conjunction with the main Flood Control Outlet Spillway to more fully manage Lake Oroville storage levels, until being taken out of service on May 19, 2017. CDWR also reactivated its river valve operation capability at the base of Oroville Dam, which added additional flow release capacity.

1.4.3. Debris Removal and Dredging Activities

Shortly following the initial discovery of erosion at the main Flood Control Outlet Spillway on February 7, 2017, CDWR began preparing for potential use of the emergency spillway, located west and adjacent to the main spillway. To prevent additional material from washing into the Thermalito Diversion Pool, CDWR cleared the hillside below the Emergency Spillway of trees, vegetation, rock, and debris, and used the cleared hillside and seasonal streambed to convey flows over the emergency spillway.

Despite the preparation activities employed by CDWR, flows passing over the Emergency Spillway caused significant erosion to the bare hillside below the Emergency Spillway. This was coupled with ongoing erosion of the main Flood Control Outlet Spillway since the initial February 7, 2017, observation, thereby filling in portions of the Thermalito Diversion Pool with additional sediment. The sediment deposition caused the Thermalito Diversion Pools to rise above safe operating levels for the Hyatt Power Plant, rendering it out of service and prompting CDWR to fortify the powerhouse to prevent flooding.

On February 16, 2017, CDWR began intense efforts to remove debris and sediment from the Thermalito Diversion Pool. The removal efforts were implemented using land-based and barge-based excavators. In addition, CDWR graded, fortified, and placed shotcrete on a large area of the eroded hillside below the Emergency Spillway.

Approximately 1.4 million cubic yards (CY) of debris was removed from the Thermalito Diversion Pool from February 27 to June 1, 2017. By November 1, 2017, 2.0 million CY of debris had been removed from the Thermalito Diversion Pool.

1.4.4. Rapid Flow Increases and Reductions

Between February and June 2017, four periods of rapid flow reduction from the Flood Control Outlet Spillway occurred. In addition to the February 27 flow reduction described above, three additional flow reductions occurred on March 27, May 1, and May 19, 2017 (Table 1).

The fish habitat in the Lower Feather River below the Fish Barrier Dam is generally divided into the Low Flow Channel (LFC) and High Flow Channel (HFC) based on differences in flow and habitat conditions (Figure 1). The LFC is an 8.1 river mile (RM) section between the Fish Barrier Dam and the Thermalito Afterbay Outlet where discharge is mostly stable at 600-800 cfs, except under flood conditions or when flow increases are needed for river temperature management. The HFC is a 59 RM section between the Thermalito Afterbay Outlet and the confluence with the Sacramento River.

As inflows and lake levels receded, CDWR ceased operation of the main Flood Control Outlet spillway to facilitate sediment removal and inspect damage. The most notable of these reductions occurred on February 27, 2017, when spillway releases decreased from 60,000 cfs to 0 cfs (Figure 2). Due to the abrupt flow reductions in the Feather River and potential environmental impacts, CDWR conducted operations to rescue stranded fish in collaboration with the California Department of Fish and Wildlife (CDFW). Additional fish rescues occurred in the Feather River following subsequent flow reductions.

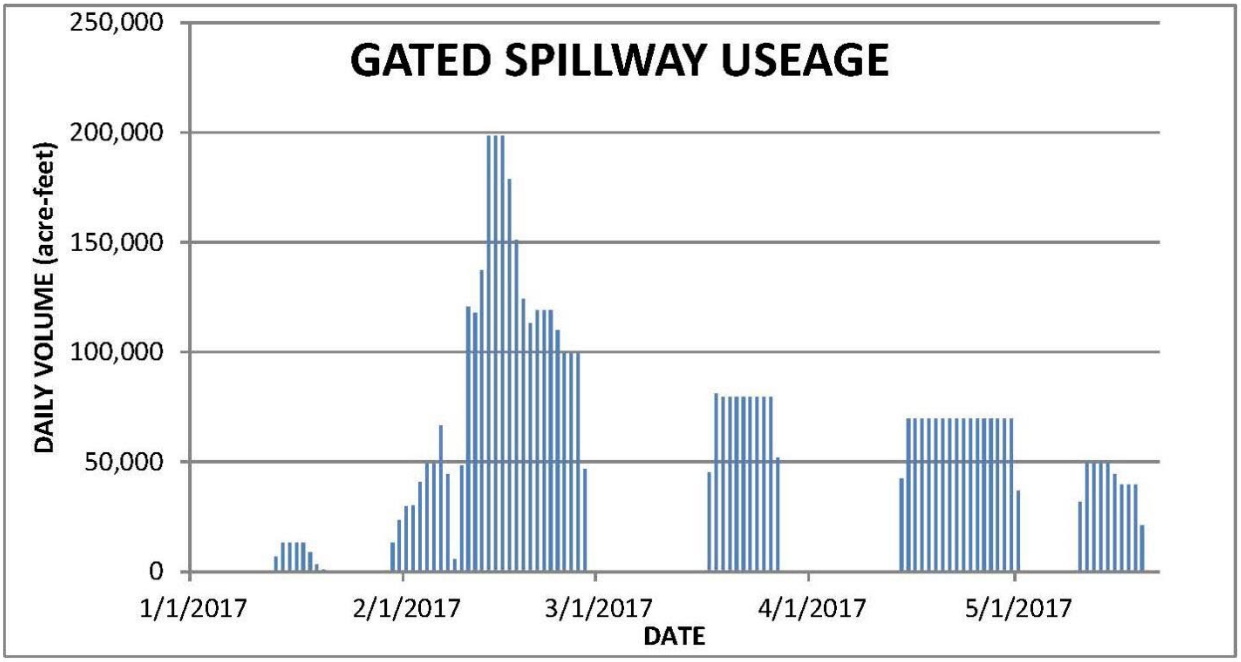

Figure 2. Flood Control Outlet Spillway releases during 2017, including intermittent zero release periods (Source: CDWR 2018).

Additional abrupt flow reductions occurred three times until May 19, 2017, when the Flood Control Outlet was taken out of service for the remainder of the year (Figure 2). Although the Incident necessitated reducing releases from the Flood Control Outlet to 0 cfs in the Thermalito Diversion Pool, discharge in the LFC and HFC remained at or above minimum flows required for protection of fisheries resources. Flows were released from the Thermalito Diversion Pool into the LFC to maintain a minimum flow of 600 cfs and water was discharged from the Thermalito Afterbay Outlet into the HFC so that flow never dropped below the minimum requirement of 1700 cfs.

1.4.5. Emergency Actions Undertaken at the Feather River Hatchery

In anticipation of adverse effects to juvenile Chinook salmon at the FRH due to high turbidity following the Oroville Dam Spillway Incident, approximately 2 million CV spring-run Chinook salmon and 4.2 million fall-run Chinook salmon were moved to the Thermalito Annex Facility, where water is sourced from a well and not affected by the water quality in the Feather River. In addition, a sedimentation channel was set up at the FRH for the 2.5 million fall-run Chinook salmon that remained on-station. During the evacuation period, staff continued to mitigate for silt in the inland ponds and raceways at the FRH. Medicated and probiotic feed was provided and salt baths were employed to improve fish health at the FRH during the Oroville Dam Spillway Incident. After fish were moved in response to the Oroville Spillway Incident, fish fed well and remained in good condition at the FRH and at the Thermalito Annex.

Approximately 750,000 CCV steelhead eggs also remained on-station at the FRH. A large number of the egg incubation stacks were equipped with ultra violet (UV) filtration; however, six of the egg stacks were without adequate filtration. The eggs could not be evacuated due to space constraints at the Thermalito Annex Facility and the fragile state of the incubating eggs. In order to address the high turbidity levels in the incoming water, FRH staff used "domestic" water from a fire hydrant to dilute the water and reduce turbidity. Concerns regarding the presence of chlorine in "domestic" water prompted FRH staff to seek out alternative means of improving water quality to the CCV steelhead egg stacks. To account for the presence of chlorine, FRH staff installed a high-capacity charcoal filter system. The system included 6-feet tall cylinders filled with charcoal. A system of pumps and pipes routed water through the filters before being pumped into the CCV steelhead egg incubation stacks. Eggs and fry remained in good condition throughout the incubation and rearing season. When space was available at the Thermalito Annex, steelhead juveniles were transferred from the FRH to the Annex Facility to allow for intensive cleaning of raceways. Upon completion of FRH repairs in August, CCV steelhead were moved back to the FRH for continued rearing until their release.

In the early morning on May 10, 2017, the primary pump supplying well water to the Thermalito Annex Facility failed, drastically reducing the water supply to the raceways, killing approximately 70,000 fall-run Chinook salmon juveniles. CV spring-run Chinook salmon at the Facility were unaffected. CDFW staff first observed fall-run Chinook salmon exhibiting signs of stress along with mortalities in the raceways due to low dissolved oxygen levels. Hatchery staff immediately started supplying supplemental oxygen to the raceways to keep fish alive. CDFW notified CDWR staff, who manage the wells and water supply to the Facility, and CDWR electricians made immediate repairs to restart the pump motor and resume the flow of water. In response to this event, CDFW and CDWR staff developed additional redundancy measures to prevent future pump failures.

In 2017 following the Oroville Dam Spillway Incident, approximately 5 million fall-run Chinook salmon and approximately 1.7 million spring-run Chinook salmon were released from the FRH, representing 83 and 85 percent of the annual production goal, respectively (CDWR 2019). Additionally, approximately 663,000 CCV steelhead were reared and released during the winter of 2018. This is approximately 213,000 more than is required for normal mitigation (CDWR 2019). Although the overall numbers of juvenile spring-run Chinook salmon released in 2017 was short of the 2 million release goal, the success observed from 2018 and 2019 adult returns are expected to make up for the slight reduction in total production that occurred during 2017. The management actions taken to ensure the survival of eggs and juveniles at the FRH likely helped to minimize the overall impacts resulting from the Oroville Dam Spillway Incident.

1.4.6. Recovery Actions

The recovery period includes all activities involving permanent reconstruction of the damaged facilities, along with the supporting activities needed to facilitate that reconstruction. Recovery activities include reconstruction of the Flood Control Outlet spillway, augmentation of the Emergency Spillway and adjacent cutoff wall, implementation of elements proposed in CDWR’s Phase 1 Site Rehabilitation Specification and Plan, relocation of a buried transmission line and fiber optic communications line, and all activities necessary to support those efforts.

1.4.6.1. Flood Control Outlet and Emergency Spillway Repairs

The first phase of construction in 2017 included construction activities on the entirety of the Flood Control Outlet Spillway, except the uppermost 730-foot section below the spillway gates. During this first construction phase (May to November 2017), the subsequent 870-foot portion of the upper Flood Control Outlet Spillway section was demolished, excavated, and replaced with a reinforced structural concrete floor and walls. Construction activities on the middle spillway portion during 2017 included: blasting, demolition, and excavation for roller-compacted concrete (RCC) fill; constructing concrete backfill and RCC foundation for the reinforced concrete chute; and constructing RCC walls. CDWR reconstructed the 350-foot lower portion of the Flood Control Outlet Spillway by removing the remaining portions of the spillway, constructing cutoff walls, and installing structural concrete. In addition to the removal of damaged concrete, CDWR laterally excavated soil and weathered rock along the right and left sides of the Flood Control Outlet spillway (which were unstable, due to the severe erosion from the spillway failure). Preparation work for the repairs included selective demolition and removal of the damaged spillway, soil, rock, grout and shotcrete. CDWR also conducted controlled blasting of the damaged spillway. In addition, CDWR cleaned the spillway foundation with pressure washers and compressed air, prior to the addition of dental concrete, leveling concrete, RCC, structural concrete, and a drainage network.

The second phase of construction consisted of replacement of the remaining 730-foot portion of the upper Flood Control Outlet Spillway during the 2018 construction season (May 2018 to November 2018). The upper portion of the spillway was removed and replaced with structural concrete, then secured to the underlying hillside. In addition, CDWR removed the RCC walls from the 1,050-foot section of the middle portion of the spillway and replaced them with structural walls. CDWR also removed the surface layer of RCC and installed structural concrete on the reduced RCC surface. Finally, CDWR hydro-blasted and resurfaced the energy dissipaters (dentates) at the bottom of the Flood Control Outlet Spillway.

CDWR has proposed to leave the majority of the existing Emergency Spillway in place. Installation of additional measures to fortify the existing structure and prevent erosion immediately downstream of the dam during any future use of the Emergency Spillway has occurred. CDWR has left the existing ogee spillway (which comprises the eastern portion of the Emergency Spillway) in place and has applied shotcrete armoring below the spillway. CDWR has fortified the ogee overflow spillway by installing a RCC concrete buttress and splash pad on the downstream side of the Emergency Spillway. The RCC buttress is a curved topped berm with a drainage system, placed against the Emergency Spillway monoliths to increase stability. CDWR has also removed and replaced the broad-crested weir (or crest cut-off wall), comprising the western portion of the Emergency Spillway. The western structure has been removed and replaced with a new 10-foot deep, 2½-foot-wide reinforced concrete cutoff wall. Construction activities associated with the cutoff wall included selective asphalt demolition and removal of the previous broad-crested weir, excavation of a 10 x 2.5-foot ditch, cleaning the trench of loose material, steel lattice reinforcement, and concrete pouring and shaping.

In addition to the improvements along the Emergency Spillway, CDWR installed a RCC splash pad behind the buttress and Emergency Spillway consisting of a 5 to 10-foot-thick RCC apron. The RCC splash pad is stair-stepped to dissipate energy, and is contoured to direct flows to a main armored drainage channel. Additionally, CDWR installed a vertical secant pile cutoff wall at the downhill end of the splash pad, and approximately 750-feet downslope of the Emergency Spillway. Secant pile wall construction involved selective demolition of the previous emergency rock slope protection, drilling holes for secant piles, concrete reinforcement installation, and steel reinforcement above the secant piles.

1.4.6.2. Relocation of Buried Power Lines and Other Prospective Recovery Actions

Although the majority of the spillway reconstruction and rehabilitation activities have already occurred, CDWR is proposing to implement elements of their Phase 1 Site Rehabilitation Specification and Plan, which includes site maintenance, site stabilization, and limited revegetation efforts on areas impacted by the spillway failure. These activities will take place near the Flood Control Outlet and Emergency spillways (upstream of the Fish Barrier Dam) when they occur.

Additionally, CDWR proposes to relocate a portion of its buried transmission line, located between the Hyatt Power Plant switchyard and the Thermalito Diversion Dam Power Plant. Both Power Plants are located upstream of the Fish Barrier Dam (see Figure 1). CDWR would also relocate a portion of a buried fiber optic communications line, which runs parallel to the transmission line. CDWR would abandon in place an approximately 3.5-mile buried section of the transmission line. As a replacement, it would relocate an approximately 3.8-mile section of the buried line starting at the Hyatt Power Plant, and continue almost to the Thermalito Diversion Power Plant, where it would join with a pre-existing section of buried line approximately 0.8 miles north of the Power Plant. The new buried fiber optic communications line would be co-located with the relocated buried transmission line along the entirety of the route, and would span the entire distance between the Hyatt and Thermalito Diversion Power Plants. Part-way between the Hyatt and Thermalito Diversion Power Plants, the buried fiber optic line would diverge south outside of the project boundary, where it would connect to the Oroville Field Division facility, located approximately two miles to the south. Construction activities involved with the installation would include the use of excavators, trenching equipment, shoring equipment, loaders, and dump trucks.

1.4.7. Conservation Measures Implemented by CDWR

On February 7, 2017, when signs of the Flood Control Outlet Spillway failure were observed, it became evident that salmonids at the FRH were at risk, due to anticipated increases in turbidity (suspended sediment). FRH receives raw water from the Feather River at the Thermalito Diversion Dam (see Figure 1) and distributes it to the hatchery buildings and fish rearing areas. Given this, the hatchery’s primary water source could not be decoupled from the impacts of increased suspended sediment accumulation in the Thermalito Diversion Pool resulting from the Spillway Incident.

An effort to protect the fish and the facilities that support them was initiated and included the following:

- Movement of fish to the Thermalito Annex which relies on groundwater wells, rather than water from the Feather River;

- Creation of a sediment settling basin within the hatchery rearing channel to pump/circulate clean, settled water into the headboxes in the rearing channel;
- Development of alternative sources of water using a fire hydrant at the FRH;
- Cleaning out mud in the incubation stacks and inland ponds;
- Monitoring and maintaining turbidity and water quality levels;
- Use of supplemental medicated and probiotic feed to improve the health of the fish;
- Additions of salt to prevent disease; and
- Cleaning of raceways.

On February 27, 2017, release rates from the Oroville Dam Flood Control Outlet Spillway were rapidly decreased to accommodate the required emergency assessments and continued to decrease until releases ceased over the Flood Control Outlet Spillway. Flows remained low for about one week in the LFC and HFC, but never went below minimums for each channel. During this first rapid flow reduction CDWR, CDFW, and NMFS mobilized significant personnel and resources to implement fish rescues. The effort included flying the river on multiple days to identify stranding pools using real-time mapping so crews could be deployed to over 50 miles of river daily to areas in most need of rescue efforts. During the three other rapid flow reductions (March 27, May 1, and May 19, 2017), CDWR and CDFW continued to perform fish rescues based on data gathered during the prior events. As rescue efforts progressed through the season, fewer and fewer fish were found in stranding pools.

In August 2017, CDWR completed the addition of 5,000 CY of salmonid spawning gravel in the LFC and removed a gravel plug from Moe's Side Channel to excavate and reconnect the channel to the Feather River to restore the channel to normal function.

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, each Federal agency must ensure that its 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 provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

FERC has determined the proposed action is not likely to adversely affect Sacramento River winter-run Chinook salmon. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations (Section 2.12). As noted by FERC, critical habitat designated for Sacramento winter-run Chinook salmon is outside the action area.

2.1. Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "jeopardize the continued existence of" a listed species, which is "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). Therefore, the jeopardy analysis considers both survival and recovery of the species.

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 as a whole for the conservation of a listed species" (50 CFR 402.02).

The designations of critical habitat for species analyzed in this biological opinion use the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR 424.12) replaced 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 PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition does not change the scope of our analysis and in this opinion we use the terms "effects" and "consequences" interchangeably.

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

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their habitat using an exposure-response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly 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, or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

2.2. Rangewide Status of the Species and Critical Habitat

This biological 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' "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 of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the essential PBFs that help to form that value, for the conservation of the species. This biological opinion analyzes the effects of the proposed action on the following evolutionarily significant units (ESUs) and distinct population segments (DPS): the threatened CV spring-run Chinook salmon ESU (*Oncorhynchus tshawytscha*), the threatened CCV steelhead DPS (*O. mykiss*), and threatened sDPS green sturgeon (*Acipenser medirostris*). See Table 2 for species and Table 3 for critical habitat information.

Table 2. Description of species, current ESA listing classification, and summary of species status.

Species	Listing Classification and Federal Register Notice	Status Summary
Central Valley spring-run Chinook salmon ESU (CV spring-run)	Threatened, 70 FR 37160; June 28, 2005 (Original listing – 64 FR 50394; September 16, 1999)	According to the NMFS (2016a) 5-year species status review, the status of the CV spring-run Chinook salmon ESU had improved since the 2011 5-year species status review (through 2014), due to extensive restoration and increases in spatial structure of historically extirpated populations (Battle and Clear creeks), which were trending in the positive direction. However, during the 2012 to 2016 drought, researchers observed high pre-spawn and egg mortality and uncertain juvenile survival, and since 2015, researchers have found many of the dependent populations in decline (NMFS 2016a). In 2017, CDFW reported the lowest CV spring-run Chinook salmon escapement ever (CDFW 2018).

Species	Listing Classification and Federal Register Notice	Status Summary
California Central Valley steelhead Distinct Population Segment (CCV steelhead)	Threatened, 71 FR 834; January 5, 2006 (Original listing – 63 FR 13347; March 19, 1998)	According to the NMFS (2016b) 5-year species status review, the status of CCV steelhead has changed little since the 2011 status review, which concluded that the DPS was likely to become endangered within the foreseeable future. Most populations of natural-origin CCV steelhead are 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. The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to natural-origin 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.
Southern DPS of North American green sturgeon (sDPS green sturgeon)	Threatened, 71 FR 17757; April 7, 2006	According to the NMFS (2015) 5-year species status review, some threats to the species have recently been eliminated, such as take from commercial fisheries and removal of some passage barriers, but the species viability continues to be constrained by factors, such as a small population size, lack of multiple spawning populations, and concentration of spawning sites into just a few locations. The species continues to face a moderate risk of extinction.

Table 3. Description of critical habitat, designation details, and status summary.

Species	Designation Date and Federal Register Notice	Status Summary
Central Valley spring-run Chinook salmon critical habitat (CV spring-run)	September 2, 2005; 70 FR 52488	Critical habitat for 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, the Sacramento River, the Yolo Bypass, as well as portions of the northern Delta. 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. Currently, many of the PBFs of CV spring-run Chinook salmon critical habitat are degraded, and provide limited high quality habitat. Although the current conditions of CV spring-run Chinook salmon critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain are considered to have high intrinsic value for the conservation of the species.

Species	Designation Date and Federal Register Notice	Status Summary
California Central Valley steelhead critical habitat (CCV steelhead)	September 2, 2005; 70 FR 52488	Critical habitat for CCV steelhead includes stream reaches of the Feather, Yuba, and American rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the Sacramento River, the Yolo Bypass, as well as portions of the northern Delta. 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. Many of the PBFs of CCV steelhead critical habitat are currently degraded and provide limited high quality habitat. Although the current conditions of CCV steelhead critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in the Sacramento/San Joaquin River watersheds and the Delta are considered to have high intrinsic value for the conservation of the species as they are critical to ongoing recovery effort.

Species	Designation Date and Federal Register Notice	Status Summary
Southern distinct population segment of North American green sturgeon (sDPS green sturgeon)	October 9, 2009; 74 FR 52300	Critical habitat includes the stream channels and waterways in the Delta to the ordinary high water line. Critical habitat also includes the mainstem Sacramento River upstream from the I Street Bridge to Keswick Dam (including the Sutter and Yolo bypasses and the lower American River confluence with the mainstem Sacramento River upstream to highway 160 bridge), the Feather River upstream to the fish barrier dam, and the Yuba River upstream to Daguerre Point Dam. Coastal bays and estuaries in California (San Francisco Bay, Suisun Bay, San Pablo Bay, and Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor) as well as the lower Columbia River estuary are also included as critical habitat for sDPS green sturgeon. Coastal marine areas include waters out to a depth of 60 fathoms from Monterey Bay in California to the Strait of Juan de Fuca in Washington. Currently, many of the PBFs of sDPS green sturgeon are degraded and provide limited high quality habitat. Although the current conditions of green sturgeon critical habitat are significantly degraded, the spawning habitat, migratory corridors, and rearing habitat that remain in the Sacramento River watershed, the Delta, and nearshore coastal areas are considered to have high intrinsic value for the conservation of the species.

2.2.1. Recovery Plans

In July 2014, NMFS released a final Recovery Plan for SR winter-run Chinook salmon, CV spring-run Chinook salmon, and CCV steelhead (NMFS 2014). The Recovery Plan outlines actions to restore habitat, access, and improve water quality and quantity conditions in the Sacramento River to promote the recovery of listed salmonids. Key actions for the Recovery Plan include conducting landscape-scale restoration throughout the Delta, incorporating ecosystem restoration into Central Valley flood control plans that includes breaching and setting back levees, and restoring flows throughout the Sacramento and San Joaquin River basins and the Delta.

In August 2018, NMFS released a final Recovery Plan for the sDPS green sturgeon (NMFS 2018), which focuses on fish screening and passage projects, floodplain and river restoration, and riparian habitat protection in the Sacramento River Basin, the Delta, San Francisco Estuary, and nearshore coastal marine environment as strategies for recovery.

2.2.2. Global Climate Change

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). Projected warming is expected to affect Chinook salmon in the Central Valley. 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 Chinook salmon populations in the Central Valley can persist (Williams 2006).

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.

CCV steelhead will experience similar effects of climate change to 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).

The Anderson Cottonwood Irrigation District (ACID) 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 19 miles downriver of the ACID Dam where water temperature is warmer than at the ACID Dam during late spring and summer. Thus, if water temperatures increase with climate change, temperatures adjacent to the ACID Dam 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.

In summary, observed and predicted climate change effects are generally detrimental to these listed species (McClure *et al.* 2013, 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 the uncertainty associated with these projections increases over time, the direction of climate change is relatively certain (McClure *et al.* 2013).

2.3. 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).

The Action Area extends from the upstream limit of anadromy at the Fish Barrier Dam in Oroville, California to the confluence of the Feather and Sacramento rivers near Verona. The Feather River lies within United States Geological Survey (USGS) hydrologic unit code (HUC) 18020106. The FRH is also included in the Action Area, because CV spring-run Chinook salmon and CCV steelhead reared at this facility were affected by the Federal action.

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. 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 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

2.4.1. Climate Change

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 green sturgeon.

2.4.2. 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.

Oroville Dam was completed in 1968 as the centerpiece of the State Water Project (SWP). Oroville Reservoir has the second largest storage capacity of California reservoirs at approximately 3.5 million acre-feet. In addition to water storage and conveyance for use in the

SWP, the dam and associated facilities generate power and provide flood protection for downstream communities. Additionally, the reservoir provides a variety of recreational opportunities for the public. In general, winter and spring-runoff is stored in Oroville Reservoir and water is released in late spring and summer for diversion at the South Sacramento-San Joaquin River Delta (Delta) pumps and to maintain water quality conditions in the Delta.

The Feather River is the largest tributary of the Sacramento River located in California's Central Valley. The 9,324 square kilometer watershed above Oroville Dam primarily drains the western slope of the Sierra Nevada north of the Yuba River watershed and is bounded by Mount Lassen to the north and the Diamond Mountains to the north east, with 59 percent of the watershed below snowline (Koczot *et al.* 2005). Elevations in the watershed range from 10,463 feet (2,774 meters) atop Mount Lassen, 150 feet at Oroville, and 25 feet (15 meters) at the confluence with the Sacramento River. The four forks of the Feather River (West Branch, North, Middle, and South) all flow into an arm of Lake Oroville and are captured by Oroville Dam. Below Oroville Dam, the Feather River is joined by Honcut Creek, the Yuba River, and the Bear River before joining the Sacramento River.

The Feather River below Oroville Dam supports populations of multiple anadromous fishes that are listed as threatened or of special concern, including CCV steelhead, CV spring-run Chinook salmon, CV fall/late fall-run Chinook salmon, and sDPS green sturgeon. These species are entirely dependent on flow releases to the Lower Feather River from Oroville Dam. Non-natal juvenile Sacramento River winter-run Chinook salmon are also expected to seasonally rear in the lower-most reaches of the Feather River. Additionally, the FRH was constructed in 1967 to mitigate for CV spring-run Chinook salmon, CV fall-run Chinook salmon, and CCV steelhead production lost due to the construction of Oroville Dam. Currently, the FRH produces spring- and fall-run Chinook salmon, as well as CCV steelhead.

2.4.2.1. 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 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.

The fish habitat in the Lower Feather River below the Fish Barrier Dam is generally divided into the LFC and the HFC based on differences in flow and habitat conditions. The LFC is an 8.1 RM section between the Fish Barrier Dam and the Thermalito Afterbay Outlet where discharge is mostly stable at 600-800 cfs, except under flood conditions or when flow increases are needed for river temperature management. The HFC is a 59 RM section between the Thermalito Afterbay Outlet and the confluence with the Sacramento River. The flows and temperatures in the HFC are greater and fluctuate more, relative to the LFC (Seesholtz *et al.* 2004). The LFC in comparison to the HFC has a higher gradient, cooler summer and fall water temperatures, and a lower, more stable flow level. Native fishes, particularly anadromous salmonids, are observed more frequently in the LFC while non-native fishes including piscivorous striped bass (*Morone saxatilis*) and black bass (*Micropterus* spp.) tend to be observed more frequently in the HFC (Seesholtz *et al.* 2004). Both reaches have degraded native fish habitat conditions as a result of anthropogenic activities including bank protection, gravel mining and dredging, loss of bed material recruitment, riparian vegetation removal, diversions, flow regulation, and flood control (Buer *et al.* 2004; Williams *et al.* 2016).

2.4.3. 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. Project 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 (LWM) that would otherwise wash downstream and replenish spawning and rearing habitat. The FRH also has effects upon listed fish species through several mechanisms. These and other factors are considered below.

2.4.3.1. Blocked Habitat

Project 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 Project facilities varies by species. For sDPS green sturgeon, Mora *et al.* (2009) 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 Project facilities block 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. For Chinook 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. 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. 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.

2.4.3.2. Altered River Flow

The past and current operation of the Project creates a hydrograph that is markedly different from the historical condition. 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) stated that dams have probably had a much greater effect on stream-type Chinook salmon (*e.g*., spring-run Chinook salmon) than ocean-type Chinook (fall-run Chinook), due to longer migrations and longer resident times in rivers. The National Research Council (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.

The Project operations have substantially altered the flow regime in the LFC and HFC compared to pre-dam conditions. The primary function of Oroville Dam is to store winter and spring-runoff for later release into the Lower Feather River for SWP water uses. This flow regulation has resulted in changes to the yearly, monthly, and daily stream flow distributions, bankfull discharge, flow exceedance, peak flow, and other hydraulic characteristics (Buer *et al.* 2004). Mean monthly flows in the LFC are 5 to 38 percent of pre-dam levels, partially as a result of diversion into the Thermalito Complex (Sommer *et al.* 2001a). Mean total flow below the Thermalito Afterbay Outlet is lower than historical levels during February through June but higher from July through January, flattening the annual hydrograph (Sommer *et al.* 2001a). Minimum instream flows in the LFC and HFC are substantially reduced compared to average monthly pre-dam flows (NMFS 2016a). The pre-dam bankfull discharge (two-year recurrence interval flow event) was approximately 65,000 cfs for the Feather River at Oroville; in contrast, the bankfull discharge post-dam is approximately 2,000 cfs for the LFC and 26,000 cfs for the HFC (NMFS 2016a). Other flow frequencies and durations have changed pre- and post-dam as well; for example, the 10-year recurrence event has decreased from 160,000 to 75,000 cfs and the 50-year event from 240,000 to 180,000 cfs (NMFS 2016a).

2.4.3.3. 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 LWM. 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.

2.4.3.4. 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. The Project, 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 virus (IHNV), *Renibacterium salmoninarum* (bacterial kidney disease [BKD]), and *Flavobacterim psychrophilum* (cold water disease) (CDWR 2004). Although all these pathogens occur naturally in the Feather River Basin, the Project 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 FRH 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 IHNV in Chinook salmon at the FRH. 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).

2.4.3.5. 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 Central Valley Regional Water Quality Control Board (CVRWQCB) has listed the lower Feather River as impaired by sources of mercury, certain pesticides, and toxicity of unknown origin (CDWR 2007).

Findings and other pertinent information related to monitored water quality parameters have been reported by CDWR (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 (CDWR 2007).

Exceedance of water quality objectives for aluminum, iron, and copper were observed in CDWR's water quality studies (CDWR 2004), but could not be associated with Project operations or recreational activities. Petroleum products and pesticides were largely undetected in water samples collected for CDWR's water quality studies (CDWR 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 (CDWR 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.

2.4.3.6. 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 (CDWR 2007). Riparian vegetation is important to aquatic habitats, because it provides overhanging cover for rearing fish, streamside shading, and a source of terrestrial and aquatic invertebrate contributions to the fish food base (CDWR 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.

2.4.3.7. Water Diversions

CDWR 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 Project facilities. These settlements recognized the senior water rights of those agencies and that CDWR 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 acre feet 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 acre feet 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.

CDWR 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. 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 and barriers to migration at locations such as the Sunset Pumps. Reduction in flows has likely reduced the quantity and quality of habitat in the Lower Feather River during some periods of the year.

2.4.3.8. Water Management

As an integral part of the California SWP, the Project is 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 the U.S. Fish and Wildlife Service (USFWS); and other agreements.

Many early restrictions placed on Project operations primarily focused on SR 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 Project's ability to meet water temperature requirements in that year, and depending on precipitation, in following years.

2.4.3.9. Flood Control

The Project is 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 Project is 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 (CDWR 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).

2.4.3.10. 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 salmon, due to lower water temperatures.

In addition, survival of CCV steelhead eggs is reduced by anglers walking on redds in spawning areas while targeting hatchery CCV steelhead or salmon. Roberts and White (1992) 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). Currently, there are no regulations restricting river access to provide protection for spawning areas in the Feather River.

2.4.4. Feather River Fish Hatchery Operations

2.4.4.1. Background and Overview

The FRH was constructed in 1967 to mitigate for the loss of Chinook salmon and CCV steelhead spawning habitat blocked by Project facilities. FRH 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 FRH Annex, is located at RM 55 and includes an office, maintenance building, and four rearing raceways. The FRH 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 FRH 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.

FRH-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).

The FRH CCV 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 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 FRH 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 Project facilities. The production goal for the program is to release 400,000 yearling CCV steelhead annually at three fpp. The FRH 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 CDWR and CDFW, 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.

2.4.4.2. Hatchery Operations and Practices

The FRH has affected salmonids in the Feather River. Historical artificial propagation 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, FRH 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 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 FRH fish ladder remains open during the spring months (closing on June 30), and those fish ascending the ladder are marked with an external tag (Hallprint 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 FRH 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 broodstock. 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.

Hatchery-induced selection (often called domestication selection) is another factor when considering hatchery program effects. This 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, typically from the same population. Hatchery 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).

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. Previous FRH operations included the transport and release of FRH 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 FRH produced CV spring-run Chinook salmon 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.

Some studies conducted by CDFW indicate that 8 percent of FRH 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 (CDWR 2007). To date, only a few FRH 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 FRH CV spring-run Chinook salmon and CV spring-run Chinook salmon in Butte, Mill, and Deer creeks appears to have been minimal (CDWR 2007).

2.4.4.3. 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 FRH 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. 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 2004, 100 percent of the CV spring-run Chinook salmon smolts have been marked and tagged (adipose fin clip and CWTs).

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. Specific reaches of the Feather River were identified by the investigators as trouble areas, or "mortality hotspots" 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 survive at higher rates, suggesting there are no clear answers regarding the survival of hatchery smolts released in the lower river.

The number of juvenile CCV steelhead currently being released annually is 450,000. Of that amount 400,000 juveniles at four fpp or larger (generally released at three fpp) are mitigation for the construction of Project facilities. 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 FRH 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 15, 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 are then 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 brood year 1998, 100 percent of the juvenile hatchery-origin CCV steelhead released from California fish hatcheries into anadromous waters have been marked via adipose fin clip (California Hatchery Review Project Appendix VIII Feather River Hatchery Steelhead Program Report June 2012).

2.4.4.4. Summary of Hatchery Practices

Past operations of the FRH 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 near the hatchery, or in the Feather River. This may have adverse effects on the

Chinook salmon populations in the streams where the straying fish spawn. The FRH 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.

2.4.5. Status of Species and Critical Habitat in the Action Area

2.4.5.1. Background

Before the construction of Project facilities, 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 LFC. 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 Project facilities were built, a number of dams were built further upstream.

While earlier dams had altered the extent of upstream passage, the construction of Project facilities changed the amount and extent of available habitat for upstream migrating salmonids. This reduction in habitat has forced CV spring-run Chinook salmon to spawn in the same areas used by fall-run Chinook salmon, with minimal temporal separation in spawn timing. 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.

2.4.5.2. Central Valley spring-run Chinook salmon

The CV spring-run Chinook salmon ESU includes all naturally spawned populations of spring-run Chinook salmon in the Feather River as well as fish from the FRH. NMFS' Central Valley Technical Recovery Team (TRT) 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 FRH 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, FERC 2007).

Before construction of Project facilities, 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 Project facilities, 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, their 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 FRH where the fish are then artificially propagated.

There are multiple issues of concern with both the FRH and the naturally spawning fish in the river. The primary problem is the overlap in time and space with fall-run Chinook salmon, leading to hybridization between the two runs in the river. Past hatchery practices that historically led to mixing and interbreeding of the two runs within the hatchery has also played a role. Although hatchery practices have improved, and strong efforts are made to differentiate and separate CV spring-run Chinook salmon from fall-run Chinook salmon in the Feather River, it is likely that 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, likely resulting in redd superimposition and increased genetic introgression.

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 influence the duration of downstream migration, exposing migrating salmonids to increased predation. Changes in the hydrograph can also reduce lateral movement of the river. This along with the loss of sediment and large wood transport downstream of Oroville Dam has likely resulted 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.

2.4.5.2.1. Central Valley 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 (CDWR 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 Project 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. Therefore, 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 dams on the West Branch and North Fork of the Feather River and the Project facilities, 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) (CDWR 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 (CDWR 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 (CDWR 2002a, 2007, FERC 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, CDWR 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 (CDWR 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).

2.4.5.2.2. Abundance

The abundance of CV spring-run Chinook salmon in the Feather River is highly variable by year. 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, 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 salmon runs. Additionally, CDFW's GrandTab[1] data only reports CV spring-run Chinook salmon adults that returned to the hatchery to spawn in the fall, completely ignoring the much

[1] The CDFW Fisheries Branch Anadromous Resource Assessment Unit compiles annual population estimates of Chinook salmon in the Sacramento and San Joaquin river systems. The GrandTab report is a compilation of sources estimating the late-fall, winter-, spring-, and fall-run Chinook salmon total populations for streams surveyed. Estimates are based on counts of fish entering hatcheries and migrating past dams, carcass surveys, live fish counts, and ground and aerial redd counts.

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).

2.4.5.2.3. 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 FRH has an annual production goal of 2 million CV spring-run Chinook salmon smolts per year.

2.4.5.2.4. 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 (CDWR 2012b). Juvenile salmonids are found at higher frequencies where substrate is larger than sand and small in-stream cover and overhanging vegetation is present (CDWR 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.

2.4.5.2.5. Diversity

In the Spatial Structure section, 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) 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 salmon 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 FRH from fall-run Chinook salmon by opening the ladder at the FRH 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, FRH staff keep 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.

2.4.5.2.6. 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 FRH 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. In the 2016 status review, NMFS (2016b) identified that the adverse impacts of the FRH 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 (NMFS 2016a) of CV spring-run Chinook salmon discussed that since 2002, CDFW, CDWR, 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 FRH 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) 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 salmon.

2.4.5.3. Central Valley spring-run Chinook salmon Critical Habitat

2.4.5.3.1. Delineation of Critical Habitat 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). 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.

2.4.5.3.2. Status of Critical Habitat Physical or Biological Features 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). 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. CDWR 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 and support juvenile growth and mobility; water quality and forage supporting juvenile salmonid development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks (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 offers 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 wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks that support 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.

2.4.5.3.3. 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 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.

2.4.5.4. California Central Valley steelhead

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 Project facilities. FRH CCV steelhead are also included in this designation. The current Feather River CCV steelhead population appears to be almost entirely supported by the FRH 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 (CDWR 2007). Due to the construction and operation of hydropower projects, including the Project facilities (*i.e.*, Oroville Dam and the Fish Barrier Dam), the upper Feather River basin is no longer accessible to CCV steelhead. The FRH was designed and is operated to replace reduced CCV steelhead production, attributable to the construction of the Project facilities.

2.4.5.4.1. Abundance

The number of CCV steelhead entering the FRH each year generally increased between 1967 and 2003. CCV steelhead returns to the FRH 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 affected Chinook populations in the Central Valley), resulting from a shift in the Pacific Decadal Oscillation (PDO), which is highly correlated with sea surface temperature in the northern California Current area. This PDO warm phase shift may have also affected CCV steelhead populations of both hatchery and natural origin. The most recent drought (2012-2015) has also likely impacted CCV steelhead populations. Returns have varied widely over the years.

2.4.5.4.2. 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 FRH is artificially maintained. The FRH has an annual production goal of 400,000 yearling CCV steelhead to mitigate for construction of the Project facilities. The FRH 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 CDWR and CDFW, which addresses impacts from SWP pumping in the Delta. There is no specific target set for adult abundance.

2.4.5.4.3. Spatial Structure

CCV steelhead spawn in the Feather River between December and March, with the peak spawning occurring in late January (CDWR 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 FRH. 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 (CDWR 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 (CDWR 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 FRH 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.

2.4.5.4.4. Diversity

CCV steelhead in the Feather River belong to the Northern Sierra Nevada Diversity Group, and are classified as a Core 2 population. Core 2 populations are assumed to have the potential to meet the moderate risk of extinction criteria and are considered to be of secondary importance for recovery efforts (NMFS 2014). Core 2 populations provide increased life history diversity to the DPS and are likely to provide a buffering effect against local catastrophic occurrences that could affect other nearby populations, especially in geographic areas where the number of Core 1 populations is lowest. 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.

2.4.5.4.5. Viability of California Central Valley steelhead in the Action Area

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. FRH data shows that nearly all returning adults are of hatchery origin, suggesting that natural reproduction is low and possibly unsustainable on its own (NMFS 2016b).

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 FRH. 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 FRH, 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.

2.4.5.5. California Central Valley steelhead Critical Habitat

2.4.5.5.1. 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.

2.4.5.5.2. Status of Critical Habitat for Central Valley Steelhead in the Action Area

The conditions of the PBFs for CCV steelhead in the Feather River are the same as for CV spring-run Chinook salmon. Although habitat conditions within the action area are degraded, the importance of this area for the conservation of CCV steelhead is considered 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.

2.4.5.6. Southern DPS Green Sturgeon

Green sturgeon are long-lived and widely ranging across the North American west coast, but the 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 spawning activity has also been noted in the Yuba River (CDFW 2018 and 2019). In this section, we focus on sDPS green sturgeon usage of the Feather River. The Feather River contains at least two known sDPS green sturgeon spawning areas, and also provides for a migratory corridor to access the Yuba River.

2.4.5.6.1. Abundance

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 U.C. 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, NMFS 2015a) 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 note that the Feather River is highly valuable from an sDPS green sturgeon conservation perspective. This is because the Feather River is one of the only places 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. Spawning has also been documented recently in the Yuba River (CDFW 2018 and 2019); however, those adults must utilize the Feather River as a migratory corridor, further validating its importance to the sDPS.

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.

2.4.5.6.2. 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.

2.4.5.6.3. 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, CDFG 2002, CDWR 2007). However, 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) modeled that in the absence of impassable dams and altered hydrographs, sDPS green sturgeon would utilize certain areas of the upper Feather River. Based on the Mora *et al.* (2009) analysis, the construction of the Project 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) provides simplistic hypothetical models of spatially structured populations. The most applicable model to sDPS green sturgeon is unknown. However, recent studies utilizing acoustic telemetry suggest that the sDPS green sturgeon spawning in the Feather River are unlikely to be independent from the main population. Adult sDPS green sturgeon tagged near the spawning grounds in the Feather River were later detected in the Sacramento River during the next spawning cycle and remained there near the spawning grounds during the estimated spawning window. Additionally, at least one adult sDPS green sturgeon that was previously tagged in the Sacramento River has been recently detected near the spawning grounds in the Feather River (CDWR unpublished data).

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 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 Project, are ongoing to address the effects of the Sunset Pumps weir on anadromous fish.

2.4.5.6.4. 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 CDWR 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, 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.

2.4.5.6.5. 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 Project facilities (NMFS 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 in the LFC 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 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 few known spawning locations in the Feather River (the Thermalito Afterbay Outlet and the LFC near the Fish Barrier Dam), a single catastrophe or environmental change (man-made 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 (USFWS 1995). The current suitability of habitat in the Feather River is almost entirely dependent on releases from the Project, and continued current operations of the Project are likely to further attenuate high flow events.

2.4.5.7. Southern DPS 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, and passage throughout the river).

The PBFs for sDPS green sturgeon critical habitat referenced in Section 2.2 *Rangewide Status of the Species and Critical Habitat* that are specific to riverine systems apply in the Feather River. These include:

- food resources
- substrate type or size
- water flow
- water quality
- migratory corridor
- water depth
- sediment quality

Southern DPS 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. Pool depths of equal to or greater than 5 meters 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.

2.4.5.7.1. Status of Southern DPS Green Sturgeon Critical Habitat in the Action Area

Green sturgeon critical habitat is considered to be degraded in the action area. Within the Feather River, habitat quality and quantity is an important factor 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 near Verona. Within this context, the most problematic issue for sDPS green sturgeon is likely 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, prohibit sturgeon passage at low flows, thereby exacerbating the problem of low flows. The migratory corridor PBF is also problematic, as the habitat in the lower Feather River is heavily impacted by unscreened water diversions that may impose a 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 five 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 Outlet. The total area of the pools is greater than 164,500 square meters. 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.

2.4.5.8. 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 previously 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 Project 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. However, 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. In addition, 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.

2.5. Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

Adverse effects resulting from the emergency actions taken in response to the Oroville Dam Spillway Incident were primarily related to the following: (1) suspended sediment mobilization and turbidity increases from operation of the Flood Control Outlet and Emergency spillways and dredging within the Thermalito Diversion Pool, and (2) redd dewatering, redd scour, and stranding as a result of rapid flow increases and decreases.

2.5.1. Suspended Sediment Effects on Listed Species

Suspended sediment is widespread and pervasive, occurring to some extent in all streams (Waters 1995). Suspended solids refer to the mass (mg) or concentration (mg/L) of inorganic and organic matter held in the water column of a stream, river, or reservoir by turbulence (Bilotta and Brazier 2008). High concentrations of suspended sediment (and/or suspended solids) can have adverse effects on salmonids. The severity of these adverse effects depends on the sediment concentration, duration of exposure, life history timing, and sensitivity of the affected life stage (Newcombe and MacDonald 1991; Bilotta and Brazier 2008). Increases in suspended sediment above the background level related to the Oroville Dam Spillway Incident Emergency Response likely affected ESA-listed species through physical impairments, behavioral responses, availability of preferred forage, and minor changes in habitat quality.

The effects to ESA-listed species from increased suspended sediment generated during the Oroville Dam Spillway Incident Response are related to the concentration levels and exposure duration. Research investigating relationships between suspended sediment concentrations and exposure duration provide general predictors for salmon and steelhead response. High levels of suspended sediment can be lethal to salmonids; lower levels can cause chronic sublethal effects including loss or reduction of foraging capability, reduced growth, reduced resistance to disease, reduced respiratory ability, increased stress, and interference with cues necessary for homing and migration (Bash *et al*. 2001). Sub-lethal effects are those that are not directly or immediately lethal, but are detrimental and have some probability of leading to eventual death via behavioral or physiological disruption.

Turbidity levels as low as 20 Nephelometric Turbidity Units (NTU) can cause behavioral changes in salmonids. A study by Sigler *et al*. (1984) demonstrated a reduction in salmonid growth rates after chronic exposure to elevated turbidity as low as 25 NTU over 14 days. Exposure to suspended sediment levels above 20 NTU for greater than 4 hours can cause gill irritation and behavioral responses, which include alterations to feeding and social hierarchy (Berg and Northcote 1985). As the turbidity levels approach 60 NTU, feeding may cease (Berg and Northcote 1985). At high enough concentration levels, the addition of fine sediment to channels is likely to lead to displacement from or avoidance of preferred rearing areas, or abandonment of preferred spawning grounds, which increases losses due to competition, disease, predation, or, for juvenile fish, reduce the ability to obtain food necessary for growth and maintenance (Newcombe and Jenson 1996).

Single turbidity measurements as high as 974 NTU and total suspended solids as high as 753 mg/L were recorded at Auditorium Riffle in the Feather River LFC in the days following the incident (CDWR 2019). Turbidity and total suspended solids gradually declined over several days following the incident and then remained at values approximately between 25 and 115 NTU and 23 and 55 mg/L, respectively, until the end of February (CDWR 2019). A single measure of turbidity in the HFC (near the Gridley Boat Ramp) peaked at 620 NTU on February 10, 2017 before decreasing over the next week (Figure 3).

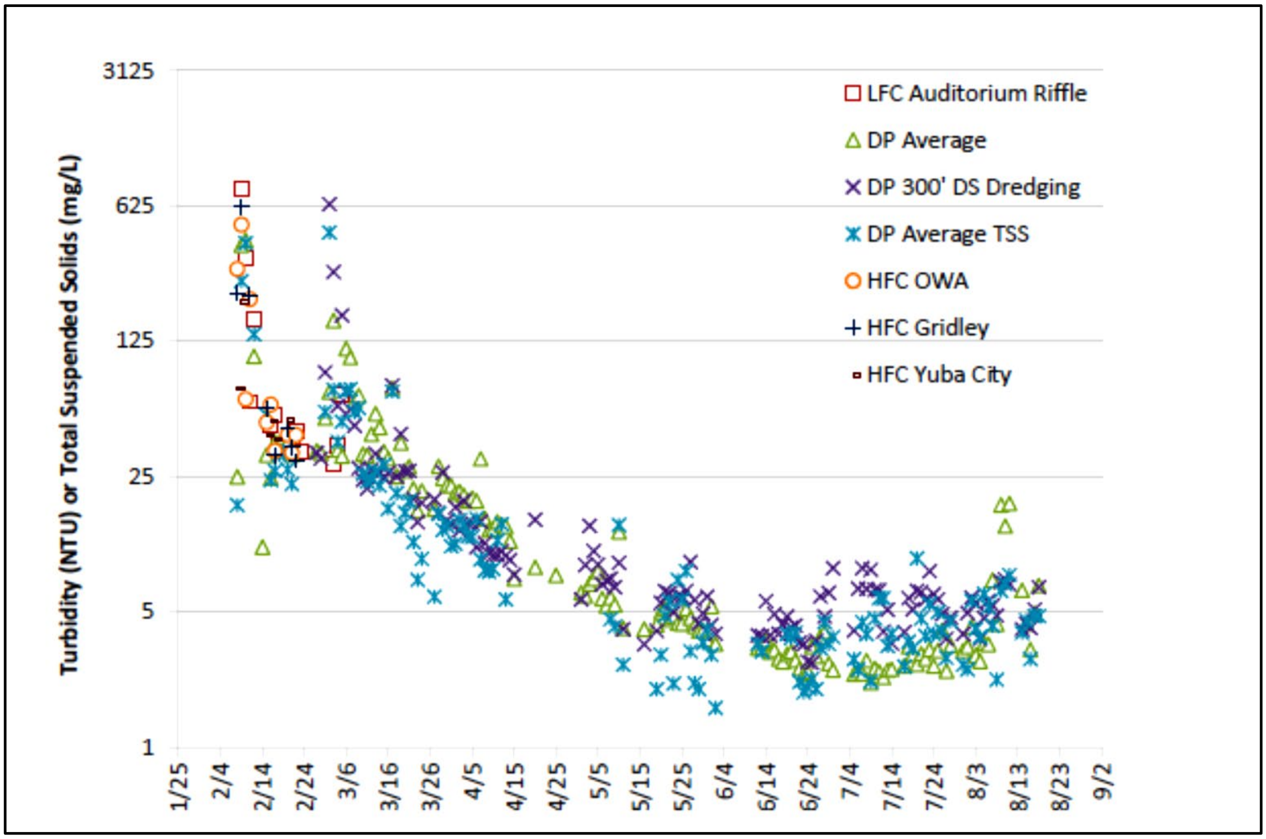

Figure 3. Average turbidity (NTU) measured in the Feather River. Average turbidity (NTU) measured in the Feather River. Locations include the HFC at multiple locations, the LFC, the Thermalito Diversion Pool at multiple locations (Diversion Pool Average), and daily average of Total Suspended Solids (TSS) measured at 12 separate locations in the Thermalito Diversion Pool (DP Average TSS). Auditorium Riffle is the uppermost site in the Lower Feather River below the Fish Barrier Dam, followed downstream by the HFC Oroville Wildlife Area (HFC OWA) site, then HFC Gridley, and HFC Yuba City. Note base 5-log scale on y-axis.

When the Thermalito Diversion Pool was being dredged, average turbidity 300 feet downstream from the dredging operation peaked at 639 NTU on March 2, 2017. After the spike on March 2, turbidity quickly began to drop in the Thermalito Diversion Pool to approximately 32 NTU by March 10 (Diversion Pool average for this day) and continued to decline steadily throughout the rest of the year (Figure 3). Turbidity in the Thermalito Diversion Pool generally remained above 20 NTU until early April, suggesting that turbidity in the Feather River downstream was also somewhat elevated beyond background levels until early April. Turbidity in the Thermalito Diversion Pool continued to decline after early April until early June when it leveled off and generally remained at values between 3 and 7 NTU.

Comparing turbidity and flow data in the HFC between 2017 and a similar wet year, 2006 (when flows reached 80,000 cfs), suggests that the Oroville Dam Spillway Incident emergency response resulted in higher turbidity in the HFC than is typically observed in a wet year. In 2006, the highest turbidity observed in the HFC was 23.1 NTU, while in 2017 the highest average turbidity observed in the HFC was 620 NTU. Also important to note, flows in 2006 never exceeded 65,000 cfs in the LFC, while flows in 2017 were nearly double that observed in 2006.

The increased turbidity in the Feather River downstream of the Fish Barrier Dam had the potential to adversely affect CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon. The timing of increased turbidity from the Oroville Dam Spillway Incident emergency response overlaps with the presence of rearing and migrating juvenile CV spring-run Chinook salmon and CCV steelhead, upstream migrating adult CV spring-run Chinook salmon, and spawning CCV steelhead. In addition, the Oroville Spillway emergency response suspended sediment effects overlap with upstream migration, spawning, and rearing of sDPS green sturgeon. Specific potential effects to each species and life stage are discussed in greater detail below.

2.5.1.1. Adult Migration, Holding, and Spawning

CV spring-run Chinook salmon typically arrive at FRH between mid-May and June (NMFS 2016a). CV spring-run Chinook salmon hold in large pools, mainly in the LFC upon arrival and through the summer before spawning in the fall (NMFS 2016a). Adult CCV steelhead typically enter the Feather River from September to November and then hold until spawning (NMFS 2016b). Adult CCV steelhead begin spawning in the Lower Feather River in late December, typically peaking in late January and ending by late-March (Cavallo *et al.* 2003; Hartwigsen and Reid 2009). Adult sDPS green sturgeon typically start entering the Feather River in February, hold before spawning, with spawning occurring from April through June (NMFS 2015). Therefore, we expect that a small proportion of upstream migrating and holding adult CV spring-run Chinook salmon, holding and spawning adult CCV steelhead, and upstream migrating and holding sDPS green sturgeon were exposed to elevated turbidity resulting from the Oroville Dam Spillway Incident emergency response.

2.5.1.1.1. Central Valley spring-run Chinook salmon

Previous studies suggest that adult salmonids may be the life stage least impacted by elevated suspended sediment levels (Bash *et al.* 2001). Elevated turbidity does not appear to directly interfere with homing, although in extreme cases adult salmonids may stray from natal streams with very high suspended sediment concentrations (Quinn and Fresh 1984). Elevated turbidity can, however, delay adult upstream migration and adult salmonids may seek out turbidity refugia (Bash *et al.* 2001). Several studies have documented active avoidance of turbid areas by adult salmonids (Bisson and Bilby 1982; Lloyd 1987; Servizi and Martens 1992; Sigler *et al.* 1984).

Adult CV spring-run Chinook salmon may have attempted to avoid elevated turbidity by seeking out less turbid locations. However, the turbidity levels experienced in spring 2017 during adult migration of CV spring-run Chinook salmon were approximately 10 NTU or less (April-June), similar to those experienced in 2006 and not at a level expected to cause significant delay or adult avoidance. Tributaries and areas of emerging subsurface flow may be used as turbidity refugia (Maslin *et al.* 1996). However, there are few tributaries to the Lower Feather River. The main tributaries, the Yuba and Bear rivers and Honcut Creek, were turbid during this time as well, but were likely less turbid than the Lower Feather River during the peak immediately following the Oroville Dam Spillway Incident. Given the low probability of adult spring-run Chinook salmon presence when turbidity was significantly elevated, any adverse effect are expected to have been minor and short in duration. Therefore, increased suspended sediment likely had a minimal effect on CV spring-run Chinook during upstream migration and holding.

2.5.1.1.2. California Central Valley steelhead

CCV steelhead would have largely arrived on the spawning grounds prior to the Oroville Dam Spillway Incident, because peak spawning occurs in January. Adult steelhead spawning at the FRH was concluding for the season when the incident occurred, indicating that adult upstream migration was essentially over. Minimal to no impacts to CCV steelhead migration by suspended sediment resulting from the emergency response likely occurred.

Some portion of the adult spawning population may have experienced high levels of suspended sediment during the Oroville Dam Spillway Incident emergency response. CCV steelhead spawning that occurred towards the end of the spawning season during elevated suspended sediment concentrations in the Lower Feather River may have experienced reduced egg fertilization rates. This negative relationship between suspended sediment concentration and egg fertilization has been documented in the laboratory with sockeye (*O. nerka*) and coho salmon (*O. kisutch*) (Galbraith *et al*. 2006), and may be similar for other salmonids. However, the sustained high flows throughout the winter of 2017 likely precluded successful spawning throughout the majority of the spawning season (see Section 2.5.2 *Effects of Rapid Flow Fluctuations on Listed Species*). Any CCV steelhead eggs that were present during January and February were likely already displaced as a result of high wintertime flows that scoured spawning gravels and redds. During the very short period at the beginning of March, when flows would be suitable for spawning (600-2500 cfs), turbidity had dropped significantly to between 28 and 66 NTU, as recorded at Auditorium Riffle over three days in early March (Figure 3). Photographs of gravel taken during late February and early March by CDWR revealed clean gravel bars throughout the LFC, further evidence that fine sediment deposition from a suspended load of silts and clays was not occurring in spawning habitat, even at minimum flows. Therefore, a very small proportion of the spawning adult CCV steelhead present in the Feather River during the end of the spawning season may have experienced reductions in egg fertilization rates as a result of increased suspended sediment caused by the Incident. However, the sustained high flows that occurred earlier in the spawning season were likely the greater driver with regard to reducing CCV steelhead spawning success in 2017.

Redd, snorkel, and spawning data confirm that steelhead spawning was quite successful in 2018 (the first year of spawning after the incident). More adult steelhead were observed spawning in 2018 than any previous year recorded, and more steelhead juveniles were recorded in snorkel surveys and beach seining than in any previous survey year (CDWR 2019). Although spawning of steelhead in 2017 may have been adversely affected by elevated sediment levels, there is no conclusive data illustrating the extent to which adult spawning was affected. The elevated numbers of both adult and juvenile steelhead observed during 2018 indicates that the emergency response likely injured or killed a very small proportion of the adult spawners or their resulting progeny.

Furthermore, CCV steelhead adults would have benefited from the gravel additions carried out in 2017 and from the work performed in Moe's Side Channel (CDWR 2019). CDWR data demonstrates that 46 percent of all redds constructed in 2018 were in Moe's Side Channel and 93 percent were constructed in the uppermost reaches, above Lower Auditorium Riffle (CDWR 2019). Adult steelhead appeared to be selecting the uppermost habitat in the Feather River, demonstrating a routine and even increased use of this area. The effect of gravel additions in 2017 and work performed in Moe's Side Channel likely benefitted CCV steelhead in the Lower Feather River. Thus, we expect a very small proportion of the Feather River steelhead population was adversely affected as described above, by initial high sediment levels resulting from the emergency response. However, the negative effects of reduced egg fertilization rates are generally expected to be offset by the 2017 gravel supplementation efforts, through improvements to the substrate (infusion of preferred size gravel and cobble, and disturbance of any remaining sediment that had settled from the emergency response) and increases in available habitat.

2.5.1.1.3. Southern DPS Green Sturgeon

Adult green sturgeon were detected in the system as early as January 24, 2017, near Shanghai Bend. However, based on several years of unpublished acoustic telemetry data, the peak of adult sturgeon migration into the Feather River generally occurs after March 15, so it is likely that only a small fraction of the sturgeon population was present during the Oroville Dam Spillway Incident emergency response. Sturgeon evolved to withstand high turbidity conditions and actively avoid areas of low turbidity (Cech and Doroshov 2004). They have adaptations, such as barbels and electroreceptors that allow them to feed irrespective of water turbidity (LeBreton *et al.* 2006). Green sturgeon are a highly mobile species that can travel thousands of miles to spawn (Moser *et al.* 2016) and would be able to migrate the short distance out of the Feather River if conditions were not favorable. Annual dual identification sonar (DIDSON) surveys conducted in the Feather River concluded that one of the largest abundance estimates of adult sturgeon occurred in 2017. Therefore, minimal effects were expected to occur to adult sDPS green sturgeon from elevated turbidity resulting from the Oroville Dam Spillway Incident emergency response during their migration, holding, or spawning.

2.5.1.2. Eggs and Larvae

2.5.1.2.1. Central Valley spring-run Chinook salmon

Given the documented success of spawning and the continued use of similar spawning habitat in 2017 and 2018 when compared to previous years, there is no data to suggest that CV spring-run Chinook salmon eggs or larvae were adversely affected as a result of the emergency response. Increased turbidity experienced immediately after the Oroville Dam Spillway Incident had long subsided when adult spawning began during the fall, and new gravel was placed in much of the primary spring-run Chinook salmon spawning area. High flows experienced throughout winter and spring appeared to mobilize fine, suspended sediment away from spawning areas toward floodplain or off-channel areas, allowing spawning habitat to remain fairly clean. Particle size data collected from 453 representative Chinook salmon redds during 2017 confirms there were no adverse changes to spawning gravel (CDWR unpublished 2017). Gravel particle size distributions are likely to have improved over the past several years from additions of new gravel in 2014 and 2017. Moe's Side Channel was also enhanced in 2017, providing additional spawning and incubating habitat than existed prior to the Oroville Dam Spillway Incident. For these reasons, impacts to CV spring-run Chinook salmon eggs and larvae were not expected from increases suspended sediment resulting from the emergency response to the Oroville Dam Spillway Incident.

2.5.1.2.2. California Central Valley steelhead

CCV steelhead spawning in the Lower Feather River primarily occurs from late December through March, with egg incubation from approximately December through April, and alevin emergence from approximately March through May (NMFS 2016b). Although turbidity was quite high during primary egg incubation, flows were also very high and fairly sustained throughout the springtime. It is probable that any suspended sediment would have been carried far below the primary steelhead spawning areas in the LFC before settling out. CDWR observations of spawning gravel areas used by CCV steelhead for spawning saw no signs of sediment accumulation, but rather normal signs of gravel movement after a relatively high flow event. Some areas, however, did fill in from gravel movement while other areas scoured, as is typical of an alluvial system after a high flow event. Signs of sediment accumulation were observed in expected areas (higher elevation overbank areas, backwaters, floodplains, and velocity shadows behind bars). Therefore, short-term effects as a result of increased sedimentation immediately following the spillway failure and subsequent dredging activities may have occurred, but were likely minimized as a result of the sustained high flows. Due to scouring flows that began in early January because of high levels of precipitation and reservoir releases, eggs and larvae present in the LFC during the majority of the spawning and incubation period were likely displaced from redds and washed downstream as high flows mobilized spawning gravels and scoured redds. It is possible that a very small proportion of the steelhead eggs and larvae remained in redds, despite the high scouring flows that occurred. The eggs that remained would have been fertilized and incubating within the substrate, and thus had no means of avoiding impacts associated with increased turbidity. In summary, few if any incubating steelhead eggs and larvae would have been present in redds and exposed to reduced water quality and impaired respiration (low dissolved oxygen) as a result of increased suspended sediment from actions taken in response to the Oroville Dam Spillway Incident. The majority of the steelhead redds present in the LFC were likely scoured prior to the Incident from high wintertime flows that likely displaced eggs and larvae from spawning gravels, washing them downstream. Furthermore, the data presented above also show that steelhead spawning was very successful in 2018, with record numbers of redds and juveniles recorded in various surveys, demonstrating that the CCV steelhead population in the Feather River was minimally affected as a result of the emergency response.

2.5.1.2.3. Southern DPS Green Sturgeon

Green sturgeon spawning in the Feather River occurs from April through June, with larvae hatching from eggs within 6 to 8 days after fertilization (NMFS 2015). Approximately 10 days post-hatch, larval green sturgeon start exogenous feeding and begin to disperse downstream (NMFS 2015).

Information about the effects of suspended sediment and deposited fine sediment on green sturgeon eggs and larvae is limited. Turbidity in the Thermalito Diversion Pool generally remained above 20 NTU until early April, suggesting that turbidity in the Feather River downstream was also somewhat elevated beyond background until early April. Turbidity in the

Thermalito Diversion Pool continued to decline after early April until early June when it leveled off and generally remained at values between 3 and 7 NTU. Therefore, although turbidity levels were generally declining throughout the spawning period, the earlier arriving adult spawners may have been adversely affected. However, eggs collected during spawning surveys appeared in good condition and did not have any visible abnormalities or fungal growth on them; although this is based on a very small sample size obtained on a single day. Larval sturgeon collected in June were small (22-27 mm) and may have been impacted if particulates, after a rapid flow decrease, accumulated in the interstitial spaces used for cover or in the open spaces in which they feed. Studies of fine sediment impacts to closely related and co-occurring white sturgeon have documented adverse effects. For example, white sturgeon recruitment failure in the upper Columbia River (McAdam 2015) and the Nechako River (McAdam *et al.* 2005) is believed to be a result of egg and embryo mortality, due to increased fine substrates at spawning sites. In a laboratory experiment, fine sediment cover significantly reduced white sturgeon embryo survival and embryo survival was negatively correlated with duration of fine sediment cover (Kock *et al.* 2006). Larval white sturgeon appear to prefer the small interstitial spaces provided by small gravel, as this refuge habitat decreases predation by sculpins (McAdam 2015). Spawning substrate surveys at several sDPS green sturgeon spawning locations in the Sacramento River found that are eggs generally collected in pockets of small to medium gravel within larger substrate (Poytress *et al.* 2011). Another study of Sacramento River sDPS green sturgeon spawning habitat suitability found that preferred spawning substrate was gravel and sand (Wyman *et al.* 2017). Green sturgeon spawning habitat studies in the Sacramento River and studies on the effect of fine sediment on white sturgeon embryo and larval survival suggest that green sturgeon embryos and larvae may have been negatively impacted, if the Oroville Dam Spillway Incident emergency response produced fine sediment that accreted on their spawning habitat.

However, the majority of spawning likely occurred while flows were higher in April and May when detection of eggs and larvae were harder to document due to the dilution effect from the large volume of water that was being sampled. The spawn timing is supported by two milting male green sturgeon tagged by CDWR in early May, which indicates adults were already in spawning condition. The high flows in the LFC in April and May likely kept fine sediment from settling out in the spawning area, and instead may have provided a positive effect. It is possible that elevated flows reduced turbidity in the LFC, limiting potential adverse effects to green sturgeon spawning at this time.

Although measurements of turbidity and suspended solids were high during and immediately following the Oroville Spillway Incident, sustained flow pulses greater than 40,000 cfs in spring of 2017 are likely to have flushed fine sediment deposited during the incident response and reduced or eliminated potential impacts to green sturgeon spawning. Turbidity and suspended sediment had decreased by April, when green sturgeon spawning likely started. Similarly, only minor sediment deposition was noted in the upper reaches of the Feather River, where most green sturgeon spawning occurs, and therefore we expect minimal exposure and minimal adverse effects to eggs and larvae occurred.

2.5.1.3. Juvenile Rearing

Short-term increases in suspended sediment may disrupt feeding activities or result in avoidance or displacement of fish from preferred habitat. Juvenile salmonids have been observed to avoid streams that are chronically turbid (Lloyd 1987) or move laterally or downstream to avoid turbidity plumes (Sigler *et al.* 1984). Bisson and Bilby (1982) reported that juvenile coho salmon avoid areas with turbidity exceeding 70 NTU. During periods of elevated turbidity in mainstem rivers, juvenile salmonids may seek out refuge in less turbid non-natal tributaries including intermittent streams (Maslin *et al.* 1996). Sigler *et al.* (1984) found that prolonged exposure to turbidities between 25 and 50 NTU resulted in reduced growth and increased emigration rates of juvenile coho salmon and steelhead compared to controls. These findings are generally attributed to reductions in reactive distance and the ability of salmon to see and capture prey in turbid water (Waters 1995). In laboratory studies, juvenile salmonids have been observed to transition from drift feeding to benthic feeding during periods of elevated turbidity (Gregory and Northcote 1993; Rowe *et al.* 2003). However, some field studies suggest that juvenile salmonids will continue to drift feed during turbid conditions despite the reduced reactive distance (Arndt *et al.* 2002; White and Harvey 2007). Chronic exposure to high turbidity and suspended sediment may also affect growth and survival by impairing respiratory function, reducing tolerance to disease and contaminants, and causing physiological stress (Waters 1995). Berg and Northcote (1985) observed changes in social and foraging behavior and increased gill flaring (an indicator of stress) in juvenile coho salmon at moderate turbidity (30-60 NTU). In that study, behavior returned to normal quickly after turbidity was reduced to lower levels (0-20 NTU). Turbidity in the Lower Feather River appears to have remained at elevated levels for over two weeks (Figure 3), which may have reduced foraging success and growth for juvenile salmonids that remained in the Action Area, as has been observed in previous studies (Sigler *et al.* 1984).

Juvenile CV spring-run Chinook salmon and CCV steelhead may have attempted to behaviorally avoid the elevated turbidity by seeking out less turbid locations; several studies have documented active avoidance of turbid areas by juvenile salmonids (Bisson and Bilby 1982; Lloyd 1987; Servizi and Martens 1992; Sigler *et al.* 1984). Tributaries and areas of emerging subsurface flow may have been used as turbidity refugia (Maslin *et al.* 1996). However, there are few tributaries to the Lower Feather River and the main tributaries, the Yuba and Bear rivers, were likely turbid during this time as well, but may have been less turbid than the Lower Feather River. Juvenile salmonids may also use turbidity as a cue for downstream migration, likely due to the cover from predators that it provides (Jensen *et al.* 2012). However, turbidity and flow are highly correlated in most river systems, so it is uncertain which factor provides the migration cue, but in 2017 both factors were likely operating.

Juvenile CV spring-run Chinook salmon and CCV steelhead that may have migrated downstream in response to elevated flows and turbidity may have located high quality rearing areas on downstream floodplains inundated by high flows (Sommer *et al.* 2001; Katz *et al.* 2017). Juvenile salmonids forced to leave protective habitat due to elevated turbidity may have increased their exposure to predators. However, the increased predator exposure may have been offset by greater cover provided by elevated turbidity and access to shallower floodplain habitats (Gregory and Levings 1998), in addition to reduced predator densities due to a larger volume of water from high flow levels. Data on returns of two-year old spring-run Chinook salmon smolts (coded-wire-tagged and subsequently released into the Lower Feather River at Gridley and

Boyd's Pump Boat Ramp) captured at various locations in 2018 (from brood-year 2016, released in 2017) indicate that rearing conditions in the Lower Feather River and elsewhere were quite good. Returning age-two fish released in late March and early April 2017 far outnumbered returning age-two, three, and four-year old fish released in 2015 combined, indicating a high level of success during emigration when compared to other recent release groups.

Deposited fine sediment can decrease production of the macroinvertebrate prey of juvenile salmonids (Wu 2000; Chapman 1988; Phillips *et al.* 1975; Suttle *et al.* 2004; Colas *et al.* 2013). Rivers with high fine sediment content tend to have low densities of macroinvertebrates and be taxon-poor (Larsen *et al.* 2011, Buendia *et al.* 2013, Descloux *et al.* 2013). Low macroinvertebrate density from high fine sediment concentration leads to less available food for juvenile salmonids with potential impact on growth and survival (Suttle *et al.* 2004). More recent studies have shown no mortality of macroinvertebrates, despite extremely high sustained sediment; however, increased drift (downstream) of macroinvertebrates may be expected. While there is no data to suggest that fine suspended sediment from the response to the Oroville Spillway Incident impacted macroinvertebrate production, it is likely that decreased food availability from initially high turbidity led to a shift in prey selection from grazing to burrowing macroinvertebrates, which are less available as a food source for fish. This shift may have increased fish foraging activity as a result of lower prey abundance (FERC 2018).

Sustained high flows experienced through the spring of 2017 likely provided an abundance of habitat for off-channel and floodplain rearing that was highly beneficial for emigrating juveniles. Due to the extended connectivity to floodplain habitat and the flow of nutrients from floodplains back to the main channel, there was an increase in the exchange of nutrients between the main-channel and some floodplain areas from the response to the Oroville Dam Spillway Incident. Sustained high flows throughout winter and spring in response to the Oroville Dam Spillway Incident likely benefitted nutrient exchange between these floodplain habitats and the main river channel, as flooded habitat was inundated for lengthy periods of time.

2.5.1.3.1. Central Valley spring-run Chinook salmon

In the Feather River, CV spring-run Chinook salmon alevins emerge from the gravel in November and December (NMFS 2016a, Bilski and Kindopp 2009). The majority of juvenile CV spring-run Chinook salmon in the Lower Feather River emigrate as fry, with fry emigration peaking in December and then slowly declining from January to March (Bilski and Kindopp 2009). A small number of CV spring-run Chinook salmon remain in the Lower Feather River before emigrating in the spring and an even smaller number appear to emigrate in the winter as yearlings (Bilski and Kindopp 2009).

Although rearing conditions were quite good overall, juvenile or yearling CV spring-run Chinook salmon that remained in the Lower Feather River to rear during the peak of suspended sediment may have experienced reduced growth as a result of impaired reactive distance to prey, impaired respiratory function, reduced tolerance to disease, and physiological stress. However, the good return of hatchery-origin two-year old spring-run Chinook salmon indicates successful outmigration of this cohort and returns in 2019-2020 (*i.e.*, of ages 3 and 4) should confirm the trend (observed from data collected in 2018). Although juvenile production following the incident was documented to be successful, suspended sediment introduced into the Lower

Feather River as a result of the Oroville Spillway Incident response likely exposed juvenile CV spring-run Chinook salmon to impaired water quality (*i.e.*, low dissolved oxygen, etc.) resulting in behavioral changes such as avoidance of areas with increased turbidity. Due to the duration and intensity (*i.e.*, during peak turbidity levels) of exposure, a very small proportion of the rearing and emigrating juveniles likely experienced injury or death as a result of reduced respiration and increased physiological stress.

2.5.1.3.2. California Central Valley steelhead

The capture of juvenile CCV steelhead in Lower Feather River rotary screw traps (RSTs) primarily occurs in March and April, with considerably lower catch in May and June (Bilski and Kindopp 2009). The majority of captured juvenile CCV steelhead were less than 150 millimeters fork length (mm FL), with very few larger smolt sized fish captured (Bilski and Kindopp 2009). Rearing juvenile CCV steelhead are present in the Lower Feather River year-round (Seesholtz *et al.* 2004).

Although rearing conditions were quite good overall, juvenile or yearling CCV steelhead may have experienced short-term reduced growth as a result of high turbidity and suspended sediment. This could have led to short-term impacts, such as impaired reactive distance to prey, impaired respiratory function, reduced tolerance to disease, and physiological stress. However, a relatively recent study found no impact of repeated exposures of suspended sediment on survival or body condition of *O. mykiss* fry, but did find smaller linear growth and mass (relative to the control) after 19 days (Shaw and Richardson 2011). Given the presence of juvenile CCV steelhead in the Feather River during the peak turbidity events, suspended sediment introduced into the Lower Feather River as a result of the Oroville Dam Spillway Incident likely affected behavior through exposure to reduced water quality. Given the timing of the elevated suspended sediment, it is expected that very few age-0 (juvenile) steelhead were present and exposed to peak turbidity levels. It is expected that the majority of the CCV steelhead present during that time were yearlings or larger juveniles that would be capable of avoiding highly turbid areas. However, those juvenile CCV steelhead that were unable to actively avoid areas of the Feather River during peak turbidity levels were likely injured or killed due to impaired respiratory function or increased physiological stress.

2.5.1.3.3. Southern DPS Green Sturgeon

Little is known about green sturgeon early life history in the Feather River, but data from 2011 through 2018 provides some insight. Based on larval catch in the LFC in 2017 and the HFC during 2018 (A. Seesholtz, pers. comm.), juveniles could likely be found throughout the Feather River. Larvae likely metamorphose into juveniles beginning as early as late-April. Assuming they would exhibit the same behavior as the juveniles in the Sacramento River (B. Poytress, pers. comm.), the majority would out-migrate in the late fall/early winter. Juvenile sturgeon evolved in turbid settings, so periods of increased turbidity during the high spring flows were unlikely to hamper their ability to find food. By early June, turbidity levels had dropped significantly (*i.e.*, 4-10 NTU). High spring flows are expected to have swept away the suspended sediments, which might fill in the interstitial spaces used for cover from predators. Given that green sturgeon spawning is expected to have occurred after the initially high February 2017 sediment levels, juvenile green sturgeon were not likely present, and therefore not exposed to the increased turbidity resulting from the Oroville Dam Spillway Incident emergency response.

2.5.2. Effects of Rapid Flow Fluctuations on Listed Species

Between February and June 2017, four periods of rapid flow reduction from the Flood Control Outlet Spillway occurred. These flow reductions occurred on February 27, March 27, May 1, and May 19, 2017 (Figure 4). Potential effects of these four periods of rapid flow reduction are described below.

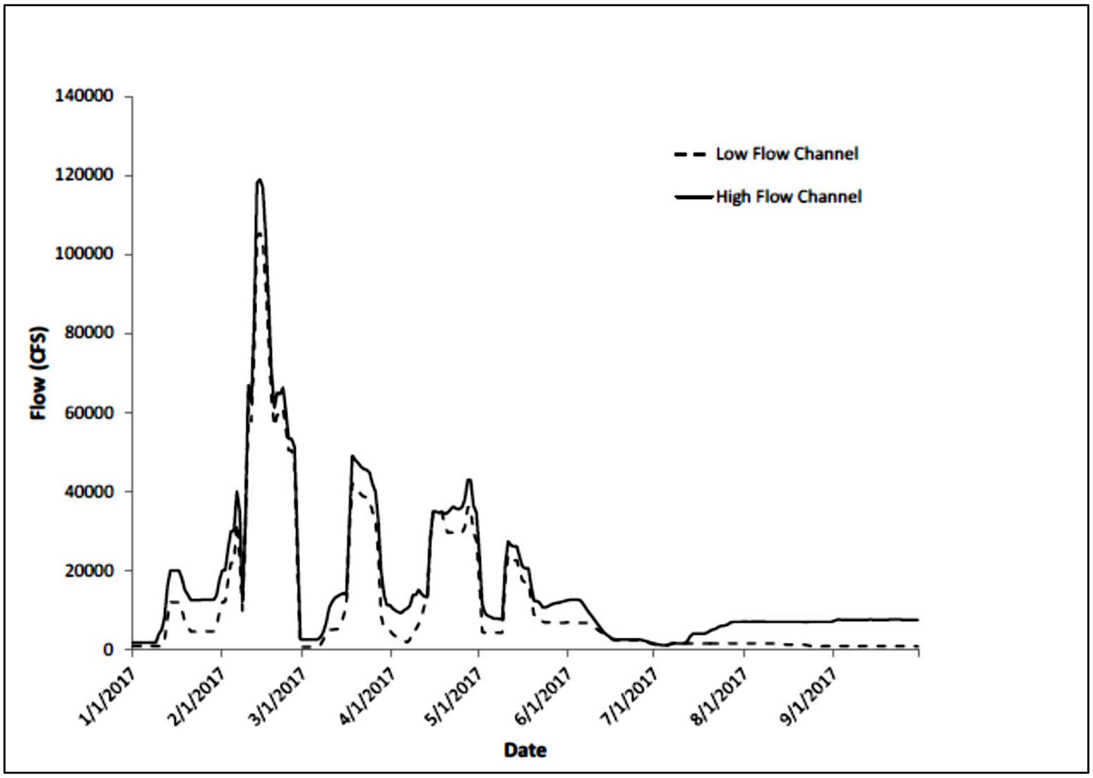

Figure 4. Discharge in the Low Flow Channel and High Flow Channel of the Feather River between January 1, 2017, and September 30, 2017 (Source: CDWR 2018).

2.5.2.1. Adult Migration, Holding, and Spawning

2.5.2.1.1. Central Valley spring-run Chinook salmon

CV spring-run Chinook salmon enter the Feather River and hold from March through October, with a peak immigration in May and June. Thus, three of the four rapid flow increase, then decrease periods overlapped with the adult migration period. Rapid flow increases may have attracted spring-run Chinook salmon from other basins into the Feather River (sometimes called "attraction flows"). However, flows were also high in the Sacramento River and Yuba River during this period, suggesting olfactory cues from these systems would remain strong during the increased flows in the Feather River. By the last rapid flow decrease (May 19, 2017 - a drop of over 10,000 cfs), the Lower Feather River had continued to experience high flows throughout the spring, maintaining the likelihood that attraction flows were occurring. Based on available data, the rapid flow fluctuations associated with the CDWR's emergency response likely did not result in increased straying of Feather River spring-run Chinook salmon to other systems in the Central Valley.

Adult CV spring-run Chinook salmon holding in the Feather River would have experienced mostly beneficial conditions due to high spring flows. Turbidity peaks had significantly receded by the time adults would have been holding and the four major flow reductions were mostly complete. The larger fish encountered during stranding surveys were very likely 2- or 3-year-old fall-run Chinook salmon planted in Lake Oroville in previous years that washed over one of the spillways. The average fork length of the adult Chinook salmon encountered during the surveys was 48 centimeters (cm) and the largest individual was approximately 65 cm, indicating younger or slower growing individuals. This would be expected for Chinook salmon that have matured in freshwater (*i.e.*, Lake Oroville) as compared to those that have matured in the ocean. Given that adult Chinook salmon (3+ years old) returning from the ocean average 80 cm or more, and only 2-year olds are roughly 65 cm or less, it appears that these individuals were most likely fall-run Chinook salmon planted in Lake Oroville during prior years that escaped during the emergency high flow releases (White *et al*. 2017). Further, it is extremely unlikely they would be CV spring-run Chinook salmon, since there is no data to suggest that adults enter the Feather River and arrive to holding areas in late February and early March (the time of the largest flow reductions). Flow reductions occurring in early and mid-May possibly forced holding adult CV spring-run Chinook to seek out alternate areas. However, as described above, earlier arriving adult CV spring-run Chinook salmon holding in the Feather River likely experienced ideal holding conditions as flows were elevated, increasing the number of potential holding pools. As flows were reduced, they were held at or above the minimum flows required for protection of fisheries resources. Therefore, although holding adult CV spring-run Chinook salmon were likely exposed to flow reductions as part of the response to the Oroville Dam Spillway Incident, conditions (*i.e.*, flows and temperatures) remained suitable for continued holding and were comparable to what would be expected during a normal year.

Flows were held higher in the LFC than the minimum required in both 2017 and 2018 to promote optimal spawning. Given that the rapid flow fluctuations occurred long before adult spring-run Chinook salmon began spawning in mid-September, data suggests CV spring-run Chinook salmon spawning was not exposed to rapid flow changes resulting from the Oroville Dam Spillway Incident response.

2.5.2.1.2. California Central Valley steelhead

Adult CCV steelhead enter the Feather River between August and December and spawning occurs between December and March with a peak in late January (Hartwigsen and Reid 2009; Kindopp *et al.* 2003). All CCV steelhead produced at CV hatcheries are marked with an adipose fin clip, but are not tagged to identify hatchery of origin. Thus, it is unknown if the incident caused straying of out-of-basin hatchery CCV steelhead into the Feather River or caused Feather River fish to stray to other basins. However, as described above, the timing of the resulting flow pulses makes it unlikely that straying of CCV steelhead occurred, since nearly all CCV steelhead were already on the spawning grounds when the incident began. Additionally, the FRH had completed their 2017 CCV steelhead spawning at least a week before the incident occurred, indicating the peak of adult spawning had passed. Although the end of the spawning period overlapped with the first rapid flow reduction event, most fish should have already arrived on the spawning grounds; therefore, flow pulses were unlikely to result in increasing straying or altering adult migration patterns of CCV steelhead in the Feather River.

By January 13, flows in the LFC were already at 7,800 cfs and rising. After that, flows in the Feather River were never lower than 4,000 cfs until February 28, when flows from the Flood Control Outlet Spillway ceased. Between January 13 and February 28, it is assumed that the sustained high flows would have precluded any successful CCV steelhead spawning due to the mobilization of spawning gravels and the temporary lack of available habitat suitable for spawning. Flows following the Spillway Incident (February 7, 2020) increased to 112,000 cfs, which is high enough to have scoured the majority if not all of the redds constructed during the winter of 2017 (see Section 2.5.2.2 below). Stranding data shows that at least some CCV steelhead fry emerged during 2017. These individuals were likely produced early in the spawning season and emerged before the high flows began, finding refuge during the high flows in slower velocity flooded areas. Therefore, it appears that CCV steelhead spawning was likely disrupted to a degree prior to the Spillway Incident. The substantial increase in flows up to 112,000 cfs following the Spillway Incident likely contributed to the resulting delayed and/or failed spawning attempts; however, based on the high reservoir levels prior to the Incident, flow levels would have been comparable to those expected for a no-incident scenario (cbec eco engineering 2020). Expected operations without the Oroville Spillway Incident were modeled for the period from February 7- May 31, 2017 with a release schedule in accordance with the 1970 USACE's Report on Reservoir Regulation for Flood Control - Oroville Dam and Reservoir. The maximum release under this no-incident scenario is 150,000 cfs (Figure 5).

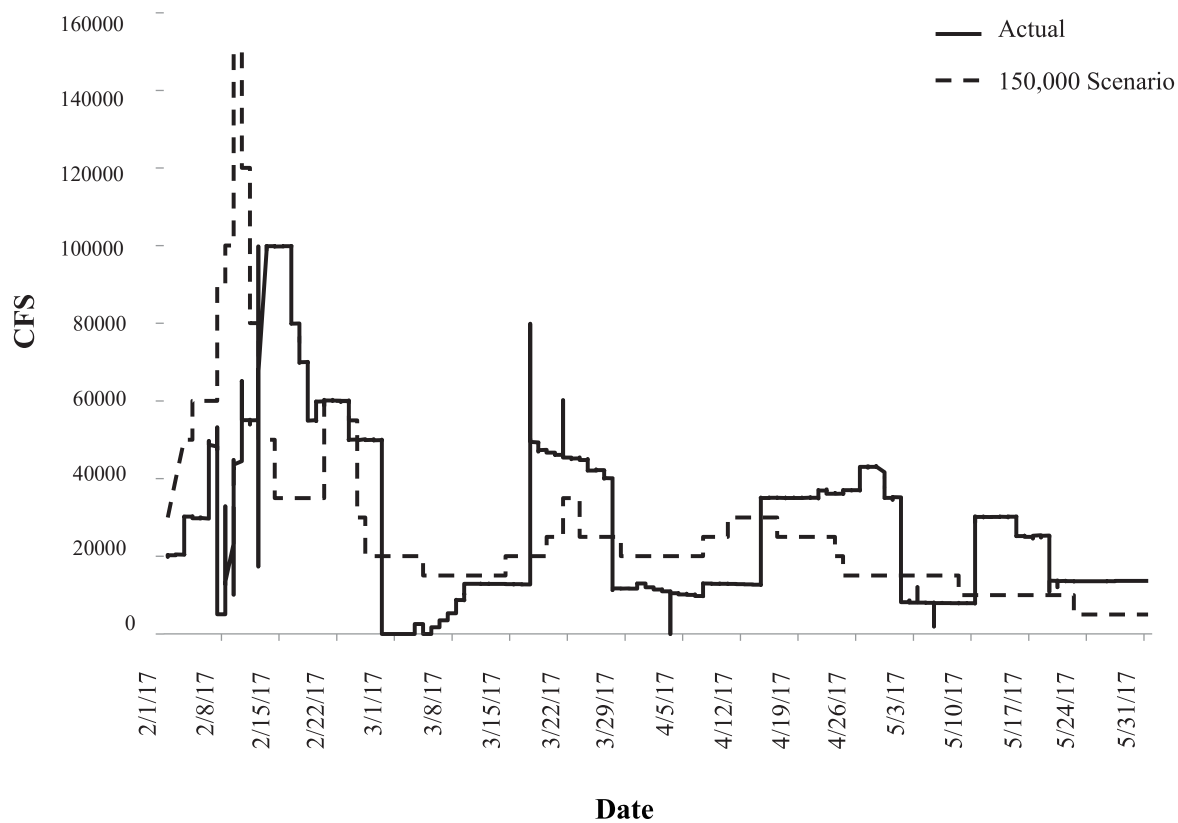

Figure 5. Releases from Oroville Dam between February 1 and May 31, 2017 (solid line) and modeled flows assuming the Oroville Spillway Incident has not occurred (150,000 cfs scenario - dashed line) (Source: CDWR 2018).

As previously stated, the timing of the first significant flow reduction coincided with the end of the CCV steelhead spawning window (late February). Fourteen adult CCV steelhead, comprising both hatchery and natural origin, were found stranded as a result of the rapid reductions in flow. Stranded adult CCV steelhead were concentrated in the LFC, and it is unknown if the individuals found in isolated pools were pre-spawn adults holding and waiting for conditions to improve prior to spawning, or whether they were post-spawn kelts beginning to migrate downstream. Given they were captured after several high flow events, it is likely that they were in fact pre-spawn holding adults and not post-spawn migrants. Spawning may have been curtailed or interrupted from rapidly changing flows, as indicated by the adult CCV steelhead that were found stranded. Therefore, adult CCV steelhead holding and spawning was likely impaired to a degree through reductions in available habitat resulting from the rapid flow reductions that occurred in response to the Oroville Dam Spillway Incident. Furthermore, it is expected that a fairly large proportion of the Feather River CCV steelhead population (see Table 4) was stranded from exposure to rapid flow fluctuations, resulting in injury or death for some of the stranded individuals. Rapid re-connectivity of isolated pools and relocation activities conducted by CDWR likely helped to mitigate some of the adverse impacts described above.

2.5.2.1.3. Southern DPS Green Sturgeon

Green sturgeon were detected in the system as early as January 24, 2017, near Shanghai Bend. Based on several years of unpublished telemetry data, the peak of sturgeon migration into the Feather River generally occurs after March 15, so it is likely that only a small fraction of the sturgeon population was present during the operation of the Emergency and Flood Control Outlet spillways. However, acoustically tagged sturgeon did migrate into the Feather River during the incident and throughout the emergency response period. This appears to suggest that adult sturgeon were not negatively influenced by the flow fluctuations occurring in the Feather River system since they could have continued their migration up the Sacramento River instead to avoid unfavorable conditions.

The exact drivers that stimulate green sturgeon to find and ascend the Feather River are unknown. Data is also limited on how green sturgeon decide which river they will ascend and at exactly what time. However, in years of higher flows there appears to be increased aggregations of adults, and spawning has been observed at two different locations in the Lower Feather River. Given the high flows experienced during the majority of 2017 (spring), even with rapid flow reduction events, it is likely that conditions were ideal in the Lower Feather River for green sturgeon to ascend, due to significant attraction flows. Additionally, the flow "split" between the Feather and Yuba Rivers would have been, at most times, favorable to the Feather River, likely attracting more fish into its upper reaches. The boulder weir at Sunset Pumps can limit passage at lower flows, but would have been inundated for the majority of the migration season, making passage feasible. For these reasons, flow reductions associated with the emergency response were unlikely to adversely affect green sturgeon migration or holding.

Given that green sturgeon adults were likely present during the Oroville Dam Spillway Incident, there may have been undetected impacts. Any behavioral changes, such as avoidance of impacted areas, would be difficult to detect and therefore may have occurred as a result of rapid flow fluctuations in the Feather River. However, no green sturgeon were detected when sampling for environmental DNA (eDNA) nor were any detected using traditional sampling gear in any pools sampled, wet or dry. However, a large aggregation of sturgeon (believed to be mostly green sturgeon based on the two individuals captured) was observed in 2017 near the Fish Barrier Dam, with spawning documented shortly thereafter (CDWR unpublished data). The successful adult spawning documented indicates that green sturgeon spawning was likely minimally affected by the rapid flow fluctuations resulting from the Oroville Dam Spillway Incident emergency response.

2.5.2.2. Eggs and Larvae

2.5.2.2.1. Central Valley spring-run Chinook salmon

No spring-run Chinook salmon eggs or larvae were present during flow reductions; therefore, impacts from flow reductions were not expected to have occurred.

2.5.2.2.2. California Central Valley steelhead

CCV steelhead spawning in the Feather River generally begins in December, peaks in January and trails off in late winter (Kindopp *et al.* 2003). It is likely that a large proportion of the 2017 CCV steelhead redds had been constructed and embryos (eggs and larvae) were incubating during the first period of rapid flow fluctuations. The majority of CCV steelhead spawning occurs in the LFC and flows in this reach averaged approximately 32,000 cfs on the day prior to the Incident and were also relatively high during the peak month of January before the Incident (up to approximately 7,000 cfs). Any redds created before January 13 are likely to have been scoured as a result of the sustained high flows prior to the Incident. By February 4, 2017, average daily flows in the LFC had already reached 22,000 cfs, a level that is certainly high enough to start mobilizing steelhead spawning gravel. By February 6, flows in the LFC had reached 31,000 cfs, a flow capable of mobilizing native bed material. Flows experienced after the spillway incident began (February 7, 2020) increase to 112,000 cfs, a level that is high enough to have scoured the majority, if not all of the redds constructed during the winter of 2017 (cbec eco engineering 2020). At these high flows, CCV steelhead were likely confined to spawning in Hatchery Side Channel and river margins, as depths and velocities moved away from spawning suitability criteria in more open, somewhat unprotected areas (Kindopp *et al.* 2003).

When flows from the spillway ceased and flows in the LFC returned to approximately 600 cfs, it is likely that any redds remaining after the high flows that were constructed on the river margins were stranded and dewatered. However, the Hatchery Side Channel would have remained somewhat stable, due to its relative protection from high flows (up against the levee) and redds constructed prior to the rapid flow reductions did remain viable in this area. Snorkel surveys conducted in 2017 by CDWR identified over 50 young-of-the-year CCV steelhead in Hatchery Side Channel, indicating successful spawning and incubation did occur. Embryos incubating in dewatered redds can continue to develop and survival of those embryos depends on the length of time dewatered, developmental stage, and the environmental conditions in the intra-gravel environment (Neitzel and Becker 1985). No surveys were performed to evaluate redd stranding and flows did eventually increase above pre-incident levels. However, flow fluctuations, combined with the long period of minimum flows in the LFC (> 7 days), resulted in possible stranding and dewatering of CCV steelhead redds that reduced embryo survival or caused total loss of some redds.

Within the Feather River, it is unlikely that many CCV steelhead were spawning on the river margins at flows of approximately 7,000 cfs, due to the lack of suitable spawning habitat at these flows. The LFC is heavily leveed, and as flows increase above 3,000 cfs, river margins become deeper and swifter. Furthermore, because CCV steelhead are iteroparous, they can postpone spawning and return to the ocean. Later spawners (late February or later) may have elected to migrate back to the ocean to return in later years when conditions may be more suitable. Given available information, it is likely that a large proportion of the CCV steelhead redds that were present during January and February were exposed to significant high flows. These flows would have scoured the majority, if not all, of the redds that were present, displacing eggs and fry, resulting in possible injury and/or death. A small proportion of adult CCV steelhead may have successfully spawned later in the season once flows had been reduced, in areas that later became dewatered resulting in injury or death to incubating eggs and/or larvae from lack of oxygen. Despite the successful juvenile production that occurred following the emergency response, it is likely that a small number of steelhead eggs and larvae were adversely affected from stranding and redd dewatering due to flow reductions in response to the Oroville Spillway Incident.

2.5.2.2.3. Southern DPS Green Sturgeon

The extent to which flow reductions may have affected green sturgeon eggs or larvae is unclear. Green sturgeon are known to spawn in deeper portions of a stream channel (Moyle 2002), where eggs and larvae would have likely remained inundated. The tail-end of the spawning season may have been adversely affected after a rapid flow decrease in late May. Emergency flow operations ended on May 31 and normal flow operations were reinstituted on June 1. It was noted during egg and larval sampling during June that sediments were not swept out of the area as rapidly as anticipated and there was a larger concentration of particulates in samples. However, the eggs appeared in good condition, were well developed, and did not have any fungal growth on them; although this is based on a very small sample size (two eggs), obtained on a single day. Larval sturgeon collected in June were small (22-27 mm) and may have been impacted if particulates, after a rapid flow decrease, accumulated in the interstitial spaces used for cover or in the open spaces in which they feed. Therefore, flow reductions may have adversely affected a very small proportion of sDPS green sturgeon eggs and/or larvae through impaired respiration and possible injury due to increased sediment that may have settled in spawning areas. However, the preferred habitat type for incubating eggs and larvae (deeper, benthic habitat) may have reduced the likelihood of exposure. Further, the collection of both eggs and larvae in good condition indicates that both spawning and egg incubation were successful for a number of individuals present during the emergency response.

2.5.2.3. Juvenile Rearing

Stranding that occurred after the Oroville Spillway Incident was extensively surveyed, documented, and evaluated by the CDWR Division of Environmental Services, Pacific States Marine Fisheries Commission, and CDFW (White *et al*. 2017). Estimated total stranding is described for each target species below, and summarized in Table 4. The range of values reported for each target species originates from identifying the lowest and highest estimates reported of stranded individuals across the total sampled area (Tables 6 and 16 of White *et al.* 2017). All evaluated stranding was classified as having occurred in “wet pools” (ponds that retained water for the duration of the sampling) or in “dry pools” (depressions that desiccated soon after the high flow event occurred and were dry at the time of physical sampling). All extrapolated numbers of stranded fish are estimated from taxa-specific sampling densities in wet pools only, as the total area (m^2) of dry pools in the affected area was not possible to calculate.

The overall conclusion of the stranding report was that while the spatial and temporal extent of stranding was considerable, overall mortality from stranding was probably very low for species of concern. Stranding surveys were conducted at 187 stranding ponds located between RM 14 and RM 66 along the Feather River (Figure 1) during reduced flow levels between February 27 and March 15, 2017. Of the total 187 stranding pools that were sampled, 117 (62.6%) contained salmonids. Juvenile fall-run Chinook salmon were the most abundant salmonid encountered during sampling. All other target salmonid taxa each comprised less than 0.5 percent of the total stranding catch (White *et al.* 2017). Most of the sampled stranding pools (169 or 90.4%) were actual ponds that retained water throughout sampling (*i.e.*, wet pools). However, 18 (9.6%) were located upon substrate that percolated quickly and had no water remaining in them when sampling occurred (*i.e*., dry pools). Stranding survey results suggest that mortalities of Chinook salmon and steelhead were low (2.2-5.6%, respectively) in stranding pools that retained water (*i.e*., wet pools), but 100 percent when the substrate drained quickly (*i.e*., dry pools)

Most of the juvenile salmonids that remained isolated in pools are expected to have been reconnected to the mainstem Feather River when flow levels were increased on multiple occasions throughout the spring. Recent passage data suggests that most CV spring-run Chinook salmon had already emigrated downstream of the Feather River prior to the first major flow reduction on February 27. The high flows (>100,000 cfs) experienced in mid-February likely pushed a majority of the juvenile salmonids downstream to rearing areas in the Sutter and Yolo Bypasses and the Delta. The expanded floodplains within the Feather River basin would also have been expected to provide beneficial rearing habitat for any remaining individuals, based upon previous research that documented enhanced growth in floodplains relative to non-floodplains. Additional surveys were conducted during three subsequent flow reductions that occurred in April and May (Figure 2) and very few Chinook salmon, and even fewer steelhead, were observed.

The extent or impact of stranding in unobserved, rapidly desiccated pools is unknown. It was also not possible to effectively document potential stranding in the lowermost reaches of the Feather River (RM 14 to RM 0), due to significant connectivity of very large ponds during much of the stranding survey. However, eDNA sampling was conducted to identify green sturgeon and salmonids stranded in larger ponds (White *et al.* 2017). Stranding overall was higher in the HFC than in the LFC, although individual species' stranding distributions differed.

2.5.2.3.1. Central Valley spring-run Chinook salmon

The Oroville Spillway Incident occurred during a period of time when most juvenile spring-run Chinook salmon are expected to be downstream of the Action Area (CVPIA Comprehensive Assessment and Monitoring Program data 2000-2015). Prior monitoring indicates that spring-run sized salmon were generally caught soon after the RSTs were deployed in November, with highest catches usually occurring in December, indicating that emigration begins immediately after emergence (White *et al.* 2017). The cumulative capture of spring run in screw traps also slowed significantly by March, indicating that most had emigrated from the lower Feather River, and few remained upstream of RSTs to rear and overwinter (White *et al*. 2017). Thus, the late timing of the emergency down-ramping, relative to typical spring-run emergence and emigration, likely contributed to the low observed stranding incidence for spring-run sized Chinook salmon, relative to fall-run sized Chinook salmon. The stranding that did occur for spring-run Chinook salmon was largely concentrated in the HFC, indicating that most fish had either emigrated downstream prior to the event, or were transported downstream by high flows. Juvenile spring-run Chinook salmon were the second-most abundant run sampled during the event, accounting for 1.6 percent of the total Chinook salmon salvaged (see Table 4), indicating that a considerable number of juveniles were potentially stranded as a result of rapid flow fluctuations. Spring-run Chinook salmon are typically nearly 70 mm by late February, making them less vulnerable to stranding during this time of year than fall-run Chinook salmon, on average. Most of the spring-run Chinook salmon encountered during surveys were recovered alive (96%) from wet pools. Although the great majority of spring-run Chinook salmon were found alive in wet pools and were likely reconnected to the river when flows increased, some of the stranded juveniles were found in dry pools and some likely perished from predation or desiccation in quickly drying wet pools. Therefore, a small proportion of the emigrating juvenile spring-run Chinook salmon in the Feather River were stranded and likely injured or killed from exposure to the rapid flow fluctuations in response to the Oroville Dam Spillway Incident.

2.5.2.3.2. California Central Valley steelhead

The timing of the first significant flow reduction occurred in late February, a time when steelhead yearlings were likely to be emigrating from the Lower Feather River. The majority of the 39 yearlings identified during stranding surveys were found in the HFC, many of them hatchery-origin. A single fry-size CCV steelhead was also sampled in the HFC during stranding surveys (see Table 4). These results indicate that a significant number of juvenile and yearling CCV steelhead were stranded from exposure to flow reductions in response to the Oroville Dam Spillway Incident. Although rapid re-connectivity of isolated pools and rescue activities conducted by CDWR helped to reduce the overall mortality, a small proportion of the emigrating juvenile CCV steelhead were likely injured or killed from stranding due to exposure to rapid flow fluctuations during the emergency response.

2.5.2.3.3. Southern DPS Green Sturgeon

Traditional methods conducted during the stranding surveys found no juvenile green sturgeon and eDNA sampling in larger ponds was also negative for green sturgeon. Spawning of adult green sturgeon did not likely begin until April or May and therefore any juveniles produced in 2017 would not have experienced the extreme rapid flow reductions experienced by salmonids earlier in the year. By the time juveniles were rearing in the system, flow conditions in the LFC were relatively high and should have been ideal for rearing. Flows reductions in early and mid-May did have the potential to adversely affect juvenile green sturgeon. However, green sturgeon typically inhabit deeper water, and the smaller scale of the flow reduction that occurred in May likely contributed to their absence in stranding surveys. Subsequent flow reductions in June were not rapid and should have therefore been protective of juvenile green sturgeon. Given their preference for deeper water habitats and the timing of their presence in the Feather River (only present during less intense flow fluctuations later in the year), green sturgeon juveniles were unlikely to be affected by flow reductions associated with the Oroville Dam Spillway Incident response.

2.5.3. Effects of the Emergency Actions Undertaken at the Feather River Hatchery

2.5.3.1. Central Valley spring-run Chinook salmon

At the time of the Oroville Dam Spillway Incident, approximately 2 million CV spring-run Chinook salmon juveniles were present and rearing at the FRH. In anticipation of adverse effects due to the high turbidity levels following the Oroville Dam Spillway Incident, the spring-run Chinook salmon juveniles were moved to the Thermalito Annex Facility, where water is sourced from a well and was not affected by the increased sediment in the Feather River. After fish were moved to the Thermalito Annex Facility, they appeared to feed well and remained in good condition. Due to increased rearing densities and crowding, juvenile growth was somewhat slowed; however, they still appeared larger than the in-river cohorts (CDWR unpublished 2017). CV spring-run Chinook salmon were marked and tagged (100% adipose fin clipped and coded wire tagged) following normal hatchery procedures, prior to their release in the Feather River. In 2017, approximately 1.7 million spring-run Chinook salmon were released into the Feather River, representing 85 percent of the annual production goal.

Although the overall numbers of juvenile spring-run Chinook salmon released in 2017 was short of the 2 million production goal, the success observed from 2018 and 2019 adult returns are expected to make up for the slight reduction in total production during 2017. Although growth of juvenile spring-run Chinook salmon may have slowed due to increased rearing densities and crowded conditions at the Thermalito Annex, overall effects were minor as indicated by the somewhat normal production levels that were achieved. In the end, the ultimate objective of the FRH spring-run Chinook salmon hatchery program is to produce enough fish so that an adequate number of adults return to maintain a healthy program. The number of juveniles released is one tool to obtain the desired results, but if the survival of the juveniles produced is better than typically observed and the ultimate objective of returning adults to the hatchery and river is achieved (to maintain the program), the exact number of juveniles released is likely not as critical as other factors (*e.g*. in-river and ocean survival) that heavily influence the number of returning adults. Therefore, due to the swift conservation measures enacted to minimize impacts at the FRH, the Oroville Dam Spillway Incident Emergency Response overall had minor adverse effects on CV spring-run Chinook salmon from the FRH.

2.5.3.2. California Central Valley steelhead

As incoming water to the FRH approached turbidity levels near 650 NTU, it was determined that the existing filtration capabilities were not adequate to protect the 750,000 CCV steelhead eggs that were incubating in egg stacks. The eggs could not be moved from the FRH due to space constraints at the Thermalito Annex Facility and fragility of the eggs. An alternate water supply was put into place to reduce turbidity related impacts to the incubating eggs. FRH staff utilized "domestic" water from a fire hydrant to serve as the water source for the incubating eggs. Due to concerns over the presence of chlorine in "domestic" water, a high-capacity charcoal filter system was installed with pumps and pipes to route and filter water before being pumped into the CCV steelhead egg incubation stacks. Even during the evacuation period, FRH staff remained on-station and continued to mitigate for silt in the egg incubation stacks. Eggs and fry remained in good condition throughout the incubation and rearing season (CDWR unpublished 2017). When space was available at the Thermalito Annex, CCV steelhead juveniles were transferred from the FRH to the Annex to allow for intensive cleaning of raceways and other holding tanks and ponds. Upon completion of the FRH repairs in August, CCV steelhead were moved back to the FRH for continued rearing, prior to their release.

Although CCV steelhead eggs and juveniles at the FRH were moved and handled more than normal, and a clean and stable water supply was challenging to achieve, no significant mortality occurred. Due to concerns over potential water quality impacts during the Oroville Dam Spillway Incident, the FRH produced and raised additional CCV steelhead eggs and juveniles. As a result of the highly effective nature of the conservation measures that were implemented, CCV steelhead production numbers at the FRH were significantly increased. During 2017, approximately 663,000 CCV steelhead juveniles were produced for release in winter of 2018, approximately 213,000 above the normal mitigation goal (CDWR unpublished 2017). 182,000 were released into the Thermalito Afterbay to promote a local fishery. In mid-February of 2018, the remaining 481,000 yearling CCV steelhead, approximately 50,000 more than normal production levels, were released into the Feather River at Boyd's Pump Boat Launch. The additional production of CCV steelhead from FRH may have helped to mitigate for any impacts to naturally spawning steelhead in the Feather River that may have been adversely affected as a result of the Oroville Dam Spillway Incident. Therefore, the management actions taken to ensure survival of eggs and juveniles at the FRH likely helped to minimize any adverse effects to CCV steelhead produced at the FRH resulting from the Oroville Spillway Incident, and CCV steelhead at the FRH overall had minor adverse effects as a result of the Oroville Dam Spillway Incident Emergency Response.

2.5.4. Effects of the Recovery Actions

During the ensuing recovery phase (which lasted from approximately November 2017 to the end of 2019), CDWR has managed Lake Oroville storage levels to avoid use of both the Emergency Spillway and Flood Control Outlet Spillway to facilitate the ongoing reconstruction efforts. Work activities in the Flood Control Outlet and Emergency Spillway areas included blasting, excavation, rock crushing, pressure washing, grading, and vegetation clearing. These activities have the potential to contribute high levels of sediment to surface waters without proper management and protection measures. However, CDWR has implemented best management practices (BMPs), such as straw wattle installation, hydroseeding, creation of settling ponds, and creation of erosion barriers to prevent any adverse effects resulting from increased turbidity. CDWR also worked to install and utilized multiple concrete batch plants. The operation of the batch plants, along with the heavy use of concrete and grout during construction could have resulted in short-term adverse effects to water quality if not properly contained. However, CDWR directed wastewater associated with construction activities into settling ponds located at the base of the Flood Control Outlet Spillway. After the recovery phase construction activities concluded, multiple construction-use locations remained where sediment may have been introduced into surface waters. CDWR has adhered to an operational protocol for the ponds, which includes monitoring and managing water levels and regularly removing water from the pools for dust control activities during the recovery-phase construction activities.

In order to minimize the potential for erosion and turbidity-related impacts, FERC recommended that CDWR develop a post-construction Water Quality Protection Plan. The plan includes measures to prevent erosion at any area impacted by construction efforts. At a minimum, the plan is intended to outline measures for long-term disposition of the spoil piles, disrupted soil surfaces, and any other sediment sources. Monitoring conducted by CDWR indicates that these measures have been effective in reducing construction-related impacts and turbidity levels have remained low during the early recovery phase from May to August 2017 (Figure 3). Consequently, due to the location of the construction activities (near the Flood Control Outlet and Emergency spillways where ESA-listed species are not present), adherence to erosion control BMPs, and the development of a post-construction Water Quality Protection Plan, adverse effects to ESA-listed species and designated critical habitat downstream of the Fish Barrier Dam are not expected to have occurred during the recovery phase spillway construction activities.

In addition to the recovery activities that have already occurred described above, FERC has proposed the following prospective recovery activities. CDWR has requested to replace portions of a buried 13.8-kV Hyatt-Thermalito Transmission Line and fiber optic communications line. CDWR is also proposing to implement elements of a Phase 1 Site Rehabilitation Specification and Plan, which includes site maintenance, site stabilization, and limited revegetation efforts on areas impacted by the spillway failure. Like the other recovery phase construction activities, this disturbance could displace soils and make them more vulnerable to wind and water erosion. The proximity of these prospective recovery activities to the Thermalito Diversion Pool also creates the potential for runoff, possibly adversely affecting water quality during and following construction.

However, given the locations of the proposed prospective recovery actions (upstream of the Fish Barrier Dam) and the erosion control BMPs that will be implemented by CDWR, adverse effects to ESA-listed species and their designated critical habitat are not expected to occur. Furthermore, project operations and river conditions are expected to remain within the normal range of operating conditions during this period.

2.5.5. Effects of the Proposed Action on Critical Habitat

There is no indication that rapid flow changes or increased sediment resulted in long-term adverse effects to the PBFs of critical habitat for listed species. Rather, the majority of the potential impacts to critical habitat were associated with increased levels of sand-sized sediment transported downstream from the Thermalito Diversion Pool. The severity of the sediment-related impacts was minimized with high flows immediately following the Spillway Incident and subsequent high flows that continued to mix sand-sized sediment with native gravels in the Lower Feather River. This mixing of material appeared to minimize impacts to prime holding and spawning areas in the Lower Feather River. Although small amounts of this sediment likely settled in the lower velocity areas and low-gradient reaches of the Feather River, the majority of the sediment-based impacts to critical habitat PBFs occurred immediately following the spillway failure and were partially mitigated by the mixing of sediment with native gravels that is expected during high flow events. Furthermore, these impacts were likely to be limited in their temporal and spatial extent.

As previously discussed, the recovery actions related to the spillway repairs and rehabilitation were implemented upstream of the Fish Barrier Dam, near the Thermalito Diversion Dam. Furthermore, the prospective recovery actions (relocation of the buried transmission line and communications line), including any remaining terrestrial rehabilitation work (site maintenance, site stabilization, and limited revegetation efforts on areas impacted by the spillway failure) will also occur upstream of the Fish Barrier Dam. This area is not currently designated as critical habitat for ESA-listed species in the Feather River, as it is upstream of the current limit of anadromy. Given the location of the recovery actions and the erosion control BMPs implemented by CDWR, adverse effects to the PBFs of designated critical habitat for ESA-listed species in the Feather River are not expected to have occurred. Furthermore, adverse effects are not anticipated to occur during the proposed prospective recovery activities. The erosion control measures that will be implemented and the post-construction Water Quality Protection Plan developed by CDWR are expected to ensure that potential impacts as a result of the prospective recovery activities do not extend downstream into designated critical habitat. Furthermore, the site maintenance, site stabilization, and revegetation efforts resulting from the Phase 1 Site Rehabilitation Specification and Plan have the potential to improve riparian vegetation in areas impacted by the spillway failure.

Effects to the PBFs of critical habitat as a result of the Oroville Dam Spillway Incident Emergency Response are described below:

Thermal Refugia: No changes in water temperature or holding habitat beyond those that normally occur were observed during or after the emergency response. CDWR continued (and continues) to operate to the 1983 Agreement and NMFS 2004 biological opinion temperature requirements.

Spawning and Rearing Habitat: No long-term changes in spawning or rearing habitat have been observed since the Oroville Dam Spillway Incident Emergency Response. However, elevated flows following the Incident reached levels (112,000 cfs) that likely contributed to scouring that was already occurring as a result of high wintertime flows. The elevated flows mobilized a significant proportion of the available spawning gravel within the LFC, although modeling conducted by cbec eco engineering (2020) suggests similar conditions would have been likely for a no-incident scenario. Nonetheless, this scouring likely resulted in short-term reductions in available spawning habitat in the Feather River. However, gravel that was placed in the LFC during 2014 to augment salmonid spawning habitat helped to minimize any adverse effects associated with scouring. Although a significant amount of the gravel placed during 2014 was mobilized during high flows, much of that material was deposited elsewhere in the Lower Feather River; therefore, it is still available for use as spawning habitat. Further, additional gravel was added in 2017 following the Incident to supplement CCV steelhead and CV spring-run Chinook salmon spawning habitat.

There were also no signs of fine sedimentation within spawning gravels in the upper river reach, as documented during escapement and redd surveys performed in the Feather River (CDWR 2019). Particle size distributions observed in salmonid redds created in 2017 and 2018 reflect what has been routinely observed for the Feather River. The lack of fine sediment observed in spawning areas was likely due to the mixing of sand-sized material with native gravel, and the long-duration high flows experienced throughout the spring of 2017. By the time flows began to drop significantly, turbidity levels were also close to normal, making any changes to spawning and rearing habitat unobservable. Even so, the above discussion documents short-term adverse effects to spring-run Chinook salmon juvenile rearing habitat from increased suspended sediment. Similarly, increased sediment likely had a short-term adverse effect on rearing habitat for CCV steelhead.

The following data indicate the effect of these impacts to critical habitat PBFs was likely limited and/or mitigated by other factors:

- Spawning distributions of Chinook salmon were also consistent with previous years, indicating limited changes in behavior and spawning habitat.

- Pre-spawn mortality of adult female Chinook salmon was the lowest ever recorded in 2017 and near record lows in 2018, especially given the number of spawning adults. This further demonstrates that any potential changes to spawning habitat were minimal.

- Juvenile spring-run Chinook salmon released from the FRH directly into the Lower Feather River in 2017 performed well and likely took advantage of extended rearing in flooded off-channel and floodplain habitats. The result of sustained high flows throughout the spring of 2017 was highly beneficial for creating long-term, high-quality rearing habitat.

Changes noted in sturgeon spawning or rearing habitat mimicked those expected after a high flow event. High flows throughout spring continued to mobilize any remaining fine suspended sediment out of the spawning and rearing areas as there were no signs of unusual fine sedimentation in spawning or rearing gravels, or collected by sampling gear. Nonetheless, sDPS green sturgeon critical habitat was likely adversely affected in low-velocity locations and lower reaches of the river (*i.e.*, migratory corridors), where fine sediment likely accumulated following the spillway failure. These low-velocity reaches are not considered to be spawning or rearing habitat and are more likely to be used for foraging during juvenile migration. Green sturgeon are particularly well-suited for feeding in sandy substrate (using proboscis/barbels), indicating that effects resulting from increases in suspended sediment were likely very minor in these areas. Although there may have been short-term changes in prey composition and/or availability, it is expected that by the time juvenile sDPS green sturgeon were present in these areas, prey levels would have reestablished and stabilized.

As previously mentioned, the largest number of adult sturgeon residing in a spawning area within the Feather River was estimated during 2017, as compared to prior years. In addition, 2017 is the only year that both sturgeon eggs and larvae have been collected in the same season, indicating that the effects from the increased sediment load were likely minor in nature and short in duration.

Connectivity of Habitat: During periods of rapid flow reduction, juvenile CV spring-run Chinook salmon, and adult and juvenile CCV steelhead became isolated from the mainstem Feather River. During this time, rapidly vanishing pools resulted in considerable fish mortality. The rapid reduction in flows to the minimums required for the protection of fisheries resources (600 cfs in the LFC and 1,700 cfs in the HFC) resulted in disconnected habitat (as demonstrated by juvenile stranding and mortality) and temporarily reduced the amount of available habitat in the Feather River.

Although rapid flow reductions killed individuals, some permanent access to floodplain habitat remained in 2017, due to longer sustained high flows. Higher than normal late-winter and spring flows also enhanced the ability of adult green sturgeon and CV spring-run Chinook salmon to pass the Sunset Pumps rock weir to quickly access prime holding and spawning habitat.

Nutrient exchange between floodplain and main-channel habitat was also extended during 2017, due to sustained high flows. This extended connectivity would have positive benefits for floodplain habitats by allowing fine suspended sediment to deposit into off-channel and floodplain areas and allow exchange of nutrients from floodplains to the river.

Gravel Recruitment: There is no information to suggest that gravel recruitment was adversely affected by emergency response actions. Bedload movement analysis shows that gravel recruitment and movement would have occurred under a no-incident scenario, probably very similar to amounts observed during the incident. Observations of salmonid spawning habitat by CDWR after flow reductions revealed typical movement of spawning gravel in the Lower Feather River after a significant high-flow event, with some areas gaining and some losing gravel, typical of an alluvial system.

CDWR took measures to excavate gravel from Moe's Side Channel resulting from the movement of gravel that was placed during the 2014 B105 Gravel Supplementation Project. Despite being high-quality spawning gravel, the movement of the material during high flows closed off access to Moe's Side Channel. Removal of this material reconnected the side-channel to the river and allowed normal function in 2017 and 2018. In doing so, the number of Chinook salmon and steelhead redds increased significantly. Chinook salmon redds increased by 652 percent from 2016 and steelhead redds also increased over the long-term average from 13 to 75 (a 469% increase). Four of the past 11 years of steelhead redd sampling were incomplete due to poor visibility; however, it appears that steelhead aggressively targeted Moe's Side Channel for spawning in 2018, making that area the most utilized site for steelhead redds in the Feather River in 2018, which also marks the most successful year of steelhead spawning recorded.

Large Woody Debris: No adverse effects to large wood have been identified as a result of response actions.

Loss of Riparian Vegetation and Shade: As previously stated, some streambank erosion is expected during normal high flows; however, there is no indication that widespread riparian vegetation was adversely affected from the emergency response actions taken. Increased flows throughout spring along with elevated turbidity likely deposited high quality sediment onto floodplains and off-channel areas, increasing potential recruitment of riparian vegetation when flows receded, potentially benefiting some areas of critical habitat in the long-term.

Nutrient Inputs: There is no indication that nutrient inputs were adversely affected from emergency response actions taken. It is likely that longer duration and higher winter and spring flows actually increased access to nutrients from floodplain habitats within the Lower Feather River corridor and beyond. As stated above, this connectivity provided the extended opportunity for suspended sediment to be deposited in off-channel and floodplain habitat. Extended high flows also allowed nutrients from the floodplain to be accessed and brought back to the main river channel, creating abundant food resources for listed and special status species rearing in the main river channel.

Food Resources: Recent research demonstrates that significantly increased suspended solids often has little or no effect on benthic macroinvertebrates during short periods. The two suspended sediment peaks observed relatively soon after the Oroville Dam Spillway Incident were less than some of those observed in the literature. Furthermore, given that flows to the river had already been increased steadily between January 10 and February 6 (to over 39,000 cfs on February 6), gravel substrate used by macroinvertebrates and periphyton was already being mobilized in the LFC, causing normal high flow disturbance to these communities of invertebrates. These disturbances are normal in functioning rivers, and populations of invertebrates are expected to rebound quickly. Conversely, high sediment loads may have contributed to a shift in prey selection, and likely decreased capture efficiency during elevated levels. Based on the data available, suspended sediment likely had a short-term effect on invertebrate food resources of listed species.

2.6. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 402.17(a)). 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.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the Action Area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

Non-Federal actions that that are reasonably certain to occur in the action area include: (1) angling subject to State regulations; (2) continued agricultural practices; (3) water withdrawals, diversions, and transfers; (4) mining activities; (5) population growth and urbanization; (6) exposure to contaminants; and (7) non-Federal bank stabilization projects.

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 zero (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. 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) 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 (NMFS 2015b). Southern DPS green sturgeon are also caught as bycatch as a result of the white sturgeon and Chinook salmon fisheries in Lower Feather River. Heppell (2007) showed that even low levels of adult and subadult sturgeon fishing mortality rates can have large effects on the population.

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 significant cumulative effects 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.

2.7. Integration and Synthesis

The 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 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), 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) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.7.1. Central Valley spring-run Chinook salmon

2.7.1.1. 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 the Northern Sierra Nevada diversity group. The three extant populations passed through prolonged periods of low abundance before increasing in abundance moderately (Mill and 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 (NMFS 2016a).

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 Project 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 area of habitat for the survival and recovery of the species.

2.7.1.2. Summary of the Effects of the Proposed Action on Feather River spring-run Chinook salmon

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.

Given the low probability of adult spring-run Chinook salmon migrating during the peak of the incident when turbidity was elevated, any adverse effects are expected to be minimal. The timing of increased flows in the Feather River through the adult spring-run Chinook salmon migration period likely reduced migration impediments, like the boulder weir at Sunset Pumps. Additionally, when a flow differential exists (higher Yuba River flows in spring) between the Feather and Yuba rivers, it is thought by some to play a role in potential straying of FRH origin Chinook salmon into the Yuba River. With sustained high flows being released from the Feather River throughout the spring, this flow differential would not have been "in effect" in 2017, creating ideal conditions for Feather River spring-run Chinook salmon to find and ascend the Lower Feather River, making it to the hatchery or LFC holding and spawning areas very quickly. Based on the timing of the four flow reductions in response to the Oroville Dam Spillway Incident response, rapid flow fluctuations were unlikely to have adversely affected adult spring-run Chinook salmon migration in the Feather River.

Turbidity peaks had significantly receded by the time adult spring-run Chinook salmon would have been holding. Over-summer holding of CV spring-run Chinook salmon occurs between May and September when turbidity levels had dropped significantly. Therefore, suspended sediment had little-to-no effect on CV spring-run Chinook salmon holding. Adult CV spring-run Chinook salmon holding in the Feather River would have experienced good conditions due to increased spring flows. The final two major flow reductions may have forced CV spring-run Chinook to seek out alternate holding areas; however, holding adult spring-run Chinook salmon were not exposed to flows below the minimums required for the protection of fisheries resources. Therefore, despite being present during the flow reductions in response to the Oroville Dam Spillway Incident, holding adult spring-run Chinook salmon were unlikely to have been adversely affected.

CV spring-run Chinook salmon spawning occurs in September and early October, well after turbidity levels had subsided substantially. Data presented demonstrates highly successful Chinook salmon spawning, very low pre-spawn mortality, and normal spawning distribution following the incident. Flows were held higher in the LFC than the minimum required in both 2017 and 2018 to promote optimal spawning. Moreover, given that the rapid flow fluctuations occurred long before adult spring-run Chinook salmon began spawning in mid-September, there is no data to suggest that adult spring-run Chinook salmon spawning was exposed to the flow reductions that occurred in response to the emergency.

No spring-run Chinook salmon eggs or larvae were present in the gravel during flow reductions as determined by the time of year, indicating that flow ramping had no effect on these life stages. Given the documented success of spawning and the continued use of similar spawning habitat in 2017 and 2018 compared to previous years, there is no data to suggest any adverse effect to spring-run Chinook salmon eggs or larvae. High turbidity experienced immediately after the Oroville Dam Spillway Incident response had subsided when spawning began. Additionally, new gravel was placed in much of the primary spawning areas utilized by adult spring-run Chinook salmon, improving overall habitat availability. High flows experienced throughout winter and spring likely mobilized any fine suspended sediment away from spawning areas toward floodplain or off-channel areas, allowing spawning habitat to remain in good condition. Particle size data for salmon redds confirms there were no adverse changes to spawning gravel composition. Moe's Side Channel was also rehabilitated, providing even better spawning and incubating habitat than existed prior to the Oroville Dam Spillway Incident. Taking into account the timing of their presence in the Feather River and the improvements to spawning habitat described above, CV spring-run Chinook salmon eggs and larvae were unlikely to have been adversely affected from the actions taken in response to the Oroville Dam Spillway Incident.

Elevated turbidity in the Feather River may have resulted in positive effects for Chinook salmon by providing increased cover during juvenile emigration. Data on returns of 2-year-old spring-run Chinook salmon smolts coded-wire-tagged and released into the Lower Feather River during 2017, and subsequently captured at various locations as 2-year-olds in 2018, indicate that rearing conditions and, therefore, survival in the Lower Feather River was likely good following the emergency response.

Although overall conditions were quite good, the small proportion of juvenile or yearling CV spring-run Chinook salmon that remained in the Lower Feather River to rear during the elevated turbidity period may have experienced short-term reduced growth, impaired respiratory function, reduced tolerance to disease, and physiological stress. Based on available data, suspended sediment introduced into the Lower Feather River as a result of the Oroville Dam Spillway Incident response may have resulted in injury or death for a small proportion of the naturally produced CV spring-run Chinook salmon juveniles rearing during the peak of the turbidity events.

A large proportion of juvenile CV spring-run Chinook salmon had likely already migrated out of the Action Area, but some juvenile and yearling spring-run Chinook salmon were actively rearing during the four rapid flow reduction events, resulting in the stranding of juveniles in off-channel pools. Most of the wet pools were reconnected to the main channel with subsequent high flows, and provided opportunities for stranded fish to return to the river. Thus, some of the juveniles utilizing floodplain and off-channel ponds may have actually obtained a growth benefit from access to these habitats. However, the observed and expected mortality documented (see Table 4) indicates that stranding due to rapid flow reductions resulted in injury and/or death for a small proportion of the juvenile CV spring-run Chinook salmon emigrating downstream in the Feather River.

During the Oroville Dam Spillway Incident, appropriate measures were taken to maintain water quality at both the FRH and the Thermalito Annex. Although growth of juvenile spring-run Chinook salmon may have slowed due to increased rearing densities and crowded conditions at the Thermalito Annex, overall effects were minor as indicated by the somewhat normal production levels that were achieved. Even during "normal" production years at the FRH, the mitigation goal of 2 million spring-run Chinook salmon is not always reached. The documented success of juveniles released in 2017 are expected to help meet the ultimate objective of having enough adults return in 2019 to maintain the hatchery program. Furthermore, since the FRH spring-run Chinook salmon program now takes a "conservation" approach to spawning, rearing, and releasing fish, in order to minimize impacts to other stocks, fewer hatchery produced fish is typically more desirable, as long as the hatchery program remains viable. Given that the annual production was only short of the target by a few hundred thousand juveniles during 2017, the Oroville Dam Spillway Incident Response overall had minor adverse effects on CV spring-run Chinook salmon from the FRH.

Based on the information presented, we conclude that the emergency response actions taken likely adversely affected CV spring-run Chinook salmon in the Feather River through exposure to increased sediment and rapid flow fluctuations. However, improvements to spawning habitat below the Fish Barrier Dam (through gravel augmentation, *etc*.) and sustained high flows during the migration periods helped to minimize many of the adverse effects resulting from response to the Oroville Dam Spillway Incident.

2.7.1.3. 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 populations' proximity to Mt. Lassen and the probability of a large-scale wildfire 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.

The effects of the Oroville Dam Spillway Incident response were likely confined to the Feather River, and therefore likely had no effect on CV spring-run Chinook salmon populations outside of the watershed. Emergency response and recovery actions likely resulted in short-term, localized impacts associated with increased sediment and rapid flow fluctuations. However, these effects were limited to a very small fraction of the CV spring-run Chinook salmon ESU. Successful adult spring-run Chinook salmon spawning in the Feather River coupled with successful juvenile production and outmigration following the Oroville Dam Spillway Incident response indicates that the viability of the CV spring-run Chinook salmon ESU was not adversely affected.

Therefore based on our analysis of available evidence, NMFS concludes that the emergency actions taken in response to the Oroville Dam Spillway Incident would not be expected to appreciably reduce the likelihood of both the survival and recovery of the CV spring-run Chinook salmon ESU.

2.7.1.4. Summary of Effects of the Proposed Action on 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.

2.7.1.5. 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 that 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. However, higher than normal late-winter and spring flows resulting from the Oroville Dam Spillway Incident response likely enhanced the ability of CV spring-run Chinook salmon to pass the Sunset Pumps rock weir to quickly access prime holding and spawning habitat.

2.7.1.6. Spawning Habitat

Spawning habitat quantity and quality has likely improved following the Oroville Dam Spillway Incident response. Gravel placed in 2014 to augment salmonid spawning was mobilized during high flows, but much of that material was deposited elsewhere in the Lower Feather River and, therefore, is still available as spawning habitat. Additional gravel was added in 2017 to supplement CCV steelhead and CV spring-run spawning gravel following the high flows resulting from the Spillway Incident response. There were also no signs of fine sedimentation in spawning gravels in the surveyed portions of the upper river reach. As noted above, particle size distributions observed in salmonid redds created in 2017 and 2018 reflect what has been routinely observed for the Feather River. To the extent sand-sized materials were deposited in the LFC, it was mixed into existing substrates (causing no observable change in bed composition) or deposited in velocity shadows on gravel bars, and in overbank areas where smaller sized material would be expected to deposit as flows receded (cbec eco engineering 2020). In these locations, both sand and finer material (silts) are beneficial to riparian habitat development. The lack of fine sediment observed in spawning areas is likely due to the long duration high flows experienced throughout the spring of 2017 that likely mobilized any fine sediment that may have been deposited when flows were low or near minimums while dredging was still occurring, and turbidity was still slightly higher than normal.

2.7.1.7. Rearing Habitat and Juvenile Migratory Corridors

During periods of rapid flow reduction, spring-run Chinook salmon and CCV steelhead became isolated from the mainstem Feather River. During this time, rapidly vanishing pools resulted in fish mortality. Although rapid flow fluctuations adversely affected individuals and disconnected habitat for a short period of time, some longer-term access to floodplain habitat remained in 2017, due to longer sustained high flows.

Nutrient exchange between floodplain and main-channel habitat was extended during 2017 due to sustained high flows. This extended connectivity would have positive benefits for floodplain habitats by allowing fine suspended sediment to deposit into off-channel and floodplain areas and allow exchange of nutrients from floodplains to the river.

Juvenile CV spring-run Chinook salmon released from the FRH directly into the Lower Feather River in 2017 performed well and likely took advantage of extended rearing in flooded off-channel and floodplain habitats. The result of sustained high flows throughout the spring of 2017 was likely beneficial for creating long-term, high-quality rearing habitat.

2.7.1.8. Summary of Risk to the Value of 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. Although there were likely adverse impacts associated with increased sedimentation and rapid changes in flows, those impacts appeared to be low in magnitude and short in duration. Successful adult spawning and juvenile outmigration following the Incident supports this conclusion. Based on the analysis of available evidence, the Oroville Dam Spillway Incident response was unlikely to have appreciably diminished the value of critical habitat for the conservation of CV spring-run Chinook salmon.

2.7.2. California Central Valley steelhead

2.7.2.1. 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. Although not always possible, adult steelhead can sometimes be visually distinguished from resident rainbow trout by assessing characteristics such as length (*O. mykiss* that are greater than 18 inches are usually considered anadromous steelhead), body depth (steelhead tend to have long, slender bodies, while rainbow trout are shorter in length with rounder bodies), and coloration (silvery, deciduous scales are characteristics of anadromy, whereas darker coloration is more typical for resident fish).

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 inaccessible due to Shasta and Keswick Dams) south to the Kings River 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 independent 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 (adults 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 Good *et al.* [2005)]). However, due to the large resident rainbow trout *(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 Project 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.

2.7.2.2. Summary of the Effects of the Proposed Action on Feather River steelhead

The migration of adult CCV steelhead was likely complete or nearly complete when the Oroville Dam Spillway Incident response occurred, so any effect on migration would have been limited. Elevated flows during the winter of 2017 prior to the Spillway Incident likely precluded successful spawning and resulted in scouring of gravels in spawning areas. These conditions persisted following the Spillway Incident, when flows were elevated significantly (112,000 cfs). However, modeling conducted by cbec eco engineering (2020) suggests that these conditions would have been likely for a no-incident scenario due to the reservoir levels prior to the Spillway Incident. Suspended sediment levels were high during the assumed second half of CCV steelhead holding and spawning, and therefore may have reduced fertilization rates of CCV steelhead eggs during the end of the 2017 spawning season. However, steelhead evolved to spawn during winter storm events when turbidities could remain high for some time. Young-of-the-year steelhead were observed in the summer of 2017 and record numbers were observed during snorkel surveys in 2018 (CDWR 2019). Therefore, CCV steelhead holding and spawning were likely adversely affected by suspended sediment due to impaired respiration and increased physiological stress during peak turbidity levels. Spawning was also adversely affected as a result of increased flows, which likely precluded successful spawning and scoured much of the available spawning habitat. However, these effects were likely offset, in part, by gravel supplementation in the spawning areas, increasing the overall availability of spawning habitat in the Feather River.

The timing of the rapid flow fluctuations makes it unlikely that straying of adult CCV steelhead occurred, since nearly all CCV steelhead were already present on the spawning grounds when the incident began. Furthermore, the FRH had completed their 2017 CCV steelhead spawning at least a week prior to the Oroville Dam Spillway Incident response. Although the end of the spawning period overlapped with the first rapid flow reduction, most adult CCV steelhead should have already arrived on the spawning grounds; therefore, the resulting flow pulses were unlikely to have increased straying or altered adult migration patterns.

The timing of the first significant flow reduction coincided with the end of the CCV steelhead spawning window (late February). Fourteen adult CCV steelhead (both hatchery and natural origin) were found stranded during surveys. Adult CCV steelhead were concentrated in the LFC, and it is unknown if the adult CCV steelhead found in isolated pools were post-spawn kelts beginning to migrate downstream or if they were holding, waiting for conditions to improve before spawning. In any case, it is likely that CCV steelhead spawning may have been curtailed or interrupted, possibly reducing the reproductive success for those adults that were exposed to rapidly changing flows.

Although turbidity levels were very high for short periods, those periods typically corresponded with high flows that would likely transport suspended sediment downstream of CCV steelhead spawning habitat. Redd survey, snorkel, and beach seine data all confirm that steelhead spawning was very successful in 2018 (the first full year of spawning after the incident). More steelhead juveniles were recorded in snorkel surveys and beach seine monitoring than in any previous survey year.

Steelhead eggs may have suffered reduced fertilization rates during spawning from increased turbidity on two occasions. However, steelhead could have postponed spawning briefly and resumed after turbidity levels quickly dropped and conditions improved. Only eggs actively being fertilized during the two short, peak turbidity events are likely to have suffered from reduced fertilization, though it is assumed that fish would be unlikely to attempt spawning under such conditions. Sustained high flows that occurred during the majority of the spawning season mobilized spawning gravels in the LFC, resulting in unfavorable spawning conditions and a temporary reduction in suitable spawning habitat. However, snorkel and beach seine data from 2017 demonstrate that spawning was successful, and 2018 redd mapping, snorkel surveys, and beach seine data all show significant use of the available spawning habitat and very successful incubation and emergence of eggs and larvae (evidenced as juveniles). Therefore, a very small proportion of CCV steelhead eggs may have been injured or killed from exposure to increased sedimentation immediately following the spillway failure. However, the high reproductive success documented in 2018 indicates that the overall exposure was likely minimal and did not result in significant mortality.

When flows from the Oroville Dam spillway ceased and flows in the LFC returned to approximately 600 cfs, it is possible that redds constructed on the river margins were stranded and dewatered. However, the Hatchery Side Channel would have remained somewhat stable due to its relative protection from high flows (up against the levee). No surveys were performed to evaluate redd stranding and flows did eventually increase above pre-incident levels. However, flow fluctuations combined with the long period of minimum flows in the LFC (> 7 days) resulted in possible stranding of CCV steelhead redds that reduced embryo survival or caused total loss of some redds. CCV steelhead may have spawned in areas that later became dewatered and therefore a small proportion of the steelhead eggs and larvae present during the rapid flow fluctuations were likely to have been injured or killed from lack of oxygen during dewatering.

Juvenile or yearling CCV steelhead that remained in the Lower Feather River to rear during the elevated turbidity period may have experienced short-term reduced growth, impaired respiratory function, reduced tolerance to disease, and physiological stress. Based on available data, suspended sediment introduced into the Lower Feather River as a result of the Oroville Dam Spillway Incident response likely adversely affected CCV steelhead juveniles rearing during the peak of the turbidity events, through behavioral changes such as avoidance of prime rearing areas. Individuals that were unable to actively avoid areas with peak levels of suspended sediment may have been injured or killed as a result of impaired respiration and increased physiological stress.

The timing of the first significant flow reduction was in late February, a time when CCV steelhead yearlings were likely to be emigrating the Lower Feather River. The majority of the 39 yearlings encountered during stranding surveys were found in the HFC, many of them were of hatchery-origin (Table 4). A single fry-size CCV steelhead was observed in the HFC during stranding surveys. Given these detections, a large proportion of juvenile and yearling CCV steelhead were likely to have been adversely affected from stranding due to rapid flow reductions. Although rescue activities and rapid re-connectivity of isolated pools helped to reduce overall mortality, a small proportion of the stranded individuals were likely killed through increased susceptibility to predation, or the drying of the pools prior to increases in flows, which re-connected isolated pools with the main river channel.

Although CCV steelhead eggs and juveniles at the FRH were moved and handled more than normal, and a clean and stable water supply was challenging to achieve, no significant mortality occurred. Due to concerns over potential water quality impacts during the Oroville Dam Spillway Incident, the FRH produced and raised additional CCV steelhead eggs and juveniles. As a result of the highly effective nature of the conservation measures that were implemented, CCV steelhead production numbers at the FRH were significantly increased. An additional 213,000 CCV steelhead yearlings were produced, 182,000 of which were released into the Thermalito Afterbay for a put-and-take fishery. It is expected that an unknown number of these steelhead will leave the Thermalito Afterbay before being harvested and will enter the Feather River. It is possible that a proportion of these steelhead will contribute to the overall production of CCV steelhead in the Feather River by returning as adults to spawn at the FRH or in-river. An additional 31,000 yearling CCV steelhead were released into the Feather River in 2018 in order to augment normal production releases and mitigate for potential impacts to the naturally spawning steelhead that may have been adversely affected as a result of the Oroville Dam

Spillway Incident. The management actions taken to ensure survival of eggs and juveniles at the FRH likely helped to minimize any adverse effects to CCV steelhead produced at the FRH resulting from the Oroville Spillway Incident.

2.7.2.3. Summary of the Effects of the Proposed Action on the California Central Valley steelhead DPS

The effects of the Oroville Dam Spillway Incident response were likely confined to the Feather River, and therefore likely had no effect on CCV steelhead outside of the watershed. Emergency response actions likely resulted in short-term, localized impacts associated with increased sediment and rapid flow reductions and fluctuations. However, these effects were limited to a very small fraction of the CCV steelhead DPS.

As previously discussed, redd survey, snorkel, and beach seine data all confirm that steelhead spawning was very successful in 2018 (the first full year of spawning after the incident). More steelhead juveniles were recorded in snorkel surveys and beach seining than in any previous survey year. The high reproductive success of CCV steelhead in the Feather River following the Oroville Dam Spillway Incident response indicates that the viability of the DPS was not significantly impacted.

Based on our analysis of available evidence, NMFS concludes that the emergency response actions taken in response to the Oroville Dam Spillway Incident would not be expected to appreciably reduce the likelihood of both the survival and recovery of the CCV steelhead DPS.

2.7.3. Effects of the Proposed Action on 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. The discussion above regarding PBFs of critical habitat for CV spring-run Chinook salmon above also applies to CCV steelhead in the Feather River.

2.7.3.1. Summary of Risk to the Value of Critical Habitat for the Conservation of the Species

Many of the PBFs that are essential for the conservation of CCV steelhead are currently degraded. As a result of implementing the emergency response actions, some of those PBFs, such as spawning and rearing habitat, were likely improved overall as a result of the Oroville Dam Spillway Incident response, despite some of the short-term, minor impacts that likely occurred.

The majority of the impacts to critical habitat were associated with short-term increases in suspended sediment and scouring of spawning gravels in the Feather River immediately following the Oroville Dam Spillway failure. As discussed above, the severity of these impacts was minimized with simultaneous and subsequent high flows that transported sediment away from critical holding and spawning areas in the upper reach of the Lower Feather River. It is expected that a small amount of this sediment likely settled in the lower velocity areas and low gradient reaches of the Feather River. However, the majority of the sediment-based impacts to critical habitat were likely short in duration and occurred immediately following the spillway failure.

The rapid flow fluctuation events likely affected fish behavior, but had a minor effect on designated critical habitat. The elevated flows that occurred during the winter of 2017 prior to the Spillway Incident resulted in scouring of spawning gravels. These conditions persisted following the spillway failure and flows were increased significantly (up to 112,000 cfs). However, it is expected that these conditions would have been likely for a no-incident scenario, due to heavy precipitation and reservoir levels (cbec eco engineering 2020). As flows were rapidly reduced, the availability of habitat was also potentially reduced, as water receded from floodplain habitats back to the main river channel. These potential impacts to critical habitat PBFs were offset to a degree by the actions and habitat improvements implemented by CDWR, including gravel augmentation, sustained high flows throughout the spring that carried sediment away from critical spawning areas, and large increases in flows, which quickly re-connected many of the previously isolated pools.

Based on the analysis of available evidence, NMFS concludes that the Oroville Dam Spillway Incident emergency response actions did not appreciably diminish the value of the critical habitat for the conservation of CCV steelhead. This is primarily due to the extensive conservation measures implemented to increase spawning and rearing habitat quantity and quality, which likely contributed to the successful adult spawning and juvenile production documented following the Spillway Incident.

2.7.4. Southern DPS of Green Sturgeon

2.7.4.1. Summary of the Status and Viability of the Species

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. The risk of extinction is believed to be 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 (NMFS 2010).

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), 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 applies to any DPS or ESU represented by a single population, and if this were to be applied to sDPS green sturgeon directly, it could be said that sDPS green sturgeon face a high extinction risk. However, upon weighing all available information (and lack of information), NMFS has stated the extinction risk is moderate (NMFS 2010).

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).

There is a strong need for additional information about sDPS green sturgeon, especially with regards to a robust abundance estimate, a greater understanding of their biology, and further information about their micro- and macro-habitat ecology.

2.7.4.2. Summary of the Effects of the Proposed Action on Green Sturgeon in the Feather River

Acoustically tagged green sturgeon consistently migrated into the Feather River during the incident and throughout the response period, which suggests that suspended sediment and increased flows did not adversely affect adult green sturgeon migration, since they could have continued their migration up the Sacramento River instead of entering the Feather River. Based on several years of unpublished telemetry data, the peak of green sturgeon migration into the Feather River generally occurs after March 15, so it is likely that only a small fraction of the sturgeon population was present during the Oroville Dam Spillway Incident response. Green sturgeon are a highly mobile species that can travel thousands of miles to spawn (Moser *et al.* 2016) so it is possible that they would be able to migrate the short distance out of the Feather River, if conditions were not favorable. Annual DIDSON surveys in the Feather River determined that one of the largest abundance estimates of adult sturgeon occurred in 2017. Thus, although some adult sDPS green sturgeon may have exhibited some behavioral changes, such as avoidance of highly turbid areas, adult green sturgeon were unlikely to have been adversely affected by elevated turbidity from the Oroville Spillway Incident response during their migration, holding, or spawning.

Given the high flows experienced during the majority of 2017 (spring), even with the four rapid flow reduction events, it is likely that conditions were ideal in the Lower Feather River for green sturgeon to ascend due to significant attraction flows. The boulder weir at Sunset Pumps would have also been inundated for the majority of the migration season, making adult passage very easy. A large aggregation of adult sturgeon (believed to mostly be green sturgeon based on the two individuals captured) was observed near the Fish Barrier Dam, with spawning documented shortly thereafter. Therefore, flow reductions associated with the emergency response were unlikely to have had an adverse effect on green sturgeon migration, holding, or spawning.

Although measurements of turbidity and suspended sediment were high for short periods during and immediately following the Oroville Spillway Incident, sustained high flows greater than 40,000 cfs in spring of 2017 would have flushed fine sediment deposited during the incident response downstream of critical spawning areas, reducing the potential impacts to green sturgeon spawning habitat. Turbidity and suspended sediment levels had decreased significantly by April when green sturgeon spawning was likely underway. Since surveys began in 2003, eggs and larvae have only been collected in the same spawning season once, that being 2017 indicating that adult spawning and juvenile production were successful. Suspended sediment may have affected a very small proportion of the sDPS green sturgeon eggs or larvae present in the Feather River due to reduced respiration or increased susceptibility to predation. However, their preference for deeper water habitat coupled with higher flows that likely transported sediment downstream of critical spawning habitat, indicates that increased suspended sediment levels resulting from the emergency response efforts had minimal effects on sDPS green sturgeon in the Feather River.

The tail end of the spawning season may have been adversely affected after the rapid flow decrease in late May. However, eggs collected during surveys appeared in good condition and did not have any fungal growth on them; however, this is based on a very small sample size (two eggs), obtained on a single day. Larval sturgeon collected in June were small (22-27 mm) and may have been adversely affected if particulates, after a rapid flow decrease, accumulated in the interstitial spaces used for cover, or in the open spaces in which they feed. Furthermore, sDPS green sturgeon preference for deeper water habitat likely precluded any habitat losses or stranding resulting from the rapid flow reduction in May, as supported by the lack of larval sturgeon encountered during standing surveys and rescue activities. Therefore, sDPS green sturgeon eggs and larvae were likely to have been adversely affected by the emergency response. However, the effects were likely very minor and short in duration, as illustrated by the collection of both eggs and larvae in good condition following the Incident.

Juvenile sturgeon evolved in turbid settings, so periods of moderate increases in turbidity during the high spring flows should not have resulted in behavioral changes or hampered their ability to find food. By early June, turbidity levels had dropped significantly (*i.e.*, 4-10 NTU) and high spring flows would have swept away suspended sediments which might fill in interstitial spaces used for cover from predators. Therefore, there is no evidence to suggest that sDPS green sturgeon juveniles were adversely affected by suspended sediment increases caused by the response to the Oroville Dam Spillway Incident.

Traditional methods conducted during the stranding surveys found no juvenile green sturgeon and eDNA sampling in larger ponds was also negative for green sturgeon. Adult green sturgeon spawning likely did not begin until April or May, and therefore any juveniles produced in 2017 would not have experienced the extreme rapid flow fluctuations experienced by salmonids earlier in the year. By the time juveniles were rearing in the system, flow conditions in the LFC were relatively high and stable, and should have been ideal for rearing. Flows reductions in early June were not rapid, and should have therefore been protective of juvenile green sturgeon. Based on the available information, sDPS green sturgeon juveniles were unlikely to have been adversely affected from flow reductions associated with the Oroville Spillway Incident.

2.7.4.3. Summary of the Effects of the Proposed Action on the Green Sturgeon DPS

The effects of the Oroville Dam Spillway Incident response were likely confined to the Feather River, and therefore likely had no effect on sDPS green sturgeon outside of the watershed. Emergency response actions likely resulted in short-term, localized impacts associated with increased sediment and rapid flow ramping. However, these effects were likely limited to a very small fraction of the sDPS.

As previously discussed, the collection of both green sturgeon eggs and larvae during sampling efforts following the emergency response indicates that successful spawning occurred. Eggs collected during sampling appeared in good condition and did not have any fungal growth on them. Additionally, juvenile green sturgeon were not detected during stranding surveys. Given the expected timing of adult spawning, any juveniles produced in 2017 would not have experienced the extreme rapid flow reductions experienced by salmonids earlier in the year. Therefore, we conclude that the emergency actions taken in response to the Oroville Dam Spillway Incident would not be expected to appreciably reduce the likelihood of both the survival and recovery of sDPS green sturgeon.

2.7.5. 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.

2.7.5.1. Food Resources

Within freshwater riverine systems, this PBF includes abundant prey items for larval, juvenile, subadult, and adult life stages. Recent research demonstrates that significantly increased suspended solids often has little or no effect on benthic macroinvertebrates during short periods. The two suspended sediment peaks observed relatively soon after the Oroville Dam Spillway Incident were less than some of those observed in the literature (see Table 5 in BA). Furthermore, given that flows to the river had already been increased steadily between January 10 and February 6 (to over 39,000 cfs on February 6), gravel substrate used by macroinvertebrates and periphyton was already being mobilized in the LFC, causing normal high flow disturbance to these communities of invertebrates. These disturbances are normal in functioning rivers, and populations of invertebrates are expected to rebound quickly. Conversely, high sediment loads may have contributed to a shift in prey selection for predatory fish, and likely decreased capture efficiency during elevated levels. Based on the data available, increased suspended sediment likely had short-term, minor effects on invertebrate food resources consumed by sDPS green sturgeon in the Feather River.

2.7.5.2. 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), subadults, and adults (*e.g*., substrates for holding and spawning). Although 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.

Changes noted in sturgeon spawning or rearing habitat mimicked those expected after a high flow event. High flows throughout spring continued to mobilize any remaining fine suspended sediment out of the spawning and rearing areas, as there were no signs of unusual fine sedimentation in spawning or rearing gravels or collected by sampling gear. Rearing habitat may have been adversely affected if particulates, after a rapid flow decrease, accumulated in the interstitial spaces used for cover or in the open spaces in which they feed. However, turbidity was quite normal during spawning, egg incubation, and juvenile rearing, so a flow reduction in late-May should not have increased suspended sediment loads in spawning or critical rearing areas.

Nonetheless, the high sediment load observed immediately during the response period likely settled in the lower river reaches, and within designated critical habitat. Thus, there were likely short-term, minor impacts to critical habitat resulting from elevated suspended sediment levels. Conversely, the largest number of adult green sturgeon residing in a spawning area (below the Fish Barrier Dam) was estimated during 2017. In addition, 2017 is the only year that both sturgeon eggs and larvae have been collected in the same season, indicating that the functional effects from the increased sediment load were likely minor in nature.

2.7.5.3. Water Flow and Migratory Corridors

Sunset Pumps is a potential physical upstream migration barrier for sturgeon in the Lower Feather River (USFWS 1995). 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. Given the high flows experienced during the majority of 2017 (spring), even with the four rapid flow reduction events, it is likely that conditions were ideal in the Lower Feather River for green sturgeon to ascend due to significant attraction flows. The boulder weir at Sunset Pumps would have also been inundated for the majority of the migration season, improving passage for adults. Therefore, there were likely short-term benefits from the emergency response effort as a result of elevated flows and increased connectivity of habitat within the migration corridor.

2.7.5.4. Summary of Risk to the Value of Critical Habitat for the Conservation of the Species

Based on the analysis of available evidence, the proposed action was unlikely to have resulted in long-term impacts to the PBFs of designated critical habitat for sDPS green sturgeon that support their migration, spawning, and production in the Lower Feather River. Short-term impacts to the PBFs occurring immediately following the emergency response were mostly minor, likely resulting in behavioral changes such as avoidance of highly turbid areas. Therefore, NMFS concludes that the Oroville Dam Spillway Incident emergency response actions did not appreciably diminish the value of critical habitat for the conservation of sDPS green sturgeon.

2.8. 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, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of CV spring-run Chinook salmon, CCV steelhead, or sDPS green sturgeon or destroy or adversely modify their designated critical habitat.

2.9. 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 ITS.

The recommendations provided by NMFS during the emergency response function in place of terms and conditions with respect to the incidental take caused by the emergency response, and are incorporated here as terms and conditions of this consultation. Thus, to the extent that the emergency response action was performed in compliance with those recommendations, the associated incidental take is considered exempt from the ESA take prohibition.

2.9.1. Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take as a result of the Oroville Dam Spillway Incident Emergency Response is reasonably certain to have occurred as follows:

- Take in the form of injury or death to juvenile CV spring-run Chinook salmon and CCV steelhead, and adult CCV steelhead as a result of stranding and entrainment from rapid flow fluctuations.
- Take in the form of injury or death to juvenile and adult CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon as a result of increased suspended sediment and turbidity from dredging activities and erosion caused by use of the damaged Flood Control Outlet Spillway and the Emergency Spillway.
- Take in the form of injury or death to FRH produced CV spring-run Chinook salmon and CCV steelhead as a result of increased suspended sediment, increased handling, and transportation to and from the Thermalito Annex Facility.

Stranding that occurred after the Oroville Spillway Incident was extensively surveyed, documented, and evaluated by the CDWR Division of Environmental Services, Pacific States Marine Fisheries Commission (White *et al*. 2017), and CDFW. Estimated total stranding is summarized for each target species below in Table 4. The range of values reported for each target species originates from identifying the lowest and highest estimates reported of stranded individuals across the total sampled area (Tables 6 and 16 in White *et al*. 2017). The overall conclusion of the stranding report was that, while the spatial and temporal extent of stranding was considerable, overall mortality from stranding was probably very low for species of concern. Additionally, the benefits conveyed to juvenile salmonid species via access to floodplain resources in the sustained high-flow conditions were likely substantial. However, we do not know the extent or impact of stranding in unobserved, rapidly desiccated pools. It was also not possible to effectively document potential stranding in the lowermost reaches of the Feather River (RM 14 to RM 0) due to significant connectivity of very large ponds during much of the stranding survey. However, eDNA sampling was conducted to identify green sturgeon and salmonids stranded in larger ponds (White *et al.* 2017). Stranding overall was higher in the HFC than in the LFC, although individual species' stranding distributions differed.

Table 4. Observed and extrapolated numbers of special status species stranded in wet pools during the Oroville Spillway Incident and resulting response actions. Subsequent high flows reconnected most wet pools with the main channel.

Target Species	Life Stage	Observed Stranded	Extrapolated Range Stranded[1]
Sacramento River winter-run Chinook salmon[2]	Juvenile	2	NA – 0
CV spring-run Chinook salmon	Juvenile	71	4817 – 5380
Hatchery CCV steelhead	Yearling	19	1289 – 1631
Hatchery CCV steelhead	Adult	4	58 – 268
CCV steelhead	Fry	1	70 – 87
CCV steelhead	Yearling	20	575 – 1355
CCV steelhead	Adult	10	145 – 676
Green Sturgeon	Juvenile	0	N/A
Green Sturgeon	Adult	0	N/A

Source: White *et al*. 2017

[1]The range of values reported for each target species originates from identifying the lowest and highest estimates reported of stranded individuals across the total sampled area.

[2]Determined to be Sacramento River winter-run Chinook salmon using "Length-at-Date" Criteria. These individuals were more likely either the progeny of early-spawning CV spring-run Chinook salmon or were FRH fall-run Chinook salmon released into Lake Oroville during prior years (White *et al.* 2017). Genetic samples were not collected from these two individuals, so DNA analysis cannot be completed to determine their true run. However, given that adult winter-run Chinook salmon do not spawn in the Feather River and juvenile winter-run Chinook salmon are only suspected to rear in the lower-most reaches, the individuals identified as winter-run Chinook salmon during the stranding surveys were very unlikely to actually be winter-run Chinook salmon.

All evaluated stranding was classified as having occurred in "wet pools" (*i.e*., ponds that retained water for the duration of the sampling) or in "dry pools" (depressions that desiccated soon after the high flow event occurred and were dry at the time of physical sampling). All extrapolated numbers of stranded fish are estimated from taxa-specific sampling densities in wet pools only, as the total area of dry pools in the affected area was not possible to calculate. Mortality in dry pools was 100 percent, while mortality in wet pools ranged from 2.2 to 5.6 percent for salmonid species.

It is not possible to precisely quantify and track the number of individuals that are expected to have been incidentally taken per species as a result of increased suspended sediment and turbidity from the Oroville Dam Spillway Incident Emergency Response due to the varying population size (annually and seasonally), annual variations in the timing of spawning and migration, variation in individual habitat use within the action area, and difficulty in observing injured or dead fish. However, it is possible to estimate the extent of incidental take by designating as ecological surrogates those elements of the project that are expected to result in take that are more predictable and/or measurable, with the ability to monitor those surrogates to determine the extent of take that occurred. The most appropriate ecological surrogate for the extent of incidental take as a result of increased suspended sediment and turbidity is the magnitude and temporal extent of turbidity caused by the Oroville Dam Spillway Incident Emergency Response.

As described in *Section 2.5.1 Suspended Sediment Effects on Listed Species,* sediments generated by the Oroville Dam Spillway Incident Emergency Response are likely to have resulted in both lethal and sub-lethal effects, including physical harm to species, as well as effects due to changes in the prey base and feeding behavior.

Single turbidity measurements as high as 974 NTU and total suspended solids as high as 753 mg/L were recorded at Auditorium Riffle in the Feather River LFC in the days following the Oroville Dam Spillway Incident (see Figure 3 in *Section 2.5.1. Suspended Sediment Effects on Listed Species*). Turbidity and total suspended solids gradually declined over several days following the incident and then remained at values approximately between 25 and 115 NTU and 23 and 55 mg/L, respectively, until the end of February. A second peak occurred when the Thermalito Diversion Pool was being dredged on March 2, 2017. The average turbidity measured 300 feet downstream from the dredging operation peaked at 639 NTU, before gradually dropping to approximately 32 NTU by March 10. Turbidity in the Thermalito Diversion Pool generally remained above 20 NTU until early April. Turbidity in the Thermalito Diversion Pool continued to decline after early April until early June when it leveled off and generally remained at values between 3 and 7 NTU.

Based on the discussion above outlining the magnitude and duration of increased suspended sediment resulting from the Oroville Dam Spillway Incident Emergency Response, ESA-listed species present in the Feather River from early February through early April were likely exposed to turbidity levels that may have resulted in both lethal and sublethal effects, including loss or reduction of foraging capability, reduced growth, reduced resistance to disease, reduced respiratory ability, increased stress, and interference with cues necessary for homing and migration (Bash *et al*. 2001). As turbidity levels declined from mid-March through early April, the likelihood of lethal and sub-lethal effects decreased. However, turbidity levels were such that ESA-listed species present in the Feather River may have exhibited behavioral changes, such as avoidance of prime rearing or spawning habitat and reduced or altered feeding.

Following the initial failure of the Flood Control Outlet Spillway, high turbidity levels and sediment in the Feather River entered the FRH water supply system. In an effort to protect fish present at the FRH, CDFW began to relocate juvenile fish to the Thermalito Annex Facility, located just west of the Thermalito Afterbay. This effort resulted in approximately 2 million CV spring-run Chinook salmon and 4.2 million fall-run Chinook salmon being transferred to the Thermalito Annex Facility. At the FRH, CDFW also implemented various measures to preserve the fish that remained on site, including: creating a sediment settling basin within the hatchery rearing channel; developing an alternate water source using a filtration system and domestic water from a fire hydrant; cleaning out mud in the incubation stacks and inland ponds; monitoring and maintaining turbidity and water quality, using medicated and probiotic feed; adding salt to prevent disease; and cleaning raceways. The actions implemented by CDFW preserved many fish, but the overall event, including elevated turbidity and sedimentation in the hatchery resulted in delayed development and mortality.

The majority of the incidental mortality that occurred at the FRH affected non-listed CV fall-run Chinook salmon, as a result of increased suspended sediment (especially for the juveniles that remained on-station at the FRH) and the pump failure that occurred at the Thermalito Annex Facility. Although there were no significant mortality events documented for FRH CV spring-run Chinook salmon, it is evident that some level of mortality occurred, as demonstrated by the release of 1.7 million spring-run Chinook salmon smolts following the Oroville Dam Spillway Incident, representing a deficit of approximately 300,000 smolts (annual production goal is 2 million smolts). However, the level of production that occurred following the Incident is not outside of the range that is typically produced during a normal year. It is likely that some losses of juvenile FRH spring-run Chinook salmon occurred through initial exposure to increased suspended sediment levels, prior to being evacuated to the Thermalito Annex Facility. Additionally, the increased level of handling and transportation likely resulted in injury and mortality as a result of increased physiological stress and exposure to various machinery/mechanical equipment (fish crowders, pumps for loading juvenile salmonids into fish transport trucks, *etc*.). However, the amount or extent of take resulting from the Oroville Dam Spillway Incident Emergency Response cannot be precisely quantified due to varying levels of incidental mortality that occurs during juvenile rearing in a hatchery environment. As juvenile salmonids mature in the hatchery, artificial propagation activities (*i.e*., capture, handling, tagging, disease, crowding, movement from different holding areas, *etc*.) can result in incidental mortality, making it nearly impossible to quantify the level of take that occurred as a result of the Oroville Dam Spillway Incident Emergency Response. Furthermore, as noted above, the number of juvenile spring-run Chinook salmon released from the FRH following the Oroville Dam Spillway Incident was within the normal range for this facility (RMIS, 2020).

As described in *Section 1.4.5. Emergency Actions Undertaken at the Feather River Hatchery,* CCV steelhead eggs present at the FRH during the Oroville Dam Spillway Incident were unable to be evacuated and were therefore exposed to significant levels of suspended sediment for a short period of time. Although it is likely that a small proportion of the CCV steelhead eggs were lost during the initial high suspended sediment levels through reductions in dissolved oxygen levels, the rapid response of FRH staff in developing an alternative water supply with filtration likely precluded significant incidental mortality. Similarly to FRH spring-run Chinook salmon, the increased level of handling and transportation that occurred likely resulted in injury and mortality to FRH steelhead as a result of increased physiological stress and exposure to various machinery/mechanical equipment. The discussion above regarding the inability to precisely quantify the amount or extent of take resulting from the Oroville Dam Spillway Incident Emergency Response due to varying levels of incidental mortality that occurs during juvenile rearing in a hatchery environment also applies to FRH steelhead. As juvenile salmonids mature in the hatchery, artificial propagation activities (*i.e*., capture, handling, tagging, crowding, movement from different holing areas, etc.) can result in incidental mortality, making it nearly impossible to quantify the level of take that occurred as a result of the Oroville Dam Spillway Incident Emergency Response.

Although the amount or extent of take could not be quantified, the FRH retained additional CCV steelhead eggs and juveniles for release during the 2018 season (approximately 213,000 more juveniles were released than required for mitigation) in anticipation of increased levels of incidental mortality resulting from the Oroville Dam Spillway Incident Emergency Response.

2.9.2. Effect of the Take

In the biological 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.

2.9.3. Emergency Consultation Terms and Conditions

As described above, the recommendations provided by NMFS during the emergency response function in place of terms and conditions with respect to the incidental take caused by the emergency response, and are incorporated here as terms and conditions of this biological opinion. NMFS sent a letter to FERC on February 24, 2017, expressing concern regarding the potential effects to CV spring-run Chinook salmon, CCV steelhead, and sDPS green sturgeon as a result of rapid reduction in flows from the Flood Control Outlet Spillway of 60,000 cfs down to zero cfs. These rapid reductions were being proposed to minimize damage to the Flood Control Outlet Spillway and complete the dredging of the Thermalito Diversion Pool. Adverse impacts due to a rapid reduction in flow, such as decrease in available habitat and stranding of fish in off-channel pools were listed among the concerns. Dredging can affect the species listed above, as well as fish at the FRH due to changes in water quality such as increasing turbidity and changing DO and pH levels.

The letter included a list of recommendations to reduce the impacts on anadromous species, critical habitat, and EFH in the Feather River downstream of the Fish Barrier Dam during and after dredging operations, which took place from February 27 to October 20, 2017. Although most of the recommendations from NMFS were followed, CDWR was unable to implement some of the NMFS recommendations, because of the intense and immediate nature of the dredging operations, and the need to reduce flows during daylight hours to create the safest possible conditions for monitoring the spillway. A summary of the recommendations and associated actions taken are listed below:

1) **Reductions in flows should occur during hours of darkness on the Feather River to protect juvenile salmonids, especially Chinook salmon.**

Action taken: During initial dredging activities, from February 27 to March 17, decreases in release rates from Oroville Dam occurred mainly during daylight hours to provide for critical day-time monitoring of the Flood Control Outlet Spillway, which was being visually monitored for damage on a continuous basis. Day-time monitoring was required for the safety of CDWR personnel and contractors and to allow the most effective monitoring conditions.

2) **Reductions in flows (down ramping rate) should occur as slowly as possible, to allow fish to follow the receding water elevation.**

Action taken: On February 27, 2017, release rates from Oroville Dam Flood Control Outlet Spillway were rapidly decreased to accommodate the required (emergency) assessments and continued to decrease until zero cfs was released over the Flood Control Outlet Spillway. Also, there was concern that damage to this structure may be exacerbated during flow reductions below about 40,000 cfs, due to the possibility of increased head cut erosion. Flows remained low for about one week in the LFC and HFC, but never went below minimums for each channel. Flow levels were increased slightly on March 7 and release rates began to rise again until they peaked around 43,000 cfs on March 17. In addition to the February 27 flow reduction described above, three additional flow reductions occurred on March 27, May 1, and May 19, 2017.

3) **Minimum flows should be maintained at all times. Flows should not drop below the minimum instream flows. If flows are expected to drop below the minimum instream flows, CDWR should release water from the spillway to ensure minimum instream flows are met.**

Action taken: Water was released from the Thermalito Diversion Dam into the LFC to maintain a minimum flow of 600 cfs. Water was discharged from the Thermalito Afterbay Outlet, so that flow entering the HFC never dropped below the minimum flow of 1,700 cfs.

4) **Consider initially dredging a channel through the debris that will allow water to flow to maintain minimum flows or more. Provide flow through the river valves and/or the powerhouse. Repairs at the powerhouse and river valves should be prioritized to provide water to the Feather River immediately.**

Action taken: Water was released from the Thermalito Diversion Dam into the LFC to maintain minimum flow of 600 cfs. Water was discharged from the Thermalito Afterbay Outlet, so that flow entering the HFC never dropped below the minimum flow of 1,700 cfs during dredging operations. Dredging operations were accelerated to remove material deposited in the Thermalito Diversion Pool. Removing this material allowed Hyatt power plant to come on-line quickly, so water could continue to be released from Lake Oroville and continue down the Feather River when lake levels dropped below the Flood Control Outlet Spillway.

5) **Address water supply issues (quantity and quality) at the FRH and the Thermalito Annex. Ensure adequate water is available to these facilities and that the turbidity, DO, and pH stay below levels that will stress fish.**

Action taken: CDWR and CDFW closely monitored water parameters and supply issues. To ensure adequate water quality for fish, approximately 2 million spring-run Chinook salmon and about 4.2 million fall-run Chinook salmon were moved to the Thermalito Annex facility. A sedimentation channel and filtration system was set up for the fish and CCV steelhead eggs that remained at the FRH.

6) **Monitor/survey for stranding in the Feather River and implement fish rescues as possible.**
   a) Aerial photography of the Feather River prior to flow reductions and after flow reductions will assist in prioritizing locations to survey.
   b) Put boats, equipment, and people on the river to survey for fish stranded in pools.
   c) Prioritize areas to survey based on areas of higher risk. Use aerial surveys to identify areas of high risk.
   d) For large pools, and for pools with unknown stranding, sample for presence using eDNA for Chinook salmon, steelhead, and sturgeon.
   e) Plan on more than 5 days for monitoring and potential rescues. Monitoring and rescue operations should occur throughout the period of reduced flows and the dredging activities.
   f) Collect samples and information about stranded, rescued fish, and dead fish.
      i) Take pictures and video of locations and fish sampled. Check the date stamp on the cameras. With the video frequently verbally record the time, date, and location.
      ii) In the case of surveys, the numbers and species of fish should be estimated and recorded.
      iii) In the case of fish rescues, the numbers and species of fish should be identified and pictures taken. Where possible and it will not significantly impact the implementation of the fish rescue, tissue samples and scales should be collected. The date, time, location, presence or absence of adipose fins, and who collected the samples needs to be recorded on the bags. Number the bags and locations. If ethanol is available, use it to preserve samples, otherwise freeze.
      iv) In the event of dead fish, pictures should be taken, the carcasses should be placed in a plastic sealing bag, and record the date, time, location, presence or absence of adipose fins, and who collected the sample recorded on the bag. Number the bags and locations. Freeze large fish as soon as possible.

Action taken: Aerial surveys were performed to determine the extent of stranding ponds and focus field staff efforts on areas of concern. An aerial survey was completed on February 26 prior to the decrease in release rate and another on February 27 when flow in the LFC dropped to 600 cfs to determine the stranding pools in the LFC and HFC created by the decrease in flow. Another two flights were completed on February 28; one to inform on-ground surveys and another to gather high-resolution aerial orthorectified photographs (orthophotographs)[2] of the stranding areas on the entire Lower Feather River, consisting of 67 RMs. The upper 53 RMs of

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[2] Raw aerial or satellite imagery cannot be used in a GIS until it has been processed such that all pixels are in an accurate (x,y) position on the ground. Orthorectified images have been processed to apply corrections for optical distortions from the sensor system, and apparent changes in the position of ground objects caused by the perspective of the sensor view angle and ground terrain.

the high-resolution aerial orthophotographs were used to map and measure ponded areas using ArcView GIS v.10.4.

On-the-ground stranding pool surveys and rescues began on February 27 starting at RM14 through RM 66. Boats were dispatched with crews of 3-4 people / boat to sample ponds that were disconnected from the river. During the first week of initial sampling, there were many additional sampling crews provided by CDFW and Pacific States Marine Fisheries Commission (PSMFC) from surrounding areas, in addition to local CDWR crews. Using this exceptionally large workforce, the majority of stranding pools were sampled during the initial week following flow reductions. A reduced team, consisting of local CDFW, CDWR, and PSMFC crews, was responsible for subsequent sampling of larger pools that were previously inaccessible due to size and/or were connected to the mainstem of the lower Feather River during initial sampling. Rescue activities consisted of returning live stranded fish to the nearest safely accessible portion of the Feather River via 5-gallon buckets filled with river water.

Significant floodplain that developed below the confluence with Sutter Bypass (below RM 14) made surveys in this area impossible. Larger ponds in the remaining 14 miles were sampled using eDNA techniques to detect the presence of salmonids and sturgeon. Overall, 27 unique sites were sampled between the confluence with the Sacramento River at Verona (RM 0) to Riverbend Park (~RM 65) within the Upper Low Flow Channel and processed using quantitative polymerase chain reaction (qPCR) by Cramer and Associates GENIDAQS team. The eDNA sampling commenced when the water levels receded during the second stranding event (early April) and sampling continued in many remaining large pools until the end of June, well after the end of the fourth flow reduction event. A total of five ponds (19%) were tested using eDNA sampling techniques in the LFC, with the majority concentrated in the Upper LFC. The remaining 22 ponds (81%) sampled for eDNA were distributed among the HFC, including the lowermost region that could not be sampled using traditional field methods

Primary on-the-ground surveys ended on March 15, when flows had increased to 40,000 cfs and most of the pools had reconnected with the Lower Feather River. Additional sampling occurred during subsequent ramp-down events. Managers monitored the flow levels through time and local CDWR, CDFW, and PSMFC crews were re-dispatched to evaluate whether additional stranding events occurred, whenever water levels were reduced throughout the spring. The second, third, and fourth flow reduction events were much shorter in duration, later in the salmonid rearing season, and down-ramping rates were more conservative. Thus, the impact of stranding for fishes remaining in the Lower Feather River system was likely reduced. A total of 92 pools (90 Wet) were sampled during the second event, 37 pools were sampled or identified during the third event, and 11 pools were visually sampled during the fourth. There were a total of 377 live fall-run Chinook salmon, of which 49 were derived from the Feather River Hatchery (*i.e.*, ad-clipped; FL range 65 mm to 83 mm) and 70 were mortalities. During the second event, only one live late fall-run Chinook sized salmon and 15 live spring-run Chinook salmon were rescued. Additionally, there were only three live steelhead yearlings rescued, two wild and one from the FRFH. There were no target taxa found during the third or fourth events.

Recovery was the primary focus of stranding survey efforts; however, as noted in the Methods, the fork lengths (FL) of salmonids were measured whenever it would not compromise the health of the fishes. Tissues samples and otoliths (adult CCV steelhead) were collected from many of the observed salmonid mortalities. Although crews were diligent to collect and preserve dead individuals encountered during the survey, there was little attention paid to the need to collect tissue samples of unusual sized live fishes. Information on location, date, and basic species information was recorded. Samples were preserved by freezing or alcohol. Photographs were taken of some locations to further document observations.

7) **Monitor water quality, turbidity, DO, pH, and adjust dredging operations if these parameters reach levels that may adversely affect fish at the Fish Barrier Dam or in the hatchery.**

Action taken: CDWR and CDFW closely monitored water parameters and supply issues with regards to FRH. To ensure adequate water quality for fish, approximately 2 million spring-run Chinook salmon and about 4.2 million fall-run Chinook salmon were moved to the Thermalito Annex facility. A sedimentation channel and filtration system was set up for the fish and CCV steelhead eggs that remained at the FRH.

When the Thermalito Diversion Pool was being dredged, average turbidity in the Diversion Pool 300 feet downstream from the dredging peaked at 639 NTU on March 2, 2017. Turbidity and total suspended solids gradually declined over several days following the Oroville Dam Spillway Incident after peaking on March 2 and then remained at values approximately between 30 and 70 NTU and 10 and 30 mg/L, respectively, for a month.

8) **Water should be released from the Thermalito Afterbay to augment flows in the Feather River, while maintaining water deliveries to the Thermalito Annex.**

Action taken: Water was released from the Thermalito Afterbay Outlet into the Lower Feather River to meet flow requirements.

9) **If possible, install turbidity curtains or booms to reduce potential turbidity levels, to the maximum extent possible.**

Action taken: This was not possible due to the large area being dredged with multiple vessels, and high flows in the short timeframe that was available.

10) **Coordinate with the Corps, Yuba County Water Agency, PG&E, and the Nevada County Irrigation District to augment flows from storage in the Yuba watershed. Also, coordinate with South Sutter Water District regarding the availability of water from the Bear River for flow augmentation.**

Action taken: Minimum flows were maintained in the LFC and the HFC during dredging; therefore, no flow augmentation was necessary. Flows to the Lower Feather River were quite high throughout the winter and spring, except when flows were reduced for spillway inspections.

11) **Deploy as many people as possible to survey and respond to fish stranding, and coordinate with CDFW.**

Action taken: An exceptionally large workforce consisting of staff from CDWR, CDFW, NMFS, and PSMFC was deployed to sample stranding pools and perform fish rescues during the first week of sampling following flow reductions for dredging. During the second week, a reduced team from the same agencies sampled larger pools that were previously inaccessible. CDWR continued to sample and rescue fish (as possible) immediately after each subsequent flow reduction (White *et al.* 2017).

12) Submit a report of the activities and results to NMFS within 30 days.

Action taken: Due to the extensive nature of the rescue and sampling effort and the long duration of the work (well past 30 days), CDWR was not able to submit a full report of the results of the stranding effort until November. However, CDWR did submit email updates to NMFS as data was available during the stranding surveys and weekly meetings were held to discuss all aspects of the spillway response including water quality and stranding efforts.

2.10. 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).

In the context of this opinion, effects of the agency action on listed anadromous fish species and critical habitat have already occurred as a result of the Oroville Dam Spillway Incident Emergency Response, and since the action was concluded prior to the initiation of this after-the-fact consultation, no conservation recommendations are identified. FERC has also proposed some prospective recovery actions. However, as described in *Section 2.5.4 Effects of the Recovery Actions* and *Section 2.5.5 Effects of the Proposed Action on Critical Habitat*, the proposed prospective recovery actions are not expected to adversely affect ESA-listed species or their designated critical habitat. This is due to the location of the proposed work (and area where ESA-listed species and their designated critical habitat are not present) and the BMP's to be implemented by CDWR.

2.11. Reinitiation of Consultation

This concludes formal consultation for the Oroville Dam Spillway Incident Emergency Response.

As 50 CFR 402.16 states, reinitiation of consultation is required and shall be requested by the Federal agency or by the Service 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 ITS 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 identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

In the context of this opinion, except for prospective recovery actions, effects of the agency action on listed anadromous fish species and critical habitat have already occurred as a result of the Oroville Dam Spillway Incident Emergency Response, and since the action was concluded prior to the initiation of this after-the-fact consultation, the reinitiation triggers set out in 50 CFR 402.16 are not applicable, except potentially the reinitiation trigger set out in (2).

2.12. "Not Likely to Adversely Affect" Determinations

2.12.1. Sacramento River winter-run Chinook salmon

The distribution of Sacramento River winter-run Chinook salmon spawning and initial rearing historically was limited to the Little 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). 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 NFH barrier weir). Approximately 299 miles of former tributary spawning habitat above Shasta Dam is inaccessible to winter-run Chinook salmon. Most components of the winter-run Chinook salmon life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the construction of Shasta Dam.

The greatest risk factor for Sacramento River winter-run Chinook salmon lies within its spatial distribution (NMFS 2011), and the fact that there is still only one population that spawns below Keswick Dam in the Sacramento River. 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 Chinook salmon 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.

As described above, Sacramento River winter-run Chinook salmon do not spawn in the Feather River, so no adults would be expected to be migrating or holding in the Feather River during the Oroville Dam spillway emergency response and recovery actions. Any adults that were migrating up the Sacramento River and migrated off-course into the Feather River would have had ample opportunity to turn around and migrate back to the Sacramento River if conditions were unsuitable. For the same reasons, no adult winter-run Chinook salmon would be expected to be holding in the Feather River. Based on the data available, suspended sediment likely had no effect on adult winter-run Chinook salmon migration, holding, or spawning.

Again, given that winter-run Chinook salmon spawning has not been documented in the Feather River and is not expected to occur, there was likely no effect on winter-run Chinook salmon eggs or larvae from the actions taken in response to the Oroville Spillway Incident.

Although juvenile CV spring-run Chinook salmon and CCV steelhead are known to spawn and rear in the lower Feather River, Sacramento River winter-run Chinook salmon are not. Any non-natal rearing winter-run Chinook salmon juveniles present during the emergency response effort were likely present in the lower-most reaches of the Feather River and would have had ample opportunity to quickly emigrate if conditions became unsuitable. Therefore, juvenile winter-run Chinook salmon may have been affected, but were not likely to be adversely affected, by elevated suspended sediment resulting from Oroville Dam Spillway Incident Emergency Response.

Similarly to the discussion above regarding suspended sediment impacts, given the very low likelihood of adult winter-run Chinook salmon presence in the Feather River, flow fluctuations resulting from the emergency response and recovery actions likely had no effect on adult winter-run Chinook salmon migration, holding, or spawning. The same conclusion has also been reached for winter-run Chinook salmon eggs and larvae, since adult spawning is not expected to have occurred in the Feather River.

While winter-run Chinook salmon are not known to spawn in the Feather River, two winter-run-sized fish were collected from wet pools in the high-flow channel and determined to be Sacramento River winter-run Chinook salmon using "Length-at-Date" Criteria. These individuals were more likely either the progeny of early-spawning spring-run Chinook salmon or were FRH fall-run Chinook salmon that had been released into Lake Oroville during prior years (White *et al.* 2017). Genetic samples were not collected from these two individuals, so DNA analysis cannot be completed to determine their true run. However, given that adult winter-run Chinook salmon do not spawn in the Feather River and juvenile winter-run Chinook salmon are only suspected to rear in the lower-most reaches, the individuals identified as winter-run Chinook salmon during the stranding surveys were very unlikely to actually be winter-run Chinook salmon. Winter-run Chinook salmon juveniles may have been affected, but were not likely to be adversely affected, from stranding due to flow reductions in response to the Oroville Dam Spillway Incident.

Based on this analysis NMFS concurs with FERC that the proposed action is not likely to adversely affect Sacramento River winter-run Chinook salmon.

As noted by FERC, critical habitat designated for Sacramento winter-run Chinook salmon is outside the action area.

3. Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA , EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR

600.10). 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. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)].

This analysis is based, in part, on the EFH assessment provided by FERC and descriptions of EFH for Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Project

The action area for the proposed action has been identified to include EFH for Pacific Coast salmon. CV spring-run Chinook salmon (*Oncorhynchus 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 ESA Section 7(a)(2) biological opinion for the proposed action addresses effects of the action on listed CV spring-run Chinook salmon and their critical habitat. This EFH consultation will concentrate on the following designated Habitat Areas of Particular Concern (HAPCs): (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 likely adversely affected EFH for Chinook salmon. We conclude that the following adverse effects on EFH designated for Pacific Salmon likely occurred:

There is no indication that rapid flow fluctuations or increased suspended sediment (turbidity) resulted in long-term adverse impacts to EFH for Pacific Coast salmon. Rather, the majority of impacts to HAPCs for Pacific Coast salmon were associated with very high suspended sediment levels in the Feather River immediately following the Oroville Dam spillway failure. The severity of these impacts was minimized by two important co-occurring factors: (1) high flows that immediately mobilized and mixed LFC spawning area sediment with sand-sized material that was transported over the Thermalito Diversion Dam into the Lower Feather River, and (2) high flows that transported fine suspended sediment away from critical holding and spawning areas in the upper reach of the Lower Feather River onto overbank and floodplain areas (cbec eco engineering 2020). Although a small amount of this sediment likely settled in the lower velocity areas and low-gradient reaches of the Feather River, the majority of the sediment-based impacts to EFH were minor and occurred immediately following the spillway failure. Thus, by definition there were likely adverse effects to EFH from the response to the Oroville Spillway Incident. Functionally, however, these impacts were likely to be limited in their temporal and spatial extent.

Nutrient exchange between floodplain and main-channel habitat was extended during 2017 due to sustained high flows. This extended connectivity would have positive benefits for floodplain habitats by allowing fine suspended sediment to deposit into off-channel and floodplain areas and allow exchange of nutrients from floodplains to the river. Although rapid flow increases and decreases adversely affected individuals as a result of redd dewatering and stranding, some permanent access to floodplain habitat remained in 2017, due to longer sustained high flows. Higher than normal late-winter and spring flows also enhanced the ability of Chinook salmon to pass the Sunset Pumps rock weir (passage impediment under certain flows) to quickly access prime holding and spawning habitat.

No changes in water temperature or holding habitat beyond those that normally occur were observed during or after the emergency response actions. CDWR continued (and continues) to operate to the 1983 Agreement and NMFS 2004 biological opinion temperature requirements.

No long-term changes in spawning or rearing have been observed, despite the significant scouring of spawning gravels that occurred. High flows that began before the Spillway Incident occurred and continued for weeks after the Incident mobilized steelhead spawning gravel and native bed material. Flows after the Spillway Incident began (February 7, 2020) increased to 112,000 cfs and were likely large enough to have scoured the majority if not all of the redds constructed during the winter of 2017 (cbec eco engineering 2020).

Gravel placed in 2014 to augment salmonid spawning was mobilized during high flows, but much of that material was deposited elsewhere in the Lower Feather River, and therefore is still available as spawning habitat. Additional gravel was also added in 2017 to supplement Chinook salmon spawning gravel. There were also no signs of fine sedimentation within spawning gravels in the surveyed portions of the upper river reach. Particle size distributions observed in salmonid redds created in 2017 and 2018 reflect what has been routinely observed for the Feather River. The lack of fine sediment observed in spawning areas may be due to the long duration high flows experienced throughout the spring of 2017. These flows likely mobilized any fine sediment that may have been deposited when flows were low or near minimums while dredging was still occurring, and turbidity was still slightly higher than normal. By the time flows began to drop significantly, turbidity levels were also declining to normal levels, making any changes to spawning and rearing habitat unobservable.

3.3. Essential Fish Habitat Conservation Recommendations

In the context of this EFH analysis, effects to the HAPCs described above have already occurred as a result of the emergency response effort, and since the action was concluded prior to the initiation of this after-the-fact consultation, no additional EFH Conservation Recommendations are proposed at this time. The recommendations provided by NMFS during the emergency response serve as the conservation recommendations intended to avoid or minimize impacts to Pacific Coast salmon EFH. Responses to those recommendations can be found in *Section 2.9.3 Emergency Consultation Terms and Conditions*. FERC has also proposed some prospective recovery actions. However, as described in *Section 2.5.4 Effects of the Recovery Actions* and *Section 2.5.5 Effects of the Proposed Action on Critical Habitat*, the proposed prospective recovery actions are not expected to adversely affect EFH. This is due to the location of the proposed work (compared to the area where EFH is designated) and the BMP's to be implemented by CDWR

4. 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.

4.1. 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 and their designated non-federal representative, CDWR. Other interested users could include citizens of affected areas, and others interested in the conservation of the affected ESUs/DPS. Individual copies of this opinion were provided to FERC. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adheres to conventional standards for style.

4.2. 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.

4.3. 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. 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.

5. References

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