UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
Portland, OR 97232

November 27, 2017

Aaron O. Allen, Ph.D.
U.S. Army Corps of Engineers – North Coast Branch
2151 Alessandro Drive, Suite 110
Ventura, California 93001

Re: Endangered Species Act Section 7(a)(2) Biological Opinion for the Arroyo Grande Creek Waterway Management Program (File No. SPL-2012-00317-JWM)

Dear Dr. Allen:

Enclosed with this letter is NOAA's National Marine Fisheries Service's (NMFS) biological opinion for the U.S. Army Corps of Engineers' (Corps) permitting of the San Luis Obispo Flood Control and Water Conservation District's (District) Arroyo Grande Creek Waterway Management Program (proposed action), pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 *et seq*.). The biological opinion describes the effects of the proposed action on threatened South-Central California Coast (S-CCC) steelhead (*Oncorhynchus mykiss*) and designated critical habitat for the species in accordance with ESA section 7. An administrative record of this consultation is on file at NMFS' Long Beach office.

After reviewing the best available scientific and commercial information, the status of the S-CCC steelhead, the environmental baseline, expected effects of the proposed action, cumulative effects, and the combined effects of the environmental baseline, the proposed action, and cumulative effects, the biological opinion concludes the proposed action is likely to jeopardize the continued existence of threatened S-CCC steelhead, and is likely to adversely modify or destroy designated critical habitat for this species. NMFS first informed the Corps of this determination in its draft biological opinion and draft reasonable and prudent alternative (RPA) of July 11, 2016. Since issuance of the draft biological opinion in July 2016, NMFS worked collaboratively and utilized the expertise of the Corps and District to refine the RPA, pursuant to the requirements of 50 CFR 402.14(g)(5). The RPA allows the District discretion for undertaking the proposed action, yet in a manner that ensures the proposal would not jeopardize the survival and recovery of threatened steelhead, or adversely modify or destroy this species' critical habitat. This biological opinion includes the collaboratively developed RPA.

Please contact Brittany Struck at (562) 432-3905 or at Brittany.Struck@noaa.gov if you have a question concerning this consultation, or if you require additional information.

Sincerely,

Barry A. Thom
Regional Administrator

Enclosure

cc: Wade Horton, San Luis Obispo County Flood Control and Water Conservation District, San Luis Obispo
Roger Root, U.S. Fish and Wildlife Service, Ventura
Margaret Paul, California Department of Fish and Wildlife, San Luis Obispo
Ronnie Glick, California Department of Parks and Recreation, Oceano Dunes District, Pismo Beach
Administrative File: 151422WCR2014CCO00264; PCTS: WCR-2014-1677

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion

Arroyo Grande Creek Waterway Management Program
NMFS Consultation Number: WCR-2014-1677

Action Agency: U.S. Army Corps of Engineers

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
South-Central California Steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	Yes	Yes

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

Issued By: ______________________
Barry A. Thom
Regional Administrator

Date: November 27, 2017

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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

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

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

1.2 Consultation History

As the information below illustrates, our history collaborating with the San Luis Obispo Flood Control and Water Conservation District (District) on the proposed action began long before we received the request for formal consultation under Section 7 of the ESA from the Army Corps of Engineers (Corps).

In a letter dated November 30, 2005, 12 years ago, NMFS expressed concerns with the activities that are the basis of the District's Arroyo Grande Creek Channel Waterway Management Program. In addition to communicating the expected harmful effects of the proposed action on threatened steelhead and habitat for this species to the project proponents, NMFS outlined recommendations for avoiding and minimizing the effects in the action area. Four years later on August 19, 2009, to assist the District in formulating the draft Environmental Impact Report (EIR) for the proposed action, NMFS advised the District on the expected adverse effects to steelhead and designated critical habitat as a consequence of the preferred alternative. Our concerns with the preferred alternative included: (1) confining a creek within an artificially defined corridor, (2) reducing habitat complexity to increase flood conveyance of the channel, and (3) perpetuating the existing disconnect between the creek and the historical floodplain.

On September 30, 2014, the Corps submitted a consultation request involving the District's Arroyo Grande Creek Channel Waterway Management Program (proposed action). Yet, after reviewing the consultation request and accompanying information, NMFS determined the consultation package did not sufficiently describe the manner in which the proposed action may affect threatened South-Central California Coast (S-CCC) steelhead (*Oncorhynchus mykiss*) and designated critical habitat for this species, and therefore formal consultation could not be initiated. In a letter dated November 13, 2014, NMFS advised the Corps and the District of this determination and identified the types of information that they should provide us for the purpose of initiating formal consultation for the proposed action. Because the proposed action is complex with respect to fish-passage design hydraulics, technical discussions occurred between NMFS, the Corps, and the District.

A conference call was held on December 3, 2014, to further inform the effects to designated critical habitat and steelhead movement through the action area. During the call, NMFS also reviewed and sought clarification on the preliminary responses provided by Waterways Engineering, Inc., to NMFS' letter dated November 13, 2014. On January 26, 2015, the Corps submitted hydraulic figures describing the expected channel velocity and shear stress in the active channel due to the proposed action.

The Corps submitted the final Biological Assessment (BA) and related consultation information documents to NMFS in a letter dated April 21, 2015, which was received by NMFS on April 27, 2015. In a letter dated July 23, 2015, NMFS explained to the Corps that although 90 days had elapsed since the formal consultation had been initiated, the District had not yet defined the permit duration. Because the permit duration is important to consider when assessing effects of an action, NMFS requested a 90-day extension in the duration of the formal consultation from September 9, 2015, to December 8, 2015.

On December 4, 2015, NMFS requested the District to clarify the relationship between the 10-year flood hydrologic analysis and Phase 2 of the proposed action as described in the EIR. On January 11, 2016, the District officially determined Phase 2 is not likely to occur in the future (Corps 2016a). Therefore, Phase 2 of the proposed action is not considered in this biological opinion.

NMFS issued a draft biological opinion to the Corps on July 11, 2016. The draft biological opinion concluded the proposed action is likely to jeopardize the continued existence of threatened steelhead and is likely to destroy or adversely modify designated critical habitat for this species. Therefore, NMFS provided a draft reasonable and prudent alternative (RPA) to the proposed action.

On August 16, 2016, NMFS met with the Corps to receive the Corp's initial feedback and comments on the draft biological opinion and the draft RPA (Corps 2016b). On September 8, 2016, NMFS, the Corps, and the District met again to discuss the feasibility of NMFS' draft RPA. During this meeting, the District, NMFS, and the Corps discussed the option of refining and then finalizing the draft RPA based on the Corps and the District's expertise, pursuant to the requirements of 50 CFR 402.14(g)(5), or the option of developing a new proposed action, and agreed to decide a path forward by October 15, 2016.

On October 5, 2016, the District requested a two-week extension until October 28, 2016, to prepare their official response regarding NMFS' draft RPA. An additional request for time was made by the District to extend the response due date to November 3, 2016, to coordinate internally with leadership and District Counsel, to continue preparing their formal response letter, and to inform District decision makers about the draft biological opinion and the draft RPA.

On November 3, 2016, NMFS received from the Corps a copy of the Farella, Braun & Martel's letter, on behalf of the District, dated November 3, 2016 (hereafter "FBM letter"). On November

10, 2016, NMFS again met with the Corps and the District to receive feedback from the District on the draft biological opinion and the draft RPA. The District also presented their own proposed reasonable and prudent alternative (hereafter "proposed RPA") for NMFS to consider. This proposed RPA generally included a wider riparian buffer, reduced vegetation management near bridges, a focused sediment-removal plan, and a willingness to accept reduced freeboard due to retaining more roughness of the existing riparian corridor between the levees.

On November 17, 2016, NMFS held a teleconference with the Corps and the District. The subject teleconference was an opportunity for NMFS to provide feedback to the District on their proposed RPA. The substantive elements of the teleconference are memorialized in NMFS' December 9, 2016 letter to the Corps. In general, during the teleconference NMFS continued to advise the Corps and the District to address the adverse effects due to the proposed raising of the levees, and NMFS explained that partial levee setbacks, removals, or combination of these, would increase floodplain habitat and create prospects for growth and survival of juvenile steelhead.

In a letter dated December 21, 2016, NMFS responded to the substantive elements contained in the FBM letter.

On February 23, 2017, NMFS attended a field meeting with the Corps and the District to provide feedback on the District's revised vegetation buffer memorandum and revised sedimentation-management plan, which NMFS received on February 9, 2017. NMFS' feedback was in the form of four principal messages, which are memorialized in NMFS' letter dated March 23, 2017, to the Corps. During the field meeting, the District described an alternative project to be considered within the revised RPA that would address, in part, the anticipated adverse effects of raising the existing levees on threatened steelhead and its designated critical habitat. The District's proposal included reverting 8.28 acres of land back to wetted habitat for rearing steelhead (District 2017b, 2017d).

On April 4, 2017, NMFS held a teleconference with the Corps and the District to (1) seek clarity on the final details of the District's initial and ongoing sediment-removal framework and approach under the District's proposed RPA, (2) provide the District with regional example measures to minimize ongoing sediment-removal channel disturbance, and (3) present an evaluation of the District's proposed RPA relative to the adverse effects described in the July 11, 2016, draft biological opinion. During the call, the District provided a general outline with goals and objectives for the proposed creation of lagoon rearing habitat for steelhead, which the District termed the Meadow Creek Lagoon Management Plan (District 2017b).

On April 17, 2017, NMFS shared the first draft of the revised RPA with the Corps and the District. This revised RPA reflected the extensive collaboration with, and expertise of, the Corps and District, including suggested revisions, comments, and new information provided to NMFS since the issuance of the July 11, 2016, draft biological opinion.

On May 15, 2017, the District provided their comments to NMFS on the draft revised RPA along with seven additional documents based on the topics and issues discussed during the April 4, 2017, teleconference. The documents and comments the District provided contributed to the framework and structure of the RPA.

After NMFS reviewed the District revisions to the draft revised RPA and the additional seven documents, NMFS coordinated and held a conference call on May 19, 2017, to ensure clarity and understanding on all proposed revision, changes, and design elements related to the riparian buffer, sediment removal, and reverting 8.28 acres of land back to wetted habitat for rearing steelhead.

In response to clarifying details that arose during the May 19 teleconference, the District provided to NMFS on May 24, 2017, additional comments to the draft revised RPA along with revisions to the Meadow Creek Lagoon Management Plan, additional details for proposed lagoon water-quality monitoring under the RPA, and finally details on cumulative percentages for the revised riparian buffer throughout the action area.

In preparation for the June 22, 2017, meeting with the Corps and the District, on June 15, 2017, NMFS provided the Corps and the District with an updated version of the revised RPA reflective of comments, details, and new information received by NMFS since May 15, 2017. During the June 22, 2017, meeting, NMFS worked collaboratively with the Corps and the District on final revisions to the RPA framework, content, and language.

On June 28, 2017, NMFS held a conference call with the Corps and the District to discuss available mechanisms, pathways, and options to minimize the amount of time to complete RPA sub-element 3. In a letter dated July 24, 2017, the District shared three concerns with the Corps: (1) project implementation limitations, (2) implementation schedule, and (3) the framework for lagoon management.

On September 8, 2017, through electronic communications, NMFS shared a final draft of the RPA with the Corps and the District. In a letter dated September 18, 2017, the District explained to the Corps their additional comments, concerns, and questions on the final draft of the RPA. On September 21, 2017, NMFS convened a conference call with the Corps to discuss the District's feedback on the final draft of the RPA and provide general responses including NMFS' basis and rational for timelines within the final RPA.

During the October 4, 2017, conference call between NMFS, the Corps, and the District, NMFS explained the basis and rationale for RPA implementation timelines including language within RPA sub-element 3 that allows for flexibility in design/planning and construction timelines. In a letter dated October 5, 2017, the District expressed to the Corps agreement with the final draft of the RPA.

1.3 Comments on the Draft Biological Opinion

We received comments on the draft biological opinion from the Corps, and counsel and an environmental consulting firm on behalf of the District.

Generally, the Corps' comments focused principally on the specific authorities under the Clean Water Act in which the RPA could be implemented. In this regard, we revised the justification for the RPA to reflect the various authorities that are relevant to elements of the RPA.

The comments received from District counsel and environmental consulting firm were substantive, generally involving the following elements of the draft biological opinion (1) legal framework, (2) description of the action and expected impacts, (3) effects of the action, (4) status of the species, (5) jeopardy and adverse modification findings, and (6) reasonable and prudent alternatives. Our responses to the comments received are memorialized in our letter dated December 21, 2016, and have been used to refine the draft biological opinion and produce this biological opinion.

One particular comment contained in the FBM letter suggests that certain effects that NMFS identifies as "effects of the action" (*e.g.*, maintaining an artificially narrow riparian buffer width, consigning a large portion of the creek in the action area to a flood-control channel, and continuing to limit connection between the active creek channel and floodplain areas) reflect existing conditions, *i.e.*, continuation of current site conditions, not effects of the action. However, expecting these effects to result from the proposed action is reasonable based on the administrative record for the biological opinion, and federal regulation implementing Section 7 of the ESA. We explain the basis for this expectation as follows.

First, the District's own information clearly indicates the proposed action would negatively alter existing habitat conditions. Evidence of this alteration includes an illustration depicted in Figure 2-4 of this biological opinion, which was received from the District as part of the description of the proposed action. The subject figure shows the "Existing Conditions" in the action area (top panel) and how the existing conditions would be altered owing to the proposed action (bottom panel, "Proposed Management Areas"). The figure shows the cross-section view of the action area under flow conditions that meet flood conveyance capacity of the levee system. All woody vegetation beyond the buffer zone will be removed and in some cases replanted in upstream areas where there appears to be a lack of woody vegetation coverage in the buffer zone. Second, although the proposed action will clearly create new adverse effects, including a deterioration in the species pre-action condition, federal regulation (81 FR 7214) allows NMFS to conclude an action would cause ''destruction or adverse modification'' of designated critical habitat when direct or indirect alterations appreciably diminish the value of critical habitat for the conservation of a listed species, including alterations that preclude or significantly delay the capacity of the habitat to develop essential physical or biological features over time. Many activities that are the basis of the proposed action preclude or significantly delay the development of physical and biological features of designated critical habitat for threatened steelhead. These activities include the following:

- maintaining an artificially narrow riparian buffer width,
- removing vegetation from select areas of the action area,
- removing surficial channel-bed sediments and shaping the creek channels to force the formation of secondary channels,
- consigning a large portion of the creeks in the action area to a flood-control channel, and
- continuing to limit connectivity between the active creek channel and historical floodplain areas.

These effects meet the foregoing standard and therefore must be considered as effects of the action. As described later in this biological opinion, we find that the proposed action is likely to "destroy or adversely modify" designated critical habitat because the action results in:

(1) an alteration of the quantity and quality of the essential physical or biological features of designated critical habitat,
(2) precludes or significantly delays the capacity of that habitat to develop those features over time, and
(3) appreciably diminishes the value of critical habitat for the conservation of the species.

With regard to NMFS' interaction with the Corps and the District throughout the consultation, our review of the administrative record shows that NMFS staff actively engaged with District staff to clarify certain aspects of the proposed action. The clarifications and any related data received from this staff exchange informed the draft biological opinion and this biological opinion, and are corroborated in the administrative record.

1.4 Proposed Action

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

The proposed action seeks to manage the lower Arroyo Grande Creek and a portion of Los Berros Creek (tributary to Arroyo Grande Creek) for the next 16 years through a comprehensive set of actions designed to achieve higher flood-control capacity of the leveed, lower three miles of Arroyo Grande Creek channel and the Los Berros Creek channel. The increased flood-control capacity will provide flood protection up to a 10-year storm event. Major elements of the proposed action include: reducing channel roughness to achieve increased flood conveyance, long-term vegetation management, long-term sediment management, an increase in the height of portions of the existing levee system including freeboard[1], and habitat alteration through construction of permanent log structures within only the Arroyo Grande Creek channel. Each element above involves construction-related activities and long-term operation (implementation) of the program provisions. Elements of the proposed action are described in detail as follows.

Vegetation Management: The proposed vegetation management program for Arroyo Grande Creek will consist of maintaining a 10-foot vegetation buffer on both sides of the low-flow channel; the width of the low-flow channel is currently about 25 feet. Where riparian vegetation exists on the Los Berros Creek Channel, a 5-foot vegetation buffer will be maintained on both sides of the active low-flow channel. The width of each buffer would be measured at breast height, though the measured width may not necessarily represent the width of the riparian canopy. Woody vegetation outside of the buffer would be removed completely to allow for high flows to access secondary channels (see sediment management program), thus providing increased conveyance and flood capacity. Woody and non-woody vegetation within the buffer will be undisturbed, with the exception of trees that have fallen over and are a risk to the integrity of the levee (*e.g.*, lodged against levee or bridge) or have the potential to increase the risk of flooding (*e.g.*, have fallen across the channel and are obstructing flow). If a tree is removed because it has fallen over, the root ball will be left intact to enable re-sprouting and to help stabilize soils.

[1]The design freeboard for the proposed action varies throughout the action area in accordance with the flood risk. Freeboard was increased for the north levee to protect dense residential areas and direct overtopping to the south where there are mostly farmland with only a few residences. The design freeboard has the *potential* to provide some areas with more flood protection (*e.g.*, 20-year flood event (or more)). However, the proposed action is designed to provide the entire project area with flood protection for up to a 10-year event (District feedback, December 8, 2015).

Areas within the buffer that are currently devoid of mature woody vegetation would be utilized for the purposes of mitigating the loss of woody vegetation that will occur elsewhere within the project site, outside of the buffer areas (Habitat Mitigation and Monitoring Plan (HMMP) 2014). Any tree initially removed outside of the buffer will be replanted inside the buffer during construction to raise the levees. To improve riparian habitat throughout both channels in addition to replanting existing trees within the buffer, remaining gaps in the riparian buffer would be revegetated with native riparian species including cottonwood, sycamore, alder, box elder, and willows (only the latter within the Los Berros Creek Channel) as close to a 2:1 ratio as possible using the Riparian Woodland Palette (HMMP 2014). This ratio is below the typical 3:1 ratio because space is limited for planting given scope of maintenance areas outside of the buffer. To ensure survival, the newly planted trees will be spaced no closer than 10 feet. Both efforts of replanting existing trees and introducing new woody vegetation within the buffer are intended to create a continuous riparian buffer throughout the action area (except at crossing sites explained below).

There are specific portions of the action area where the protective buffer management will not apply. All woody vegetation will be removed completely within the delineated buffer area occurring 40 feet upstream and 25 feet downstream of existing bridges. Existing bridges where proposed removal will occur include crossings at the following: Highway 1, 22nd Street, and the Union Pacific Railroad Road Trellis Bridge. Vegetation will be removed by hand crews and will include the use of mechanized and non-mechanized hand equipment such as chainsaws, loppers, etc., for approximately 195 feet of stream channel (*i.e.*, 65 feet of disturbed channel for each of the three crossings) in the action area. No debris will be allowed to enter the stream channel and debris from invasive species will be separated, bagged and disposed at a designated landfill. Native vegetation cut from the channel will be mulched on site and placed at the back side of the levees or hauled offsite.

Vegetation management activities will be combined with an active program to remove non-native vegetation from Arroyo Grande Creek. Non-native species to be actively removed include Himalayan blackberry, English ivy, fennel, weeping willow, giant reed, castor bean, poison hemlock, and geranium. Non-native species management activities will include use of goats, application of herbicides, or removal by hand of plant and root ball. Non-native vegetation removed from the channel will be bagged and disposed of accordingly to limit their spread. If herbicide applications are necessary, they will be conducted by an individual holding a valid Qualified Applicators License. The Qualified Applicator must use herbicides that are approved for use in and adjacent to aquatic areas (*i.e.*, Rodeo® or similar) (HMMP 2014).

With regard to attaining a desired channel roughness for flood-conveyance purposes, the District proposes that vegetation management would be conducted as often as necessary to maintain a composite channel roughness of 0.04 (see Figure 2-4 for relative comparison in roughness values). Vegetation management activities would likely occur annually. However, a measure of uncertainty is present because management will depend on the amount of re-growth and available District funding to implement long-term management. Based on vegetation management activities that have occurred over the last four years, regrowth of managed vegetation occurs during the spring and summer, requiring annual maintenance.

As part of the vegetation management, woody vegetation would be removed and then replaced with non-woody vegetation (riparian scrub and grasses) at a 2:1 ratio (HMMP 2014). The Transition Zone seed mix and Riparian Scrub Enhancement seed mixes will be used to achieve this ratio. Woody understory vegetation (*e.g.*, coyote brush [*Baccharis pilularis*]) would be replaced at a 2:1 ratio with the native non-woody (scrub or riparian) seed mix. The seed mix includes mulefat, mugwort, sky lupine, sticky monkey flower, and creek monkey flower.

With regard to the schedule and timing of vegetation management, woody vegetation removal would occur between July 1 and October 15 of any given year for Arroyo Grande Creek and Los Berros Creek. The extent of work needed after the first year will be determined with surveys and quantified for contracting purposes. This contract work is expected every year. The survey for annual vegetation management will identify areas of invasive plants to be targeted for removal and monitoring in subsequent years. With regard to overgrowth of non-native species, particularly in the Los Berros Creek channel, vegetation management to remove the invasive species would occur in early spring to prevent the vegetation from going to seed. If activities occur prior to July 1, protocols to avoid impacts to the low-flow channel will be followed. These will include a start date no earlier than April 15 and activities will occur when the channel is dry. Additionally, NMFS will have 30 days to review the vegetation management work plan before activities commence in re-establishing the initial phase (*i.e.*, first-year) condition (County 2010a)

Sediment Management: The Corps proposes a two-step process for sediment management within the action area to improve flood conveyance and modify the existing creek to a condition that will enhance sediment transport: (1) an initial phase of sediment removal that will be completed the first year (*i.e.*, first-year condition), and (2) a long-term sediment management program that will rely on periodic monitoring of sediment conditions in the channel and continually modifying conditions of the channel to maintain elements of first-year condition. Sediment removal might not be required again for several years or longer depending on factors that influence sediment distribution in the action area such as frequency and magnitude of storm events (BA 2015). When surveying indicates additional sediment removal is needed, plans will be prepared and submitted for review to the agencies in the work plan. The approach to achieve first-year condition, which is proposed to be maintained for the duration of the proposed action (16 years), is described below.

The first-year sediment program will involve removal of excessive sediment that has built up outside of the active channel to create artificial, secondary channels beyond the protective vegetative buffer; specifically, sediment would be removed to a depth of 1.5-foot above the existing riffle thalweg elevation in the leveed portion of the Arroyo Grande Creek channel and 1-foot above the existing riffle thalweg elevation of Los Berros Creek channel. Sediment that has accumulated as a bar feature in the vegetative buffers will not be removed. Secondary channels will be excavated in designated off-channel areas to create overflow paths during high-flow events. Based on the current configuration of the primary (low-flow) channel, secondary channels will crisscross the primary channel as the primary channel meanders between the levee-side slopes.

In the action area, secondary channels are expected by the District to become activated during higher flows, which on average, occur once a year. Sediment removal beyond the initial removal would occur in response to large floods or sedimentation events (approximately every 5 years). The amount and timing of future sediment management activities would be determined based on annual monitoring data and would be conducted to reestablish the designed elevation of the secondary channels established during the initial phase of sediment removal. Additionally, NMFS will have 30 days to review the sediment maintenance activities work plan before activities commence in re-establishing the initial phase (*i.e.*, first-year) condition (June 3, 2015, District document responding to NMFS' initial questions on the proposed action).

Placement of woody structures: First-year condition will require installation of large wood (log) structures in the action area. A total of 36 large wood structures will be installed. Two types of large woody structures, Type B and Type A, will be constructed at each primary and secondary channel intersection. One type of large wood structure (Type B Log-Habitat Structure) will be placed at the downstream end of each secondary channel as it joins the primary channel. The structure is expected to provide protection from any head-cutting into the secondary channel and therefore expected to enforce the location of the primary channel. The structure has also been designed to encourage pool scour at the confluence of the secondary and active channel and mimic an undercut bank. The second type of large wood structure (Type A Log-Habitat Structure) is expected to protect the head of bar that would exist at the downstream side of the secondary and active channel confluence. This structure would maintain the location of the secondary channels in relation to the primary channel while also creating a hard point that is designed to encourage turbulence and creation of a pool at the confluence of the channels. Although both types of structures are designed to meet different habitat and channel stability objectives, they are expected by design to promote pool scour, encourage variability in substrate and flow-field conditions, and provide deep pools and cover for steelhead. The lifespan of these structures is estimated to be 30 years.

Dewatering and relocation of steelhead: To construct the channel connections and woody structures, approximately 50 feet of the Arroyo Grande Creek channel at a total of 36 sites will need to be dewatered, totaling 1,750 feet of channel. Using steelhead density estimates of 0.6 fish per 100 feet of channel from the 2006 abundance surveys (Dvorsky and Hagar 2008), the District estimates approximately 11 juvenile steelhead will require relocation during dewatering activities for the entire action area. The proposed action incorporates protection measures to minimize effects on steelhead during dewatering.

Schedule for maintaining secondary channels: The objective of the annual-maintenance program is to keep the secondary channels open for flood flows, thus some maintenance of the secondary channels is expected over the long-term. Post first-year sediment-management activities will likely consist of an excavator, located on the top of the levee, scooping and removing built up sediment. Removed sediment will be placed in a dump truck, at the top of the levee, and then discharged off-site in a District-approved area. Long-term sediment management activities are not expected to involve removal of vegetation or use of equipment within flowing water. The District proposes to use the same work windows as the vegetation maintenance work window, July 1 to October 15.

Repair of Existing Levees: Under the proposed action, the District would repair the levees along a portion of Los Berros Creek channel and along Arroyo Grande Creek channel from the Highway 1 Bridge to approximately 1,500 feet upstream of Guittons Crossing to provide 10-year flood protection to surrounding agricultural and residential communities. In general, this effort will repair portions of the levees so that the height at particular locations will be at grade with the existing grade elsewhere along the levees. The repair effort is needed due to damage from vehicular and horse traffic, along with natural elements/weather, which have all cumulatively eroded the earthen levee in certain areas (May 25, 2017, District feedback). As part of the repair, the existing levees will be raised an average of 1.25 feet with the inside slope of the levee at 2:1, the outside levee at a slope of 1.5:1, and top of levee width not less than 15 feet. Although the District provided an average for the levee raise, the increase in levee height in specific location is likely to be higher or lower with some locations not being raised at all (BA 2015). The north levee will be 12 inches above the south levee throughout the project area and 24 inches above the south levee adjacent to the residential areas upstream of the 22nd Street Bridge. The design freeboard has the potential to provide these residential areas with more flood protection, possibly protection against a 20-year flood event (Drexhage 2015). Levee repairs will require 18,000 cubic yards of fill material. All levee-repair work would take place either on the top or the outside of the existing levee, where feasible, and not impinge upon the wetted channel.

Adaptive Management and Monitoring Plan: Under the proposed action, the District proposes to adaptively manage and monitor the action area over the life of operating the proposed action in Arroyo Grande and Los Berros creeks. In this regard, the proposed Mitigation and Monitoring Plan will guide long-term vegetation and sediment management within the action area.

To inform adaptive management, the proposed action defines performance measures (PM) and monitoring efforts (ME) for the vegetation monitoring plan and the sediment monitoring plan (as described in County 2010a). A summary of the PM and ME for vegetation management is as follows. The PM and ME for sediment management are presented subsequently.

- **PM 1**: Finalize the annual vegetation management work plan by July 1. The draft work plan will be submitted for review and comment by NMFS on or before May 1 with comments expected back from NMFS on or before June 1. The final work plan should be in place by July 1 for implementation. If invasive removal is needed, a final work plan just for invasive removal shall be in place by May 1. The work plan will address Performance Measures 2 through 4 (below).
- **ME 1**: Each year in late spring, a report will be prepared defining the proposed vegetation management work plan to be conducted in the summer and early fall. The work plan will incorporate field notes and maps to define the management actions that will be carried out each year. Issues addressed in the work plan will include proposed areas of revegetation based on mapped gaps in riparian vegetation, locations and densities for focused plantings of non-willow species, areas and species type of non-native removal efforts, and depictions of areas where woody vegetation needs to be removed outside the riparian buffers. The work plan should be detailed and specific enough to provide a year-to-year road map to the group tasked with conducting the proposed activities. Where feasible, woody vegetation outside of the buffer recommended for removal should be flagged to allow independent review by regulatory agency staff.
- **PM 2:** Increase riparian canopy cover. The primary objective of maintaining a riparian buffer is to create a continuous riparian canopy through the project area that provides benefit to terrestrial and aquatic species that rely on cover habitat, cool water temperatures, and other functions provided by a continuous and diverse riparian corridor. The intent of this

performance measure is to maintain or increase riparian canopy cover through the project area.

- **ME 2**: Measure canopy cover every three years and report the percent cover in the annual Vegetation Management Work plan. The area of measurement shall include that between the centerlines of the north and south levees and the east and west project boundaries.
- **PM 3**: Increase riparian species richness and density in the action area. Candidate species include but are not limited to sycamore, alder, and cottonwood. A performance target will be adapted as necessary during annual consultation with regulatory agencies.
- **ME 3**: Preparation of the first Vegetation Management Work Plan shall include (1) a description of the number and approximate diameter at breast height (DBH) of the existing candidate species within the project area and (2) a planting plan for candidate species. Each subsequent annual work plan shall include an update of the number of individual candidate species, the DBH, and a planting/maintenance plan, as applicable.
- **PM 4**: Achieve a riparian corridor that is free of invasive non-native species. An eradication strategy will need to be developed and discussed in the annual work plan. The performance target would be to conduct most of the eradication efforts prior to 2015 with no net increase in infected areas beyond 2015. Key species to eradicate would be *Arundo*, ivy, Himalayan blackberry, and castor bean. Removal techniques may include application of herbicide, removal by hand of plant and rootballs, or the use of goats.
- **ME 4**: Map the presence of significant areas of non-native invasive species within the project area.

A summary is presented below of specific PMs and MEs for the sediment-management element of the proposed action. Generally, the habitat monitoring will occasionally occur in the same year that sediment-management activities are undertaken, but the management plan will be prepared in May/June and the previously conducted habitat assessments would apparently inform the plan content (San Luis Obispo County 2015a). Monitoring instream habitat includes assessing the creation of pools and the zone of influence (*i.e.*, turbulent, aerated zones from water cascading over the placed log structures), including pools that form as a result of the natural log structures placed in the active channel. The surveying will be completed following the initial sediment removal and after the cross sections are established. This will assist in determining the amount of accumulation that occurs over a specific period of time. The frequency of future sediment removal activities are not known and could be unnecessary for several years or more (San Luis Obispo County 2015a).

- **PM 1:** Finalize a work plan for sediment management activities by September 1 of year prior to when activities are expected to occur. The work plan should be submitted for review and comment by NMFS on or before August 1 with expected comments back from NMFS within 30 days from receipt of the draft work plan (June 3, 2015, District document responding to NMFS' initial questions on the proposed action). The work plan will address Performance Measures 2 through 5.
- **ME 1:** Prepare, review and finalize work plan for sediment management.
- **PM 2:** Sedimentation in the action area does not reduce capacity in any one location beyond the defined freeboard.
- **ME 2:** Cross-section monitoring will be conducted periodically in the Arroyo Grande Creek channel to determine if sediment accumulation in the secondary channels has reduced conveyance to the extent where additional sediment management is required. Cross-section

monitoring data will be used in conjunction with the hydraulic model to determine if the levee freeboard has been compromised, *i.e.*, the freeboard must not be less than 2.0 feet. In any given year, if the cross-section data and modeling results show that a 4.6 year event cannot be contained without the freeboard, the District would prepare a sediment-management plan, based on the cross-section monitoring data, to remove sediment from the secondary channels to achieve 4.6 year flood protection with 2 feet of freeboard. If a 4.6-year event cannot be contained without freeboard, it severely limits the ability of Zone 1/1A to meet its obligations to residents in the District and will likely lead to another levee failure similar to the 2001 levee system breach on the south side. Cross-section monitoring and preparation of a sediment management work plan would consist of the following:

1. Permanent cross-section locations will be established along the project reach following sediment management activities to achieve the first-year condition (see Sediment Management section). Cross-sections will be established every 500 feet along the channel and at the upstream and downstream sides of each of the bridges.

2. All of the established cross-sections will be measured after first-year conditions are established and roughness will be estimated for each to establish a baseline. A report will be produced and a database established.

3. Periodically, at the discretion of the District, a portion of the cross-sections will be re-surveyed to evaluate the degree of sedimentation. The cross-sections surveyed in any given year will be incorporated into the hydraulic model along with the roughness estimates and a determination will be made regarding the need for dredging of any secondary channels.

4. Re-surveying of established cross-sections should occur as early as possible following the cessation of winter rains (*i.e.*, April/May). A report cataloging the results of the survey will be used to determine if a sediment management plan is necessary.

5. If sediment management is required, a sediment management plan will be prepared outlining where sediment management is needed, what quantity of sediment will be removed, when the activity will occur, and what equipment and approach will be used. The sediment management plan will be submitted to the agencies for review and comment.

6. If a sediment management plan is prepared, it will be submitted for comment to the agencies by August 1 of the year prior to any proposed dredging activities. NMFS' comments are expected 30 days after the submittal of the draft plan.

- **PM 3:** Sediment management activities in the project area do not result in long-term aggradation in the lagoon and loss of lagoon volume. Evaluation of this performance measure will require a survey of the lagoon prior to the first year of sediment management activities to establish a baseline condition. The performance goal will be to avoid a measurable trend toward lagoon filling beyond the range of observed variability created by cycles of an open and closed lagoon mouth (*i.e.*, natural breaching events triggered by elevated spring or winter flows during a storm event). Changes (or variability) in lagoon volume are caused in part by the flow as driven by the initial stored water volume behind the barrier beach, tidal prism, river flow, set up of water against the lagoon side of the barrier beach by wind, barrier elevation, volume above mean sea level, and longshore and cross-shore sediment transport on the ocean side. Given these factors and evidence of channelization since 1934 along with regulated flows from Lopez Dam since 1969, the District chose a deviation of +/- 25 percent from observed variability in lagoon volume based on a six year moving average of measured conditions.

- **ME 3:** To evaluate potential long-term sediment impacts on the lagoon from sediment management activities in Arroyo Grande Creek and to detect if the 25 percent variability threshold has been reached, cross-sections will be established in the lagoon.

  1. A total of four cross-sections will be established, approximately equally spaced throughout the lagoon. The cross-sections were established in 2010 to develop a baseline and to understand year-to-year natural variability in lagoon morphology prior to initiation of long-term sediment management activities.

  2. The four cross-sections will be monitored every 3 years following the first year sediment management activities and a report will be prepared.

  3. If after 9 years sediment management shows no effect on the lagoon (*i.e.*, sediment impacts to the lagoon remain within the 25 percent variability range), then cross-sections monitoring will be reduced, following discussions with regulatory agencies.

- **PM 4:** Increase or maintain the cover rating through the project reach. Cover habitat is important for rearing juvenile steelhead, especially with the known presence of non-native predatory species, as well as providing refuge areas for adult steelhead during high flow conditions. A current cover rating will need to be established for the project area. Depending upon the timing of first year sediment management activities additional surveys may be required to establish current channel conditions (*i.e.*, the amount and extent of cover habitat for steelhead).
- **ME 4:** To evaluate changes in aquatic habitat conditions in the action area, habitat assessments will be conducted through the project reach every three years using protocols established in the California Salmonid Stream Habitat Restoration Manual (Flosi *et al.* 1998). The habitat assessment will repeat the work conducted by the California Conservation Corps in 2004 or a later survey if it is determined to represent a more accurate current channel condition. The assessment work will be conducted in late summer/early fall of each monitoring year with a report prepared and submitted by December 1. The report will also include recommendations for adaptive management.
- **PM 5:** Increase or maintain average maximum pool depth through the project reach. A long-term goal of the project is to improve local scour to enhance pool formation. A baseline of average maximum pool depth was established for the action area through the last comprehensive habitat survey of the project area in 2004 by the California Conservation Corps. Depending upon the timing of first year sediment management activities additional surveys may be required to establish current channel conditions.
- **ME 5:** Same as ME 4.

Minimization Measures: The proposed action incorporates a number of measures that are intended to minimize adverse effects on threatened steelhead. A summary of these measures follows, including a list of proposed best-management practices (Table 1). Readers wishing for additional details regarding the proposed minimization measures are referred to the biological assessment.

When feasible, all work activity occurring within the active low-flow channel shall be conducted when the channel is dry or at its lowest flow condition (late summer). When it is not feasible to work in a dry channel, the District will dewater a portion of the active channel to complete the work activity. If management or construction activities require the temporary dewatering and relocation of steelhead, these activities will utilize gravity flow and, where temporary surface-water diversions are needed, diversions will be constructed independently for each project element, or group of project elements, to minimize the duration that any particular segment of stream channel is dewatered.

Dewatering activities may require the temporary relocation of steelhead. To minimize adverse effects to steelhead, the proposed action requires the following measures:

- Block nets will be placed at the upper and lower extent of the diversions or coffer dams to ensure that steelhead upstream and downstream do not enter the areas proposed for dewatering. Block nets will not be removed until installation of all cofferdams, bypass pipes or channels, diversion dams or other facilities designed to dewater or divert flow, are completed.
- If electrofishing techniques are utilized during steelhead relocation activities, at least one member of the field crew will be familiar with NMFS electrofishing guidelines and have a minimum of 100 hours of field experience with electrofishing techniques.
- Electrofishing may not be performed if water temperatures exceed 18°C, or could reasonably be expected to rise above this temperature during the activities.
- Electrofishing shall not be utilized in areas where water conductivity is greater than 350 uS/cm. Only direct current (DC) shall be used. At least one assistant shall aid the biologist during electrofishing by netting stunned steelhead and other aquatic vertebrates.
- Each electrofishing session must start with all equipment settings (voltage, pulse width, and pulse rate) set to the minimums needed to capture steelhead. These settings should be gradually increased only to the point where steelhead are immobilized and captured, and not allowed to exceed the specified maxima:
    - Voltage = 100V (Initial) – 400V (Max); Pulse width= 500 uS (Initial) – 5 uS (Max);
    - Pulse rate = 30 Hz (Initial) – 70 Hz (Max).
- A minimum of three passes with the electro-fisher will be utilized to ensure maximum capture probability of steelhead within the area proposed for dewatering, unless the number of steelhead captured in the second pass is less than 10 percent of the first pass. In that case, two passes are adequate. If steelhead are present on any pass, a minimum of 20 minutes will separate the beginning of each pass through the Project reach to allow time for steelhead that are not captured to become susceptible to electrofishing again.
- All captured steelhead will be held in water with temperatures not greater than ambient in-stream temperatures. If cooling is used, water temperatures will be maintained not more than three degrees Celsius less than ambient in-stream temperatures. All captured steelhead will be held in well oxygenated water, with a dissolved oxygen level of not less than seven

parts per million. Prior to release, the following information shall be recorded: 1) enumerate fish by species, 2) visual determination of age of steelhead, 3) enumerate steelhead injuries and fatalities by age class, 4) enumerate successfully relocated steelhead by age class for each relocation site, and 5) date and time of release of steelhead to each relocation site. Steelhead shall be subject to the minimum handling and holding times required. All captured steelhead will be allowed to recover from electrofishing and other capture gear before being returned to the stream. All captured steelhead will be processed and released prior to any subsequent electrofishing pass or netting effort.

- All captured steelhead will be released upstream of the block nets to facilitate redistribution into flowing water following construction activities and re-watering of the channel.

Table 1. Description of the Best Management Practices that are incorporated in the proposed action for the purpose of minimizing water-quality impacts (BA 2015).

Best Management Practice	Intent of Best Management Practice
No persons, equipment, or material shall be allowed outside the designated limits of disturbance.	Use of only the approved access routes shown on the plans.
The stockpile areas shall be fully enclosed with silt fence and boundary fence.	Avoid sediment entering the active channel.
All equipment shall be stored, maintained and refueled in a designated portion of the stockpile area.	The contractor shall adhere to a spill prevention plan, to be prepared by the contractor and submitted for review by the engineer.
Contractor shall immediately stop all operations during a spill.	Devote all on-site personnel to the containment and cleanup of any fuel, fluid or oil spill, to the satisfaction of the engineer.
The contractor shall be responsible for the regular cleaning of all mud, dirt, debris, etc., from any and all adjacent roads and sidewalks.	The contractor shall be responsible for continuous dust control in accordance with the conditions of the permits.
All excess soil shall be disposed of off-site.	Minimize risk of excess soil remaining in the project area.
No debris, rubbish, creosote-treated wood, soil, silt, sand, cement, concrete, or washings thereof, or other construction-related materials or wastes, oil, or petroleum products or other organic material or earthen material shall be allowed to enter into, or be placed where it may be washed by rainfall or runoff into the active stream channel of either the Arroyo Grande or Berros creeks.	Any of these materials placed within or where they may enter the creek shall be removed immediately. When construction is complete, any excess material shall be removed from the work area so that such materials do not wash into either creek.
All disturbed areas of bed and bank shall be stabilized, winterized, and vegetated with appropriate native vegetation prior to the end of the work window.	Adequate erosion control measures shall be constructed and maintained to prevent the discharge of earthen materials to the creeks from disturbed areas under construction and from completed construction areas.
No equipment shall be operated in areas of flowing or standing water. No fueling, cleaning or maintenance of vehicles or equipment shall take place within any areas where an accidental discharge to the creek may occur; construction material and heavy equipment must be stored outside of the ordinary high water mark.	All work done within the creek shall be completed in a manner so as to minimize adverse effects to steelhead and their habitat; measures shall be employed to minimize disturbances along the channel that will adversely affect the water quality of the creeks.

“Interrelated actions” are those that are part of a larger action and depend on the larger action for their justification. “Interdependent actions” are those that have no independent utility apart from the action under consideration (50 CFR 402.02). There is no activity that is interdependent or interrelated with the proposed action.

1.5 Action Area

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

The action area is within San Luis Obispo County, California, near the City of Arroyo Grande and the community of Oceano. The action area is entirely within the unincorporated areas of San Luis Obispo County. The action area is a linear corridor with two segments: (1) beginning on Arroyo Grande Creek 0.14 miles upstream of the confluence of Los Berros Creek and continuing downstream to and including the confluence of Arroyo Grande Creek Lagoon with the Pacific Ocean, and (2) beginning at the Century Lane Bridge on Los Berros Creek and continuing downstream to the confluence with Arroyo Grande Creek. This area is within Flood Control Zone 1 (Arroyo Grande Creek channel)/1A (Los Berros Creek channel) (Appendix A).

The total length of creek channels considered in the proposed action is approximately 3.5 miles. The action area on Arroyo Grande Creek covers 2.8 miles of designated critical habitat for threatened steelhead, out of a total of 13 miles of critical habitat for this creek system (21.6% of critical habitat); the action area on Los Berros Creek covers 0.7 miles out of a total of 10.78 miles of critical habitat for this creek system (6.5% of critical habitat).

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

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

2.1 Analytical Approach

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

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

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

- Identify the range-wide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.
- Reach jeopardy and adverse modification conclusions.
- If necessary, define a reasonable and prudent alternative to the proposed action.

To conduct the analysis, NMFS examines an extensive amount of information from a variety of sources. Specifically, NMFS utilizes the "best scientific and commercial data available"[2] standard to develop the content of biological opinions. For example, NMFS relies on the principal conventional sources of acceptable scientific information: peer-reviewed, published ecological literature, grey literature, and expert opinion regarding the effects of anthropogenic habitat changes on the species and their habitat. Further, detailed background information on the biology and status of the species and critical habitat has been published in a number of documents including peer-reviewed scientific journals, primary reference materials, and governmental and non-governmental reports. For information that has been taken directly from published, citable documents, those citations have been referenced in the text and listed at the end of this document.

Additional information regarding the effects of the proposed action on the listed species in question, their anticipated response to these actions, and the environmental consequences of the actions as a whole was formulated from the aforementioned resources referenced in the Consultation History section including information submitted by the Corps and the District (*e.g.*, BA 2015, Corps 2016a). The effects, including the degree and extent of the expected effects, are informed by the District's own environmental and commissioned documents. The intensity, severity, and extent of adverse effects are presented within the limits established by the available information, including information contained in the scientific literature.

As a reminder to the reader, the District is seeking a 16-year Corps permit for the proposed action, however, indirect effects of maintaining (repairing) the existing levee will extend far into the future. Therefore, NMFS expects the proposed action will have indirect effects with a duration of at least 50 years.

[2] Endangered and Threatened Wildlife and Plants: Notice of Interagency Cooperative Policy on Information Standards under the Endangered Species Act. Available here: http://www.nmfs.noaa.gov/pr/pdfs/fr/fr59-24271.pdf

2.2 Range-wide Status of the Species and Critical Habitat

The status, or level of extinction risk, of threatened S-CCC steelhead is primarily based on parameters considered in their recovery plan, status reviews, and listing decisions. The status of the species informs the description of the species' likelihood of both survival and recovery, and the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The following information summarizes the range-wide status of steelhead and designated critical habitat for this species.

2.2.1 Overview and Summary Status of the Listed Species, and Terminology

Oncorhynchus mykiss exhibit two principal life-history forms: "anadromous" and "resident." The anadromous form spends a portion of its overall life history in the ocean before returning to freshwater for spawning. The resident form spends its entire life in freshwater. Only the anadromous form and their progeny originating downstream of impassable barriers to upstream migration are listed under the ESA. The terms "steelhead" and "anadromous *O. mykiss*" are often used to describe the anadromous form and in this regard are used in this biological opinion. The listed unit of anadromous *O. mykiss* is termed a "distinct population segment" or DPS (NMFS 2006), and the listed unit contains several individual or fish-bearing watersheds. In accordance with the listing decision, this biological opinion uses the DPS terminology and provides NMFS' conclusion as to the likelihood of jeopardy to the species based only on effects to the listed DPS.

The status of the S-CCC steelhead populations was assessed by NMFS' Biological Review Team (BRT) in 1996 (Busby *et al.* 1996), 2005 (Good *et al.* 2005), 2011 (Williams *et al.* 2011), and 2016 (NMFS 2016a). Abundance of adult steelhead in the S-CCC DPS declined from a historical high abundance of 25,000 returning adults, to an estimate of 4,750 adults in 1965 for five river systems (Pajaro, Salinas, Carmel, Little Sur, and Big Sur) (CDFG 1965), to fewer than 500 adults currently (Boughton and Fish 2003, Good *et al.* 2005, Helmbrecht and Boughton 2005, Williams *et al.* 2011).

In 2002, steelhead occurrence was assessed in most of the coastal drainages between the northern and southern geographic boundaries of south-central California (Boughton and Fish 2003). Steelhead were considered to be "present" in a basin if adult or juvenile *O. mykiss* were observed in any stream reach that had access to the ocean (*i.e.*, no impassable barriers between the ocean and the survey site), in any of the years 2000–2002 (*i.e.*, within one steelhead generation). Of 36 drainages in which steelhead were known to have occurred historically, between[3] 86% and 94% were currently occupied by *O. mykiss*.

The S-CCC DPS of threatened steelhead is at risk of becoming endangered in the foreseeable future. The subject DPS is listed under the ESA as a "threatened" species, which the ESA defines as:

> "…any species which **is likely to become an endangered species** [emphasis added] within the foreseeable future throughout all or a significant portion of its range."

[3] The range in the estimate of occupancy occurs because three basins could not be assessed due to restricted access.

NMFS' latest 5-year status review for the S-CCC DPS of steelhead states the following:

> "The extended drought and drying conditions associated with projected climate change has the potential to **cause local extinction** [emphasis added] of *O. mykiss* populations and thus reduce the genetic diversity of fish within the South-Central California Coast Steelhead Recovery Planning Area." (page 55, NMFS 2016)

Moreover, NMFS' recent assessment of viability for steelhead provides an indication that the S-CCC DPS may be currently experiencing an increased extinction risk (Williams *et al.* 2016). Evidence for this increase in extinction risk is a fairly steady 15-year decline in abundance of anadromous adults in the Carmel River, which is the one population within the S-CCC DPS range with a reasonably long history of monitoring.

2.2.2 Steelhead Biology and Ecology

Oncorhynchus mykiss is one of seven Pacific salmonid in the genus *Oncorhynchus* that are native to the Pacific Coast of North America. Globally, steelhead are found in the western Pacific through the Kamchatka Peninsula in Asia, east to Alaska, south to southern California, and even reported in Baja California del Norte (Ruiz-Campos and Pister 1995).

The S-CCC DPS of steelhead is near the southern limit of the anadromous form of *O. mykiss* in North America, and the DPS includes all naturally spawned anadromous populations of *O. mykiss* in coastal river basins from the Pajaro River in Monterey County southward to but not including the Santa Maria River in San Luis Obispo County. South of the Big Sur coast, steelhead populations include San Simeon, Santa Rosa, San Luis Obispo, Pismo, and Arroyo Grande Creeks (62 FR 43937; 71 FR 834). In general, adult steelhead spawn in upstream reaches within coastal watersheds, and the progeny rear in freshwater or estuarine habitats prior to migrating to the sea.

A summary is below of steelhead life history and habitat requirements. Additional information on the biology and ecology of this species can be found in the South-Central California Coast Steelhead Recovery Plan (NMFS 2013) (see also Bjornn and Reiser 1991 for life history and habitat requirement information generally pertaining to the species, some of which is included in this presentation).

The major freshwater life-history stages of steelhead considered here involve river entry and upriver migration of adults to spawning habitat, adult spawning and incubation of embryos, freshwater rearing of juvenile steelhead, and smoltification and emigration of juveniles to estuary[4] and ocean environments. Each of these is summarized as follows.

***River entry and upriver migration of adults to spawning habitat*:** When elevated river discharge breaches the sandbar at the river mouth, usually in winter and early spring, adult steelhead leave the ocean and enter the freshwater river, typically their natal river, and begin what can represent a long upriver journey to natal spawning areas. Serving as an environmental cue, the elevated river discharge during and shortly after periods of rainfall in south-central California is essential for creating and maintaining migration opportunities for adult steelhead to swim upriver and navigate

[4] Our use of the term "estuary" in this biological opinion includes freshwater lagoons.

physical features normally constituting obstacles during relatively low river discharge. In this regard, the migratory behavior and ecology of adult steelhead is strongly associated with the natural pattern (*i.e.*, timing, frequency, duration, rate of change) and magnitude of river discharge (Shapovalov and Taft 1954).

The intended destination of adult steelhead in unimpaired waterways is typically the upper reaches, including small tributaries, where the flow-related characteristics and channel-bed conditions are well suited for the production of young (Montgomery *et al.* 1999). Indeed much of the spawning habitat for adult steelhead is often confined to upper reaches in a watershed. Steelhead must arrive at spawning areas at the proper time and in relatively good condition to increase the likelihood that the life cycle would be completed. Delayed upriver migration can lead to energy costs to migrants and failure to reach spawning areas (Hinch and Rand 1998, Geist *et al.* 2000, Caudill *et al.* 2006, Caudill *et al.* 2007).

***Adult spawning and incubation of embryos*:** The magnitude and duration of streamflow contributes significantly to the availability and quality of spawning habitat for steelhead. Streamflow defines the channel area that is wetted and establishes the distribution of water-column depths and velocities that are suitable for spawning. Upon reaching instream areas with suitable water-column depths and velocities and substrate particle types, female steelhead excavate a depression or pocket in the channel bed with tail undulations that are sufficient to mobilize certain particle types. Into this pocket the female and male steelhead will simultaneously release eggs and milt. Depending on the size of the female and the number of eggs deposited in each pocket, the spawning pair may continue to form new egg pockets in an upstream direction, enlarging the overall size of the nest.

When the adults are spent and spawning is complete, the adults begin the downstream journey with the intention of re-entering the ocean. Steelhead do not necessarily die after spawning and may return to the ocean, sometimes repeating their spawning migration one or more years. Occasionally, adult steelhead may remain or become trapped in rivers after spawning, typically as a result of exceedingly low streamflows, particularly during drought conditions (*e.g.*, Barnett and Spence 2011). Barnett and Spence (2011) observed 40 percent of steelhead kelts[5] during the summer were still alive in late October and in fair condition. Additionally, considering hydrologic conditions in northern California streams (Santa Cruz Mountains), authors believed movement of kelts through riffle habitats was negligible due to low stream flows, though hydrologic connectivity among habitats was maintained. In the context of the south-central California hydrologic regime, complete disconnect occurs between habitat units (*e.g.*, drying of isolated pools) resulting in less available over-summering habitat, thus a greater risk of extremely low over-summer survival rates for the threatened S-CCC DPS of steelhead. This underscores the importance of elevated streamflows that maintain pool habitat for the return journey of the adults to the ocean.

When selecting a site for spawning, an adult female is simultaneously selecting the site where the incubating embryos will remain for 3 to 8 weeks prior to hatching and a few weeks more before emerging from the nest and beginning free existence in the water column. Proper development of the embryos and the newly hatched young remaining in the gravel is best supported with spawning gravels relatively free of sand and smaller particles, which allows cool, clean, and well-oxygenated

[5]Adult steelhead that has successfully spawned and is returning to the ocean.

water to percolate through the nest. Depending on the location and depth of the gravel pocket that contains the young, nests can be susceptible to high flows capable of scouring the channel bed.

***Freshwater rearing of juvenile steelhead*:** Upon emerging from the gravel and beginning existence in the water-column, juvenile steelhead must find suitable habitat to sustain growth and survival. Habitat requirements of juvenile steelhead change as they grow and develop, and environmental features and conditions can influence the quality and availability of habitat for juvenile steelhead. These factors can compel juvenile steelhead to undertake movements in search of suitable habitat that ultimately lead to production of large smolts and a likelihood of better ocean survival (Hayes *et al.* 2011). This underscores the value of hydrologic connectivity within a watershed for growth and survival of juvenile steelhead; a watershed showing hydrologic connectivity is expected to favor full expression of various life history pathways (*e.g.*, emergence of young in upstream tributaries and movement downstream in spring and early summer to the mainstem river or estuary, and upstream return in fall, Hayes *et al.* 2008). By contrast, a watershed with limited hydrologic connectivity restricts fish movement and may only marginally support, if at all, these pathways, increasing the potential that the watershed would be unable to sustain growth and survival, and produce large smolts.

The open water column within streams represent the initial sites of rearing for life stages of juvenile steelhead, from the emergence of fry to the time when juveniles have grown sufficiently large for their seaward migration. The yolk-sac fry emerge from nests about 2 to 6 weeks after hatching, and forage along low-velocity channel margins and utilize gravel-cobble substrate and instream vegetation for cover. At first the fry congregate in schools, but as time passes the fish grow and spread throughout the stream, selecting individual territories with access to adequate cover and food (Shapovalov and Taft 1954).

Upon reaching around 70 to 80-mm in length, age-0 steelhead typically associate with low-velocity shallow areas of the stream, and constituent habitats such as shallow riffles and runs (Spina 2003, Spina *et al.* 2005). As juvenile steelhead grow, the habitats they prefer change and we see larger, older juveniles preferring deeper water, including pools for over-summering. In addition to water-column depth, the age-1 and older juveniles can associate with large woody debris, boulder clusters, and undercut stream banks. The larger, older juveniles may be more restricted to the parts of the watershed that provide shaded perennial pools of sufficient depth, and such habitats can be primarily concentrated in headwater streams well-fed by precipitation events, where baseflows are stable, riparian canopies relatively complete, and sediment transport and movement produce an abundance of pools (Harrison and Keller 2007, Boughton *et al.* 2009). During the dry season in river systems that provide a level of hydrologic connectivity, juvenile steelhead can access seasonal retreats within the available watershed network as dry-season flows decline and water quality changes (Bramblett *et al.* 2002, Hayes *et al.* 2011).

Seasonal estuaries (or freshwater lagoons) form when decreased streamflow allows marine processes to build a sand berm at the mouth of each river system. Juvenile steelhead can over-summer in these habitats, where rapid growth can lead to smoltification at an early age and large size at ocean entry, which enhances survival to adulthood (Ward *et al.* 1989, Hayes *et al.* 2008). In addition to supporting individual fish that migrate directly to the ocean, estuaries provide a seasonal rearing area for juvenile steelhead that subsequently migrate to and rear in upstream reaches (Hayes *et al.* 2011). Further, Hayes *et al.* (2011) observed juvenile steelhead moving between freshwater and estuarine habitats seasonally and adjusting their osmoregulatory physiology as needed. The presence of a properly functioning estuary in a watershed is crucial for allowing juvenile steelhead to pursue life-history pathways that favor growth and increases the likelihood of smolt-to-adult survival (Bond *et al.* 2008). The Arroyo Grande Creek Lagoon is typically closed by a sandbar during much of most summers, but in 2011, it was reportedly only closed for about one month beginning sometime in August -- 2003 was the last time the lagoon remained open all summer (Rischbieter 2012). When a sand berm closes the estuary, habitat capacity for juvenile steelhead may increase.

In fall and winter, baseflows can rebound in certain sections or reaches of streams as atmospheric temperature drops, and channels formerly dry during the summer can begin flowing again, even before the first wetting rains arrive. Juveniles captive in isolated habitats and reaches can now gain access to a much larger area of instream habitat. During winter high flows, juvenile salmonids temporarily seek low velocity, off-channel habitats such as backwater pools, side channels, and inundated woody riparian vegetation that serve as refugia.

***Smoltification and emigration of juveniles to ocean*:** Transformation of steelhead parr into smolts is the preparation for ocean existence and includes changes in shape and color, osmoregulation (salt balance) and energy storage (Quinn 2005). The species become smolts and migrate to the ocean at an early age, typically before age 3 (Hayes *et al.* 2008, Hayes *et al.* 2011). Larger size at ocean entry is known to increase ocean survival and return of adults to natal streams (Ward *et al.* 1989). For this reason, a waterway that produces a large number of sizeable smolts is expected to experience high returns of adult steelhead.

Hydrologic connectivity in a coastal watershed is essential if juvenile steelhead are to undertake the annual downstream migration to river mainstems and subsequently the estuary as part of their anadromous life cycle. Watersheds with ample hydrologic connectivity allow juveniles to leave upper reaches and migrate downstream through progressively large tributaries and arrive at mainstem confluences, then downstream through river mainstems, ultimately reaching the estuary and, for some individuals, the ocean. This route of travel contrasts with the truncated route of juveniles in watersheds where intermittent hydrologic connectivity precludes individuals from safely transitioning from one reach to another - this often traps the fish in habitats prone to desiccation, especially in watersheds where water development is prevalent.

For smolts that successfully reach the ocean, the individuals grow and reach maturity at age 2 to 5 while in the ocean. This ocean-going life history pattern, known as anadromy, leads to more rapid growth than can be accomplished by nonanadromus individuals that spend their entire life in freshwater.

The downstream movement of juvenile steelhead appears related to photoperiod (day length), temperature, and the magnitude of streamflow, with periods of elevated discharge during and shortly after rainfall events witnessing the largest number of downstream migrants (Spina *et al.* 2005). The strong positive association between the number of downstream migrants and magnitude of streamflow underscores the importance of streamflow magnitude for ensuring that the emigrants reach intended downstream destinations. As a result, factors that artificially affect the pattern and magnitude of streamflow have the potential to impact migration opportunities for smolts and their arrival at target habitats. In addition to low streamflow, high water temperature, physical barriers, low dissolved oxygen, and high turbidity can delay or halt downstream migration of juveniles and subsequent entry into estuary, lagoon, or ocean.

2.2.3 Summary Status of Designated Critical Habitat for the Species

We summarize here relevant information from the final rule (NMFS 2005; 81 FR 7414) regarding the physical or biological features of designated critical habitat essential to the conservation of the species and factors with the potential to affect critical habitat, including critical habitat within the action area that is the basis of this biological opinion.

***Underlying rationale for the designation of critical habitat*:** Section 3 of the ESA defines critical habitat as (1) specific areas within the geographical area occupied by the species at the time of listing, on which are found those physical or biological features that are essential to the conservation of the listed species and that may require special management considerations or protection, and (2) specific areas outside the geographical area occupied by the species at the time of listing that are essential for the conservation of a listed species. NMFS therefore undertook an extensive effort to identify critical habitat for threatened steelhead, and because a description of the effort is beyond the scope of this biological opinion, readers should reference the final rule regarding designated critical habitat for additional discussion and rationale behind the designation.

***Designation of critical habitat for threatened steelhead*:** The designation of critical habitat for threatened S-CCC steelhead uses the term primary constituent element or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a “destruction or adverse modification” analysis, which is the same regardless of whether the original designation identified primary constituent elements, physical or biological features, or essential features. In this biological opinion, NMFS uses the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The critical habitat designation for the S-CCC DPS of steelhead involves the sites necessary to support one or more steelhead life stages and, in turn, these sites contain the physical or biological features essential for conservation of the DPS. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas (see Table 2-1 for a detailed description of these sites). Activities with the potential to affect critical habitat for the S-CCC steelhead include: (1) groundwater extraction, (2) grazing and related rangeland activities, (3) agriculture and related water withdrawals, (4) road building and maintenance, (5) flood control, levees and channelization, (6) urbanization, (7) sand and gravel mining, (8) mineral mining, (9) dams, (10) irrigation impoundments and water withdrawals, (11) wetland (including estuaries) loss or removal, (12) introduction of exotic or invasive species, and (13) impediments to fish passage. Other typical problems were thought to be habitat degradation in the form of logging on steep erosive slopes and artificial breaching of estuaries during periods when they are normally closed off from the ocean by a sandbar (Good *et al.* 2005). The majority of estuaries and lagoons across the designation for the DPS continue to degrade as a result of upstream activities that alter natural flow patterns from the upper watershed to the lower floodplains, which are commonly disconnected from the historical floodplain. For example, Arroyo Grande Creek has an estimated 20 percent of historical estuarine habitat remaining (NMFS 2013). Other systems in the S-CCC DPS with 20 percent or less of estuarine habitat remaining include: Pajaro River, Salinas River, San Jose Creek, and Morro Creek.

Table 2-1. Physical or biological features (PBFs) of designated critical habitat (NMFS 2005, 81 FR 7414) that are relevant to this consultation and proposed action.

PBF	Description
Freshwater migration corridor	Free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
Freshwater spawning sites	Water quantity and quality conditions and substrate supporting spawning, incubation and larval development.
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
Estuarine areas	Free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

2.2.4 Condition of Critical Habitat throughout the Designated Area

This section provides a snapshot of the condition of critical habitat for threatened steelhead across the south-central California landscape. Additional information about the condition of critical habitat is included in the sections that follow.

The designated critical habitat throughout the south-central California coastal and inland landscape is not functioning properly, owing to a variety of human activities that have caused habitat destruction, modification, and curtailment (NMFS 2013). Much of the habitat is currently unable to support various life-history stages of the species, including migration to and from historical spawning and rearing habitats and the ocean, and over-summering in the river mainstem and estuary. The construction and ongoing operation of surface water storage-diversion projects and groundwater withdrawals, stream channelization for flood control, and conversion of wildlands through development and land use, have dramatically reduced the quality and availability of habitat for this threatened species and contributed significantly to the reduction in steelhead distribution, particularly in mainstem habitats such as the Pajaro and Salinas Rivers, and Pismo and Arroyo Grande Creeks (Busby *et al.* 1996, Boughton *et al.* 2005, Good *et al.* 2005, NMFS 2013). Gross over-allocation of water resources (Grantham *et al.* 2014) in the absence of meaningful streamflow provisions for steelhead (Spina *et al.* 2006) continues to reduce and, in certain locations, eliminate the quality and amount of living space for steelhead across the regional landscape. The reductions in the amount and extent of streamflow are one of the major factors responsible for range-wide declines in steelhead abundance (Hedgecock *et al.* 1994, Moyle 1994).

In terms of the actual mechanisms underlying the improperly functioning condition, dams have disrupted the natural pattern and magnitude of streamflow and movement of sediment and organic debris in coastal waterways and the estuaries of south-central California (Willis and Griggs 2003, NMFS 2013). Because the natural movement of water and organic and inorganic debris is vital for the creation and maintenance of essential habitat features anadromous salmonids require for proper life-history evolution and maintenance (Beechie and Bolton 1999, Beechie *et al.* 2010), the man-made disruption of natural fluvial processes has translated into inhospitable habitat characteristics and condition for steelhead, and loss or reduction of important life-history traits such as anadromy and migration of juvenile steelhead to the estuary or ocean.

The available information indicates the characteristics and condition of river mainstems were capable of supporting over-summering juvenile steelhead (Boughton *et al.* 2006). Flowing year round, historical accounts indicate mainstem areas possessed extensive riparian corridors and the complexity of meso-habitats that often attract multi-year freshwater rearing of steelhead (Spina *et al.* 2005). Due to a variety of anthropogenic activities, principally development of water resources and flood-control projects, mainstem habitats throughout the critical habitat designation have been significantly altered in a number of ways that have the overall effect of diminishing the functional value of mainstem habitats for supporting life history function and habitat requirements of steelhead (Shapovalov 1944, Boughton *et al.* 2005, NMFS 2013). Although the foregoing characterizations of stream conditions is largely representative of most coastal watersheds within the critical habitat designation, a few select watersheds are relatively least disturbed (*e.g.*, San Carpoforo and Arroyo de la Cruz) with aquatic habitat characteristics and condition appearing consistent with life history and habitat requirements of threatened steelhead. Unfortunately, such waterways in the range of the S-CCC DPS of steelhead, particularly in San Luis Obispo County, are few and generally experience disturbance from agriculture and groundwater extraction (NMFS 2013).

San Luis Obispo County is the southern-most area within the range of the S-CCC DPS where steelhead runs still occur. Because steelhead have undergone marked declines and current data were inadequate to ensure proper management of the resource, a special study was undertaken to survey six coastal streams--representing a cross section of stream conditions and impacts (County 2007). The study identified specific activities impinging upon the steelhead streams including modification of riparian vegetation, de-watering and impoundment, channelization and agricultural/urban developments. The loss of riparian vegetation is the consequence of channelization (Arroyo Grande Creek), urban intrusion (Santa Rosa, Arroyo Grande, and Morro Creeks) and agricultural appropriation (all streams) (County 2007).

Approximately 75 percent of estuarine habitats across the S-CCC Steelhead Recovery Planning Area have been lost, and the remaining 25 percent is constrained by agricultural and urban development, levees, and transportation corridors such as highways and railroads (NMFS 2013). Loss of wetland estuarine acreage reduces the functional ability of rearing habitat to support the life-history requirements of the species before ocean entry. Of particular note, the lower reaches of the Pajaro River and the Salinas River drainages meandered across a broad coastal plain to create a single estuarine complex that extended from Watsonville in the north to Marina in the south. However, today, the mouths of the Pajaro River and the Salinas River at the Pacific Ocean are separated from each other by approximately ten miles due to agricultural and urban developments (NMFS 2013). In the same manner for the action area and adjacent areas, an 1837 map shows Pismo Creek and/or Meadow Creek joining Arroyo Grande Creek at the Oceano Lagoon area, and today, Meadow Creek is hydrologically disconnected from the Pismo Creek watershed except in storm events when overflow can enter the Pismo Creek Lagoon through a flood gate next to the Cypress Street Bridge (CCSE 2009). Meadow Creek now flows into the Oceano Lagoon. There are also flood gates that control flows from the Oceano Lagoon to the Arroyo Grande Creek Lagoon. Collectively, these gates control the extent and duration of hydrologic connectivity of these waterways during the rainy season to prevent floods in the surrounding communities (see NMFS' October 19, 2011, letter to the County for the proposed Oceano Lagoon Management Plan/Program).

2.2.5 Climate Implications for Status of S-CCC Designated Critical Habitat

Changes in sea level, which have the potential to adversely affect important estuarine habitats, have already been reported and are expected to continue (Cayan *et al.* 2008, 2009, Ganju and Schoellhamer 2010). Researchers have projected by 2035-2064, global sea level rise will range between 6 and 32 cm above 1990 levels, regardless of emission scenarios. Between 2070-2100, the projected range of sea level rise varies between 11-54 cm to 17-72 cm depending on the emission scenario, however, based on guidance from NMFS' national climate change and ESA policy (NMFS 2016c), we use the high emissions scenario aligning with the higher magnitude range of sea-level rise (17-72 cm). These more recent estimates suggest a larger rise in sea level than previously projected by Hayhoe *et al.* (2004). A rise in sea level will most dramatically affect estuaries confined by surrounding development because their inland boundaries are prevented from naturally adjusting in response to ocean inundation.

As of this writing, the ongoing drought affecting California has led to unprecedented dry conditions in south-central California, including the observation of no flowing surface water extensively throughout reaches that would normally be accessible to steelhead. Many stream reaches that are downstream of introduced migration barriers throughout the critical habitat designation have experienced little to no flowing surface water, or surface flows that are greatly truncated over time and space, for the last five years, owing to the below-normal precipitation. These atmospheric conditions have worsened the ongoing effects of anthropogenic activities and related inability of many streams throughout the critical habitat designation to sustain life-history requirements of this species. The extended drought and the lack of comprehensive monitoring, has also limited the ability to fully assess the status of individual populations and the S-CCC DPS as a whole (NMFS 2016a).

Although it remains unclear if the current drought is due to climate variability rather than climate change, global climate change is likely to lead to increased temperatures and changes in the amount and timing of rainfall (Mannion 1995, USGCRP 2009, McClure *et al.* 2013). Specifically, future projections include increased variability of precipitation (drier dry years, wetter wet years) (DWR

2006, Largier *et al.* 2010) and increased frequency of extreme winter precipitation events (DWR 2006). Also, extreme precipitation events and flooding can affect the timing and overall supply of sediment coming from smaller tributaries (Hestir *et al.* 2013). Ultimately, climate change will probably reduce the resilience of ecosystems to natural and human disturbances and further constrain freshwater and estuarine ecosystem management.

El Niño events and periods of unfavorable ocean-climate conditions have resulted in significant swings in returning spawning run-sizes, and can threaten the survival of steelhead populations already reduced to low abundance levels due to the loss and degradation of freshwater and estuarine habitats. However, periods of favorable ocean productivity and high marine survival can temporarily offset poor habitat conditions elsewhere and result in dramatic increases in population abundance and productivity by increasing the size and correlated fecundity of returning adults. Overall, the pattern of these threats have remained essentially unchanged since the last status review (Williams *et al.* 2011), though the threats posed by environmental variability (from projected climate change and related ocean conditions) are likely to exacerbate this factor affecting the continued existence of the species (NMFS 2016a).

Studies examining the effects of long-term climate change to salmon and steelhead populations have identified a number of common mechanisms by which climate variation is likely to influence sustainability of salmon and steelhead populations. These include direct effects of temperature such as mortality from heat stress, changes in growth and development rates, and disease resistance. Changes in the flow regime (especially flooding and low-flow events) also affect survival and behavior. Expected behavioral responses include shifts in seasonal timing of important life-history events, such as adult migration, spawning, fry emergence, and juvenile migration. The movement of juvenile steelhead between upstream reaches and the estuary may be disrupted by changes in late spring, summer and early fall base flows (*e.g.*, Boughton *et al.* 2009, Hayes *et al.* 2011).

2.2.6 Population Viability

One prerequisite for predicting effects of an action on a species (including establishing a point of reference for effects analysis) involves an understanding of whether the DPS is likely to experience a reduction in the likelihood of becoming viable, *i.e.*, hypothetical state(s) in which extinction risk of the DPS is negligible and full evolutionary potential is retained (Boughton *et al.* 2006). By definition, a viable DPS is composed of viable salmonid populations (VSP) that are independent populations of Pacific salmonids (genus *Oncorhynchus*) that have a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame. Other processes contributing to extinction risk (catastrophes and large-scale environmental variation) are also important considerations, and involve drought (and associated features such as high temperatures, low streamflow, lack of sandbar breaching at the mouths of rivers), floods, and wildfire. The influence of environmental stochasticity on the DPS is expected to be high, and because environmental stochasticity increases extinction risk, the S-CCC DPS requires larger average sized populations than a DPS that is not as affected by chance fluctuations in environmental conditions (Boughton *et al.* 2006).

Four principal parameters are used to evaluate the long term viability and conversely the extinction risk for the populations that make up the threatened S-CCC DPS of steelhead. They are: (1) abundance; (2) population growth rate; (3) population spatial structure; and (4) population diversity. These specific parameters are important to consider because they are predictors of extinction risk and reflect general biological and ecological processes that are critical to the growth and survival of steelhead populations, and they are measurable (McElhany *et al.* 2000). The bases for these concepts can be found in the many publications regarding population ecology, conservation biology, and extinction risk (*e.g.*, Berger 1990, Primack 2004, see also McElhany *et al.* 2000 and Boughton *et al.* 2006). The four concepts are outlined below and are then applied to the populations that comprise the threatened S-CCC DPS of steelhead. The population viability parameters are surrogates for numbers, reproduction, and distribution, which are the criteria found within the regulatory definition of jeopardy (50 CFR 402.20). For example, the first three parameters are used as surrogates for numbers, reproduction, and distribution. NMFS relates the fourth parameter, diversity, to all three regulatory criteria. Numbers, reproduction, and distribution are all affected when genetic or life history variability is lost or constrained resulting in reduced population resilience to environmental variation at local or landscape-level scales.

Abundance**:** Information about a population's size or abundance provides an indication of the sort of extinction risk a population faces. Small populations face a host of risks intrinsic to their low abundance; conversely, large populations exhibit a greater degree of resilience. Small populations tend to be at greater risk of extinction than large populations primarily because several processes that affect population dynamics operate differently in small populations than they do in large populations. Generally, the greater the size of a steelhead population, the greater the chance it will remain viable in the long term. Within the threatened S-CCC DPS of steelhead, abundance of populations has been severely reduced from historic levels (Williams *et al.* 2011, NMFS 2016a) and this has negative implications for long term viability of this DPS.

Population growth rate**:** Population growth rate and factors that affect population growth rate provide information on how well a population is "performing" in the habitats it occupies during the life cycle. These parameters, and related trends in abundance, reflect conditions that drive a population's dynamics and thus determine its abundance. Changes in environmental conditions, including ecological interactions, can influence a population's intrinsic productivity or the environment's capacity to support a population, or both. In regard to steelhead, the greater the productivity of a steelhead population the greater its ability to recover from environmental disturbance and the greater its viability. Because of the very low abundance of returning adult steelhead in south-central California and highly variable flow conditions that can prevent migration into productive spawning areas, their population growth rates (see Primack 2004 for discussion on population size and growth rates) have also been reduced, making the DPS less resilient to disturbance, and this has further reduced the long term viability of the DPS.

Spatial structure**:** A population's spatial structure consists of both geographic distributions of individuals in a population and processes that generate that distribution. A population's spatial structure depends fundamentally on habitat quality, spatial configuration, and dynamics as well as dispersal of individuals in the population. Understanding the spatial structure of a population is important because the population structure can affect evolutionary processes and, therefore, alter the ability of a population to adapt to spatial or temporal changes in the species' environment over the long term (McElhany *et al.* 2000). Generally, steelhead populations that are thinly distributed over space are susceptible to experiencing poor population growth rate and loss of genetic diversity which result in lowered viability.

Within the threatened S-CCC DPS of steelhead, anthropogenic activities such as the introduction of migration barriers have substantially reduced the number of watersheds (or portions of watersheds) that are currently accessible to steelhead (NMFS 2013). This has significantly reduced the spatial structure of populations in the DPS (Boughton *et al.* 2005).

Diversity**:** Steelhead populations possess a suite of life history traits that exhibit considerable diversity within and among populations, and this variation has important effects on population and DPS viability. Some of these varying traits are anadromy, timing of spawning, emigration, immigration, fecundity, age-at-maturity, behavior, physiological and genetic characteristics, to mention a few. In terms of steelhead population viability, the more diverse the assortment of life history traits (or the more these traits are not restricted), the more likely the steelhead population is to survive a spatially and temporally fluctuating environment over the long term. Because anthropogenic activities have severely reduced and eliminated the expression of some life history traits of steelhead populations in south-central California, the long term viability of the DPS has declined as well. In summary, the threatened S-CCC DPS of steelhead has been severely impacted by anthropogenic factors, and this has negatively affected the abundance, productivity, spatial structure, and diversity of the populations that make up the DPS. As a result, the DPS is currently not viable and likely to become endangered (Good *et al.* 2005, Williams *et al.* 2011, and NMFS 2016a).

2.2.7 Contribution of the Arroyo Grande Creek Steelhead Population Unit to DPS Viability and Relationship to Recovery

Certain watershed-specific populations possess a high likelihood of genetic and phenotypic characteristics favoring survival in a spatially and temporally highly-variable environment (NMFS 2013). A populations such as Arroyo Grande Creek steelhead extend over a broad and geographically diverse area, and is likely able to withstand environmental stochasticity and possess ecologically significant attributes not found in most other steelhead DPS populations. Further, the Arroyo Grande Creek population is considered an independent population (Boughton *et al.* 2006), and is therefore expected to support formation of steelhead numbers in several adjacent population units (Figure 2-1). Ultimately, the Arroyo Grande Creek population has a high potential for population viability (Boughton *et al.* 2006).

The Arroyo Grande Creek steelhead population is one of only a few population units in this DPS that have been determined to have a high assurance of being independent and therefore is expected to contribute substantively to the viability of the DPS and recovery of the species. The creation and maintenance of populations in adjacent population units (*e.g.*, Los Berros Creek and Tar Springs Creek), which is expected of the Arroyo Grande Creek population, effectively increases numbers of individuals in the broad population. Given the risk of extinction that small populations face (*e.g.*, Pimm *et al.* 1988, Primack 2004), a larger number of individuals decrease the risk that the broad population would possess weakened viability. According to historical occupancy data and available habitat, a set of more extensive, though still small, populations could potentially occur in coastal

San Luis Obispo County (San Carpoforo Creek to Arroyo Grande Creek) – the fish in the Arroyo Grande Creek system may have been the most extensive of these populations (Boughton et al 2006).

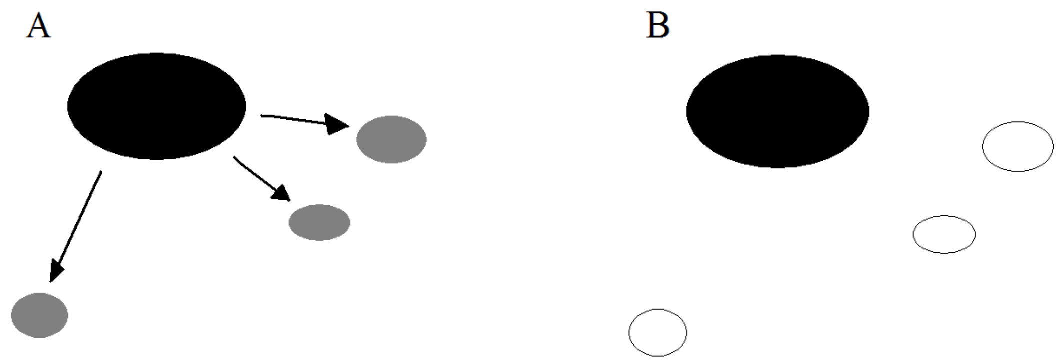


Figure 2-1. Concept of source-sink dynamic (after McElhany *et al.* 2000, Primack 2004). Circles represent habitats (*e.g.*, watersheds) with circle size indicating size of the population unit and habitat capacity (large circles = source or core population units; small circles = sink or non-core population units). Shading represents population density: white indicates empty habitat, black indicates high density, and grey indicates intermediate density. Arrows indicate migration. In favorable years, source populations show relatively stable numbers and several sink populations show arrival of immigrants (A). Populations in sink areas may become extinct in unfavorable years (B), but sinks or non-core populations can be recolonized by migrants from source populations when conditions are favorable.

Functional value of the Arroyo Grande Creek mainstem within the watershed.- The mainstem penetrates further inland, and its lower mainstems tends to be a low-gradient channel through raised marine terraces. To the extent that the lower mainstem retains perennial flow better than the upper tributaries, it serves as important over-summering habitat for juvenile steelhead (Payne and Associates 2003). The remaining habitat downstream of the dam consists of the mainstem of Arroyo Grande Creek and pockets of year-round flow on tributaries such as Los Berros and Tar Springs. The lower mainstem likely exhibits higher steelhead abundance because unregulated flows from Los Berros, Tar Springs, and Corbett/Carpenter Creek allow for introduction of coarse material for spawning and flushing of fine sediment from pools and riffles (Swanson 2006). The lower mainstem of Arroyo Grande Creek once had the capacity to allow flood waters to spread unconfined throughout the floodplain (County 2010). The extent of historical floodplains in this watershed likely made up the majority of rearing habitat for San Luis Obispo County, producing large smolts before their entry into the ocean. A comparison of historic versus present day available valley floor floodplain areas of Arroyo Grande Creek and its tributaries indicate that 15% of original floodplain remains (CDFG 2005). As a Core 1 watershed, the watershed and steelhead population both have the capacity to respond to the critical recovery actions needed to abate current threats to the value of the mainstem (NMFS 2013).

Although the S-CCC DPS has a broad geographic distribution, there are relatively few representative streams in the southern portion of the DPS where steelhead actively spawn and rear. Arroyo Grande Creek is one of the few streams at the southern portion of the DPS where age-0 and older juvenile steelhead occur during summer and fall, and sexually ripe adults occur in winter and early spring. There are numerous streams in San Luis Obispo County, but a disproportionate number in the southern portion of the DPS currently do not appear suitable for steelhead owing in part to land-use activities implemented in ways that degrade and eliminate steelhead habitat.

Arroyo Grande Creek is one of the notable exceptions. On the basis of this information, Arroyo Grande Creek maintains conservation value and is essential for the conservation of the DPS (NMFS 2005).

While the threatened S-CCC DPS of steelhead is geographically broad, extending from the Pajaro River southward to Arroyo Grande Creek, the DPS includes only a small number of watersheds that are expected to advance recovery of threatened steelhead (NMFS 2013). In particular, Table 7-1 of NMFS' South-Central California Coast Steelhead Recovery Plan identifies only 29 streams throughout the geographically broad DPS that are needed for recovering threatened steelhead. Of these 29 streams, only 11 streams are identified as "Core-1 Populations" in NMFS' recovery plan. The Arroyo Grande Creek Watershed is classified as a Core-1 Population (NMFS 2013), and the subject recovery plan states the following regarding Core-1 Populations:

> "The Core 1 populations are populations identified as the highest priority for recovery based on a variety of factors, including:

- the intrinsic potential of the population in an unimpaired condition;
- the role of the population in meeting the spatial and/or redundancy viability criteria; the current condition of the populations;
- the severity of the threats facing the populations; the potential ecological or genetic diversity the watershed and population could provide to the species; and,
- the capacity of the watershed and population to respond to the critical recovery actions needed to abate those threats. " (page 7-5)

Streams classified as Core-1 Populations are essential for recovering the DPS of steelhead as a whole. Therefore, reducing the likelihood of survival and recovery of a Core-1 Population, would have adverse consequences for the survival and recovery of the DPS as a whole. Overall, while the Arroyo Grande Creek Watershed is only one watershed throughout a geographically broad DPS, this watershed is crucial for recovering the entire South-Central California Coast DPS of steelhead (NMFS 2013).

2.3 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The definition of the environmental baseline as defined by the regulations that govern the Section 7 consultation process (stated above) differs from the District's (applicant) characterization of the environmental baseline, where the District believes the environmental baseline to be the condition of the action area as it existed in 1999, before any District-conducted maintenance activities occurred.

The presentation of the environmental baseline[6] is organized into two principal categories: (1) status of threatened steelhead in the action area, and (2) status of designated critical habitat in the action area and factors affecting the species environment within the action area.

2.3.1 Status of the Listed Species in the Arroyo Grande Creek Watershed

The number of adults returning in Arroyo Grande Creek averaged at least 1,000 fish annually during the 1940s, and in the mid-1900s the number decreased to an average of approximately 100-200 fish annually (DFG 1961). A 1996 habitat survey of the Arroyo Grande Creek system provided a density of juvenile steelhead to be 6,878 individuals per 100 feet of stream (Alley April 1997). Contemporary numbers of returning adults are estimated to be "in the dozens" and the vast majority of available habitat is found in the Arroyo Grande Creek mainstem below Lopez Dam (Rischbieter 2004), which was constructed in 1968. Observations in 2000 revealed 228 juveniles in a reach of Arroyo Grande Creek extending from Highway 1 upstream to the base of Lopez Dam (NMFS 2001), which includes a portion of the action area. In 2011, field surveys showed the species (85 individuals observed) utilizing gravel bar habitat in the lower half-mile of Arroyo Grande Creek near lagoon habitat (Rischbieter January 2012). Most recently in 2015, five juvenile steelhead were observed in Tar Spring Creek (a tributary to Arroyo Grande Creek), collected, and relocated to Arroyo Grande Creek mainstem during the Branch Mill Road Bridge replacement project (San Luis Obispo County Public Works Department 2015).

Wild steelhead abundance and spatial distribution have diminished throughout the action area as a result of anthropogenic activities, including activities upstream of the action area that create effects in the action area (NMFS 2013). These activities include in-channel habitat blockages and operation of water storage-diversion projects (Boughton *et al.* 2005, Williams *et al.* 2011, and NMFS 2013). Nevertheless, steelhead are known to be present in small numbers in the action area (Stetson Engineers *et al.* 2004). The number of adults migrating through the action area is believed to be in the dozens, perhaps occasionally low-hundreds in wetter years (Rischbieter 2004).

A1996 juvenile steelhead survey revealed the densities of juveniles increase with distance upstream (Alley 1997). Within the action area densities were approximately 20 individuals per 100 feet of stream relative to a density of 52 per 100 feet in the highest portions of the watershed downstream of Lopez Dam. There have been more recent observations of steelhead in the action area (*e.g.*, Essex Environmental 2000, SLOC 2002) that report significantly lower number of individuals relative to those observed in 1997, but it remains difficult to track the trend in status of the juvenile population from non-systematic surveys and sporadic monitoring reports that may not have the objective to systematically survey for individuals over multiple seasons within the action area. Therefore, comparing observations of individuals between years is unlikely to produce accurate results in the context of the steelhead abundance in the action area.

In contrast to the above observations of steelhead in the action area, in 2011, 78 individuals (mostly young of the year, 60-90 mm fork length) were documented through a systematic, ongoing survey effort in the action area (Rischbieter 2004-2012). Individuals were below the Meadow Creek confluence near a redd site, which is the most-downstream site of spawning ever documented in

[6] This is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area.

Arroyo Grande Creek. Presence of young of the year indicates spawning adults constructed a redd on the adjacent gravel bar earlier in the year. The available field data on steelhead observations suggest that species abundance and productivity are heavily influenced by small changes in streamflow quantity throughout spring and summer, and as adults, the species has capitalized on opportunities to spawn when hydrologic triggers provide suitable habitat conditions albeit a deviation from the traditional concept of adult steelhead spawning in the upper portions of the watershed. Similarly in southern California (Ventura Watershed), Southern California steelhead have spawned noticeably lower in the watershed in response to the lower magnitude and limited extent of available flows during certain water years (NMFS' biologist R. Bush 2016, pers. comm.), thus another example of the opportunistic nature of this species in response to hydrologic triggers of various magnitude and extent.

2.3.2 Status of Critical Habitat in the Action Area

Throughout the entire action area, steelhead habitat for rearing and migration has been restricted and confined within a levee since 1958, and as a result, the existing levee eliminates natural channel meandering (river-floodplain connection) and helps to create unnatural sediment accumulation, which specifically alters physical and biological features essential to the conservation of threatened steelhead and delays development of such features.

***Critical habitat within the action area*:** Figure 2-2, illustrates the distribution of critical habitat in Arroyo Grande Creek and Los Berros Creek (shown in black) relative to the action area (shown in red).

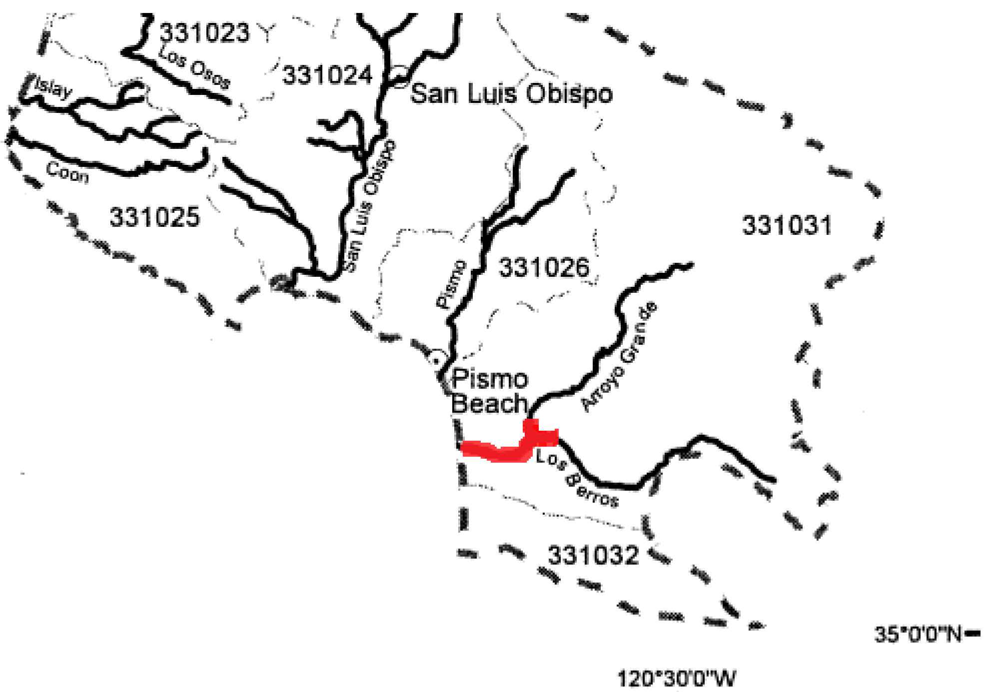


Figure 2-2. Critical habitat designated in the Arroyo Grande Creek and Los Berros Creek (black) and extent of designated critical habitat (red) in the action area (NMFS 2005).

Lopez Dam and the channelization of sections of the mainstem Arroyo Grande Creek and Los Berros Creek impact the action area's steelhead resources. Effects of these alterations combined include seasonality of surface flow, reduced extent of lagoon habitat, lagoon water quality degraded during closed periods, especially if inflow is low, and severe dewatering events due to local agricultural groundwater pumping (Rischbieter 2004). For the Arroyo Grande Creek system, habitat conditions for juvenile steelhead rearing were considered only fair (SEI 2004). Habitat is also available in Los Berros Creek, which typically has perennial flows but likely is experiencing over-exploitation of water resources, which amplifies effects to stream flow during current drought conditions. Currently in Los Berros Creek, a riparian canopy adjacent to the stream channel is absent for the majority of the action area. A developed woody riparian canopy resides farther upstream within the last 420 feet of the action area for this creek, and has been developed enough to provide shade over the low-flow channel since approximately 2011 (review of Google Earth Pro imagery). Historical riparian canopy was likely much more extensive before the natural alignment of Los Berros Creek was altered for flood-control purposes. Overall, the reviews provide evidence that several human activities (dams, water use, etc.) have reduced the ability of habitat to function properly (*e.g.*, see Grantham *et al.* 2010).

The status of the Arroyo Grande Creek steelhead habitat was evaluated in 1996 (Alley 1997). Steelhead spawning habitat was scarce due to the lack of stable hydraulic controls and absence of cobble-strewn riffles. Additionally, the streambed was dominated by fine sediment, adding to the poor spawning habitat quality. Spawning gravel quality has probably been adversely affected by disruption of gravel recruitment by Lopez Dam (draft County HCP 2004). There was also scarcity of pool rearing habitat in the action area, which contributed to the low juvenile steelhead numbers during the fall of 1996. Additional observations were made on flow connectivity through the action area, where dry season flow has been enhanced by releases from Lopez Dam compared to pre-dam baseflows. Consequently, streamflow was continuous throughout the action area during this survey effort, and it would appear that the upper portion of the action area provided overhanging vegetation and escape cover with sufficient water velocity to transport nutrients to steelhead.

More recent habitat surveys reveal a change in conditions relative to trends observed in 1996. Adult steelhead apparently used suitable habitat to spawn near the lagoon during or after the sequence of floods and persistent high flows that occurred between December 2010 and March 2011[7] (Rischbieter 2012). A second indicator that signals a change in habitat status is a greater extent and magnitude of flows going sub-surface or accelerated drying occurring earlier than usual in newly documented locations in the action area. Although no dead steelhead were observed in the research area (lower half mile of the action area), drying conditions in 2013 were the likely cause of any steelhead mortality for this water year, as conditions became too warm and confined for juvenile steelhead to move or survive (Rischbieter 2013).

The estuarine habitat in the action area has experienced significant alterations in quality and extent (reduced by 80 percent), overall reducing the function and value of this essential habitat for growth and survival of juvenile threatened steelhead (NMFS 2013). Drought in combination with

[7] A December, 2010, flood-flow included a discharge of untreated sewage into and through lower Arroyo Grande Creek via the Meadow Creek "floodgates," but comparison of survey results between 2010 and 2011 suggests that this event had no deleterious impact on the Arroyo Grande Creek fish community or its continuing recovery from the 2008-2009 dewatering - 2008 presented an unusually dry Spring, and unseasonally low streamflows may have been insufficient to allow return passage of adult steelhead past several beaver dams down to the ocean.

groundwater pumping for agriculture use and probably operations of Lopez Dam can measurably influence the duration of surface-flow connection from the creek through the lagoon to the ocean and, therefore, the occurrence of adults returning to the creek. Although many factors contribute to observed patterns in sedimentation for this system including but not limited to an upstream dam, incoming flow from upstream tributaries, and the presence of levees, likely the major contributor is the levee system, which has continually prevented sediments from being deposited on the floodplain since 1961. Instream flow now directs sediment deposits either between the levees or to the lagoon. Additionally, over time the lagoon continues to degrade due to excessive sedimentation and loss of lagoon volume with much of the lagoon consisting of shallow habitat that lacks complexity (Rischbieter 2009). The absence of high flows during the preceding winter failed to remove previously-deposited bedload, thus making the greater lagoon noticeably shallower than in past years (Rischbieter 2013).

The presence of Lopez Dam creates the most significant impact to streamflow in the lower mainstem (Swanson 2004) and is the largest system-wide stressor that alters sediment dynamics (Becker *et al.* 2010) by specifically reducing winter peak flows that have the magnitude to breech the lagoon berm and allow connectivity between the river and ocean. For example, a two-year event is only 25 percent of what it would be if the dam was not present; likewise, the 100-year event is approximately half of what it would be without the dam (County 2010a). Therefore, this lowers the frequency of access to the creek during the adult steelhead migration season and when smolts may be ready to enter the ocean. In summary, there are multiple stressors cumulatively influencing to varying degrees the current function and ecological value of the existing Arroyo Grande Creek Lagoon; these stressors each influence the dynamics of the lagoon system in a different way, thus measuring the magnitude, duration, and extent of that influence for each stressor is challenging and has not been conducted or evaluated for this lagoon system.

2.3.3 Threats to Steelhead Critical Habitat in the Action Area

The following threats are not mutually exclusive and can be grouped into a few general threat categories related to land-use activities. These threats largely determine the pervasive lower quality of steelhead habitat in the action area. Land use activities concentrated along the narrow, coastal terrace floodplains magnify impacts to instream and riparian habitats (Hunt & Associates Biological Consulting Services 2008).

While some activities are physically located outside the action area, the activities adversely affect critical habitat and steelhead in the action area (*e.g.*, in the case of land-use activities causing input of sand and smaller particles to habitats within the action area, or in the case of a water storage facility altering the pattern and magnitude of discharge in the action area). Therefore, such activities are considered here. The threats to steelhead and critical habitat in the action area are: (1) channelization, (2) agricultural and road development, (3) urbanization, and (4) regulation of flows at Lopez Dam.

Influence of Channelization on Critical Habitat: The historic channel had a much wider, active floodplain in the action area before channelization occurred. Historical accounts and a geomorphic analysis of the lower watershed and Cienega Valley (also known as lower Arroyo Grande Creek floodplain) suggest that much of the valley floor was at grade with Arroyo Grande Creek and consisted of a broad thicket of willows and other riparian trees (Dvorsky and Wingfield 2004) vulnerable to flooding because it lies at the downstream, lower gradient terminus of a highly erosive watershed (Swanson 2006a). The entire valley bottom most likely consisted of a series of active channels, flood channels, and abandoned channels with backwater wetlands (BA 2015). The active channel was able to meander based on sediment deposition, debris jams, or other obstructions. In some areas the channel was likely braided, where the floodplain was wide, and a single thread channel where constrictions such as bedrock outcrops narrowed the floodplain (BA 2015).

Because the lower Arroyo Grande Valley has a long history of flooding (JRP 2009), the Arroyo Grande and Los Berros creeks experienced channelization starting in 1959 (completed in 1961) to provide flood control within the action area. The main feature was a levee system and trapezoidal channel that confined Arroyo Grande Creek from its confluence with Los Berros Creek downstream to the Pacific Ocean (BA 2015) with an average width from levee edge to levee edge of approximately 70 feet (Swanson 2006a). Stream channelization affects nearly all hydro-geomorphic forms and processes within, upstream, and downstream of the channelized reach (Simon and Hupp 1992). Due to converting floodplain areas to channelized portions of Arroyo Grande Creek, sediment that was historically deposited on the floodplain now deposits in backwater areas behind bridges and within other portions of the action area. Collectively, the action area's flood conveyance capacity is reduced by over 80% since the flood-control project was implemented (Interim Sandbar Management Plan 2013). Evidence of severe deviation from the natural alignment of the creek is shown below with the channel thalweg at a higher elevation relative to the immediate floodplain where encroachment of agriculture is evident (Figure 2-3).

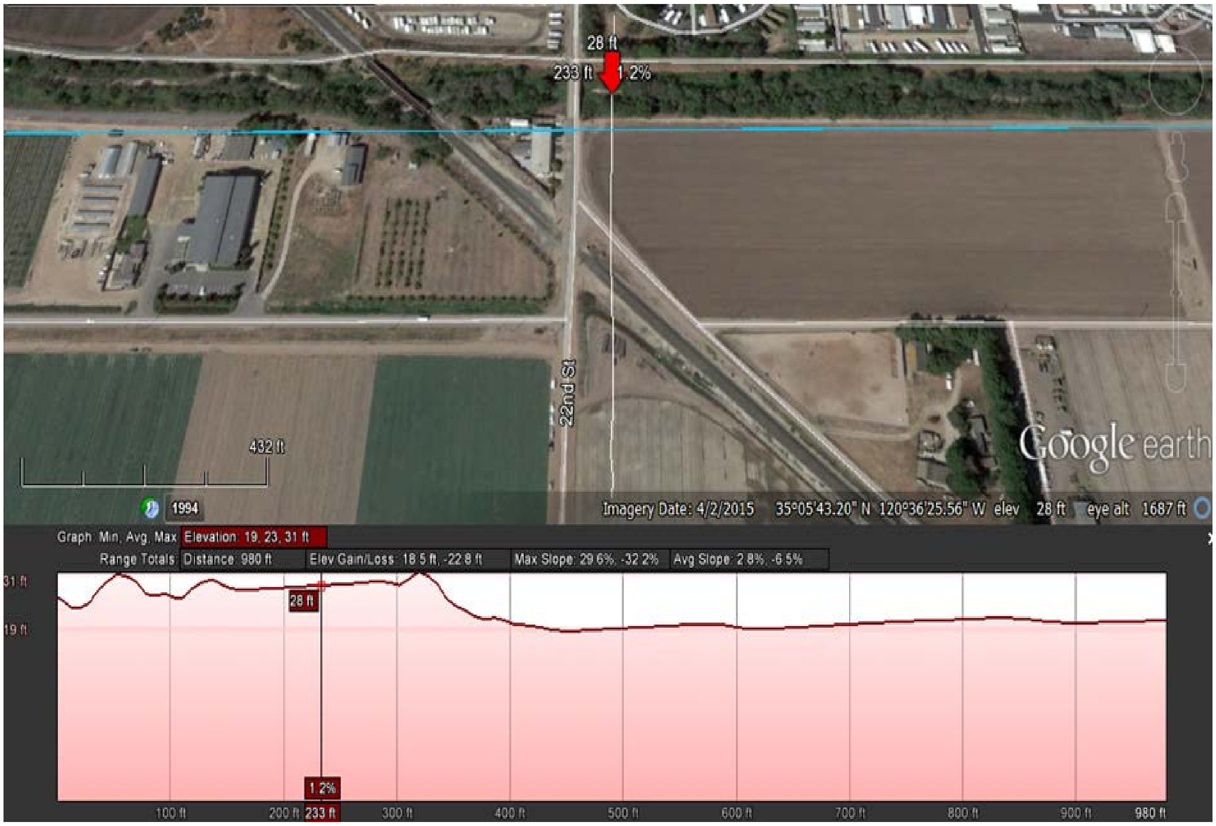


Figure 2-3. The channel thalweg upstream of the 22nd Street Bridge (red arrow) is at a higher elevation than the adjacent land parcels at 19 feet. This suggests the historical alignment of the creek has been altered due to channelization, and extent of agriculture fields has expanded to abut the existing levee. Specifically, sediment accumulation raised the elevation of the channel relative to its historical elevation when the channel was able to meander and migrate without constraint in the floodplain.

Flood control activities resulted in physical changes to the creek-channel structure. Collapse of vertical banks led to channel widening and a new inset floodplain was developed after several decades, specifically 54 years since levee construction. The vegetation changes associated with this fluvial process are described by Hupp (1992), but ultimately the action area is an aggraded channel bed with mild mass wasting (slope failure), heavy bank accretion, and a slightly meandering channel[8], which are all geomorphic attributes of a late aggradation stage and possibly a very early recovery stage in stream channel evolution following channelization (Schumm *et al.* 1984, Simon and Hupp 1987, see Table 1 in Hupp 1992). Additionally, higher channel roughness occurred over the past 54 years as a result of growth in dense wood thickets; a widened channel supports an extended vegetated buffer, which increases roughness and shear stress influencing sediment deposition in the action area.

Physical features of designated critical habitat that support the life-history needs of the species include the ability for the creek channel to meander, maintaining connectivity with the floodplain in the action area. The spatial extent of meandering has been reduced and a connection to the historical floodplain has been eliminated. Channelization severely restricts the extent and

[8] Initial meander loops begin as bends in the thalweg that ultimately produce pronounced differences in bank form relative to inside or outside banks of a bend (Hupp and Simon 1991).

vegetation distribution of the riparian corridor, while at the same time influences sediment transport, water depth and velocity of flows through the action area (Montgomery and Buffington 1998). Additionally, when flows and sediment load become altered (Leopold and Maddock 1953), channel adjustments can involve changes in width, depth, velocity, slope, roughness, and sediment size. An external influence such as a levee decreases the frequency of floodplain inundation and eliminates side-channel processes (*i.e.*, floodplain connectivity) that would sustain steelhead living space (*i.e.*, aquatic habitat), thus artificially confining the available living space for the species to the active channel within the action area.

A majority of the historic functional floodplain along Arroyo Grande Creek was lost due to a combination of severe channel incision along most of the mainstem and levee construction along lower Arroyo Grande Creek (Swanson 2006a). Available rearing habitat is measurably reduced relative to habitat that was available in the historically large lagoon complex before the presence of the levee (Jacobs *et al.* 2011). This complex was either actively filled when the area was developed for residential and commercial use, or filled as a result of excessive erosion in the upstream watershed (Swanson 2006a), or a combination of these. Consequently, designated critical habitat in Arroyo Grande Creek Lagoon continually degrades due to excessive sedimentation and loss of lagoon volume with much of the lagoon consisting of shallow habitat that lacks complexity (Rischbieter 2009).

Influence of Agriculture on Designated Critical Habitat: Arroyo Grande Creek and Los Berros Creek are bordered by a restricted 100-year floodplain, most of which has been converted to agriculture and small orchards (draft County HCP 2004). Floodwaters entering these areas via levee overtopping or failure are subsequently disconnected from both creeks.

Agriculture played an important role in the growth of the city of Arroyo Grande. Members of the Mission San Luis Obispo community farmed the land as early as 1780 (Hunt *et al.* 2009). Row crops, orchards, and vineyards dominate the agricultural landscape. Cultivated fields and open farmland encroach either side of the creek within the action area (Figure 2-3). Water is released from Lopez Reservoir into Arroyo Grande Creek to recharge groundwater supplies used for local agricultural irrigation. These releases for agricultural irrigation groundwater recharge typically occur between April and October (draft County HCP 2004).

Local agricultural activities affect instream physical habitat conditions, specifically erosion and deposition of fine sediments (draft County HCP 2004). Extensive inputs of fine sediment can reduce the abundance of food available to steelhead (Gray and Ward 1982, Bruton 1985, Doeg and Koehn 1994). After 25 years of levee operation and maintenance, between the years of 1983 and 1990, anywhere from 8,640 CY to 16,470 CY of sediment was removed from the action area, while in 1997, the District concluded that an additional 165,000 CY needed to be removed to ensure proper flood-control capacity (NRCS 1998). Additionally, local agricultural groundwater pumping results in severe dewatering of the Arroyo Grande Creek Lagoon (Rischbieter 2004), which contributes to continual sediment accumulation and reduction in rearing habitat for steelhead.

Influence of Urbanization: Conversion of wildlands can temporarily increase input rates of nitrogen and sand and smaller particles to receiving waters and therefore critical habitat for steelhead. This can lead to reductions in the quality of habitat and abundance of desirable aquatic species, and increased eutrophication of receiving waters such as estuaries and streams (Weaver and Garman 1994, Bowen and Valiela 2001). Consequently, the proliferation of urban areas, including roads and housing developments, within the Arroyo Grande Creek watershed is of concern. With increasing urbanization, a watershed can experience higher peak flows of shorter duration because the time it takes for the rain to runoff the urban landscape is much shorter than runoff rates for natural wildlands (Seaburn 1969, Anderson 1970). An increase in impervious surfaces within the watershed reportedly contributes increased runoff to the action area (Swanson 2006a).

Sediment eroded from disturbed lands are eventually transported to lower Arroyo Grande Creek (Swanson 2006a). Much of the development, both proposed and existing, provides little in the way of stormwater management or Best Management Practices (BMPs) that limit runoff and reduce impacts to the hydrology of the watershed. In addition, much of the development occurred on steep, highly erodible soils. There is approximately 385 miles of road in the Lower Arroyo Grande Creek watershed (Swanson 2006a), which create a chronic source of erosion during the rainy season that contributes fine sediment to the channel during most runoff events. Extensive loading of fine sediment in the action area has limited macroinvertebrate production and reduced the amount of cover habitat available to juvenile salmonids (Swanson 2006a). One District-led effort to control urban runoff and flooding was the construction and operation of a storm-drain system for storm-water infiltration, evapotranspiration, and ultimate drainage into Arroyo Grande Creek through the existing levee, which influences and contributes to river discharge in the action area. The new culvert outlet site into Arroyo Grande Creek is approximately 0.7 miles upstream from the Arroyo Grande Creek Lagoon.

Influence of Lopez Dam on Critical Habitat: Lopez Reservoir/Dam, constructed in 1968, impounds approximately 70 square miles of the upper watershed and continues to have negative consequences for the quality and availability of designated critical habitat in the action area.

For instance, the operation of Lopez Dam affects the natural pattern and magnitude of creek discharge in the action area (NMFS' November 25, 2004, letter to SLOC). The Lopez Dam flow schedule continues to lack variability that is considered to be beneficial for the physiochemical and biological integrity of streams (see Poff *et al.* 1997). Also, the timing of high winter discharge has shifted from February to March and the magnitude of spring discharge has decreased. Further, the current discharge during summer and fall are elevated over discharges that were present before the operation of Lopez Dam, likely due to agriculture releases. Finally, continual deviation from pre-dam flow conditions results in an ecological shift for the action area – from an intermittent portion of Arroyo Grande Creek to a portion of the watershed that now contains physical habitat elements to support rearing and even spawning of threatened steelhead.

Altered flows downstream of Lopez Dam affect passage and migration opportunities for the species (NMFS' March 29, 2010, letter to SLOC). Passage through Lopez Dam to historical spawning ground remains unavailable, which precludes the species from utilizing the entire watershed for spawning and rearing behaviors, thus shrinking available habitat to only the lower 12 miles of Arroyo Grande Creek including the action area. Migration opportunities are significantly shorter in duration relative to opportunities that would have naturally occurred. Lastly, operations shift the actual timing of migration to spring, which would be expected to favor emigration of juvenile steelhead, but not upstream migrating adult steelhead. Reducing the availability of spawning and rearing habitats is expected to translate into declines in population abundance and spatial structure within the action area (NMFS 2013), which increases the risk of species extinction and delays recovery.

Continued operations at Lopez Dam trigger geomorphic changes that translate into negative effects on stream fish (Ligon *et al.* 1995, Kondolf 1997, Trush *et al.* 2000) and amplify effects to steelhead habitat from the existing levee in the action area. These changes can include winnowing of undersized cobble, gravel, and sand from the channel bed, halting the development of mid-channel bars and islands, eliminating spawning areas due to excessive fines, simplifying instream habitat for fish, creating "habitat bottlenecks" that limit abundance of anadromous salmonids, channel incision and decreased inundation of the relatively miniscule floodplain between the levees, encroaching riparian vegetation into the stream channel, and filling pools with sediments. With regard to Lopez Dam operations and the presence of a downstream levee system, the combined effects disrupt the natural reworking of the river channel through periodic flooding, sediment aggradation and deposition, and diminished frequency of peak flows. Consequently, this led to decreased number and volume of pools and complexity of channel margin and floodplain habitat for threatened steelhead. Further, during winter, high flood flows entrained and deposited sufficient bedload to reduce the lagoon's wetted area and make remaining areas noticeably shallower (Rischbieter 2012). Both Lopez Dam and the levee system contribute to degraded habitat conditions within the action area and continue a severe deviation from the historical floodplain (DFG 2005).

Water storage and attenuation of high-flow events may reduce the frequency and duration of a viable lagoon-ocean connection (NMFS' electronic message to D. Bird on May 9, 2007, Jacobs *et al.* 2011). Specifically, cessation of flow across the beach area (lagoon closure) is a frequent occurrence. The lagoon is typically closed during summers, however in 2003, the lagoon remained open all summer (Rischbieter 2012) and was likely influenced by the new elevation/storage rating table for the reservoir, which was implemented in April of 2003 (SLOC 2002).

The reservoir is operated, in part, for irrigation purposes—an element that can lead to a reduction in high-peak floods and an increase in summer flow (Aguiar *et al.* 2001). Given that the reservoir has only spilled 14 times in 28 years of operation (1968 to 1998), peak flow events have either been muted or attenuated since construction of the dam; lower discharge events, such as those that occur during dry periods or channel maintenance storm events, are muted completely (CDFG 2005). The lack of high flows in Arroyo Grande Creek downstream of Lopez Dam results in a narrow, simplified channel with excessive siltation (Becker *et al.* 2010). Considering river-lagoon connectivity, complete loss of inflow occurred over a dozen times since 1940, though less frequently since completion of Lopez Dam (Stetson Engineers *et al.* 2004) likely due to elevated summer flows for downstream agriculture.

By changing the magnitude, frequency, or duration of floods, the combined effects of upstream regulated flows and levee structures to minimize flood risk often constitute a hazard to riparian vegetation (Friedman and Auble 2000). Decreases in flow variability reduce the spatial and temporal variability of the riparian environment, resulting in reduced area and diversity of the riparian-plant community (Nilsson 1984, Auble *et al.* 1994). Elimination of native plant species and creation of novel conditions may promote spread of exotic plant species in riparian habitat (Nilsson 1984). Currently within the action area, invasive species successfully reproduce with vigorous regrowth during winter and spring, thus limiting the growth of native riparian species. The non-native fish species, including bullhead, centrarchids, and mosquitofish, were only identified in reaches closer to Lopez Dam suggesting that the reservoir is a source of these species in the system (Swanson 2006b, 2008). Native species, including steelhead and domestic trout, became less abundant closer to Lopez Dam. However, based on more recent surveys in the action area, large-mouth bass, black crappie, green sunfish, and bluegill are commonly observed (Rischbieter 2008, 2012) suggesting that the entire system continues to be influenced by invasive/exotic plant and aquatic species.

Influence of Sediment Removal: From the time of the earliest settlements, use of the valley for homesteading, agricultural production, dairies, and cattle ranching required clearing of vegetation and active management of the channel and floodplain in the action area. Management consisted primarily of ditching the channel to provide a predictable flow path, building levees, removing willow thickets, and leveling the land (BA 2015).

Since 1959, the District performed sediment removal in the action area (HMMP 2013, 2014, BA 2015). After removing accumulated sediment from discreet locations in 1999 and 2001, following the listing of threatened steelhead in 1996, work in the reach of creek that is managed for flood control has since focused on a) managing the riparian vegetation to stabilize the banks in an effort to reduce channel roughness, b) providing continuous shade for the low-flow channel, and c) removal of nonnative, invasive species throughout the channel (HMMP 2014). Additionally, non-native vegetation outside the buffer area has been cut to near ground level by hand crews and, in 1999, 2001, and 2012, through the focused deployment of grazing animals (goats). Although the extent and magnitude of sediment removal in the action area has been reduced over the years, information indicates certain effects of the removal remain. For instance, because the sediment removal focused on meeting flood-conveyance objectives, there was apparently no regard for promoting habitat complexity and properly functioning habitat conditions in the action area. Today, the channel in the action has been straightened and resides between levees. In addition, sediment removal activities in the action area appear to have resulted in disturbance to channel stability, vegetation distribution, and modifications to channel elevation and depth, all of which influences the quality and availability of steelhead living space in the action area.

Influence of Vegetation Removal Program: The 1959 Operation and Maintenance Agreement between the Arroyo Grande Soil Conservation District, Natural Resources Conservation Service, and the San Luis Obispo County Flood Control and Water Conservation District (Zone 1), required maintenance of the flood control channel (1959 Agreement). This maintenance included vegetation removal and routine maintenance of the levee system and associated infrastructure. Riparian vegetation influences channel morphology and response potential by providing root strength that contributes to bank stability (Shaler 1891, Gilbert 1914). The effect of root strength on channel bank stability is evident in the action area where loss of bank reinforcement (*i.e.*, vegetation removal) results in channel widening (see effects of channelization). During this period of removing vegetation from the channel bottom, riparian vegetation, as a source of roughness that could mitigate the erosive action of high discharge, was limited or precluded from the action area. As a result of this stressor, channel bank stability was reduced, cover habitat was limited, and the extent of shade provided by the riparian canopy decreased.

Following a collective recognition that major changes in watershed regulations, hydrology and objectives for the watershed required a new watershed management plan (BA 2015), the 1959 Agreement was terminated on December 1, 2009.

Since 2009 and as concerns for environmental protection increased, the District has been limited in its ability to conduct periodic maintenance (BA 2015). Very limited removal of vegetation and sediment transformed the action area's composite channel roughness almost three-fold from 0.020 to approximately 0.057 (BA 2013). The increase in roughness is directly from the levee system becoming populated with a mixture of native and non-native invasive plant materials extending beyond the low-flow channel due to channel widening and the natural progression of early recovery stage in stream-channel evolution (see effects from channelization discussion above).

Evidence of Sea-Level Rise Impacts and Reduced Precipitation by 2100: Changes in sea level are occurring (refer back to the Status section), so we must consider how a rising sea has impacted the action area and look ahead using climate projections to characterize how present conditions might change. In the future, the action area will likely experience additional changes in environmental conditions due to climate change. These changes overlap with indirect effects of maintaining a levee system – without a proposal to remove the levee, effects from the existing levee will continue indefinitely in the action area. Thus, for long-term proposed actions (16-year Corps permit) with even longer indirect effects, we can no longer assume current environmental variability adequately describes environmental baseline conditions. Instead, we project baseline conditions into the future, synchronizing our projections with the duration of the effects (direct and indirect) of the proposed action we are analyzing. Below we include local information that is available at this time.

State climate change maps show sea-level rise affecting the City of Grover Beach and town of Oceano with inundation areas along Meadow Creek and the historic Los Berros Creek (Cal-Adapt web-based tool, see Barnard *et al.* 2014). In general, sea-level rise along the coast of San Luis Obispo will likely increase the magnitude of the following existing processes in San Luis Obispo County including the action area (CEC-500-2012-054): increased erosion of already retreating coastal bluffs and beaches, coastal flooding with higher storm surges and flood elevations during coastal storms, potentially inundating ecologically valuable low-lying areas, permanent inundation of coastal wetlands in the county, and salt water intrusion into coastal freshwater wells that serve agriculture and local residents. Sea-level rise will force Arroyo Grande Creek Lagoon to move inland, presuming conditions allow this habitat to migrate inland. Development placed on the landward side of current wetlands/lagoons prevent this inland migration and result in a "wetland squeeze" and ultimate loss of these valuable habitats.

Precipitation, in part, provides a general, long-term outlook on population viability through changes in hydrologic triggers for steelhead migration. Climate scenarios for continued high emissions (A2) project overall reduced precipitation for the action area (Cal-Adapt, precipitation decadal averages map). Specifically during February when historically large storm events elevated winter discharge triggering migration for the species, the projections show a continually decreasing amount of precipitation from 2020 through 2100. However, other simulations reveal that most precipitation continues to occur in winter and relatively small (less than ten percent) changes in overall precipitation are projected (Cayan *et al.* 2008). Although a small change in precipitation is projected during the twenty-first century, Cayan *et al.* (2008) explain a modest tendency for increases in the numbers and magnitudes of large precipitation events, which remain hydrologic triggers for steelhead migration. Interestingly, other modeling efforts show a greater portion of California falling within the increased precipitation zone (see Neelin *et al.* 2013).

In a series of reports released by the California Energy Commission, a set of six models showed consensus on a drier climate for Central California (Westerling *et al.* 2009). Further, even with substantial increases in precipitation projected by some models, soil moisture is expected to decline due to increased temperature and evaporation (Koopman et al 2010). Although precipitation projections are less certain in terms of the magnitude and extent of changes we can expect for the action area, it is likely the general climate conditions in the future will be overall drier than current conditions, thus drier conditions place an additional stressor on the frequency and duration of hydrologic triggers for steelhead migration opportunities. Consequently, altered migration opportunities influence the viability of the Arroyo Grande Creek steelhead population (*i.e.*, a population is viable when there is negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame).

S-CCC Steelhead Recovery Plan Recommendations to Address Threats: The final recovery plan for S-CCC steelhead identifies threats to steelhead due to agricultural and flood-control activities, including levees and encroachment into floodplains and riparian areas (NMFS 2013). As a result, the recovery plan recommends (1) addressing current land practices that are detrimental to steelhead, including flood control programs (page 7-1), dedicating space for natural stream behavior via setback levees (page 7-2), and regulating flood control and other instream activities that disrupt river and riparian habitats (page 7-25). More specifically, Table 8-1 of the recovery plan identifies the following recovery actions that are directly relevant to the proposed action:

> "Develop, adopt, and implement land-use planning policies and development standards that restrict further agricultural encroachment within the active floodplain/riparian corridor. Restrict further development in these areas to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation, and rearing, and their associated habitats. Plans should include incentives, including streamlining of applicable permitting processes, for agricultural related activities." (page 8-6)

> "Develop and implement a plan to manage agricultural development outside of the active floodplain (generally defined by 2-5 year frequency flood event) to create an effective riparian buffer; restore and re-vegetate a minimum riparian buffer. Include provisions for properly functioning riparian conditions to allow the channel to maintain natural structural diversity, and protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats. The extent of the floodplain and riparian buffer shall be determined on a case-by-case basis taking into account site specific conditions. Plans should include incentives for construction and management of off-stream water for livestock, including streamlining of applicable permitting processes." (page 8-6)

> "Develop and implement a flood control maintenance program to minimize the frequency and intensity of disturbance to instream habitats and riparian vegetation (*e.g.*,

modification of natural channel morphology and removal of native vegetation)." (page 8-7)

"Develop and implement a plan to modify channelized or artificially stabilized portions of the mainstem and tributaries, wherever feasible, to restore natural channel features and habitat functions, including natural channel bottom morphology and riparian vegetation, to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats. Focus initial efforts on high value habitats." (page 8-8)

"Develop and implement a stream bank and riparian corridor restoration plan to reduce channel incision, sedimentation from bank erosion, and reduce or eliminate the need for bank stabilization; wherever feasible, remove rip-rap and other artificial bank stabilization features on mainstems and tributaries. Replace these features with bio-engineered bank stabilization, or additional set-backs, to allow channels to maintain natural structural diversity." (page 8-8)

2.4 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

In terms of specific content, this biological opinion includes an extensive review of the scientific information that NMFS relies upon to translate the effects of the action to the Arroyo Grande Creek Watershed and, more broadly, the DPS as a whole. We emphasize that this scientific information is presented throughout this biological opinion and is not solely confined to section 2.6.3 (*i.e.,* section 2.6.3 draws upon the scientific information presented earlier in this opinion). Among other important elements, this information includes, but is not limited to, the following:

(1) An extensive discussion regarding the function and value of the Arroyo Grande Creek Watershed population of steelhead to the viability and recovery of the entire DPS (see section 2.2.7, "Contribution of the Arroyo Grande Creek Steelhead Population Unit to DPS Viability and Relationship to Recovery"), and

(2) The condition of critical habitat throughout the DPS (see section 2.2.4, "Condition of Critical Habitat throughout the Designated Area").

The expected effects of the proposed action are as follows, beginning with effects on designated critical habitat.

2.4.1 Effects on Critical Habitat for S-CCC threatened steelhead

As explained more fully in the pages that follow, the proposed action is expected to reduce the function and value of the action area as a freshwater rearing site and a freshwater migration site for threatened steelhead. The primary mechanisms contributing to this expected condition involve (1) maintaining an artificially narrow riparian buffer width, (2) consigning a large portion of the creek to a flood-control channel, (3) introducing a 25% deviation from observed variability in the volume of the Arroyo Grande Creek Lagoon, and (4) continuing to limit connection between the active creek channel and floodplain areas. The expected effects on critical habitat that we report below are projected to be widespread throughout the entire action area, owing to the broad, affected area.

Because the proposed action principally targets the area "outside the riparian buffer" (this area occasionally referred to as "secondary channels" in this biological opinion) for improving flood conveyance through the action area, these areas will continually be disturbed through vegetation and sediment removal activities annually from July 1 through October 15. The estimated extent of secondary sediment maintenance channels, alone, will be 52 percent of available designated critical habitat in the action area (see Table 2-2 for additional details regarding the expected spatial extent of effects; also see Appendix B). The estimated inundation time for the limited floodplain between the levees was determined through modeling approximations by the District due to lack of observational field data to measure flow recession rates and the exact duration of secondary channel inundation during and after every storm event (BA 2015). Because the active channel varies in width throughout the action area, the extent of the riparian corridor will vary as well when the riparian corridor includes the width of the active channel and a buffer of ten feet on both sides of the channel. For example, in areas where the active channel is narrower, the constructed riparian corridor will be narrow relative to the width between the levees, which ranges from 80 to 125 feet. The proposed action fails to provide lateral channel migration, which could result in loss of riparian functions if an insufficient buffer width is restored or preserved (Rapp and Abbe 2003, Bisson *et al.* 2009, NMFS 2016b).

Table 2-2. Extent of riparian protection for the action area given field measurements of the primary low-flow channel, including the total buffer (10-ft beyond the primary low-flow channel on each side of the channel), total protected width (sum of low-flow channel and the buffer), percent of channel protected (portion of the channel that will be protected), secondary channel width (remaining width for sediment removal), and inundation time for secondary channels (the duration of which the secondary channels will be wetted). The widest distance between the levees is 125 ft, which was used to calculate the percent of protected channel. The estimated average width between the levees is 105 ft, which is used for estimated average calculations.

	Primary Low-Flow Channel	Total Buffer	Total Protected Width	% of channel protected	Secondary Channel Width (sediment removal areas)	Inundation[9] Time for Secondary Channels
Narrow low-flow channel areas	15 ft (measured in field downstream of HW1)	20 ft	35 ft	35/125 = 28%	90 ft (72%)	Wetted channels expected for ½ day – 2 days after a five-year event or greater
Wider low-flow channel areas	48 ft (measured at the most downstream end of action area)	20 ft	68 ft	68/125 = 54%	57 ft (46%)	
Estimated Average	30 ft	20 ft	50 ft	50/105 = 48%	55 ft (52%)	

Modifying Vegetation Distribution, Abundance, and Diversity

As illustrated in Figure 2-4, the proposed action will seek to substantively modify the character, condition, and extent of the riparian corridor within the action area for the purpose of consigning a large portion of the creek to a flood-control channel. Among other impacts, the proposed action will deliberately reduce the riparian corridor, outside of the 10-ft proposed buffer, to a narrow strip of largely non-woody vegetation. As described below, reducing the width of the riparian corridor constitutes an adverse effect, based on the value and importance of the riparian corridor to the creek environment, in general, and designated critical habitat for threatened steelhead, in particular. Ultimately, the loss of any riparian vegetation is particularly a concern where land-use practices have retained only narrow riparian corridors (NMFS 2016b).

Although the proposed action would maintain a riparian-buffer width of 10 feet on each side of the channel in the action area, our analysis in the draft biological opinion indicated this width is much less than necessary to uphold the functional role of streamside riparian buffers. This role involves (1) the physical and biological control of several types of anthropogenic related pollutants (effective buffer widths between 15.1 to 164 ft, Osborne and Kovacic 1993, Castelle *et al.* 1994, Sabater *et al.* 2000), (2) a source of food and habitat for fish (*i.e.*, maintaining habitat for wildlife, 98 ft, Castelle *et al.* 1994), (3) maintaining ambient stream temperature (33 to 98 ft, Osborne and Kovacic 1993, Castelle *et al.* 1994), and (4) control of fine sediment (sand and smaller particle types) and

[9] The areas left "unprotected" are currently available for steelhead migration for approximately 2 days during large storm events (5-year event or greater) before the proposed action (*i.e.*, existing conditions).

streambank erosion (*i.e.*, reducing sediments and suspended solids in overland flow, 16.4 to 853 ft, Karr and Schlosser 1978, Osborne and Kovacic 1993, Castelle *et al.* 1994). Additionally, riparian-buffer widths equal to the maximum site potential tree height of native species are adequate for ensuring a majority of riparian functions for confined waterbodies (Pollock and Kennard 1998, also see discussion in NMFS 2016b). As a result, we concluded that the proposed action is expected to greatly diminish the natural ability of the riparian corridor to maintain water temperature, provide sources of food and living space for threatened steelhead, and control sediment and erosion. Subsequent to our draft biological opinion, the District conducted a buffer-reference study upstream of the action area to inform the final buffer dimensions under the RPA (District's February 9, 2017, revised vegetation buffer memorandum). We reviewed the results of that study and agree with the District that buffer widths in less impaired areas of Arroyo Grande Creek are typically toward the smaller size relative to the widths in the ranges described above. Nevertheless, the 10-foot buffer proposed is below these widths and likely too small to provide much of the riparian functions needed to help maintain steelhead critical habitat throughout the duration of direct and indirect effects of the proposed action. We consider the implications of diminishing the natural, functional ability of the riparian corridor in the following paragraphs.

The proposed action reduces the natural ability of the riparian corridor to filter nonpoint source pollution from entering the creek within the action area (*e.g.*, from adjacent agricultural fields and the urban area of Arroyo Grande). This pollution type is a common problem resulting, partially, from agricultural activities (Lowrance *et al.* 1995). Fine sediment, pesticides, fertilizers, and heavy metals are generally the principal pollutants and the main source of injury and long-term impairment to surface waters. Riparian vegetation provides a buffer between stream and nonpoint source pollution, in part through uptake and storage of nutrients in woody material and trapping of fine sediment along the vegetative banks (Lowrance *et al.* 1985, Copper *et al.* 1987, Murphy and Meehan 1991, Welsch 1991, Castelle *et al.* 1994). In addition, riparian vegetation protects the creek banks from eroding (Platts 1991). Relegating the native riparian corridor within the action area, which lies adjacent to extensive agricultural fields and downstream of an urban center, to a relatively small buffer width is therefore a major concern. Because nonpoint source pollution (*e.g.*, agricultural storm water discharges, return flows from irrigated agriculture, and oil, grease, and toxic chemicals from urban runoff) enters at many locations in the action area and exhibits such a large temporal variation (see agriculture and urbanization discussions in the Environmental Baseline section of this biological opinion), an increase in nonpoint source pollution to the creek within the action area from reduced riparian buffers contributes to reducing the quality and availability of freshwater rearing sites for juvenile steelhead.

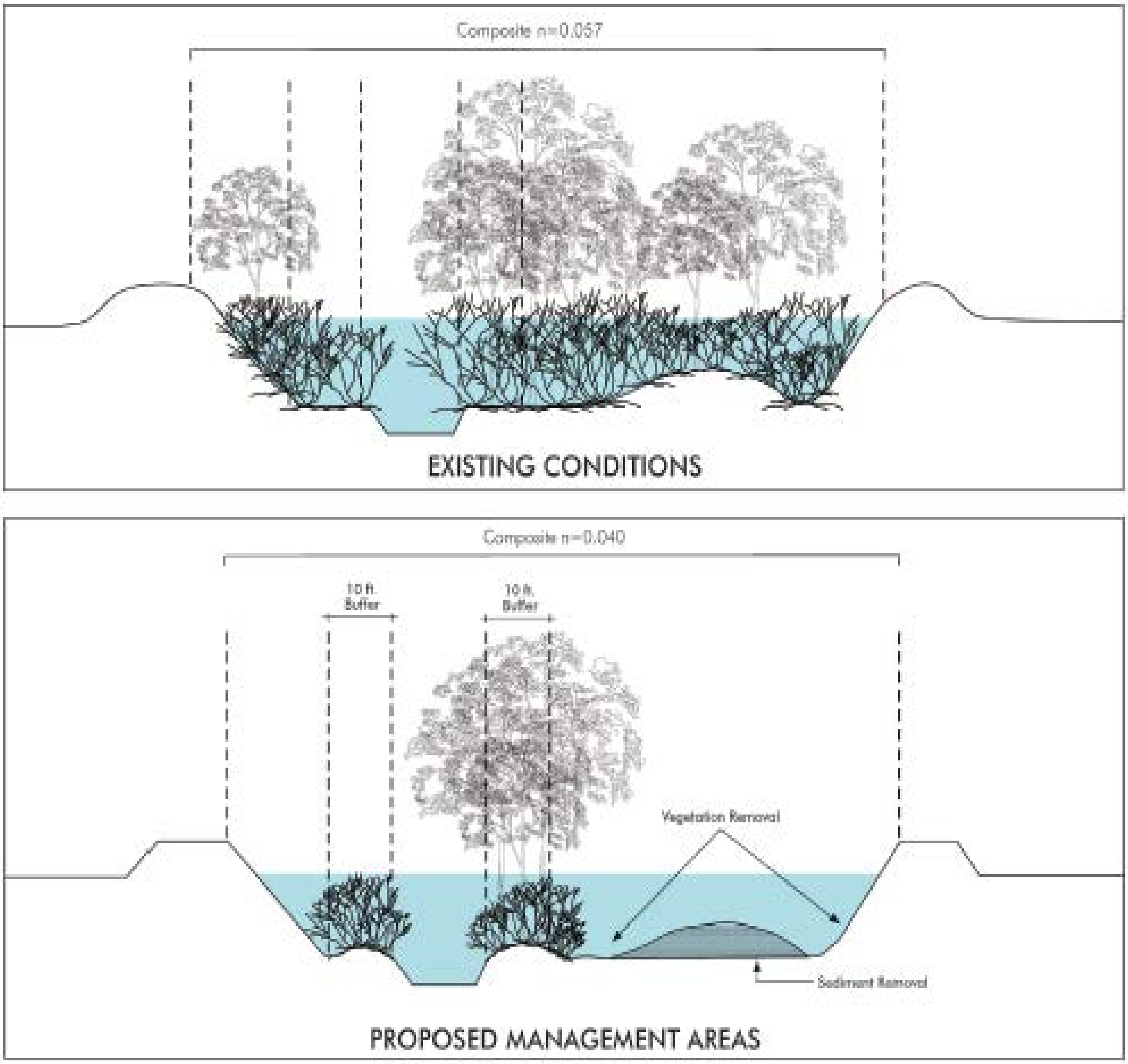


Figure 2-4. Management cross-section view of the action area under flow conditions that meet flood conveyance capacity of the levee system. All woody vegetation beyond the buffer zone will be removed and in some cases replanted in upstream areas where there appears to be a lack of woody vegetation coverage in the buffer zone. Source: Arroyo Grande Creek Channel Waterway Management Program Revegetation, Enhancement, and Mitigation Plan for Jurisdictional Areas, San Luis Obispo County, California, April 2014.

Although canopy cover will be retained along the active channel within the proposed buffer, there will be complete removal of the current canopy for areas beyond the buffer making surrounding slopes of the channel exposed to increased solar radiation (radiant heat). Habitat exposure to increased solar radiation will likely be amplified given projected climate change impacts on stream temperature. Specifically, the proposed action reduces the ability of the riparian corridor to maintain water temperature within freshwater rearing sites in the action area. To understand the influence of the proposed action in this context, it is important to recognize that water temperature can determine the quality of habitat for stream fish, including steelhead. The extent that solar radiation modifies the temperature of the water largely determines the daily and seasonal patterns of water temperature. Given the reduction in canopy density within the action area, we do not expect the proposed buffer to provide much shade to the adjacent habitat (confined within the levees). Based on sun angles throughout the day and the orientation of the channel, the removal of existing trees and woody shrubs will typically preclude formation of a protective canopy that shades the stream and lowers water temperature (*e.g.*, Murphy and Meehan 1991, Platts 1991, Moore *et al.* 2005). Water temperature is typically lower in reaches with riparian vegetation, and these reaches show less diel fluctuation than reaches with little or no riparian vegetation (Burton and Likens 1973, Hewlett and Fortson 1982). Precluding all but a vestige of canopy cover in the action area can cause stream temperature to exceed the habitat requirements of fish (*e.g.*, Hall and Lantz 1969). For these reasons, the widespread reduction in streamside vegetation types (*i.e.*, shift to primarily non-woody species), width, and abundance throughout the action area, due to the proposed action, is expected to reduce the thermal quality and availability of freshwater rearing sites for threatened steelhead.

NMFS expects the proposed action would reduce the ability and degree that riparian vegetation in the action area provides habitat and food resources to a freshwater rearing site. With regard to food resources, streamside trees and shrubs provide a significant source of organic material and, therefore, an instream energy supply for building the food chain (Platts *et al.* 1991, Welsch 1991). Maintaining the food chain in streams is important for preserving the quality of freshwater rearing sites. Streamside trees and shrubs provide food directly to the creek owing to terrestrial insect drop where they may be eaten by fish. With regard to the role of streamside trees and shrubs for creating and maintaining habitat quality and availability (Bryant 1983, Lisle 1986, Platts 1991), riparian vegetation is a source of large woody debris to the stream. Large pieces of wood in streams has an important role in controlling channel morphology, the storage and routing of organic matter and sediment, and the amount and quality of habitat for fish (Lisle 1986). The proposed action would alter the type of vegetation along the creek (*i.e.*, promote non-woody over woody vegetation), and reduce amount and extent of riparian vegetation broadly throughout the action area. The existing vegetation is expected to experience a 52 percent reduced capacity (*i.e.*, the estimated average amount of the action area to be used for sediment maintenance, see Table 2-2) to serve as a source of food and habitat to the freshwater rearing site.

Regardless of whether existing vegetation is native or non-native, removal and replanting often delays development of certain habitat functions (NMFS 2016b). The non-woody plant species proposed for planting are not expected to create and maintain the habitat values offered by the woody riparian species that the proposed action would preclude. For instance, the planted non-woody species will only attain an average height of 1-3 feet depending on the species, and these species are susceptible to the effects of elevated streamflows (HMMP 2014). Additionally, the proposed vegetation design may preclude habitat conditions that support successful growth of native species (Dewine and Cooper 2008). Further, we do not expect the non-woody vegetation to shade areas adjacent to the creek channel extensively as larger, woody species. Adjacent areas to the active channel are important because flow pathways within the action area are likely to change widely in space and time (see section “Removal of Channel-Bed Sediments and Channel Shaping” below for effects of creating channels to increase flood conveyance), thus the riparian buffer must maintain the capacity to shade areas that become wetted in response to storm flows. Given the value of riparian shade to streams in maintaining suitable water temperatures for growing steelhead and the entire functionality of the riparian corridor as a unit including adjacent areas to the stream channel, the widespread loss of vegetation is expected to diminish the ability of the action area to function as a freshwater rearing area.

The reduced diversity of vegetation in the action area, due to the selective removal of certain species, can affect sediment and soil stability. Specifically, the roots of woody species influence stability and water-erosion processes (Reubens *et al.* 2007), which are essential elements to sustain the quality of migratory and rearing habitats in the action area. Although the existing woody vegetation (*e.g.*, shrubs) that would be removed is not directly adjacent to the active channel (beyond ten feet from the low-flow channel), this vegetation provides perennial woody roots that can add strength to streambank soils (Schultz *et al.* 2004, Gomi *et al.* 2005). The extensive area of exposed soil is expected to be mobilized during periods of elevated flows throughout much of the action area due to removing vegetation outside the buffer as part of proposed sediment clearing and channel shaping (Figure 2-4). Additionally, the proposed buffer will likely be ineffective at intercepting sediment generated outside of the riparian zone (in this case within the secondary sediment management areas), or by mass movements and road erosion (Wemple *et al.* 1996, Keim *et al.* 1999, Gomi *et al.* 2005). This expectation is based on the fact that the proposed buffer is relatively small compared to suggested buffer widths in the ecological literature to maintain the integrity of the riparian corridor. Figure 2-4 shows the relative extent of the action area that will become exposed bed and bank areas once vegetation is removed. Overall, the proposed vegetation removal increases the potential for artificially accelerating channel erosion processes and decreases function and value of designated critical habitat to meet the intended conservation role for the species.

Proposed herbicide applications for vegetation removal in action area are unlikely to have adverse effects on salmonid habitat. The District will use an herbicide approved by the Environmental Protection Agency (EPA) for aquatic use in channels. It is thought to be safe for weed control in and near streams due to their limited impacts on physical and biological features of listed salmonid critical habitat (NMFS 2003). It is registered for use on aquatic plants in open-water conditions. Furthermore, the District has developed numerous mitigation measures to offset the potential adverse impacts, such as (1) responsible application guidelines, (2) reporting of all water-quality incidents, (3) reducing overall herbicide use, and (4) spill containment and clean-up plans.

The foregoing discussion of effects involved the intent to artificially maintain the proposed 10-ft riparian buffer on each side of the low-flow channel. We now shift to a specific category of vegetation removal that is proposed for select bridges in the action area, adjacent to the active channel and within the proposed protected buffer.

Under the proposed action, vegetation maintenance at three bridge locations will result in a modification within the protected buffer. In this regard, 3,049 square feet (0.07 acres) of designated critical habitat within the buffer are expected to be rendered largely incapable of fulfilling the intended conservation role for the species in terms of a freshwater rearing and migration site.

In summary, the removal of riparian and aquatic vegetation, and sediment and debris from the stream channel at the three bridge sites is expected to alter channel morphology and hydraulic conditions that provide habitat for rearing and migratory life stages of steelhead (NMFS 2004). The exposed area of soil is expected to be unstable and prone to mobilization. Vegetation loss within the cleared area is expected to reduce shade and overhead cover, increasing the amount of creek that is exposed to radiant heat. While non-woody vegetation is proposed for planting, this vegetation is not expected to shade the active channel in the same manner as woody riparian vegetation (see Davies-Colley *et al.* 2009). The combined effects from altering physical features of critical habitat such as riparian vegetation cover and shade will result in increased water temperatures that precludes the development of rearing habitat features for the species. In terms of migratory habitat during elevated winter and spring flows, these particular areas will likely become velocity barriers during the adult and juvenile migration period because the proposed vegetation for these areas will collapse as an effect of high-flow events, thus no resting or hiding areas will be available at these locations. Additionally, without a diverse mix of vegetation in these areas (mix of both woody and non-woody species) to provide a suitable source of terrestrial invertebrates versus aquatic, which are typically less energy-rich than terrestrial invertebrates (see McCarthy *et al.* 2009), food quantity and quality for rearing juveniles is expected to be low, although, there will likely be nutrient drift into these areas from upstream areas within a riparian buffer in the action area that produce plant debris and insects, which eventually enter the waterway.

After issuing the draft biological opinion on July 11, 2016, we received District clarification on the proposed action. The District will not need to dewater the work area before beginning vegetation-removal efforts at the bridges. Therefore, there will be no effects to habitat from dewatering activities and no temporary disruption or elimination of freshwater rearing sites for threatened steelhead. According to the description of the proposed action and as a reminder for the reader, temporary diversions elsewhere in the action area will be constructed independently for each project element, or group of project elements, to minimize the duration that any particular segment of stream channel is dewatered (BA 2015).

In conclusion, adverse effects to designated critical habitat are expected at the bridge locations. This expectation is based on the extent, amount, and degree of modification to the existing riparian buffer at these locations. Consequently, elevated water temperature from lack of a riparian canopy upstream and downstream of bridge crossings will result in unsuitable rearing and migration habitat for both juvenile and adult steelhead.

Removal of Channel-Bed Sediments and Channel Shaping Between the Levees

The removal of sediment and organic debris, and the related channel shaping and smoothing, are expected to have three principal effects on designated critical habitat for threatened steelhead: (1) eliminating complex habitat features that arise from natural fluvial processes, (2) reducing the amount of creek channel that would be available to provide important habitat functions and values for threatened steelhead, and (3) increasing the amount and extent of exposed fine sediment (*e.g.*, sand and smaller particle types) that could be mobilized and eventually settle in important habitats for steelhead. Each of these is described more fully as follows.

The natural movement of water, sediment and organic debris in streams is central to the formation of complex and abundant habitats that water-dependent species like steelhead require for fulfilling life-history function (Poff *et al.* 2007, Sutton *et al.* 2007). Through the removal of sediment and debris, the channel shaping, and the proposed creation and maintenance of the secondary channels (*e.g.,* Figure 2-4), the proposed action would disrupt the role of natural processes in shaping important critical habitat features over a vast portion of the creek channel in the action area. Even if these habitat features develop in response to a particularly large flow event, the features would be eliminated by the proposed ongoing maintenance of the secondary channels. The effects to designated critical habitat for steelhead involve habitat loss and simplification, and a reduced ability of the affected area to function as a freshwater rearing site and freshwater migration site.

A substantial portion of the creek in the action area would be relegated to a flood-control channel, with no value as habitat for threatened steelhead. In this regard, creek habitats would be eliminated or simplified owing to the widespread removal of sediment and channel shaping throughout the action area. Although sediment removal and channel-shaping activities would be undertaken "outside the riparian buffer" (or similar phrase), in reality these activities would be undertaken in what normally constitutes the riparian corridor and creek channel (*e.g.*, Figure 2-4).

A decrease in channel roughness, including in the active channel, is expected to result and constitute an adverse effect of the proposed action. The District proposes that all woody vegetation will be removed across the entire channel, including through the active channel, for a distance of 40 feet upstream and 25 feet downstream of existing bridges (page 11 of the this biological opinion). When woody vegetation is removed from a stream channel, channel roughness can decrease (in addition, the proposed action includes other activities that are expected to decrease channel roughness) (*e.g.*, a source of wood debris to the stream is eliminated, and habitat complexity is reduced). Decreased roughness translates into a reduced amount and type of suitable cover and instream areas with low water velocity for steelhead during migration, for example. Furthermore, velocity barriers are likely to form in the vicinity of bridges in the action area. Under a flow scenario of 200 cfs (bankfull discharge, which is estimated every 1-2 years), and according to District-provided channel velocity profiles, average channel velocity will significantly increase immediately downstream of both 22nd Street Bridge and Highway 1 Bridge. This biological opinion speaks to the areas upstream and downstream of bridges where velocity barriers may form as a result of removing woody vegetation and channel shaping through sediment removal, owing to the proposed action. Because the 1-D HEC-RAS model output provides only an average channel velocity profile and considering the measurable decrease in channel roughness from sediment and vegetation removal, it is reasonable to expect even higher water-column velocities within the sediment removal/secondary channel areas (*i.e.*, outside of the active channel and beyond the proposed artificially delineated riparian buffer). Lastly, the District's own schematic (Figure 2-4 of this biological opinion) clearly indicates channel roughness would decrease owing to the proposed action (*i.e.,* Manning's *n* decreases from 0.057 to 0.040).

Overall when NMFS considers the spatial extent between the levees, consigning a large portion of the action area to serve as a flood-control channel, at the exclusion of designated critical habitat for steelhead, is expected to decrease the quality (*e.g.,* eliminating velocity shelters and cover habitat) and availability (*e.g.*, because less of the habitat remains) of freshwater rearing sites and freshwater migration sites.

NMFS expects the extensive area of exposed soil in the secondary channels throughout the action area to alter sediment load received by the Arroyo Grande Creek lagoon. Sediment load and associated transport are major factors when considering possible changes to lagoon volume as a result of the proposed action. The District recognized that there will be a deviation from observed variability in lagoon volume owing to the proposed action (BA 2013, 2015); the proposed performance goal allows a deviation up to 25% from observed variability based on a six-year moving average of measured conditions. Changes in sediment load (*i.e.*, channel and basin sedimentation) into lagoons can generally result in the following effects to rearing habitat: (1) decreased water-column depth (*i.e.*, living space), (2) increased lagoon sensitivity to radiant heat (due to shallower depths and less water volume), (3) disrupted benthic assemblages through altering patterns of tidal flushing (*e.g.*, Nordby and Zedler 1991), and (4) degraded water quality. In addition to changes in sediment load, cycles (duration and frequency) of an open and closed lagoon mouth (*i.e.*, natural breaching events triggered by elevated spring or winter flows during a storm event) contribute to changes (or variability) in lagoon volume. However, sediment deposition that decreases lagoon depth can also influence the frequency of breaching events. The berm at the mouth of a shallower lagoon will be overtopped by incoming creek flows more quickly, for example.

As noted above, factors that influence duration and frequency of lagoon dynamics can be both from natural and anthropogenic stressors. In general, lagoon-volume variability is caused, in part, by the flow as driven by the initial stored water volume behind the barrier beach, tidal prism, river flow, set up of water against the lagoon side of the barrier beach by wind, barrier elevation, volume above mean sea level, and longshore and cross-shore sediment transport on the ocean side (Kraus *et al.* 2008). As discussed in the Environmental Baseline, channelization, groundwater pumping, and Lopez Dam have altered the hydrodynamics and sediment export processes of the lagoon. Consequently, the trends for sediment accumulation in the lagoon do not reflect natural, undisturbed conditions, and lagoons tend to aggrade as sediments fill in the lagoonal space over time (Jacobs *et al.* 2011). Further, the proposed action will continue to help ensure that sediment accumulation trends deviate from natural sediment-export processes that occurred prior to channelization and Lopez Dam, thus the proposed action will perpetuate the observed variability in lagoon volume. For example, one analysis suggested that the proposed action will increase lagoon flushing at higher flows due to increased channel capacity (Swanson Hydrology + Geomorphology 2006).

According to the District, sedimentation of the lagoon is not expected as a result of the proposed action because the portion of the channel functioning as a flood-control reach will move less sediment in lower flows relative to existing conditions (District 2017a). The District also explained these portions of the channel will be more efficient at flushing the lagoon with higher flows, which are expected to move through the action area after the initial sediment removal phase (District 2017a). Regardless of the District's predictions for expected effects from the proposed action, some elements of the proposed action are a continuation of exiting conditions into the future (*i.e.*, continuation of maintaining levees/channelization in the action area for the next 50 years). Shaping of the channel bed to increase flood conveyance and continued existence and maintenance of the levee system in the action area along with stressors outside of the action area that affect conditions within the action area (*e.g.*, operation of Lopez Dam) will continue to transport an increased amount of sediment to the lagoon, thus deviating farther from natural (unimpaired) variability trends in lagoon volume.

In an effort to minimize effects of the proposed action, the proposed action includes an aggressive monitoring program for lagoon conditions that will allow early detection of variation in lagoon volume before reaching the 25% deviation threshold. Early detection of variation in lagoon volume prior to reaching a 25% deviation supports a framework for advanced planning to implement methods and alternatives to avoid conditions that result in adverse effects to steelhead rearing habitat. If monitoring reveals the proposed action results in a deviation in lagoon volume variability toward the 25% threshold, then the District would pursue lagoon restoration through sediment-management methods and floodplain-restoration alternatives identified in the Arroyo Grande Creek Erosion, Sedimentation and Alternatives Study (Swanson Hydrology + Geomorphology 2006; District 2017a).

Based on the available data and information, it remains clear the expected deviation from observed variability in lagoon volume will continue, if not contribute to an increase in adverse effects to designated critical habitat for threatened steelhead. Although the exact anticipated magnitude of the increase above the Environmental Baseline cannot be measured or predicted, this increase (from channel shaping through sediment removal and levee repairs) in addition to the ongoing effects (continued existence of the levee system) will continue to diminish the conservation value of designated critical habitat by reducing the habitat's capacity to meet the intended conservation role for the species. Thus, the expected range of deviation for variability in lagoon volume would suggest that the proposed action will continue to reinforce altered lagoon dynamics through changes in sediment transport processes without any advancement toward mimicking natural (unimpaired) lagoon dynamics that were present before anthropogenic changes within the Arroyo Grande Creek watershed.

In summary, existing lagoon dynamics have shifted away from natural (unimpaired) variability trends due to many factors (see Environmental Baseline section), but ongoing channelization (*i.e.*, maintenance/repair of the existing levee system) in combination with the rest of the proposed action elements (*i.e.*, vegetation and sediment removal, channel shaping) reinforces the trend of artificially increasing channel and basin sedimentation in the action area. To this end, a larger quantity of sediment will now move through the action area and empty into the lagoon rather than being deposited upstream. Sediment-deposition changes that do not mimic a natural (unimpaired) sediment regime are likely to amplify already degraded qualities of the existing lagoon.

To further understand the implications of the proposed sediment removal and channel shaping, particularly for freshwater migration sites in the action area, we considered how the action would affect water velocity, the quality and availability of cover, and water-column depth. The results we obtained from considering these elements are presented as follows. As a reminder to the reader, the velocity profiles below are generated from a 1-D HEC-RAS model, which provides only a coarse estimate of increased velocities within the action area.

With regard to water velocity, the proposed elimination of woody vegetation outside of the existing riparian buffer (*i.e.*, within areas where sediment would be excavated and the channel shaped) is expected to increase water velocity during high-flow events in the action area (Figure 2-5, Figure 2-6). This effect is not surprising given the intent of the proposed action is to relegate a large portion of the creek to a flood-control channel for the purpose of rapidly conveying flood flows. Depending on the magnitude of river discharge, the elevated water velocities that are anticipated have the potential of temporarily decreasing the quality of the freshwater migration corridor for steelhead (*i.e.*, higher water velocities can slow or stop migration). The delineated excavation (channel shaping) areas are expected to be inundated more frequently with a range in duration of half a day to two days depending on the size of the storm event (see Table 2-2). This inundation increasing the amount of time in which there is steelhead access to a degraded migration corridor. The quality of the corridor will be degraded for the following reasons: (1) higher water velocity, (2) elimination of resting areas from woody vegetation, (3) minimal to no food resources (*e.g.*, invertebrates), and (4) increased water temperature without cover from a woody-vegetation canopy.

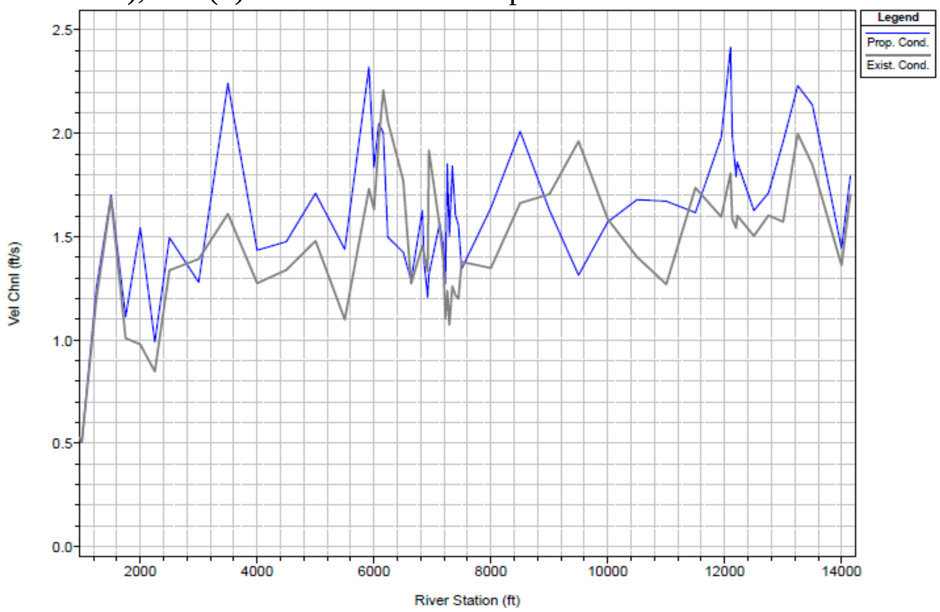


Figure 2-5. Average channel (active and secondary channels) velocity profile for Arroyo Grande Creek for existing (grey) and proposed conditions (blue) under a 200 cfs discharge scenario for the action area, which is the approximate bankfull discharge. This is the amount of water expected for the most-probable annual flood or the normal high-water mark. Source: Waterways Consulting, Inc. 2015. Note: Velocity analysis for the secondary channels alone was not available given modeling capabilities.

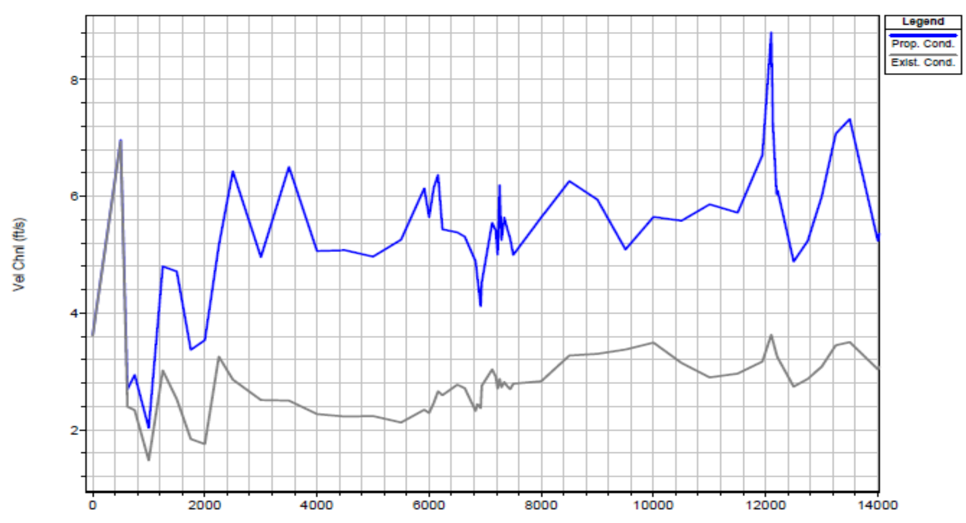


Figure 2-6. Average channel velocity profile under the 5-year storm event scenario. Source: Waterways Consulting, Inc. 2015. The increase in velocity is directly related to removal of vegetation and sediment. Note: Velocity analysis for the secondary channels alone was not available given modeling capabilities.

Regarding cover, the absence of trees and shrubs is expected to reduce the amount of cover in the freshwater migration area. The woody vegetation that naturally enhances the quality of migratory habitat for both adult and juvenile steelhead through reducing water velocity, and creating rest areas and cover (*e.g.,* Schultz *et al.* 2004), would be lacking, owing to the sediment removal and channel shaping. In particular, the secondary channels are anticipated to lack the trees and woody debris that provide instream shelter from high velocities and overhead cover that decrease visibility of salmonids to terrestrial and aquatic predators (Gibson and Power 1975, Helfman 1981).

With regard to water-column depth, proposed channel shaping efforts will reduce water-surface elevation of critical habitat in the action area, thereby reducing water-column depth with the exception of a ten-year storm event in the lower portion of the action area (RS 72+20, Figure 6 in Waterways 2015). In all other scenarios (2-year, 5-year, and 10-year storm events), both lower and upper portions of the action area will be adversely affected by changing the shape of the channel to improve flood conveyance. As juvenile steelhead become larger (including during their outmigration) they move into faster, deeper water with instream cover to minimize energy expenditure, maximize access to food, and seek protection from predators (*e.g.,* see Spina *et al.* 2005).

Deep-water habitat on which juvenile steelhead depend (*e.g.,* Pert and Erman 1994) will be reduced as a result of the proposed action. Further, the proposed altered streambed elevation results in a hydraulic change that translates into an ecological impact to critical habitat. The new channel planform will limit or delay variability (complexity) of habitat conditions, specifically the channel will lack substantial curvature-induced helical motion, which results in low variability of cross-stream (lateral) and vertical velocities (see Rhoads *et al.* 2003). These geomorphic elements can be used as ecological indicators, and as such, indicate overall habitat quality, specifically habitat diversity, would be reduced for the species (see Roni *et al.* 2008).

A diverse habitat in terms of different flow velocities is important because physical and biological features of the migration corridor support different requirements of the species based on the particular strategies for overwintering at different life stages (adult and juveniles) in the action area. For example, older steelhead favor deeper, faster water. Seasons influence habitat selection as well, where relative to summer, generally steelhead of all age classes will seek slower water velocities and greater overhead cover in the winter. Maintaining winter habitat complexity is essential for overwintering fish because habitat suitability and use can vary with time over the course of winter (*e.g.*, early winter vs. late winter vs. midwinter; day vs. night), for example, choice of winter habitat is likely determined by the need to minimize energy expenditure, with the main criterion being protection from adverse physicochemical conditions (*e.g.*, low oxygen) (*e.g.,* Cunjak 1996).

Even if the flood-recurrence interval is relatively low, this does not negate or diminish the potential adverse effects that migrating steelhead may encounter owning to the propose action. NMFS' evaluation of the scientific literature, including Shapovalov and Taft (1954), indicates that steelhead migration is positively correlated with river discharge. Specifically, more steelhead in south-central California are observed migrating during periods of elevated river discharge (Spina *et al.* 2005). Additionally under the proposed action, the species would be challenged to navigate through higher velocities for over half of the action area; thus the proposed action is reducing the amount of high-flow refugia habitat (*i.e.*, resting habitat) on which the species depends during high flows.

Changing the shape of the channel within the proposed sediment removal areas will, by extension, change the water level (*i.e.*, water depth) across the entire action area including the active channel for a given flow. Under the District's 1-D HEC-RAS cross-section analysis, the existing water-surface elevation significantly decreases under most flood-event scenarios that were analyzed, thus reducing water depth throughout the action area. As described above, this will degrade migration opportunities for juvenile steelhead.

Effects of Repairing Levees

The proposed levee repairs, including an average increase of 1.25 feet in the levee height, along lower Arroyo Grande Creek and Los Berros Creek is expected to perpetuate the ongoing artificial confinement of the two creek channels in the areas experiencing the levee repairs (*i.e.*, also termed "levee smoothing" by the District, see Figure 2 in BA 2015). Before explaining the expected effects of the levee repairs, we briefly explain our rationale for concluding that an "effect of the action" involves perpetuating the effects of the existing (to be repaired) levees into the future.

The proposed action would materially enhance or preserve the operation of the existing (to be repaired) levees to capture and retain flood flows in the creek channels over time. In a situation involving an unmaintained levee, the functional longevity for such a structure, consistent with the intended purpose of the structure, cannot be assured and is unspecified. Additionally, the operational volume and capability of an unmaintained levee for capturing and then storing a pre-defined proportion of the flood flows cannot be guaranteed. The available information corroborates that the proposed repair and maintenance would ensure operation of the levees for a specified period of time (the Corps' proposed 16-year permit) to catch and retain a pre-defined fraction of the flood flows. Through physical preservation of the levees, the proposed maintenance work (*e.g.*, sediment and vegetation removal) associated with levee repair provides a level of operation that would otherwise be unattainable and certainty that would otherwise not exist regarding the continued physical existence of the levees and habitat impairment caused by the levees if not for the proposed action. For this reason, the proposed action will ensure that the District's existing levees operate as intended for the life of the Corps' permit and, as a result, extend the existing effects of the levees into the future by approximately another 50 years (the first 50 years were 1959-2009, where there was a collective recognition that a new waterway management (flood-control) plan was needed, see Environmental Baseline section).

With regard to adverse effects on designated critical habitat, this element of the proposed action is expected to continue (1) preventing natural lateral channel migration of the creek channel, (2) confining the creek within an artificially defined corridor, and (3) propagating the existing fragmentation and disconnect between the active river channel and historic floodplains. The ecological value of maintaining connection between the active river channel and its historical floodplain is well documented (*e.g.*, Brookes 1988, Mount 1995, Ziemer and Lisle 1998). Restricting natural lateral movement of the main channel is considered an adverse effect because the movement is important for providing storage of floodwaters, sediment, macroinvertebrate production (food), and large woody debris (NMFS 2016b). In addition, floodplains can contain sloughs, side-channels, and other features that provide refugia during high flows (Wenger 1999, Boughton and Pike 2013, NMFS 2016b). The proposed action is expected to negatively affect freshwater migration corridors along the repaired levees by reducing the amount and extent of instream refugia and holding areas for steelhead migrants within edge habitats, and interfering with natural processes that increase the quality and availability of freshwater migration corridors within the action area.

The main driver, pattern, processes, and effects from maintaining (specifically repairing) a levee are pictured below and are cyclic in nature (Figure 2-7), thus repairs to the levees have the potential to accelerate habitat degradation and continually increase flood risk (Liao 2014). Below, we explain how levees can actually increase flood risk.

Raising portions of the levees as described under the proposed action is expected to minimize flood risk only for the 10-year storm event; however, there are consequences of continual maintenance and improvements to flood-control infrastructure. For instance, while increasing levee height will reduce the frequency of flooding and provide the capability to hold a greater portion of a flood, the forced deviation from the natural-flooding pattern rises over time, thereby increasing the long-term risk of levee failure under storms larger than the 10-year storm (*i.e.*, 20-year and 50-year storm events).

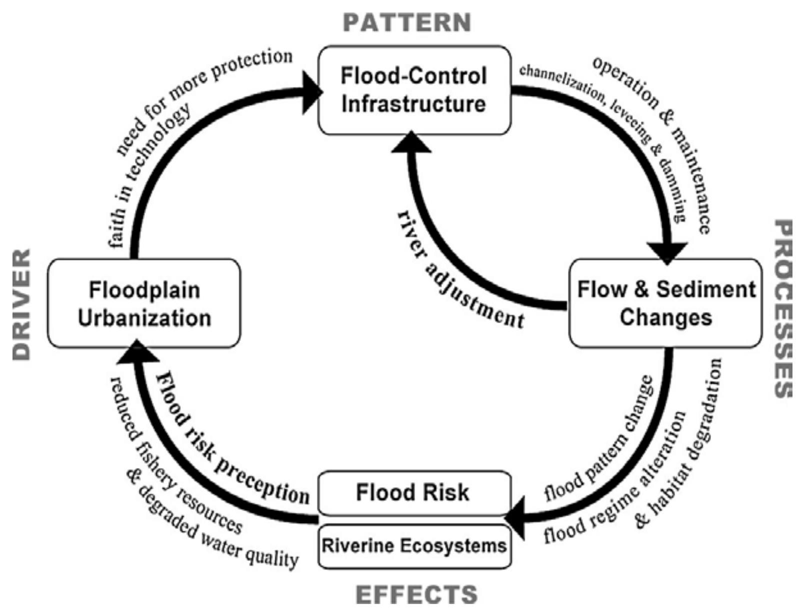


Figure 2-7. Cyclic framework that can result from flood-control infrastructure in the action area where the historical floodplain is now constricted by a developed floodplain due to urbanization and agriculture (source: Liao 2014).

There are typical, cyclic patterns that emerge with maintaining and repairing levees. Without historic floodplain storage for floodwaters, the action area will continue to be a managed flood-control system that alters the natural flooding patterns (see Pinter 2005). For example, when levees are built or repaired to protect developed floodplain areas, their presence not only reduces the frequency of flooding, but also exacerbates high water levels because now the repaired levees can hold a greater portion of the flood discharge. This triggers motivation for other flood-control activities including activities that are the same or similar to the proposed action (see socio-hydrology discussion in Baldassarre *et al.* 2013). As a result, deviation from the natural flooding pattern can become greater over time, with rare and catastrophic storm events in developed floodplain areas (*e.g.*, 16 years ago the existing southern levee failed during spring floods of 2001).

Lastly, constraining channels between levees results in higher, faster water carrying more sediment particles during floods, which can undermine the integrity of the levee structure. As floods recede, sediment is deposited between the levees (because it can no longer be deposited on floodplains) raising the channel bed and, as sediment builds up between the levees, the levee structure becomes increasingly threatened with the risk of overtopping or breeching during subsequent storms. Because the levees initially work to prevent high flows from reaching floodplains, these areas are now "safe" and more development occurs, resulting in additional infrastructure and property that must be protected, thus flood-control management typically implements designs for higher levees and, consequently over time, accumulated sediment between the levees needs to be removed to maintain floodwater-storage capacity (Liao 2014).

Continued loss of ecological value by precluding floodplain connectivity

The need to continually manage sediment in the action area arises due to the presence of the levees that confine the active channel and limit the extent of rearing habitat within the depositional zone of the action area (*i.e.*, Cienega Valley). To maintain a continual disconnect between the active channel and its historical floodplain diminishes the quality and availability (owing to the reduced habitat volume) of rearing habitat for threatened steelhead for the duration of the Corps permit (16 years) and throughout the extended life of the levee (via repaired portions of the existing levee) by: (1) decreasing water column depth (*i.e.*, living space) of rearing habitat, (2) increasing sensitivity to radiant heat throughout the action area and particularly near bridge crossings due to removal of woody vegetation, (3) degrading water quality, (4) artificially accelerating channel and basin sedimentation, and (5) reducing food and cover availability due to an artificially narrow buffer. Moreover, climate projections for the action area indicate that rainfall will be more intense and the frequency of storms will increase, further compounding the anticipated effects to the quality of steelhead rearing habitat (Inman and Jenkins 1999, McLean *et al.* 2001) available to the species for as long as the levees remain in the action area.

This biological opinion concludes that the proposed action would continue relegating a portion of Arroyo Grande Creek and Los Berros Creek in the action area to a flood-control channel. As a matter of background, "the creeks have been confined to a flood-control channel for at least 55 years" (FBM letter of November 3, 2016). In terms of considering the "effects of an action" on a listed species or designated critical habitat for the species, a key issue before NMFS involves whether the proposed action would materially preserve or enhance the existing channelization in the action area, thereby continuing to relegate the creeks to the area between levees that is managed for flood control. The proposed action specifies a number of activities that would increase conveyance of elevated flows through the action area (between the levees) to provide flood protection to adjacent communities and properties. These activities involve repairing (raising) levees in select areas (thereby ensuring the creeks remain artificially confined for an indeterminate period into the future), removing accumulations of sediment from the creek channel, shaping and smoothing the channel, eliminating vegetation, and reducing channel roughness, all for the purpose of preserving or enhancing the District's ability to operate the levees and waterway as a flood-control channel. As described in this biological opinion, relegating the creeks to a flood-control channel creates a variety of harmful effects to designated critical habitat for threatened steelhead, which have adverse consequences for the listed species.

Regarding the historical and present day interaction of the existing levees and sedimentation, we discuss the effects of channelization (*i.e.*, the effect of the levee system) on critical habitat in the action area within the Environmental Baseline analysis of this biological opinion. One effect involves an altered sediment-transportation regime. With streamflow confined between the levees since 1961, sediments deposit in the action area rather than on adjacent floodplains that once had connectivity to lower Arroyo Grande Creek. Because historic floodplains conveyed water and sediment, and served as a repository of sediment, the existing levees decrease a number of important, natural geomorphic features within the river channel. For example, channelization manipulates one or more hydraulic variables (depth, width, slope, roughness). Most importantly, channelized rivers become less variable with a decrease in pools, gravel sorting, and cover. The channel becomes homogenized with riffle-like habitat and unsorted gravels. While multiple factors influence sedimentation, sediment transport, and sediment accumulation within the Arroyo Grande Creek watershed, the levees represent a major factor within the action area that delays establishing a natural sediment regime. Ultimately, because of the existing levees, sediment accumulation between the levees precludes development of properly functioning habitat conditions to support the life history of steelhead, specifically, preventing physical and biological features from developing over the duration of the proposed action (50 plus years from the present day). This proposed action, including the repair of levees and removal of vegetation between them, would ensure that these impacts continue into the future. Thus, the degradation of steelhead habitat in the future via these levee impacts constitutes part of the effects of the proposed action.

Proposed Measures to Minimize the Effects

Under the proposed action, a number of activities are identified by the District as minimizing effects of the action on designated critical habitat for threatened steelhead, or creating beneficial effects. NMFS' review of these activities generally suggests many activities would not be effective in minimizing the principal major effects, nor would any substantive benefits be created, as described more fully as follows.

While restoration of temporarily impacted areas within the levees will be undertaken through a native hydro-seed mix containing an assemblage of native annual and perennial grassland species (HMMP 2014), these species are no substitute for woody riparian vegetation. As reviewed earlier in this section, riparian tree species provide numerous benefits to the physicochemical characteristics and condition of streams that support the value of steelhead critical habitat. As a result, NMFS doesn't anticipate the proposed revegetation plan would adequately minimize the effects of the riparian vegetation removal on designated critical habitat for threatened steelhead.

Although the proposed action includes both short and long-term management of sediment to reduce short-term flood risk in the action area, the District proposes to use natural channel morphology as a key element of the sediment-management plan to minimize adverse effects to designated critical habitat. The short-term action would consist of an initial sediment removal (first-year conditions) throughout the action area to remove sediment built up in off-channel areas during the past decade, establish the secondary channel profiles, and install the large wood structures. Thereafter, the proposed action attempts to mimic natural channel form and processes to minimize the frequency of future sediment management activities in the secondary channels by establishing bed elevations at the bankfull elevation to mimic a natural floodplain feature. However, the initial removal of sediment from the creek is expected to eliminate important creek-habitat features, which will not be allowed to re-establish owing to the continued sediment and vegetation removal proposed. Furthermore, how exactly the District would mimic the natural channel form within the secondary channels, including the specific contours, channel features, and condition, is not clear from a review of the description of the proposed action including the 95% design submittal plans for the following reasons: (1) the placement of the large wood structures appears to "lock" the active channel in place to preclude migration of the active channel after large storms, and (2) the rationale for spacing between large wood structures remains undefined. Lastly, the proposed action does not appear to preclude the possibility that the future sediment removals would not eliminate the "mimicked" features.

Zones of flow variability and habitat complexity, such as streamside wetlands and riparian tree stands will be continually precluded from off-channel areas at various elevations minimizing the capacity for such physical habitat elements to maximize water quality. Elimination of woody vegetation from over half of the action area precludes the control of nonpoint sources of pollution (sediment and nutrients). Low-velocity zones help support water quality because they allow suspended sediment to settle (see section 3.2 Water Quality in NMFS 2004). However, under the proposed action, the sediment trapping skills of non-woody, grassy riparian areas may be highly variable and of short duration when several floods occur within a limited period (Naiman and Décamps 1997). The boundary of the streambed and the boundary of the riparian zone appear to be major locations for regulating and diminishing the transfer of inorganic nitrogen and phosphorus from subsurface water to stream water (Naiman and Décamps 1997), thus with a restricted riparian (woody) buffer and extensive areas proposed for non-woody vegetation (Management Zone 1C and Management Zone 1D, see terminology in HMMP 2014), the risk of degraded water quality is high. Although grassy vegetation is usually better than wooded zones at assimilating phosphorus, macrophytes and algae in grassy portions of the action area may often reach elevated levels sufficient to deplete dissolved oxygen at night (*e.g.*, Lyons *et al.* 2000). Therefore, the action area will have diminished value of physical and biological features with a low likelihood of providing the following functions (see Naiman and Décamps 1997): (1) ability to control pollutants in subsurface flow and surface runoff, where biological and chemical transformations, storage in woody vegetation, infiltration, and deposited sediments are maximized, and (2) ability to contribute to nitrogen, phosphorus, and sediment pollution removal.

Existing woody vegetation within the buffer will be enhanced. Planting within these buffer areas will establish and enhance approximately 3.41 acres of riparian overstory and bankside understory that would remain undisturbed during vegetation and sediment removal efforts elsewhere in the action area (HMMP 2014). Arroyo Grande Creek and Los Berros Creek will be planted with a diversity of woody vegetation (willows, cottonwood, and alder) within areas that are devoid of vegetation or consist of non-native (ruderal) habitat within the 10-ft and 5-ft protected riparian buffer, respectively. Proposed establishment of overstory in Los Berros Creek and enhancement within Arroyo Grande Creek would provide an opportunity to increase cover, but isn't expected to minimize adverse effects to shade elsewhere, particularly where shade over the active channel will be lost at three bridge crossings. Thus, the action area's ability to maintain cooler water temperatures may be compromised in specific areas. Canopy density within the action area will undergo a severe reduction and in some places a complete elimination of riparian canopy (bridge crossings) over the stream channel. Consequently, this will result in an artificially narrow buffer unable to provide shade in areas that the species utilizes during rearing and migration behaviors. Finally, even with a more robust 10-foot vegetated buffer, we anticipate the shade benefits are minimal, as described above. Ultimately, the narrow buffer width that would result from the proposed action represents a significant departure from the riparian buffer width that would exist if not for the proposed action. In addition, the proposed buffer width is not expected to produce the riparian benefits that are typically associated with wider buffers, thus providing the lowest quality of protection against adverse effects to designated critical habitat.

The proposed action includes installation of 36 log structures within the 10-foot buffer area and within the in-stream wetland habitat of Arroyo Grande Creek (BA 2015; District 2017e). The estimated total area of disturbance would be approximately 0.52 acre (0.34 in USACE Other Waters and 0.18 in USACE Wetlands). As designed, these log structures will produce localized scour, an increase in pool depth and volume, an increase in escape cover provided by large wood, and variability in substrate and flow condition. However, the structures will locally preclude the low-flow channel from migrating into the secondary channels (*i.e.*, sediment maintenance areas) but may not preclude the low-flow channel in other areas from migrating into the secondary channel. This may happen because in some areas spacing between log structures is at a greater distance allowing the low-flow channel to meander outside of the buffer after the 10-year storm event, for example, thus triggering a maintenance event. The total area of these structures, including indirect habitat features created by the logs themselves such as increased pool size, is approximately 1.22 acres. The stationary log structures fail to provide local lateral channel migration by helping to lock the active channel in place, which prevents natural processes (*i.e.*, channel migration) from functioning that would minimize adverse effects on the quality of critical habitat in the action area (*e.g.*, Bisson *et al.* 2009).

The design of the wood structures attempts to maintain the shape and form of both the primary active channel and the secondary (excavation) channels for flood conveyance in the action area. Specifically, the downstream terminus of each secondary channel will be protected with a large wood structure to prevent headcut migration and the potential for avulsion of the primary channel into the secondary channel (Figure 2-8). A vegetated, mid-channel bar will be maintained between the primary and secondary channel to enforce establishment of a stable bankfull channel where aquatic habitat conditions would be undisturbed. However, there is no assurance the mid-channel bar would be effective in this regard, and due to limitations of the available modeling efforts to show how channel narrowing may affect the distribution and magnitude of adjacent water-column velocities, information to inform this portion of the effects analysis remains unavailable.

The District expects these log-habitat structures to provide sinuosity and complexity to the channel, refugia for steelhead, and improve water quality (HMMP 2014). However, these log-habitat structures, which could also be called "meander jams," can deflect flow and define subsequent channel development making it difficult to determine how to minimize adverse effects to biological and physical features of designated critical habitat in the context of geomorphic-based processes that will avoid delayed development of in-channel features contributing to rearing and migration habitat (*e.g.*, Abbe and Montgomery 2003). Field observations and sequential aerial photographs are not being proposed by the District to monitor and minimize uncertainty with implementing a meander-jam design in the action area.

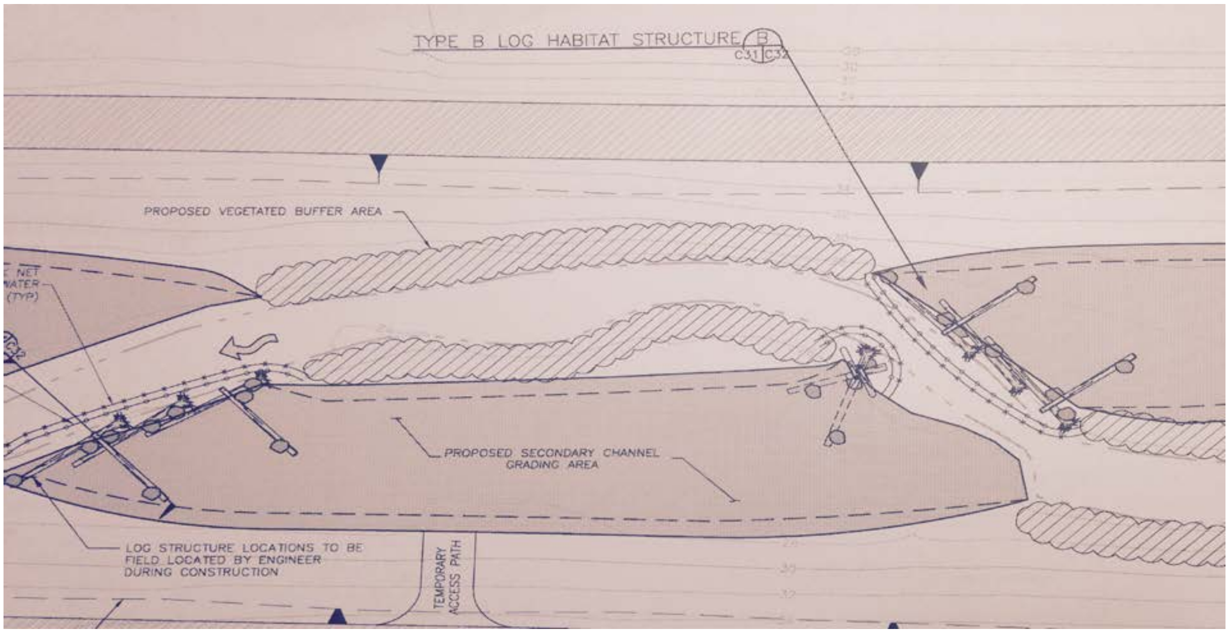


Figure 2-8. Engineering designs depicting a portion of the action area with placement of a secondary channel, buffer, and log-habitat structures. The proposed design has the intent to maintain the spatial extent of the created secondary channel by incorporating permanent structures to lock the active channel in place. Source: Proposed action 95% design submittal in Corps' consultation package dated September 30, 2014.

Ultimately, attempting to simulate steelhead habitat in this manner between levees has an extremely low likelihood to produce much habitat value because the levees create high-velocity and sediment conditions in the winter that are likely to disrupt any habitat created. Further, the presence of the levees constrains the channel, and consequently, any habitat that is created is likely to be very small and support few steelhead.

Although the proposed action includes adding log structures to the creek channel, our review indicates the manner of placement would do little to reduce the effects of the action. In particular, if restoration projects are not designed to address the underlying processes causing habitat degradation (*e.g.*, channelization, loss of floodplains), the unaddressed system drivers will ultimately overwhelm constructed habitat features (*e.g.*, Beechie *et al.* 2010). The primary principle of process-based restoration is that restoration actions should address the causes of degradation, rather than symptoms of it (Beechie and Bolton 1999, Kondolf *et al.* 2006). The proposed action does not include a viable framework to simulate steelhead habitat while at the same time fixing the underlying processes that are causing the value of critical habitat to continually diminish. Therefore, we anticipate the restoration aspect of the proposed action will provide little, if any, benefit to steelhead or their critical habitat.

Maintenance events directly related to removing accumulated sediment at or near the large, wood structures is not anticipated by the District based on the proposed design and expected flow and sediment transport through the action area (Waterways 2015). A plan to monitor habitat response has been proposed to evaluate changes in the frequency and quality of pools as a result of these wood structures in the action area with an established goal of maintaining or increasing pool depth (Table 1 in BA 2015). Although the District includes performance targets, the proposed action remains silent on what the District will exactly do if monitoring reports show a deviation from the described performance measure (*e.g.* increase pool depth). Lessons from the literature show that full recovery of stream and riparian function may take centuries. Recovery depends, in part, on large trees (through natural processes) providing wood to structure the channel (*e.g.*, Davies-Colley *et al.* 2009). Without a clear plan to respond to monitoring data revealing deviations from performance measures, proposed monitoring efforts remain insufficient to ensure all adverse effects are truly minimized. Therefore, the proposed minimization measures cannot promote stream recovery and riparian function in designated critical habitat throughout the duration of the proposed action including the duration of all cyclic effects (described above) due to levee maintenance and continued operations.

Another measure to minimize effects involves the proposed adaptive management for ongoing maintenance. The removal of woody vegetation outside of the buffer areas will be adaptive and based on the field evaluation conducted during the time of the removal (District 2017e). For instance, trees that are located adjacent to the buffer boundary that provide substantial shading to the creek will likely remain in place. In addition, trees that are located adjacent to the buffer boundary that contribute to the species diversity within the channel (*e.g.*, cottonwoods) will also be evaluated by the District for consideration to remain in the channel. To minimize adverse effects of vegetation removal, an effort will be made to save all non-willow trees over 6” DBH within the Transition Zone (*i.e.*, ground area within the extent of the buffer canopy).

Long-term sediment management maintenance will be conducted based on periodic monitoring of sediment conditions in the channel in order to “reset” conditions back to the first year condition. “Resetting” the first year condition will maintain the proposed flood-control design to minimize quantities of sediment and other fine materials that could be deposited in the secondary channels. The objective of the long-term management program is to manage the channel adaptively by evaluating sediment deposition every 1 to 3 years via monitoring of cross sections. To further minimize adverse effects throughout the duration of the proposed action, long-term management of the secondary channels will consist of excess sediment removal by an excavator located on the top of the levee. Heavy machinery is not expected to be needed in the channel during annual, long-term sediment management (HMMP 2014).

With respect to vegetation maintenance in the action area, there will be yearly monitoring, as necessary, until the final success criteria are met of 60% native understory vegetation within impacted areas, and 100% area cover for overstory is met (HMMP 2014). In some instances, the District anticipates the time period to reach this threshold/success criterion may take more than five years (HMMP 2014). It is anticipated that once success is sustained for a minimum of three years, the site will be self-sustaining for the duration of the proposed action. After meeting and maintaining the criteria for three years, the District will no longer conduct annual monitoring.

Failing to carry out vegetation monitoring throughout the duration of the proposed action, provides a weakened management approach and lacks the necessary details for ensuring the proposed action would reduce long-term effects that are amplified by changing environmental variables (*e.g.*, increasing water temperatures and changes in frequency and magnitude of storm events). The proposed adaptive management process doesn't provide different riparian buffer management scenarios based on future climate conditions that are relatively certain to occur in the action area (*e.g.*, under drought conditions, El Niño seasons, etc.). In anticipation of a changing climate, the adaptive management is further weakened by not having firmly established monitoring and reporting protocols after the success threshold and criteria are achieved generally within the first five years of the proposed action. Additionally, specific action criteria/triggers are missing in the plan to minimize adverse effects to designated critical habitat throughout the duration of the proposed action (16 years) including effects that delay and in some cases prevent essential biological and physical features from improving over time to resemble historical conditions when the habitat supported a healthy Arroyo Grande Creek steelhead population. With respect to storm patterns that may shift their intensity, duration, and frequency, modeled floodplain rehabilitation was shown to expand migration windows (*i.e.*, the time the species has to reach their intended spawning habitat) (*e.g.*, Boughton and Pike 2013). However, the proposed action lacks a robust strategy to moderate extreme climate events while reliably improving ecological function in the action area.

The conceptual framework for the adaptive management does not incorporate the following actions: (1) identify the uncertainty and the questions that need to be addressed to resolve the uncertainty, (2) develop alternative strategies and determine which strategies to implement, (3) integrate a monitoring program that is able to detect the necessary information for strategy evaluation, and (4) incorporate feedback loops that link implementation and monitoring to a decision-making process (which may be similar to a dispute resolution process) that results in appropriate changes in management. Ultimately adaptive-management efforts work best if they are well-informed, carefully monitored, adequately funded, collaboratively developed and focused on achieving clearly defined goals and objectives (Alverts *et al.* 2001).

Overall, the proposed measures to minimize effects to the action area are not expected to be sufficient for ameliorating the effects on designated critical habitat because they do not address the following principal effects from the proposed action: (1) maintaining an artificially narrow riparian buffer width, (2) consigning a large portion of the creek to a flood-control channel, (3) introducing a 25% deviation in addition to the altered variability in the volume of the Arroyo Grande Creek Lagoon due to effects from channelization and other factors, and (4) continuing to limit connection between the active creek channel and floodplain areas within a large portion of the action area and interfering with natural processes that increase the quality and availability of freshwater migration corridors and rearing habitat within the action area.

Future Climate Amplifies the Proposed Action's Effects on Designated Critical Habitat

Because the proposed action includes a mechanism for repairing (raising) levees, hence, extending the lifespan of the levee, and incorporates hard structures within the active channel that have a functional lifespan of 30 years, ongoing disconnect with the historical floodplain and locking the channel in place for 30 years are identified as long-term effects. These effects go well beyond the duration of the proposed action (16 years). The expected effects will overlap in time with predictable climate change effects on environmental conditions such as sea level. A regional sea-level rise model that includes the action area projects that by the year 2100, 60 of the 88 coastal plant species will be threatened by changes in sea level; 40 percent of these species will lose all suitable current habitats as a result of climate change, while sea-level rise, specifically, accounts for up to 9.2 km^2 loss in habitat for counties of San Luis Obispo, Santa Barbara, and Ventura (Garner *et al.* 2015).

The variability of lagoon volume (*i.e.*, rearing habitat capacity) is sensitive to changes in sea level, which amplifies proposed action effects to lagoon habitat. As water-surface elevation becomes reduced in the lagoon due to added sediment input from upstream sources (natural or anthropogenic), there is an additional environmental stressor of the rate at which sea level increases and the ability of the lagoon to adapt to sea level rise. Although the amount of lagoon volume loss as a result of the proposed action on a year to year basis is difficult to predict and the degree of anticipated lagoon volume variability is only a rough estimate, over the long-term (*i.e.*, 30-50 years), lagoon loss will be contributed by: (1) the long-term indirect effects of keeping the Arroyo Grande Creek channel disconnected from its historical floodplain, and (2) the rate of sea level rise. The spatial extent of urban development adjacent to the existing lagoon delays, and in some cases, prevents geomorphic conditions that allow for the lagoon to migrate inland, or for vertical accretion of the lagoon to increase at a rate that would compensate for accelerated sea-level rise. In general across the south-central and southern California coastline, coastal marsh and lagoon habitats are at risk of being converted to mudflats or deep, saltwater habitat without the same biological and physical features (*i.e.*, amount of freshwater versus saltwater, frequency of open/closed lagoon, changes in estuarine plant type, amount, and distribution) to support rearing steelhead (*e.g.*, Garner *et al.* 2015, Thorne *et al.* 2015, County of Santa Barbara 2017). Thus, sea-level rise amplifies anticipated adverse effects of the proposed action on designated critical habitat in the action area.

The temperature projections from three models agree, with high certainty, on a warmer future for San Luis Obispo County (Koopman *et al.* 2010). Annual temperature during 2035-2045 will be increased by 2.1 – 3.9°F; June through August temperatures will increase by 1.8 – 4.7°F; December through February temperatures will increase by 1.7-3.6°F. Increased temperatures will likely amplify the effects of the action on a physical feature such as stream temperature due to maintaining an artificially narrow riparian corridor, consigning a large portion of the action area to function as a flood-control reach, and continually disconnecting the active channel from its historical floodplain for approximately another 50 years given the duration of the last flood-control management agreement (see Environmental Baseline section).

2.4.2 Effects on S-CCC threatened steelhead

Our discussion for the remaining portion of the effects analysis will focus on direct and indirect effects to the species in the action area as a result of the proposed action. The following section is organized to explain effects to the species based on habitat effects explained in the previous section.

Effects on Adult and Juvenile Migrants

The principal expected effects to these life stages involve an increased potential for stranding and expenditure of energy to reach destination habitats. Each of these is described as follows.

The design and operation of the secondary channels increase the risk that adult and juvenile migrants would be stranded. The risk of stranding primarily occurs after the river stage rises and allows fish to move into newly inundated areas (BA 2015). As flows recede and considering adults and juvenile steelhead display various habitat-use behaviors in all portions of available living space, we anticipate the likelihood to be high of a portion of these fish becoming trapped in isolated pools and depressions that are formed in off-channel areas, around vegetation or adjacent to large, wood structures (*e.g.*, Sommer *et al.* 2005). All stranded fish would be highly susceptible to injury or death owing to instream drying, elevated water temperature, reduced concentrations of dissolved oxygen, and predation. Aspects of the proposed action attempt to minimize the likelihood of fish stranding. The proposal involves creating a continuous flowline and constant gradient that is connected to the primary channel at the upstream and downstream end, thereby mimicking a secondary channel. Despite these aspects, it is probable that localized depressions or poorly drained areas will develop over time as high flows access the secondary channels and localized scour and deposition occurs. The proposed action does not effectively guard against such conditions.

Stranding is possible and probable given the migratory ecology and behavior of this species. Steelhead are known to migrate along creek margins during periods of elevated discharge; because the secondary channels would be wetted when discharge is elevated, adult and juvenile steelhead are expected to utilize the secondary channels, thereby increasing the risk of stranding. Although the secondary channels will be created and maintained "outside the active channel," the channels will be constructed within the area that normally constitutes the riparian corridor, which is periodically inundated by elevated flows. As a result, steelhead are expected to encounter these channels during periods of elevated river discharge. Even if the secondary channels are wetted infrequently, the fact remains that the channels represent an area of potential stranding, which cannot be ignored when assessing "effects of the action."

Although the proposed action includes provisions to reduce the risk of stranding, the provisions don't guard against the formation of in-channel areas that would retain water as high flows recede. Due to the lack of woody vegetation, sediment management areas likely provide little if any beneficial rearing habitat during recession of spring flows. Consequently, the potential remains for collecting juvenile steelhead in residual wetted areas of the secondary channels. In addition, the lack of adequate cover in the secondary channels increases the potential that juvenile steelhead would be displaced laterally or longitudinally into areas subject to dewatering (*e.g.,* Tsuyuki and Williscroft 1977, Hawkins and Quinn 1996) and exposed to an elevated risk of predation. Therefore, when juvenile steelhead are present within the secondary channels and become stranded, then stranding occurs in an area that lacks protective cover and food availability.

Adult anadromous fish are efficient at exploiting locally slow or reverse currents during migration while avoiding high-speed current to minimize energy expenditure (Hinch and Rand 2000, Standen *et al.* 2004). Based on what the collective literature reveals, however, when migrating through high-speed currents most adult steelhead do not spend time locating lower-velocity areas (*e.g.*, the protected buffer zone). Thus, increased water velocities in the majority of the action area are expected to challenge the ability of a large portion of returning adult steelhead to reach upstream spawning habitats during elevated wet-season flows.

High-velocity migration habitat introduces a risk to the species' success in energy conservation during migration (Hinch and Rand 2000, Standen *et al.* 2002). The speed and efficiency of the migration can significantly affect energy reserves and consequently spawning fitness (Brett 1973, Bernatchez and Dodson 1987, Hinch and Rand 2000, Standen *et al.* 2002). Adults will either attempt to reduce their travel time by elevating swimming speed or experience an inability to locate suitable paths within the active channel, which would decrease ground speed – both biological responses use relatively high levels of energy during migration (see Standen *et al.* 2002, Standen *et al.* 2004). Consequently, fatigue will increase due to high-current speeds as the species moves through the action area, and fatigue typically leads to long periods of inactivity for the species (*e.g.*, Bernatchez and Dodson 1987). The combined effect of these behavioral responses is reduced spawning success for the majority of adult steelhead returning to spawn in Arroyo Grande Creek either because of reduced energy reserves or delayed arrivals at spawning locations when ideal spawning conditions have ceased.

Reduce Prospects for Growth and Survival of Juvenile Steelhead to the Smolt Stage

As a matter of background, persistence of the anadromous form of this species is dependent on habitats that produce a large number of sizeable smolts (*e.g.*, Ward *et al.* 1989). A watershed that produces fewer smolts and predominately small smolts is not expected to witness many returns of adult steelhead. In contrast, a watershed that generously produces sizeable smolts is expected to experience a large number of adult returns. This is because the larger smolts survive better in the ocean, as evidenced by their overrepresentation in adult returns to freshwater for spawning (Bond *et al.* 2008). A large number of returning adults favors survival and recovery of the anadromous life-history form in the watershed-specific population and, more broadly, the DPS as a whole. As reviewed in the section "Effects on Critical Habitat," the proposed action would diminish the function and value of designated critical habitat for steelhead. Based on the expected type, amount, and extent of adverse effects to critical habitat, we anticipate the proposed action would reduce prospects in the action area by over half (*i.e.*, over half of designated critical habitat is designed to function as a flood-control reach) for growth and survival of juvenile steelhead to the smolt stage in the action area, as explained more fully below.

Reduction in summer and winter rearing habitat areas, specifically through hydromodification including diking, ditching, and dredging, can result in changes in smolt production (*e.g.*, Beechie *et al.* 1994). The anticipated 25% deviation in the range of variability for lagoon volume has the potential to translate into a reduced number and size of juvenile steelhead that reach the smolt stage. For these juveniles, we can expect general trends of slow growth rates, reduced fitness, a lower likelihood of survival after ocean entry and consequently, less likelihood of adult steelhead returns to the watershed. Even though the degree of adverse effects cannot be quantified and only described qualitatively in terms of expected general trends, we are choosing to use the 25 percent deviation as the best available ecological indicator for determining when lagoon volume variability is negatively influencing growth and survival trends for rearing steelhead, particularly given additional stressors both within and outside of the action area that influence steelhead growth and survival metrics.

Studies of juvenile steelhead in California coastal streams have frequently shown that fish experiencing the growth benefits of estuaries and lagoons, in contrast to fish rearing in upstream reaches, can achieve a size at ocean entry that favors marine survival (*e.g.*, Bond *et al.* 2008, Hayes *et al.* 2008). In addition, large habitats are better at growing large numbers of fish than small habitats. The relative decrease in lagoon volume given the existence of the levees and required maintenance into the future means that fewer steelhead would be supported by this habitat and, therefore, fewer juvenile steelhead are expected to reach a size that favors marine survival. We anticipate that all rearing juveniles will be affected by this relative decrease in lagoon volume because the existing lagoon is only 20 percent of its historical extent, thus the current lagoon is at a reduced capacity to function as an essential migratory habitat linking upstream spawning and rearing areas with the ocean (NMFS 2005, 2013). Considering this expectation, a large proportion of juveniles within the action area are unlikely to reach a suitable size for survival in marine conditions. Although lagoons generally form a relatively small portion of a watershed, they remain a critical nursery habitat, and in turn, viable steelhead populations may depend upon healthy estuaries and lagoons (*e.g.*, Bond *et al.* 2008).

In our discussion of effects on critical habitat, we explain how loss of riparian vegetation throughout much of the action area would translate into elevated water temperature and reduced sources of food and habitat to the creek. Given the widespread reduction in riparian vegetation and concomitant decrease in shading to the creek and adjacent floodplain, observing an increase in temperature and decrease in sources of food and habitat is probable. As described in the following paragraphs, these specific impacts are expected to have a number of harmful effects on growth and survival of juvenile steelhead.

Juvenile steelhead can react to elevated water temperature in a number of ways that ultimately have negative implications for their growth and survival. During periods of high ambient stream temperatures (23-28°C), forage behavior will likely decline (decreased feeding rate) and increased agonistic activity occurs (Nielsen *et al.* 1994) along with increased vulnerability to predation followed by a biological response to seek out stratified, deep pools. Deep, cold pools are well documented as thermal refuges during times of elevated water temperature (Baigún 2003 and references therein). Physiological processes also occur to increase energy for activity and maintenance metabolism making less energy available for growth and result in overall decline in growth rate (EPA 2001 and references therein; see discussion in Myrick and Cech 2004). The proposed action is lacking a mechanism to ensure growth is not delayed or limited given the proposed created pools in the action area and given that a simple increase in the number of pools in the action area may not translate into increased steelhead abundance (Ebersole *et al.* 2001) especially considering increased warming trends for the action area (see Status of the Species section). In addition, the proposed monitoring program lacks a way to measure and quantify complex interactions between mean temperature, temperature variability and food variability, all of which influence growth potential and patterns in the species (see Boughton *et al.* 2007).

A reduction in a source of food to the creek can challenge the ability of juvenile steelhead to acquire necessary resources to sustain growth. The redistribution of energy mentioned above must be balanced by higher food intake or else weight loss can occur for the species (*e.g.*, Jobling 1994); field observation show individuals will concentrate in specific microhabitats where high rates of food intake can be achieved (Smith and Li 1983). Essentially, flood pulses that enter a floodplain create ideal conditions for primary and secondary production and ultimately provide an abundant food source for the species. The proposed action will maintain the already restricted floodplain for the purposes of conveying floodwaters rather than minimizing effects to physical and biological features that make up a food source for the species. Floodplains that offer complex habitat features support higher growth rates for juvenile salmonids (*e.g.*, Jeffres *et al.* 2008). Consequently, the volume of food sources within the action area will be continually limited and of lower quantity because the already restricted floodplain available for food production will be reduced by approximately half through channel and vegetation modifications, and in turn, growth rates for juvenile steelhead will be reduced, which is likely to result in a smaller number of juveniles reaching a good size for marine survival. Less marine survival will result in fewer adult returns to the watershed.

A decreased supply of natural woody debris entering into the creek is expected to be harmful to juvenile steelhead. Large and small woody debris create living space and increase complexity of habitat for steelhead (Lisle 1986), which typically has been actively removed as part of stream clearing to promote conveyance of flood waters (BA 2015). Removal translates into simplified habitat characteristics and conditions for steelhead. The proposed action has the functional effect of reducing the contribution and establishment of natural (*i.e.*, enters the active channel without engineering or construction efforts) woody debris in the action area. Strategic placement of log structures primarily enforces the location of simplified habitat (secondary channels), delaying formation of complex habitat that promotes conservation of energy, avoidance of predators, and protection from high-current velocities during winter (Cederholm *et al.* 1997). Although it is recommended that the installation of instream structures be used primarily as a temporary tool while larger scale watershed changes are made (Roper *et al.* 1997), for example, reforesting riparian zones to provide natural woody debris, the success of 36 proposed log structures remains uncertain due to (1) ongoing upper watershed regulations of flow that influence conditions in the action area (see Environmental Baseline section), (2) scarcity of long-term monitoring (*i.e.*, 30 years given the lifespan of the woody structures and approximately another 50 years for the life of the raised portions of the levees) of the effectiveness of instream structures (*e.g.*, Whiteway *et al.* 2010), and (3) a response plan if monitoring efforts reveal deviation from the proposed performance standards.

Effects of Capture and Relocation on Juvenile Steelhead

Proposed dewatering necessitates the need to capture and relocate steelhead from the action area. The District proposes to capture and relocate juvenile steelhead under two conditions throughout the duration of the proposed action. The first condition is expected only once before the installation of 36 log structures in the action area. The second condition is expected annually before vegetation removal efforts occur at three bridge locations within the active stream channel: Highway 1, 22nd Street, and the UPRR trellis bridge. In general, under both conditions, capture and relocation efforts will occur in summer[10]. Below provides a discussion of effects to steelhead based on the context of each condition requiring capture and relocation of the species.

Only juvenile steelhead are expected to be present when the summer work proceeds. Flows are expected to be minimal through the action area at this time. However, based on field conditions in

[10] On September 8, 2016, the District clarified that the proposed action would not require dewatering near the bridges for ongoing vegetation maintenance, thus this portion of the amount allocated for capture and relocation was unnecessary. As a result of this understanding, the amount of take in the Incidental Take Statement reflects dewatering needs for log installation and maintenance (RPA sub-element 1) and converting land back to lagoon habitat (RPA sub-element 3).

2015, flow can be present in the upper portion of the action area even under extreme drought conditions. As a result of this variability in flow conditions, we expect there to be some areas of flow that will require the District to dewater before working in the active channel to construct and place log structures. Based on the timing of instream activities, capture and relocation will not impair the migratory behavior pattern of the species, however, adverse effects are anticipated as described below.

Due to minimal pool habitat within the proposed work area and factors discussed in the *Environmental Baseline*, rearing juvenile steelhead are expected to be present, albeit in moderate numbers. Based on the number of steelhead observed during previous steelhead and habitat surveys (*e.g.*, Swanson 2006b, 2008), and the approximate length of creek dewatered based on design drawings of log structures (60 feet), the number of juvenile steelhead relocated from the 60-foot dewatering area will likely be less than 10. Based on the average juvenile steelhead density calculated by Swanson (2006) for the action area of 6.2 juveniles per 100 feet sampled, the density is reasonable to assume for the proposed action under current habitat conditions, therefore 10 steelhead is an appropriate upper limit of expected steelhead within the work area to be dewatered. There will be up to 36 areas dewatered. Thus, NMFS' expects 360 juvenile steelhead to be captured and relocated in order to install the log structures[11].

Considering the second condition for capture and relocation of steelhead during instream vegetation removal, a similar spatial extent of stream will be dewatered (approximately 65 feet) in three specific areas of the action area when flowing water is present. NMFS estimates the same number of juvenile steelhead as referenced above, where 10 steelhead are expected at each bridge dewatering zone. Annual dewatering efforts will cause the District to dewater in three places per year for a total of 16 years given the duration of the proposed action. Thus, a total of 480 juvenile steelhead will be captured and relocated upstream[12].

Before dewatering occurs under either condition, steelhead will be relocated to suitable habitat upstream in the action area. The process of capture and relocation can have physiological impacts including inducing stress and temporary disorientation. Direct injury and mortality can result from physical trauma from contact with humans or machinery. Specifically, direct injury may impair fish movement, feeding, and survival. Fish collecting gear, whether passive (Hubert 1996) or active, has some associated risk to fish, including stress, disease transmission, injury, or death. Throughout relocation efforts, elevated stress and increased distortion can be a result of potential overcrowding during the transfer phase. The amount of unintentional injury and mortality attributable to fish capture, steelhead stranding in residual wetted areas during dewatering, and actual relocation efforts varies widely depending on the method used, the ambient conditions, and the expertise and experience of the field crew. Yet, the amount of unintentional injury and mortality is expected to be limited at five percent[13] of the total allocated number of individuals to be

[11] Due to similar effects on the species proposed under the RPA described in this biological opinion, this amount of take, 360 individuals, covers one-time capture and relocation needs prior to the log-installation process (RPA element 1) and prior to converting land adjacent to the existing lagoon back to steelhead rearing habitat (RPA element 3).
[12] Given the September 8, 2016, District clarification and the elements of the RPA in this biological opinion, this amount of take, 480 individuals, covers capture and relocation needs for both ongoing maintenance and repairs to the log structures (RPA sub-element 1) and ongoing creation of alcoves (RPA sub-element 2).
[13] The draft biological opinion had lethal effects of 0.4 percent, and we raised lethal effects to 5.0 percent in this biological opinion because of the variability in steelhead population dynamics, mainly abundance, given projected rainfall and storm intensity over the time period we anticipate to implement all elements of the RPA.

captured and relocated and not subject to the variation discussed above due to the proposed protective measures and the experience of District-retained biologist.

We also consider effects during the actual placement and construction of the water diversion dam before the work area is dewatered completely. If dewatering activities go without continual turbidity assessment and monitoring during the dewatering phase of the proposed action, there is a high risk of pulses of turbid water that could go undetected, changing the level of water quality downstream of the work area. Consequently, limited, unintentional adverse effects and even injury of steelhead may occur. Small pulses of turbid water will cause salmonids to disperse from established territories (Waters 1995), which can displace fish into less suitable habitat and/or increase competition and predation, decreasing chances of survival. Prolonged exposure to elevated concentrations of inorganic sediment can cause decreased growth in salmonids (Shaw and Richardson 2001). Based on the proposed dewatering plan, the magnitude and degree water-quality alteration is expected to deviate from natural background turbidity levels with the likelihood of reaching adverse effects if no monitoring is in place specifically for changes in downstream turbidity. Even though most of the unintentional injury will be limited by the use of fish block nets as proposed by the District to direct fish movement away from the water diversion dam while the work area remains dewatered, there is no proposed continual turbidity assessment and monitoring during the dewatering phase of the proposed action to minimize all turbidity effects for individuals within the action area during dewatering efforts.

Streamflow dewatering and work area isolation could harm individual rearing juvenile steelhead by concentrating or stranding them in residual wetted areas - areas predisposed to dewatering or desiccation, increased water temperature, decreased dissolved oxygen, and predation (Cushman 1985). Based on an evaluation of previous relocation events during similar activities in pool habitat, farther south within the endangered Southern California steelhead DPS, NMFS expects under the proposed action no more than 42 juvenile steelhead will be killed or injured out of the total 840 juveniles handled during any capture and relocation effort, or during any phase of dewatering (*i.e.*, 360 handled before log structure placement[14] and 480 handled before vegetation removal[15]).

Except for steelhead killed or injured in the process (discussed above), while steelhead may endure temporary stress and disorientation, relocation or dewatering activities will not significantly reduce the fitness of individual steelhead. The temporary barrier proposed to divert water around the work area will not delay migration behaviors for steelhead based on the timing of proposed work, and rearing juvenile steelhead will still have access to upstream and downstream pools within the action area.

Although individuals will be removed from the immediate work area, we must consider potential adverse effects to individuals adjacent to the work area from activities that will occur while a portion of the stream is dewatered (*e.g.*, herbicide application). Herbicide application in the action area is unlikely to adversely affect salmonids because the District is using glyphosate herbicides in diluted amounts. Results from a comprehensive ecosystem study indicate that when glyphosate is

[14] See footnote 10.
[15] See footnote 11, which explains this amount (480 handled) will be due to maintenance and/or repairs to log structures and creation of alcoves as described under the RPA.

used according to directions, it does not cause significant adverse health or migrational changes in fish (Newton *et al.* 1984). The LC50 for glyphosate is 38 parts per million (ppm) for a 96-hour exposure for rainbow trout and 930 ppm for Daphnia magna (water flea) (CADPR 1998), so it would take a heavy application to cause detectable effects. Even the lower end of this range is unlikely to be encountered in a waterbody under any conditions other than a product spill.

2.5 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). 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. Below is mainly a description of storm-water runoff effects in the action area as a result from general non-federal activities or plans, and because future sources that generate runoff cannot be distinguished from one another as they generally are in the Environmental Baseline (*e.g.*, agriculture versus development/roads), storm-water runoff effects are categorized as cumulative effects. This section concludes with a specific discussion on a District plan to manage sediment in Arroyo Grande Creek Lagoon.

Storm-water runoff into the action area comes from a variety of sources given the stream network within the Arroyo Grande Creek Watershed (*e.g.*, Spring Creek and Newsom Springs Creek) and upstream land-use activities. Specific field measurements show that adjacent land activities reduce water quality. The following were out of suitable range: fecal coliform, total coliform, total dissolved solids, dissolved oxygen, oxygen saturation, pH, and sulfate (SWMP 2010).

The Storm Water Management Plan (SWMP) for the city of Arroyo Grande is a guide for developing and implementing the National Pollutant Discharge Elimination System (NPDES) Phase II requirements for storm-water discharges[16] in coordination with the County of San Luis Obispo. Storm-water runoff will continue to impact water quality in the action area and reduce the function and value of available PBFs essential to the conservation of the species in the action area including migration, rearing, and estuarine areas of designated critical habitat, which are only functional under suitable water-quality conditions. The intersections of 13th Street/Highway 1 and 17th-19th Street/Highway 1 in Oceano experience flooding during significant rain events because of insufficient and undersized drainage facilities and relatively flat topography (Dept. of Public Works 2013). Recognizing water-quality consequences from these flooding events and to minimize flooding impacts to the local communities, the District is designing new storm-drain improvements.

Although effects of agriculture on designated critical habitat were addressed in the Environmental Baseline section, inclusion of effects from agriculture are also addressed here due to the likelihood agriculture and the effects (*e.g.*, impairment to water quality from storm runoff events) that will occur into the future.

[16] *The State Water Resources Control Board (SWRCB) identified the City of Arroyo Grande as a small municipal separate storm sewer system (MS4) requiring coverage under the National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems (MS4s), Water Quality Order No. 2003-0005-DWQ (General Permit). A requirement of the General Permit is development of a Storm Water Management Program designed to reduce the discharge of pollutants to the maximum extent practicable and to protect water quality*. Source: City of Arroyo Grande Storm Water Master Management Plan NPDES PHASE II Program (June 2008).

Future ongoing activities of existing agriculture and residential uses adjacent to the action area are expected to continue influencing water quality through transmitting pollutants into the action area during storm runoff events (AGC Watershed Management Plan 2005). The following pollutants are commonly associated with agricultural use: pesticides and herbicides; siltation and increased erosion due to cultivation causing removal of topsoil, clogging of waterbodies, and fish kill; and fertilizers contributing nutrients such as nitrogen and phosphorus to runoff leading to eutrophication (SWMP 2010). The pollutants below are often associated with residential uses: chlorine, where high levels of chlorine are toxic to fish and wildlife; oil and gas; pesticides, herbicides, and fertilizers; and hazardous household products (SWMP 2010).

Although we briefly described the effects on channelization to the Arroyo Grande Creek Lagoon in the Environmental Baseline section, below we describe specific effects from continual, targeted efforts to manage the sand berm and future management efforts that are likely to occur into the future.

Flood-control measures throughout the basin have reduced scouring that would occur during lagoon breaches, and reduced flood-storage capacity within the Arroyo Grande Creek system (Jacobs *et al.* 2011, Interim Sandbar Management Plan 2013). It is for these reasons, the District will likely continue sandbar management of the Arroyo Grande Creek Lagoon. In the same manner, the developed portions of Meadow Creek Lagoon (MCL), coupled with the decreased frequency of scouring flood flows (due to Lopez Dam construction in 1969 and modification to historical drainage due to the Sand Canyon Flap Gates), increased sediment delivery (from watershed urbanization), and the growth of dense emergent wetland and riparian vegetation communities has resulted in a highly aggraded creek/lagoon system that is choked with fine sediment (Jacobs *et al.* 2011, Interim Sandbar Management Plan 2013).

Sandbar-management activities are reasonably certain to occur late in the dry season, when Arroyo Grande Creek Lagoon outlet is closed/overflowing and before the arrival of the first significant winter rains. Management activities such as these, and related activities such as emergency lagoon-breaching events (*e.g.*, January 29, 2016), are likely to occur and have effects on designated critical habitat with respect to maintaining suitable water depth and water quality for rearing steelhead. In response to altered rates of sedimentation in the lower creek, sandbar management is expected to continue influencing water-surface elevation of the Arroyo Grande Creek Lagoon as long as flood-control mechanisms are at play within the watershed (*e.g.*, dams, levees).

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 versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Environmental Baseline section of this biological opinion.

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step in the assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, NMFS adds the effects of the action including amplification of anticipated effects from a changing climate (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), 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) reduce the value of designated or proposed critical habitat for the conservation of the species.

As a reminder regarding the status of steelhead in south-central California, abundance of adult steelhead in the S-CCC DPS declined from a historical high abundance of 25,000 returning adults, to an estimate of 4,750 adults in 1965 for five river systems (Pajaro, Salinas, Carmel, Little Sur, and Big Sur) (CDFG 1965), to fewer than 500 adults currently (Boughton and Fish 2003, Good *et al.* 2005, Helmbrecht and Boughton 2005, Williams *et al.* 2011). There is reliable evidence that at least 18 San Luis Obispo County watersheds supported steelhead historically, and evidence of reproducing *O. mykiss* populations in recent years for each of these watersheds (Becker *et al.* 2010).

The steelhead population in the Arroyo Grande Creek system may have been the most extensive of the small populations of the San Luis Obispo County coast (Boughton *et al.* 2006), and has been identified as a critical population for the recovery of the species. Accelerated declines of the population have resulted in the current steelhead runs to be "in the dozens" (DFG 1961, Rischbieter 2004). This population remains critical for supporting sub-populations in the watershed, thus essential for the viability and the recovery of the S-CCC DPS.

2.6.1 Summary of the Environmental Baseline

The population of steelhead in the Arroyo Grande Creek watershed is very small and its habitat is degraded as a result of man-made manipulations and alterations to the natural hydrology of the Arroyo Grande Creek Watershed. While some activities are physically located outside the action area, they affect critical habitat and steelhead in the action area (*e.g.*, in the case of land-use activities causing input of sand and smaller particles to habitats within the action area, or in the case of a water storage facility altering the downstream pattern and magnitude of discharge in the action area). Steelhead persist in extremely low numbers throughout much Arroyo Grande Creek below the dam (Stetson Engineers *et al.* 2004). The factors affecting steelhead and critical habitat in the action area are: (1) channelization, (2) agricultural and road development, (3) urbanization, and (4) regulation of flows at Lopez Dam. In general, construction of upstream reservoirs and levee construction decrease flow variability and isolate a river from its floodplain.

Overall, habitat complexity in the action area has been reduced and the creek is not functioning properly. The habitat complexity and ecological functions of the lagoon have been substantially reduced as a result of: (1) loss of shallow-water habitats such as tidal channels due to, in part, increases in sea level, coastal development, and levee construction, (2) degradation of water quality through both point and non-point waste discharges, and (3) artificial breaching of the seasonal sandbar at the lagoon mouth which can reduce and degrade steelhead rearing habitat by reducing water depths and the surface area of estuarine habitat.

2.6.2 Summary of Effects of the Proposed Action

With regard to critical habitat, the proposed action is expected to alter and destroy habitat function and value in the action area as a result of (1) maintaining an artificially narrow riparian buffer width, (2) consigning a large portion of the creek in the action area to a flood-control channel and eliminating complex habitat features that arise from natural fluvial processes, (3) continuing to contribute to a reduction in lagoon volume through channelization upstream (repairing and maintaining the existing levee) as well as introducing a 25% deviation from observed current variability in the volume of the Arroyo Grande Creek Lagoon as a result of channel shaping upstream to meet the District's flood-conveyance objective, and (4) continuing to limit connection between the active creek channel and floodplain areas. The conservation value of freshwater rearing sites, including the lagoon, and the freshwater migration corridor in lower Arroyo Grande Creek is expected to be greatly reduced.

With regard to steelhead, the proposed action is expected to reduce prospects for growth and survival of juvenile steelhead to the smolt stage, and challenge the ability of adult and juvenile migrants to reach destination habitats, throughout the action area. The proposed action will reduce opportunities for feeding and growth, contributing to smaller size at ocean entry and lower adult returns. Occasionally isolating work areas from flowing water will create the need to capture and relocate juvenile steelhead. Based on species behavior to use all suitable habitat (tributaries and mainstems), we anticipate the majority of juvenile steelhead within the watershed will be affected in this manner, as they depend largely on the mainstem, in particular the lower mainstem and lagoon, to achieve suitable growth size for successful survival in the ocean. In general, across the S-CCC DPS range, the value of the lower mainstem is from the channel's capacity to retain the ability to support the full expression of various life history pathways (*e.g.*, movement downstream in spring and early summer to the mainstem or estuary, Hayes *et al.* 2008).

The proposed action will affect all adult and juvenile steelhead in the watershed by reducing the availability and quality of rearing and migration habitat in the action area. The proposed action is able to affect all individuals in the watershed because the action area is a portion of the watershed that provides access to either upstream spawning habitat or access to enter the ocean during outmigration. Based on our knowledge of how the species utilizes the watershed, specifically, how rearing individuals and migrating individuals maintain survival and fitness with suitable living space with adequate food resources, adults will experience reduced energy levels and may have a delayed arrival to spawning areas in the watershed, and juveniles will encounter reduced physical and biological features supporting their growth, thus suppressing survival and fitness before the smolt life stage. Those who achieve the smolt stage will likely be reduced in size with a low likelihood for marine survival and low likelihood for successful return to the watershed as an adult.

Ultimately, the proposed action reduces the function of migration and rearing habitat, which, in turn, will reduce individual fitness and survival. Consequently, the population's viability will decrease in response to low fitness and survival. In particular, the current availability and quality of rearing habitat is low within the action area. Further reductions in rearing habitat from the proposed action are expected to affect all juveniles in Arroyo Grande Creek watershed, because all of these individuals must rear within the action area at some point before ocean entry, and some of these individuals rear for extended periods in the lower river and lagoon. These individuals who rear for extended periods are expected to experience the greatest reduction in fitness. The productivity of the steelhead population is expected to be reduced because the number of spawning adults will decrease in response to reduced fitness of juvenile steelhead in Arroyo Grande Creek.

2.6.3 Aggregate Effects

This section determines how aggregate effects to individuals would affect the viability of their constituent populations and the extinction risk of the DPS. NMFS also determines how effects to habitat would affect the conservation value of the designated critical habitat in the action area, watershed and the entire area designated as critical habitat for the S-CCC DPS. Aggregate effects include Environmental Baseline conditions with current effects from a changing climate, as well as the effects to individuals and habitat from stressors of the proposed action, cumulative effects and any projected future climate effects expected to amplify effects from the proposed action, to determine risk to the DPS and critical habitat as a whole. After determining the effects of the action on population viability, NMFS analyzes whether the effects to the population would be likely to jeopardize the continued existence of steelhead at the DPS scale, and if reductions in the conservation value of the subarea of critical habitat (*e.g.*, action area) is sufficient to appreciably reduce the conservation value of the entire area designated as critical habitat.

The aggregate effects are expected to worsen the existing characteristics and condition of the creek in the action area, and diminish the function and value of designated critical habitat for S-CCC threatened steelhead. The aggregate effects on the species are expected to preclude the formation of a viable steelhead population in the Arroyo Grande Creek watershed, thus increasing the overall extinction risk for the entire DPS. Below is an expanded basis for these conclusions.

Given the duration of the proposed action, it is likely multiple generations of steelhead will be exposed to stressors from the proposed action. Beyond the effects of the proposed action (including indirect effects), NMFS expects that the levees will persist, in some fashion, into the future (approximately 50 years) and that some level of channel and levee maintenance will continue to be necessary because the presence of a levee and its maintenance are one part of a cyclic, continuous pattern in flood-control management. The pattern will likely continue to expose threatened steelhead and their habitat to chronic stress. Continued, altered flow into the lagoon likely restricts the carrying capacity of the lagoon and the stream/lagoon ecotone. As a reminder, levee systems generally alter sediment transport because the levee system allows for the flood waters to carry sediment longer in the water column and for a farther distance until water velocities decrease leading to accelerated sediment deposition in habitats such as depositional zones of the lower mainstem and lagoons.

Given that lack of cover, shelter and habitat quantity and quality are already limiting juvenile steelhead survival and expression of diversity in the action area, additional reductions in these habitat elements are likely to cause further reductions in freshwater rearing, life history diversity and survival. Based on the current health of the population and the effects of the proposed action on the existing biological and physical features in the action area and current conditions throughout the entire extent of designated critical habitat for the DPS, there is an extremely high risk of fewer adult steelhead returning to Arroyo Grande Creek and less resilience of the population to environmental disturbances such as sea-level rise and future projections of overall reduced rainfall amounts. Reductions in rearing habitat are expected to slow growth through increased water temperature, reduce food availability, and delaying formation of complex habitat that promote conservation of energy for migratory and rearing behaviors, avoidance of predators, and protection from high-current velocities during winter. The summation of these pressures to the species and habitat likely contribute to a reduction in juvenile size and survival, and reduce adult abundance of the Arroyo Grande Creek population. When adult abundance of a population is continually reduced into the future, the viability of a population decreases. Because of the present low viability of this population, further reductions in viability likely due to the proposed action increase the risk of extirpation for this population in the near future. With an increase in risk of extirpation in the near future, the potential for recovery of the population is reduced. Because this population has been identified as critical for the recovery of the DPS as a whole, the continual reduction in abundance of this steelhead population will contribute to an overall reduced viability of the S-CCC DPS of steelhead.

The effects of environmental fluctuations (*e.g.*, sea-level rise and rainfall patterns) and disturbances (*e.g.*, floods, wildfire, and drought) create an added risk to the S-CCC DPS viability. Changes in climate discussed within this biological opinion are expected to amplify aggregate effects on the species and designated critical habitat. The effects of the proposed action when added to the environmental baseline alone are sufficient to appreciably reduce the likelihood of both the survival and recovery for the Arroyo Grande Creek population unit of steelhead and the threatened S-CCC DPS of steelhead (*i.e.*, reduce the likelihood of the species achieving viability). The combined effects (*i.e.*, aggregate activities and projected environmental changes) are expected to amplify the effects of the proposed action on the likelihood of both the survival and recovery for the Arroyo Grande Creek population unit.

The Arroyo Grande Creek steelhead population is likely to be hastened toward extinction with this proposed action. This population is currently doing poorly for a variety of reasons, and the proposed action makes local extinction likely to occur on an accelerated timeline. We anticipate the effect on population viability is sufficient to cause extirpation in this watershed. Therefore, steelhead range contraction for the DPS is likely to occur at an accelerated rate relative to past and current observations on the southern range contraction (see Boughton *et al.* 2005). This shift in distribution translates into an overall smaller DPS comprised of even fewer viable steelhead populations with less suitable habitat, thus reducing survival, reproduction, and recovery of threatened S-CCC steelhead.

The designated critical habitat value will continually reduce at an increased rate in the action area due to the aggregate effects to the freshwater migration corridor and freshwater rearing sites within the action area. The combined effects (*i.e.*, aggregate activities and projected environmental changes) will reduce the functionality and prevent improvement over time of critical habitat in lower 3.5 miles of the Arroyo Grande Creek watershed including a portion of Los Berros Creek and the Arroyo Grande Creek lagoon, thus no longer serving the intended conservation role for listed anadromous *O. mykiss*. Ultimately, the combined effects will result in alterations that appreciably diminishes the value of critical habitat for the conservation of S-CCC steelhead. Such alterations include manipulation to physical and biological features essential to the conservation of steelhead and include manipulations that preclude and significantly delay development of such features.

Designated critical habitat in Arroyo Grande Creek and Los Berros Creek remain essential for the conservation of the species because the Arroyo Grande Creek steelhead are considered an independent population that supports sub-populations in tributaries within the Arroyo Grande Creek watershed. As habitat loss is exacerbated in the action area due to the combined effects, the functionality of the remaining habitat both inside the action area and throughout the rest of designated critical habitat throughout the watershed will no longer serve the intended conservation and recovery role for this essential population. Specifically, habitat loss diminishes the value of critical habitat in the Arroyo Grande Creek watershed, and precludes the watershed from supporting the survival and recovery of a population that directly affects the viability of the S-CCC DPS, thus the combined effects lower the conservation value of critical habitat within the range of the DPS as a whole.

2.7 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is likely to jeopardize the continued existence of the federally threatened South-Central California Coast DPS of steelhead, and is likely to destroy or adversely modify its designated critical habitat.

2.8 Reasonable and Prudent Alternative

"Reasonable and prudent alternatives" refer to alternative actions identified during formal consultation that can be implemented in a manner consistent with the intended purpose of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that are economically and technologically feasible, and that would avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat (50 CFR 402.02). As determined through the effects analyses presented in this biological opinion, the proposal to increase flood conveyance through the Arroyo Grande Creek (AGC) and Los Berros Creek (LBC) channels is expected to jeopardize the continued existence of the federally threatened South-Central California Coast (S-CCC) Distinct Population Segment (DPS) of steelhead and is likely to destroy or adversely modify designated critical habitat for this species. The following reasonable and prudent alternative (RPA) will avoid the likelihood of jeopardizing the continued existence of threatened steelhead and avoid the destruction or adverse modification of its designated critical habitat.

The District shall implement a Waterway Management Plan (WMP) that requires maintaining properly functioning freshwater rearing sites and freshwater migration sites within the action area of AGC and LBC including the existing and future restored portions of the AGC and Meadow Creek (MC) lagoon complex. To this end, the RPA has three sub-elements and all sub-elements must be implemented on parallel tracks, with the individual tasks and timing for each sub-element specified herein, to avoid jeopardizing the continued existence of the threatened S-CCC DPS of steelhead and destroying or adversely modifying critical habitat for this species. Certain elements of the proposed action will be carried forward under the RPA without undergoing substantive changes from their original description as provided to NMFS in the BA (2015), thus these elements are not mentioned in the RPA. Appendix C provides a table that details how the RPA modifies aspects of the proposed action. Because this biological opinion determined the proposed action is likely to jeopardize the continued existence of the threatened S-CCC DPS of steelhead, and destroy or adversely modify designated critical habitat for this species, the Corps is required to notify us of its final decision on the implementation of the RPA. This RPA is a product of feedback and expertise provided to NMFS by the District and the Corps during several meetings, site visits, and conference calls since the issuance of the draft biological opinion on July 11, 2016. The three sub-elements of the RPA are as follows:

1. As described in the effects analysis, the proposed action is expected to diminish the ability of the riparian corridor to serve the intended conservation role for threatened steelhead. Therefore, the District shall establish a minimum riparian-buffer width that will have a rooted width of 30-feet (15-ft on each side of the channel), where space allows given the existing levee footprint. The buffer width refers to the at-ground width that extends from the active channel margin outward to the edge of rooted vegetation. Specifically, 69% of AGC in the action will have a 15-ft riparian-buffer width on each side of the channel and 77% of LBC in the action area will have a 7.5-ft riparian-buffer width on each side of the channel (*i.e.*, a balanced riparian-buffer width will be applied to the majority of the action area). In the remaining portions of AGC, there will be a minimum riparian-buffer width of 10 feet on one side of the channel, while the other side of the channel will have a minimum riparian-buffer width of 20 feet; for remaining portions in LBC, there will be a minimum riparian-buffer width of 5 feet, while the other side of the channel will have a minimum riparian-buffer width of 10 feet. The rooted width of the buffer will always total 30 feet for AGC and 15 feet for LBC recognizing the width of the buffer may not be equal on both sides of the channel. The riparian buffer will be continuous throughout the action area with the exception at three bridge crossings. As a result of the rooted-buffer width, a maximum average canopy cover of 150 feet is expected in the action area.

    a. Habitat improvement in the AGC channel will be through design, installation, and yearly monitoring (photos) of 36 woody structures. The District will repair specific structures not functioning as designed when that portion of the channel is identified for sediment management during on-going (maintenance) sediment removal activities as specified in the *Long-term Sediment Management Removal Guidelines 5.15* document the District provided to NMFS on May 15, 2017 (District 2017a). If the subject portion of the channel is not identified for sediment management, then response (repair) actions will be taken prior to the following rainy season for malfunctioning woody structures. For example, repairs may include modification to log-structure alignment, restoring proper channel elevation, consideration of complete log-structure removal or changing location of log-structure, etc. Response actions will be developed by the District, in collaboration with NMFS, through careful review of geomorphologic processes that have occurred within the channel as a result of placement and spatial extent of woody structures.

    b. The riparian buffer will be discontinuous only within 20 feet upstream and downstream of each of the three bridge crossings: Union Pacific Railroad, 22nd Street, and U.S. Highway 1.

2. The effects analysis indicates that the ability of the action area to provide physical and biological features of freshwater rearing and freshwater migration habitat would be minimal as a result of continuing to consign and manage a large portion of the action area as a flood-control channel, including the related channelization and sediment removal. To limit the impact of sediment-management activities on freshwater rearing and migration areas and related life stages of threatened steelhead, the sediment-management program will conform to the following criteria:

    a. The initial sediment removal will occur above the Ordinary High Water Mark (OHWM)[17] and outside of the riparian-buffer width dimensions that are defined in RPA sub-element 1. Consequently, the spatial extent of initial sediment removal, including vegetation removal outside of the riparian-buffer width defined in RPA element (1), shall result in a composite channel-bed roughness value (*i.e.*, Manning's *n*) of 0.046 in AGC and 0.042 in LBC. Similarly, the initial sediment removal will be phased over the first two years of RPA implementation. Initial removal will only occur in areas where accumulated sediment above the OHWM and outside of the defined riparian-buffer widths of RPA sub-element (1) have reduced levee capacity beyond the defined freeboard (10-year flood protection). Sediment-management activities below OHWM near the low-flow channel would be undertaken solely for the purpose of creating steelhead-sheltering areas (*i.e.*, alcoves adjacent to log structures). Further, existing channel-bar features along the RPA-defined riparian buffer will be preserved to promote elements of a properly functioning riparian corridor[18] (Tabacchi *et al.* 1998, Griggs 2009, and Dickard *et al.* 2015). Initial sediment removal will occur in 22 pre-defined grading sites throughout the action area set forth in the Admin Draft 100% plans (August 2015). If the District identifies a 20% or more deviation in volume of material or changes to the dimensions in the grading tables of the Admin Draft 100% plans (August 2015), then the District will submit final construction drawings to NMFS 30 days prior to commencement of initial sediment removal activities that include proposed dimensions for each targeted sediment-removal area (length, width, and amount of sediment) within the designated off-channel area. Upon receipt from the District, NMFS will review the final construction drawings and recommend revisions to the drawings, if necessary, within 30 days of receiving the drawings. After the District receives NMFS' revisions and comments on the final construction drawings, the District shall submit to NMFS for review and potential agreement, the final drawings that have been revised in response to comments from NMFS. The District shall provide final drawings to NMFS within a reasonable time but no later than 30 days after receiving NMFS' revisions and comments and NMFS shall provide its response

[17] The term ordinary high water mark means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas (Corps Regulations, 33 CFR 328.3(e)).

[18] A healthy riparian-wetland area is in dynamic equilibrium with the streamflow forces and channel aggradation/degradation processes producing change with vegetative, geomorphic, and structural resistance. In a healthy condition, the channel network adjusts in form and slope to handle increases in stormflow/snowmelt runoff with minimal disturbance of channel and associated riparian-wetland plant communities (DOI 1998).

regarding those drawings as soon as possible, potentially within 15 days of submittal but typically within 30 days. The District must receive NMFS written agreement for the final construction drawings of the 20% deviation provision prior to conducting initial sediment removal in the action area.

b. When removing sediment to provide surrounding communities protection from a 10-year flood (*i.e.*, the ongoing sediment removal for maintenance), the manner and outcome of the removal will be consistent with rehabilitating natural geomorphic conditions and steelhead-habitat conditions. In this regard, the sediment removal shall involve only discrete, short (≤ 500 linear feet) segments where modeling results show that the capacity of the subject segment is reduced more than 50% of the design freeboard (10-year flood protection). The District will submit to NMFS a draft work plan for ongoing (maintenance) sediment removal prior to conducting sediment removal activities (District 2017a). The contents of the draft work plan will be according to the following parameters: (1) sediment removal shall not exceed 20% of the channel length (*i.e.*, no more than 2,740 feet of AGC and 640 feet of LBC) in the action area in any consecutive 2-year period, (2) magnitude (intensity) of effects to the channel from ongoing sediment maintenance will be minimized because each sediment-removal event will not exceed 500 linear feet along the channel bed, and (3) each sediment-removal site must be separated by a minimum distance of 500 feet; within this 500-ft stretch of channel there will be no sediment removal activities that will occur for that same year. Within 30 days of receiving the draft work plan from the District, NMFS will review and recommend revisions to the plan, if necessary. After the District receives NMFS' revisions and comments on the draft work plan, the District shall submit to NMFS for review and potential agreement, the draft work plan that has been revised in response to comments from NMFS. The District shall provide the final work plan to NMFS within a reasonable time but no later than 30 days after receiving NMFS' revisions and comments, and NMFS shall provide its response on the final work plan as soon as possible, potentially within 15 days of submittal, but typically within 30 days. NMFS shall concur with the work plan if it meets the criteria set forth above and other applicable information. If NMFS and the District have differences regarding the work plan, they will meet cooperatively to resolve those differences as soon as possible. The District must receive NMFS written agreement for the final work plan prior to conducting sediment removal in the action area.

c. The ongoing (maintenance) sediment-removal work plan as stipulated in RPA sub-element 2(b) must include the status of each alcove within the action area (*i.e.*, functioning as designed or needs repair) and specifications that ensure alcoves are maintained within the secondary channels and remain connected to the main channel at the downstream end to minimize stranding risk to steelhead. As a matter of clarification, the designed alcoves may fill with sediment over time, hence the need for the District to re-create these features. If the subject portion of the channel is not identified for sediment management, then response (re-creation) actions will be taken prior to the following rainy season for alcoves filled with sediment. For example, repairs may include modification to alcove alignment, restoring proper channel elevation, consideration of complete alcove removal or changing location of the alcove, etc. Response actions will be developed by the District, in collaboration with NMFS, through careful review of geomorphologic processes that occurred within the channel as a result of placement and spatial extent of alcoves.

3. The effects analysis indicates the proposed action is expected to reduce the function and value of the action area as a freshwater rearing site and freshwater migration site for threatened steelhead by continuing to limit connection between the active creek channel and natural floodplain areas, artificially confine the creeks, manage the action area as a flood-control channel, create an artificially narrow riparian-buffer width, and promote simplified creek channels. As a result, RPA sub-element 2 of the draft biological opinion stipulated the District would implement an alternative that involved levee removals and setbacks for the purpose of obtaining the District's flood-control objective. However, through our joint effort with the District to refine the draft RPA, including sub-element 2, the District has proposed to restore historic connectivity between Meadow Creek Lagoon and Arroyo Grande Creek Lagoon for the purposes of increasing habitat for growth and survival of smolt and rearing steelhead, and enhancing and protecting the lagoon wildlife and fisheries habitat into the future (hereafter referred to as the "restoration goal") (Meadow Creek Lagoon Watershed Plan, District 2017b; District 2017d). The principal objectives of the District's proposal, subject to modification during the science panel, California Environmental Quality Act, and government approval process described below, involve setting back or removing 1000-ft of levee in the vicinity of these lagoons (within the action area) or relocating or removing tidal gates, or a combination of these, and converting 8.28 acres of land owned by the District and California Department of Parks and Recreation ("State Parks") to wildlife habitat. We relied upon aspects of the District's proposal to inform this specific sub-element of this RPA, though the proposal lacks much detail, particularly regarding a development and implementation scheme. In support of the restoration goal, the District agrees to implement a preliminary design approach that includes an alternative analysis and environmental review of a preferred alternative (District 2017d). Because the environmental review and decisional processes have yet to occur, the District cannot commit to fund and implement the restoration goal at this time. Accordingly, the District shall (a) convene a panel of experts whom will advise the District's development and implementation of the preliminary design that will serve as the basis for the Joint Arroyo Grande Creek and Meadow Creek Lagoons Habitat Restoration and Improvement Project (Project), which will restore historic connectivity between said lagoons and convert 8.28 acres of land owned by the District and State Parks to properly functioning wildlife habitat, (b) develop an Integrated Feasibility Report and Environmental Impact Report (Report), and (c) implement and monitor the effectiveness of the Project to ensure attainment of the restoration goal. To this end, the District shall complete the following:

    a. The District shall convene a science panel of agency and academic technical environmental specialists and engineers ("science panel") whom will inform, through recommendations, the District's development and completion of the Report, consistent with the intent and basis of RPA sub-element 3. The members of the science panel may include regulatory, technical, and engineering specialists from the

District (and associated consultants), California State Parks, California State Polytechnic University at San Luis Obispo, Corps, California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, NMFS, and potentially other agencies. The District shall convene the science panel and will consult in advance with NMFS regarding potential panel members and receive written agreement from NMFS for the selected members no later than 90 days following the date of the Corps' permit that approves the District's Waterway Management Program.

i. The District shall develop and complete the Report stipulated in RPA sub-element 3, with input from the science panel. The District will be preparing a document in conformance with the California Environmental Quality Act (CEQA). The Report must include effectiveness-monitoring and adaptive-management programs that will allow reasonable assessment of the environmental characteristics and conditions of the area that is the basis of the Project, and the necessary management changes, including physical modifications, to ensure attainment of the restoration goal, as specified in RPA sub-element 3a. Although the primary objective of RPA sub-element 3 is to restore historic connectivity between Meadow Creek Lagoon and Arroyo Grande Creek Lagoon for the purposes of increasing habitat for growth and survival of smolt and rearing steelhead, the Project will also need to address flood impacts from removing and relocating the existing levees and tide gates (District 2017d). Specifically, the Project will need to incorporate design plans for various flood-protection alternatives (*e.g.*, levee set back, tidal gate, flood walls, etc.). An administrative draft of the Report must be provided to NMFS for review and comment no later than three years following the date of the Corps' permit authorizing the District's proposed action that is the basis of this biological opinion (*i.e.*, District's Waterway Management Program). NMFS will review and recommend revisions, if necessary, of the administrative draft Report. The District shall discuss these proposed revisions with NMFS and will decide whether and to what extent to incorporate them into the document, and then revise the administrative draft in response to NMFS' comments to produce the public review draft Report. The District shall use its discretion to prepare draft and final EIRs in conformance with CEQA and shall present the final EIR to the District's Board of Supervisors for certification. At the time of requesting certification of the final EIR, the District will make a recommendation to the District's Board of Supervisors that it authorize next steps including the preparation of regulatory permit applications and applications for available grant programs to fund the Project (District 2017d). The District shall achieve certification of the EIR, consistent with CEQA requirements, no later than 4.5 years following the date of the receipt of the Corps' permit authorizing the District's proposed action that is the basis of this biological opinion (*i.e.*, District's Waterway Management Program). The final, certified EIR can only be implemented when sufficient funds are obtained by the District. At that time, the District will recommend to the District's Board of Supervisors that the final design be completed and a construction contract be awarded to implement the Project.

ii. The Project, including effectiveness monitoring and adaptive management, shall be completely implemented, *i.e.*, fully constructed as designed consistent with the basis and intent of RPA sub-element 3, no later than 6.5 years following the date of the Corps' permit authorizing the District's proposed action that is the basis of this biological opinion (*i.e.*, District's Waterway Management Program). As part of the effectiveness monitoring and adaptive management, the District shall install a network of gages capable of measuring water levels, dissolved oxygen and salinity at the water's surface and at depth to provide a complete spatial characterization (including over water-column depth profiles) of the restored lagoon to assess whether water quantity and water quality align with the restoration goal as stipulated in RPA sub-element 3. The final schedule for Project design, construction, and implementation shall identify approximate time frames to achieve major milestones. The schedule shall indicate target time frames for each stage of the design process and deliverables to NMFS for all submittals required under each reasonable and prudent measure. The construction and implementation schedule may be revised by agreement between the District and NMFS and State Parks, during the design process as more information is developed and as administrative, logistical, or funding delays may arise before, during, and after certification of the final EIR.

2.8.1 Consistency of the Reasonable and Prudent Alternative with Regulations Implementing Section 7 of the ESA

Regulations (50 CFR §402.02) implementing section 7 of the ESA define reasonable and prudent alternatives (RPA) as alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technically feasible; and (4) would avoid the likelihood of jeopardizing the continued existence of a listed species or destroying or adversely modifying critical habitat. In the sections that follow, NMFS provides a summary evaluation regarding the consistency of the RPA with the implementing regulations.

Consistency with the Intended Purpose of the Action.—The elements of the RPA can be implemented in a manner consistent with the intended purpose of the proposed action, which is to permit the District to provide flood control to the surrounding agriculture and residential communities consistent with all federal legal obligations including being in compliance with the ESA. Between issuance of the draft biological opinion and this biological opinion, we have collaborated extensively with the District for the purpose of refining the draft RPA to produce the final RPA. Our administrate record memorializes the substantive discussion in this regard, including refinements the District applied to their proposed action while still maintaining their ability to attain the flood-control objective. Accordingly, this RPA provides the District with their desired level of flood control through discrete sediment-removal management areas between the levees, levee-repair activities, and vegetation management. The RPA allows the District to design structural modifications to the existing Arroyo Grande Creek levees that avoid increasing long-term flood risk (as described by Liao 2014) through restoring historic floodplain connectivity between Meadow Creek Lagoon and Arroyo Grande Creek Lagoon. Lastly, the RPA does not preclude the

Corps or District from maintaining the Waterway Management Program and related short-term flood-control benefits from the existing levee including levee-repair work so that the entire levee, on average, will provide 10-year flood protection throughout the entire action area.

Consistent with the Scope of the Action Agency's Legal Authority and Jurisdiction.—The RPA is consistent with the scope of the action agency's legal authority and jurisdiction as demonstrated under the Clean Water Act (CWA) Section 404 Permit Program. In particular, the RPA is consistent with the following Corps authorities: (1) Section 204 Water Resources Development Act of 1992 - Aquatic/Ecological Habitat Protection, (2) Restoration and Creation Section 205 Flood Control Act of 1948 - Small Flood Control Projects, and (3) Section 206 Water Resources Development Act of 1996 - Aquatic Ecosystem and Estuary Restoration. The section 205 program, for example, gives the Corps authority to plan and construct small flood damage reduction projects. Work under this authority may include construction or improvement of levees, channels, and dams, or nonstructural alternatives such as flood warning systems or relocation. Under Section 10 of the Rivers and Harbors Act, the Corps may authorize the construction of structures in or over any navigable water of the United States, and authorize the excavation, dredging or deposition of material in these waters (33 U.S.C. § 401 *et seq*.). Any obstruction in or alteration of a "navigable water" requires a permit if the structure or work affects the course, location, condition, or capacity of the water body. Finally, although the Corps did not originally construct the existing levee in the action area, the Corps can partner with local authorities with respect to levee safety, land-use planning and development, maintenance, repair, rehabilitation, or placement of the levee.

Feasibility of Implementing the Reasonable and Prudent Alternative.—In this section, we consider whether the RPA is technically and financially feasible, in accordance with the implementing regulations for Section 7 of the ESA. Each of these are described as follows, beginning with the consideration of technical implementation.

The RPA is technically feasible to implement for several reasons. The available space between the existing levees allows for extension of the riparian buffer beyond 10 feet on both the right and left bank of the channel in most areas. With respect to levee setbacks, removals, or modifications, similar efforts have been undertaken elsewhere (*e.g.*, see Florsheim and Mount 2002, Cosumnes River, Central Valley, CA, and the Guadalupe River levee setbacks, San Jose CA), thereby demonstrating that the RPA is neither experimental nor precedent setting. In addition, the RPA does not preclude the District from undertaking the levee repairs, the technically feasibility of which is assessed in the District's own CEQA document. Within south-central California alone, NMFS is collaborating with numerous project proponents to improve rearing conditions for threatened steelhead, including a few select projects that are exceedingly larger in scope than is currently required through implementation of this RPA (*e.g.*, Lower Pajaro River Project; South San Francisco Bay Shoreline Study). Overall, considerable information exists to indicate that the specific sub-elements of the RPA are technically feasible.

In the same manner, the amount of time it takes to complete lagoon restoration often depends on the scale, scope, and constraints (social and physical) of the restoration site. NMFS conducted a brief evaluation of several restoration projects and documented the amount of time that was needed to complete restoration work after certification of a final EIR. Seven projects were considered (Prospect Island Tidal Habitat Restoration Project, San Elijo Lagoon Restoration Project, Sears

Point Wetland and Watershed Restoration Project, Redwood Creek Restoration at Muir Beach, Batiquitos Lagoon Restoration Project, San Dieguito Lagoon W-19 Restoration Project, and the Malibu Lagoon Restoration Project). All seven projects are relatively more complex and larger in scope compared to the restoration work that would result from RPA sub-element 3. On average, the restoration efforts took/will take five years to complete after a final EIR was/is certified. Given the significantly smaller scale and scope, and fewer constraints of the restoration site identified by the District (February 23, 2017, field meeting; March 23, 2017, NMFS' letter to the Corps; District 2017d), NMFS considers two years after certification of a final EIR a sufficient period of time to complete construction and implementation of the restoration goal that is the basis of RPA sub-element 3. Additionally, the formation of a panel to guide the design process as described in RPA sub-element 3(a) is one model to approach efficient and effective restoration planning that minimizes the risk of delays during NMFS' review process. Based on NMFS' experience with this particular panel approach elsewhere, it serves as the preferred model to ensure the design planning progresses without delay especially given that most of the prospective panel members are also land owners/land managers within certain areas of the restoration site (*e.g.*, State Parks).

The RPA is financially feasible to implement, for at least a few reasons. First, the financially substantive element of the RPA, *i.e.*, sub-element 3, involves lagoon and habitat restoration for steelhead and other wildlife, which is based on the District's own proposal (February 23, 2017, field meeting; March 23, 2017, NMFS' letter to the Corps; District 2017d). For this reason, we find it reasonable to expect that the District offered this proposal with the anticipation of financially supporting the proposal through implementation and monitoring. Moreover, while the District has advised us that no funding is currently obligated to support the proposal, and by extension RPA sub-element 3, they have committed to acquiring funding (District 2017c). In addition to seeking grants, we expect the District will pursue other reasonable funding options. These options may include various sources of governmental (*e.g.*, special revenue fund) and proprietary funds, propositions, and various user fees or charges. In terms of total financing, the FY2014-2015 proposed budget to San Luis Obispo County was $524.9 million dollars.[19] Based on our experience with restoration efforts elsewhere, we anticipate the scale and scope of RPA sub-element 3 will be far less than $524.9 million dollars.

Second, it is feasible for the Corps to implement a cost-sharing program with the District considering the District is receiving funds from multiple sources to construct and implement the proposed action (*e.g.*, grant funding from California Department of Water Resources and CalFEMA grant award). Also, in 1999, the District pursued Corps Section 205 funding to rehabilitate flood-control facilities in the action area.

Third, estimated costs related to levee removal and levee/flap gate modifications and actual implementation of habitat improvement have been generated in the past and are not cost prohibitive (*e.g.*, Middle Creek Flood Damage Reduction and Ecosystem Restoration Project at the north end of Clear Lake, Lake County, CA; Lower Carmel River and Lagoon Floodplain Restoration and Enhancement Project, Monterey County, CA; San Joaquin River National Wildlife Refuge, Phase 2: Habitat Implications of Levee Breach Alternatives, Vernalis, CA; Tolt River Levee in Tolt-MacDonald Park, King County, WA).

[19] Source: http://www.slocounty.ca.gov/Assets/AD/Budget/2014-15+Proposed+Budget+General+Information.pdf

Fourth, the RPA does not trigger permanent relocation of agricultural infrastructure adjacent to the southern levee, including large barns, warehouses, and storage yards for irrigation pipes (County 2010b). The identified 8.28 acre parcel of land to convert to lagoon-rearing habitat for steelhead is adjacent to the north levee near Meadow Creek and residential and industrial development (away from agriculture parcels). As a result, no additional costs related to relocating agricultural infrastructure is expected.

Fifth, lagoon-restoration projects that are significantly larger in scope than the project that would result from RPA sub-element 3 have been found to be financially feasible. For example, the Prospect Island Tidal Habitat Restoration Project, San Elijo Lagoon Restoration Project, Sears Point Wetland and Watershed Restoration Project, Redwood Creek Restoration at Muir Beach, Batiquitos Lagoon Restoration Project, San Dieguito Lagoon W-19 Restoration Project, and the Malibu Lagoon Restoration Project, have all been financially feasible through a combination of local, state, and federal funds.

The Likelihood of Jeopardizing the Continued Existence of a Listed Species or Destroying or Adversely Modifying Critical Habitat.—In the following paragraphs, we explain why the RPA would avoid the likelihood of jeopardizing the continued existence of a listed species or destroying or adversely modifying critical habitat, consistent with regulations (50 CFR §402.02) implementing section 7 of the ESA.

The RPA is designed to address the decreased function and value, and destruction, of riparian and instream habitat, and a reduced ability of steelhead to fulfill important life-history pathways for threatened steelhead. In this regard, the RPA addresses those aspects of the proposed action that appreciably reduce or delay safe and successful rearing of steelhead in the action area while also ensuring the habitat in the action area is improved toward properly functioning for adult entry to the upper watershed and ocean entry for smolts (cf. NMFS 2016d). To this end, the RPA specifies a method of establishing a riparian-buffer width and encouraging natural processes to create and maintain rearing and migratory habitat for threatened steelhead in the action area. Further, the RPA safeguards against shrinking (and shifting northward) the spatial extent of the DPS, which would lower all four population parameters across a DPS that has shown no signs of recovery based on the most recent status review (NMFS 2016a).

RPA sub-element 1 considers the status of the S-CCC steelhead population and assures protection for the species during the interim period (approximately 6.5 years) prior to measurable benefits from floodplain/lagoon restoration. Although the buffer only increased by a minimal amount (an additional 5 feet on each side of the channel or an additional 10 feet on one side of the channel given the constraint of the existing levee footprint), the new areas within the RPA-defined buffer allow for planting of specific woody species such as sycamore, cotton wood, and box elder. These species have the capability to grow relatively larger crowns as well as grow to higher heights than the existing willow species. The projected average canopy coverage in the action area (150 feet) would exceed the current average (58.6 feet) with woody-species planting as outlined in the District's revised HMMP. Relative to the average canopy cover upstream of the action area (downstream of Lopez Dam) where canopy cover is 120 feet, the projected average canopy cover is expected to be greater within the action area. In addition to having a larger canopy cover, the riparian corridor within the action area will have increase in woody-plant diversity than existing conditions, which is characterized by nearly monotypic stands of willow (*Salix* sp) that only grow to an approximate height of 25 feet. Lastly, with a measurably wider and more diverse riparian buffer, the action area will better mimic elements of a natural (unimpaired) riparian corridor that supports the species needs during both winter and spring migration including when the species is using available habitat during the summer.

In summary, the ecological benefits of an improved riparian buffer in the interim (prior to RPA sub-element 3 being implemented) include a greater woody-canopy cover (increased number of willows preserved and additional woody species to be planted) to provide additional shade and cooler water for steelhead. The improved riparian buffer also offers a more resilient, diversified, vegetation buffer that maintains the existing integrity of the riparian corridor and improves upon that integrity with creating additional meanders and bends. These meanders and bends are made possible based on the lateral variation of the buffer where some areas in the channel will have a balanced buffer and other areas will have a longer buffer on one side of the channel (especially around alcoves, see RPA sub-element 2). This buffer design better mimics more natural "unimpaired" stream habitat. In combination with RPA sub-element 2, the result is more stable complex rearing habitat for steelhead than the proposed action. Although the increase in rooted width for the buffer is relatively small, the 15-foot width on each side (or 20-foot width on one side) places the buffer within the low-end range of the buffer-width recommendations described in the effects section above. In addition, the 15-foot width mimics the average width of riparian areas upstream of the action area that are in less-impaired condition. Above the action area, the minimum to maximum canopy widths range from six feet to 370.5 feet (District's February 9, 2017, revised vegetation buffer memorandum), and based on previous consultations near Lopez Dam, when the riparian buffer is smaller, we generally see lower plant diversity. Based on this information, NMFS expects RPA sub-element 1 will help several generations of steelhead better utilize this habitat between the existing levees. The increase in rooted-buffer width will help minimize impacts from the continued presence and repairs of the levee on current viability (its likelihood of survival and recovery) of the Arroyo Grande Creek steelhead population until rearing habitat value can increase through connecting portions of the active channel with portions of the historical floodplain (*i.e.,* RPA sub-element 3). Therefore, implementation of the wider buffer under the RPA will help ensure steelhead can access spawning grounds and reach the ocean while lagoon restoration occurs.

The ability to understand the biological and ecological needs within an action area that is already impaired and will continue to be impaired by the existing levee is complicated by the geomorphic and vegetative responses of a creek to stressors such as a levee, an upstream dam (Lopez Dam), and groundwater pumping (see discussion on determination of what constitutes an ecologically "healthy" river in Gergel *et al.* 2002). In the same manner, effects of simultaneous, different modifications can be even more difficult to distinguish, so while the 30-ft buffer under RPA sub-element 1 is still not reflective of the historically unimpaired buffer, it is reflective of less-impaired areas upstream of the action area, and the buffer will be combined with additional habitat features to collectively promote low-velocity habitat across the majority of the action area as described below in RPA sub-element 2.

RPA sub-element 2 provides a framework to maintain an ecologically complex channel (levee to levee) while allowing the District to provide flood protection for surrounding communities. To this end, initial and ongoing sediment removal between the levees will be implemented under criteria and measures that allow physical and biological features of designated critical habitat to better mimic properly functioning habitat in support of various steelhead life stages. Specifically, the creation of alcoves will supplement the log-structure design and will likely support and sustain low-velocity habitat throughout the majority of the action area by increasing channel roughness. Roughness allows the channel to decrease water velocities and produce slow-moving currents to allow the species to rest during migration. This minimizes the risk of only having small pockets or isolated areas of low-velocity habitat that are difficult for the species to detect during winter or spring migration. Habitat features to be created under this sub-element of the RPA increase the likelihood that steelhead will be able to successfully migrate and rear in the action area. In the same manner, the created alcove habitat will not only provide resting areas (deeper pools, more complex habitat), but these areas will benefit from the extended buffer as the buffer canopy (overhanging vegetation) will provide cooler water temperatures to sustain alcoves into the spring and early summer. The initial alcove creation will likely require capture and relocation of the species prior to dewatering a portion of the channel, thus the Incidental Take Statement has been updated to reflect anticipated take throughout implementation of the RPA.

Achieving recovery of the S-CCC DPS of steelhead is a long-term goal that requires addressing the loss of floodplain habitat due to the levees. The levee repairs extend the life-span and functionality of the levee from withstanding a 4.6-year flood event to withstanding the 10-year flood event, and consequently, perpetuates effects of disconnecting a waterway with its historical floodplain. RPA sub-element 3 targets the smolt life-stage of steelhead to address the amount of rearing habitat capacity that will foster an increase in smolt production over the duration of the proposed action. As a result of RPA sub-element 3, a portion of the existing floodplain will be converted to lagoon-rearing habitat in an attempt to mimic historical conditions prior to levee confinement and urban development. RPA sub-element 3 considers the viability of the Arroyo Grande Creek steelhead population by creating conditions that support the growth of healthy smolts for more juvenile steelhead, thus increasing the likelihood of adult returns to Arroyo Grande Creek. Although possible increase in adult returns won't likely be realized until after juveniles have the opportunity to utilize the 8.28 acres of new rearing habitat, the approach to managing the existing designated critical habitat (sub-elements 1 and 2) will begin to assist with the survival and recovery of threatened steelhead in the Arroyo Grande Creek watershed in the interim until RPA sub-element 3 is fully implemented. Once RPA sub-element 3 is realized, all elements of the RPA will work together to help advance survival and recovery objectives for threatened steelhead through a method to restore historically-available lagoon rearing habitat in Arroyo Grande Creek and Meadow Creek to increase healthy smolt production, thus preserving the conservation value of designated habitat throughout the S-CCC DPS range. Additionally, the indirect effects of the remaining project elements: (1) incremental extension of the levee life-span, and (2) the 6.5-year interim period before RPA sub-element 3 is complete, do not translate into jeopardizing the species or adversely modifying designated critical habitat. As described above, sub-elements 1 and 2 begin to assist with steelhead survival and recovery until sub-element 3 is completed. And, sub-elements 1-3 counteract the continued loss of channel function due to artificial confinement. The provision of additional lagoon rearing habitat is ecologically meaningful because this species displays life-history strategies that include using available lagoon environments to increase body size and fitness before ocean entry. This strategy positions the species for a higher likelihood of ocean survival, and thus an increased chance of adults returning to their respective watershed (Bond *et al.* 2008, Hayes *et al.* 2008). Continued channel confinement due to the repaired levee (extending the lifespan of the levee) will continue to delay formation of high-quality rearing habitat for juvenile steelhead in the action area, however, with RPA sub-element 3, we create an opportunity to provide suitable, functioning space that has the capacity to support rearing individuals such that steelhead in the Arroyo Grande Creek watershed will be able to survive and impacts to rearing habitat between the levees will not preclude recovery of the species.

The RPA is designed to minimize adverse effects to threatened steelhead with regard to sustaining and protecting suitable and functional rearing habitat, which is expected to promote successful smolt production in the lower mainstem of Arroyo Grande Creek. The RPA is not intended to address flow releases that negatively impact steelhead migration based on the current water-release schedule and operation of Lopez Dam. This dam is located outside of the action area but remains a stressor, which measurably affects the amount of water that reaches the existing lagoon in combination with additional stressors such as the levee system and groundwater pumping (within the action area) that also negatively impact surface flow into the existing lagoon. The RPA assumes water releases from Lopez Dam will follow current schedules. We expect the RPA to be effective in providing improved habitat conditions in the action area, and implementation of all sub-elements under the RPA will avoid causing jeopardy to the species and avoid adverse modification of designated critical habitat despite current water-release practices at Lopez Dam. Full recovery of threatened steelhead in Arroyo Grande Creek will likely require addressing flow releases and other issues in the watershed created by, or contributed by Lopez Dam, described above in the Environmental Baseline.

While take of steelhead is anticipated to occur during implementation of the RPA, measures specified in the following incidental take statement (*i.e.*, timing of construction, and survey and relocation of steelhead that would be exposed to harm or death from construction related activities or habitat creation/improvement efforts) would be implemented to minimize the effect of such taking. NMFS expects the number of steelhead lost during fish-relocation activities to be a small portion of the entire juvenile population in the watershed and unlikely to affect the increase in returning adults projected for implementation of the RPA. Accordingly, NMFS concludes the RPA would avoid jeopardizing threatened S-CCC steelhead and avoid destroying or adversely modifying critical habitat for this species.

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 incidental take statement.

2.9.1 Amount or Extent of Take

After discussions with the District on their anticipated need to capture and relocate steelhead as modified by the RPA, the District clarified capture and relocation efforts are not anticipated during vegetation removal at three bridge locations, thus NMFS has not allocated capture and relocation coverage for the proposed action's vegetation removal at three bridge locations. Incidental take for all activities were analyzed in the biological opinion's Effects of the Action Section (2.4). After clarification on the proposed action and refining elements of the RPA with the Corps and the District, the RPA will result in incidental take from: (1) installation of log structures, (2) maintenance of log structures, (3) creating alcoves, (4) floodplain/lagoon habitat improvement, and (5) elevated water temperatures upstream and downstream of three bridge crossings.

Incidental take would occur as follows:

	Amount	Frequency	Life Stage	Method	Lethal	Non-Lethal
Capture and Relocation	360	Once (at 36 locations and at the MC and AGC lagoons)	Juveniles	Dewatering to install log structures and improve floodplain/lagoon habitat	Yes; 5% of total (18 out of the 360)	342
Capture and Relocate	30	Yearly (for 16 years)	Juveniles	Maintenance of log structures and creation of alcoves	Yes; 5% of total (24 out of the 480)	456 non-lethal
Restricted rearing and migration behavior	5	Yearly (for 16 years)	Juveniles	Unsuitable water temperature near bridge locations	No	80
Total Lethal					42	
Total Non-Lethal						878
Total All	920 juvenile steelhead					

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 as modified by the RPA, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

1. Undertake measures to ensure that adverse effects to S-CCC steelhead resulting from dewatering activities, water diversion construction, and fish relocation is minimized;

2. Undertake measures to maintain water quality at pre-construction and pre-maintenance levels to avoid or minimize harm to steelhead;

3. Undertake measures to minimize effects to S-CCC steelhead resulting from habitat creation (*i.e.*, placement of log structures and creation of alcoves);

4. Prepare and provide NMFS with plan(s) and report(s) describing how listed species in the action area would be protected and/or monitored and to document the effects of the action on listed species in the action area including yearly status reports on the progress toward completing RPA sub-element 3.

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Corps or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Corps or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action as modified by the RPA would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1:

   A. The applicant shall provide a list of all BMPs and the terms and conditions of this biological opinion to their employees and contractors that are involved with implementation of the proposed action, and ensure these terms and conditions are followed for the duration of the WMP. The applicant shall retain a biologist to monitor the work area during placement and removal of cofferdams and fish block nets and to monitor during construction (of initial conditions) and maintenance (to maintain initial conditions) within the channel to ensure that any adverse effects to steelhead are minimized. Project activities shall only be conducted when steelhead are least likely to be present or affected by the proposed action. The project biologist shall have a high level of expertise in the areas of salmonid biology and ecology, biological monitoring, and handling, collecting, and relocating salmonid species.

   B. The Surface Water Diversion and Steelhead Relocation Plan, including a construction/work schedule, diagrams, field pictures, and material list shall be sent to NMFS (via email to Brittany.Struck@noaa.gov)for review 12 working days before construction or maintenance (that require dewatering) begins. NMFS will review the plan and recommend revisions to the plan, if necessary. The plan shall include equipment proposed to be used for capturing and relocating fish, when those actions will take place, how will fish be transported, and a description of the habitat where fish will be relocated. The applicant must receive NMFS agreement for the final Surface Water Diversion and Steelhead Relocation Plan prior to implementing the Surface Water Diversion and Steelhead Relocation Plan.

   C. The applicant-retained biologist shall be on site during all dewatering events to capture, handle, and safely relocate juvenile steelhead. The biologist shall note and document the number of steelhead collected/observed in the action area, the number of steelhead relocated, the date and time of collection and relocation, and a physical description of the habitat where steelhead were relocated. Juvenile steelhead shall be relocated to a suitable instream location immediately downstream of the workspace. One or more of the following preferred methods shall be used to capture steelhead: dip net, seine, throw net, minnow trap, by hand or by electrofishing. SCCC steelhead shall be handled with extreme care and kept in water to the maximum extent possible during relocation activities. All captured steelhead shall be kept in cool, shaded, aerated water protected from excessive noise, jostling, or overcrowding any time they are not in the stream until released. The biologist shall report the above information to NMFS (Brittany Struck, 501 W. Ocean Blvd., Suite 4200, Long

Beach, California 90802), including information on the actual dewatered areas - dimensions of area dewatered (width, length, average depth).

D. The applicant shall minimize mobilization of bank sediment into the creek from access roads and construction (installation of log structures) activities. Specifically, any sandbags to be used during the construction of the coffer dam for a water diversion shall only be filled with clean/washed sands or gravels. All fill material for cofferdams or access ramps shall be completely removed from the channel by November 30.

2. The following terms and conditions implement reasonable and prudent measure 2:

A. The applicant shall visually monitor turbidity levels beyond the work area boundaries and downstream when instream construction and maintenance activities occur within the protected buffer. Turbidity monitoring equipment shall be available on site, and turbidity shall be measured any time visual monitoring indicates any increase of turbidity outside of the work area. NMFS shall be notified immediately by the contractor if at any time the turbidity monitoring indicates exposure of steelhead to levels of turbidity outside of the described work area of more than a 20 percent increase above background levels. The applicant-retained biologist shall monitor in-channel activities and performance of sediment control or detention devices for the purpose of identifying and reconciling any condition that could result in take of steelhead. When turbidity levels below the work area rise above 20 percent greater than background turbidity levels, the biologists shall halt work activity to recommend measures for avoiding adverse effects to steelhead and critical habitat and ensure sediment control mechanisms are properly working. Systematic turbidity measurements shall be taken downstream of each of the three bridge crossings for a minimum of 8 times a year (two readings for each season) to minimize uncertainty that these areas will generate elevated levels of turbidity. Turbidity measurements shall be documented, compiled into a report, and submitted to NMFS' Southern California Office (501 W. Ocean Blvd., Suite 4200, Attn: Brittany Struck, Long Beach, California 90802).

B. Water temperature shall be measured upstream and downstream of each of the three bridge crossings for a minimum of 8 times a year (two readings for each season) to minimize uncertainty that these areas will provide cooler water temperature levels over time due to proposed canopy enhancement efforts by the District (3.41 acres of existing riparian overstory will be enhanced by adding trees within 10-feet of the active stream channel). Water temperature measurements shall be documented, compiled into a report, and submitted to NMFS' Southern California Office (501 W. Ocean Blvd., Suite 4200, Attn: Brittany Struck, Long Beach, California 90802).

3. The following terms and conditions implement reasonable and prudent measure 3:

A. Field observations (repeat topographic surveys) and sequential aerial photographs shall be conducted and taken, specifically at the log structures and created alcoves. Field calculations need to measure the extent of habitat creation as a result from log structures or alcoves to ensure the intent of the log-structure and alcove design is being implemented throughout the duration of the proposed action. All anticipated habitat features as a result of the log structure and alcove design (*e.g.*, pool formation) need to be monitored throughout the duration of the proposed action to identify when and if failure occurs during implementation of the habitat creation design. Field measurements related to the log structures and created habitat for steelhead shall be documented on a yearly basis, compiled into a report, and submitted to NMFS' Southern California Office (501 W. Ocean Blvd., Suite 4200, Attn: Brittany Struck, Long Beach, California 90802).

B. Most log structures change channel hydraulics to impact sediment deposition and scour patterns. Scour is elicited by increasing water velocity, either through channel constriction laterally or with a vertical drop (plunging flow). Therefore, to ensure log placement, construction, and design work as intended for habitat creation for steelhead, water velocity shall be measured at a minimum of 8 times a year (2 times per season) for the duration of the Corps permit (16 years) at multiple points along a channel cross-section including the active channel for each log structure in the action area. Field measurements related to water velocity shall be documented on a yearly basis, compiled into a report, and submitted to NMFS' Southern California Office (501 W. Ocean Blvd., Suite 4200, Attn: Brittany Struck, Long Beach, California 90802).

4. The following terms and conditions implement reasonable and prudent measure 4:

A. The District shall provide a written yearly report to NMFS by January 15 following completion of construction and for a period of 16 years following construction completion. The report shall be submitted to NMFS Southern California Office (501 W. Ocean Blvd., Suite 4200, Attn: Brittany Struck, Long Beach, California 90802) as well as emailed to: Brittany.Struck@noaa.gov. The report shall contain, at a minimum, the following applicable (depending on year) information:

1. *Construction and maintenance (within designed buffer at bridge locations and log-placement locations) related activities* – The report shall include the dates construction began and was completed; color photographs taken before, during, and after the activity from photo reference points; a discussion of any unanticipated effects or unanticipated levels of effects on steelhead and their habitat, a description of any and all measures taken to minimize those unanticipated effects and a statement as to whether or not the unanticipated effects impacted threatened steelhead or designated critical habitat.
2. *Fish Habitat* – The report shall document how the new habitat structures meet or exceed the expected benefits to steelhead rearing and migration habitat. The report will describe observed steelhead and other fish species use of the habitat structures and any observed inter-species interactions during peak juvenile migration and rearing periods. The report will detail any repair or re-vegetation necessary to maintain the structural integrity and fisheries habitat quality of the structures.
3. *Revegetation* – The report shall include a description of the locations planted or seeded, the area (m^2) revegetated, a plant palette, planting or seeding methods, the efforts taken to ensure success of new plantings, performance or success criteria, and pre- and post-planting color photographs of the revegetated areas.
4. *Steelhead Relocation and Observations* – The report shall include a description of

the location from which fish were removed and the release site including color photographs; the date and time of the relocation effort; a description of the equipment and methods used to collect, hold, and transport steelhead; the number of fish relocated; number of steelhead injured or killed; number of steelhead observed but were not collected for relocation; a description of any problems which may have arisen during the capture and relocation activities and a statement as to whether or not the activities had any unforeseen effects; and field observations of steelhead during required monitoring and measurement efforts after completion of log structure installation.
5. *Yearly status updates on RPA sub-element 3* – The report shall include a review of all actions taken by the District to achieve successful implementation of 8.28 acres of steelhead lagoon-rearing habitat.

B. Dead steelhead shall be collected and placed in an appropriately sized whirl-pack or zip-lock bag, labeled with the date and time of collection, weight, fork length, location of capture, condition of the individual, suspected cause of injury or death, and then frozen as soon as possible. If any steelhead are injured or fatally wounded, the applicant biologist will immediately notify NMFS (Brittany Struck, 562-432-3905). The purposes of the contact shall be to review the activities resulting in lethal take, to determine if additional protective measures are required, and to discuss handling procedures for injured or dead steelhead. If a steelhead mortality does occur, the project biologist shall coordinate with NMFS (Brittany Struck, 562-432-3905) to ship the carcass as soon as possible on dry ice through overnight express mail to NMFS (Brittany Struck, 501 W. Ocean Blvd., Suite 4200, Long Beach, California 90802).

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). The following recommendations would supplement the expected benefits from RPA sub-element 3 for the threatened steelhead population in the Arroyo Grande Creek watershed:

1. Monitor for the following physical processes that affect lagoon habitat conditions such as sedimentation, algal blooms, nutrient loading, and over-population of domestic waterfowl.
2. Address and resolve groundwater extraction management issues that currently have measurable effects to suitable rearing habitat conditions in the existing Arroyo Grande Creek lagoon and the future restored lagoon as described under RPA sub-element 3.
3. Sustainably manage groundwater resources, ensure sufficient freshwater input into the restored lagoon complex to avoid anoxic conditions, and mimic natural frequency and duration of open/closed lagoon cycles.
4. In coordination with NMFS, establish Corps-project guidance for future Corps projects in designated critical habitat for S-CCC steelhead to optimize rearing habitat quality including: (a) how to maximize survival and growth of smolting steelhead before ocean entry; (b) how

to protect juvenile steelhead using the summer lagoon complex as nursery habitat, and (c) recommendations to reduce and minimize the pollutants entering the lagoon complex including nutrient inputs.

5. Conduct public outreach events and programs throughout San Luis Obispo County to educate the public on watershed issues, processes, and activities that affect physical, biological, and chemical components of the restored lagoon complex as described under RPA sub-element 3.
6. In coordination with NMFS, establish Corps-project guidance for any future Corps-funded development in the historical floodplain based on NMFS' recent biological opinion to the Federal Emergency Management Agency (NMFS 2016b) on the ecological impacts to listed salmonid species from building and maintaining established communities within the historical floodplain.
7. Discuss with watershed stakeholders (such as City of Arroyo Grande, Grover Beach, Pismo Beach, Oceano, State Parks, County Airport, Sanitation District) the possibility of collaborating so that their respective general plans, as well as on-going operations and maintenance activities, remain in alignment with the goals and objectives of the Meadow Creek Lagoon Watershed Management Plan (*i.e.*, RPA sub-element 3).

2.11 Reinitiation of Consultation

This concludes formal consultation for the Arroyo Grande Creek Waterway Management Program (File No. SPL-2012-00317-JWM).

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) the amount or extent of incidental taking specified in the incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

3. 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.

3.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this opinion is the Corps. Other interested users could include the County of San Luis Obispo and citizens of Arroyo Grande and Oceano. Individual copies of this opinion were provided to the Corps. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

3.2 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.

3.3 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 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 reviewed in accordance with West Coast Region ESA quality control and assurance processes.

4. REFERENCES

Abbe, T. B., and D. R. Montgomery. 2003. Patterns and processes of wood debris accumulation in the Queets river basin, Washington. Geomorphology 51: 81-107.

Aguiar, F. C., M. T. Ferreira, and I. Moreira. 2001. Exotic and native vegetation establishment following channelization of a western Iberian river. Regulated Rivers: Research and Management 17: 509-526.

Alley, D. W. 1997. Assessment of Juvenile Steelhead Habitat and Fish Densities in Arroyo Grande Creek, San Luis Obispo County, California, 1996. D.W. Alley and Associates.

Alverts, R., Calhoun, J. M., and Lee, R. L., (technical editors). 2001. Organizational Learning: Adaptive Management for Salmon Conservation Conference Proceedings. University of Washington, Olympic Natural Resources Center, Forks, WA USA.

Anderson, D. G. 1970. Effects of urban development on floods in northern Virginia. U.S. Geological Survey Water Supply Paper 2001-C.

Auble, G. T., J. M. Friedman, and M. L. Scott. 1994. Relating riparian vegetation to present and future streamflows. Ecological Applications 4: 544-554.

Baigún, C. R. M. 2003. Characteristics of deep pools used by adult summer steelhead in Steamboat Creek, Oregon. North American Journal of Fisheries Management 23: 1167-1174.

Baldassarre, G. D., A. Viglione, G. Carr, L. Kuil, J. L. Salinas, and G. Blöschl. 2013. Socio-hydrology: conceptualising human-flood interactions. Hydrology and Earth System Sciences 17: 3295-3303.

Barnard, P. L., van Ormondt, M., Erikson, L. H., Eshleman, J., Hapke, C., Ruggiero, P., Adams, P. N. and Foxgrover, A. C. 2014. Development of the Coastal Storm Modeling System (CoSMoS) for predicting the impact of storms on high-energy, active-margin coasts. Natural Hazards, Volume 74 (2), p. 1095-1125, DOI:10.1007/s11069-014-1236-y. Cal-Adapt web-based tool, accessed in 2014 (available at http://cal-adapt.org/resources/).

Becker, G. S., K. M. Smetak, and D.A. Asbury. 2010. Southern Steelhead Resources Evaluation: Identifying Promising Locations for Steelhead Restoration in Watersheds South of the Golden Gate. Cartography by D.A. Asbury. Center for Ecosystem Management and Restoration, Oakland.

Beechie, T., E. Beamer, and L. Wasserman. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. North American Journal of Fisheries Management 14: 797-811.

Beechie, T. and S. Bolton. 1999. An Approach to Restoring Salmonid Habitat-forming Processes in Pacific Northwest Watersheds. Fisheries 24: 6-15.

Beechie, T., D. A. Sear, J. D. Olden, G. R. Pess, J. M. Buffington, H. Moir, P. Roni, and M. M. Pollock. 2010. Process-based principles for restoring river ecosystems. BioScience 60: 209-222.

Berger, J. 1990. Persistence of different-sized populations: an empirical assessment of rapid extinctions in bighorn sheep. Conservation Biology 4: 91-98.

Bernatchez, L. and J. J. Dodson. 1987. Relationship between Bioenergetics and Behavior in Anadromous Fish Migrations. Canadian Journal of Fisheries and Aquatic Sciences 44: 399-407.

Bisson, P. A., J. B. Dunham, and G. H. Reeves. 2009. Freshwater ecosystems and resilience of Pacific salmon: habitat management based on natural variability. Ecology and Society 14: 45.

Bjornn, T. C., and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19: 83-138.

Bond, M. H., Hayes, S. A., Hanson, C. V., and R.B. MacFarlane. 2008. Marine survival of steelhead (*Oncorhynchus mykiss mykiss*) enhanced by a seasonally closed estuary. Canadian Journal of Fisheries and Aquatic Sciences 65: 2242–2252.

Boughton, D. A. and H. Fish. 2003. New data on steelhead distribution in southern and south-central California. Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz. Administrative Report SC-03.

Boughton, D. A., H. Fish, J. Pope, G. Holt. 2009. Spatial patterning of habitat for *Oncorhynchus mykiss* in a system of intermittent and perennial streams. Ecology of Freshwater Fish 18: 92–105.

Boughton, D. A., H. Fish, K. Pipal, J. Goin, F. Watson, J. Casagrande, and M. Stoecker. 2005. Contraction of the southern range limit for anadromous *Oncorhynchus mykiss*. Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz. Administrative Report SC-380.

Boughton, D. A., P. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelley, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2006. Steelhead of the south-central/southern California coast: population characterization for recovery planning. Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz. Administrative Report SC-394.

Boughton, D. A., M. Gibson, R. Yedor, and E. Kelley. 2007. Stream temperature and the potential growth and survival of juvenile *Oncorhynchus mykiss* in a southern California creek. Freshwater Biology 52: 1353-1364.

Boughton, D. A., and A. S. Pike. 2013. Floodplain rehabilitation as a hedge against hydroclimatic uncertainty in a migration corridor of threatened steelhead. Conservation Biology 27: 1158-1168.

Bowen, J. L., and I. Valiela. 2001. The ecological effects of urbanization of coastal watersheds: historical increases in nitrogen loads and eutrophication of Waquoit Bay estuaries. Canadian Journal of Fisheries and Aquatic Sciences 58: 1489-1500.

Bramblett, R. G., M. D. Bryant, B. E. Wright, and R. G. White. 2002. Seasonal use of small tributary and main-stem habitats by juvenile steelhead, coho salmon, and Dolly Varden in a southeastern Alaska drainage basin. Transactions of the American Fisheries Society 131: 498–506.

Brett, J. R., and N. R. Glass. 1973. Metabolic rates and critical swimming speeds of sockeye salmon (*Oncorhynchus nerka*) in relation to size and temperature. Journal of the Fisheries

Research Board of Canada 30: 379–387.

Brookes, A. 1988. Channelized Rivers: Perspectives for Environmental Management. Wiley, Chichester.

Bruton, M. N. 1985. The effects of suspensoids on fish. Hydrobiologia 125: 221-241.

Bryant, M. D. 1983. The role and management of woody debris in West Coast salmonid nursery streams. North American Journal of Fisheries Management 3: 322-330.

Burton, T. M. and G. E. Likens. 1973. The effect of strip-cutting on stream temperatures in Hubbard Brook Experimental Forest, New Hampshire. Bioscience 23: 433-435.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle. Administrative Report SC-27.

California Department of Fish and Game. 1965. California fish and wildlife plan. Volume III supporting data: Part B, inventory salmon-steelhead and marine resources. (Available from California Department of Fish and Wildlife, 1416 Ninth St., Sacramento, CA 95814)

California Department of Fish and Game. 1961. Lopez Project.

California Department of Fish and Wildlife. 2010. California Salmonid Stream Restoration Manual. Chapter Two, Parts IX – XIII. Volume 2, 4th edition. July.

California Department of Pesticide Regulation (CADPR). 1998. Environmental fate of glyphosate. Environmental Monitoring and Pest Management Division, Sacramento, California, 13pp.

Caudill, C. C., C. A. Peery, W. R. Daigle, M. A. Jepson, C. T. Boggs, T. C. Bjornn, D. Joosten, B. J. Burke, and M. L. Moser. 2006. Adult Chinook salmon and steelhead dam passage behavior in response to manipulated discharge through spillways at Bonneville Dam. Technical Report 2006-5 prepared by the Idaho Cooperative Fish and Wildlife Research Unit for the U. S. Army Corps of Engineers, Portland.

Castelle, A. J., A. W. Johnson, and C. Conolly. 1994. Wetland and stream buffer size requirements – a review. Journal of Environmental Quality 23: 878-882.

Caudill, C. C., W. R. Daigle, M. L. Keefer, C. T. Boggs, M. A. Jepson, B. J. Burke, R. W. Zabel, T. C. Bjornn, and C. A. Peery. 2007. Slow dam passage in adult Columbia River salmonids associated with unsuccessful migration: delayed negative effects of passage obstacles or condition-dependent mortality? Canadian Journal of Fisheries and Aquatic Sciences 64: 979-995.

Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. H. Das, E. Maurer, P. Bromirski, N. Graham, R. Flick. 2009. Climate Change Scenarios and Sea Level Rise Estimates for California – 2008 Climate Change Scenarios Assessment – Final Report. PIER Report (CEC-500-2009-014-F).

Cayan, D. R., E. P. Maurer, M. D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate change scenarios for the California region. Climatic Change 87: 21-42.

Cederholm, C. J., R. E. Bilby, R. E. Bisson, T. W. Bumstead, B. R. Fransen, W. J. Scarlett, and J. W. Ward. 1997. Response of juvenile coho salmon and steelhead to placement of largewoody debris in a coastal Washington stream. North American Journal of Fisheries Management 17: 947–963.

Central Coast Salmon Enhancement. 2009. Pismo Creek/Edna Area Watershed Management Plan. Prepared for the Department of Fish and Wildlife, State of California. March. 109pp.

City of Arroyo Grande. 2010. Storm Water Management Plan, NPDES PHASE II Program. Public Works Department. January. 94 pp. (available at http://www.arroyogrande.org/DocumentCenter/View/312)

Copper, J. R., J. W. Gilliam, R. B. Daniels, and W. P. Robarge. 1987. Riparian areas as filters for agriculture sediment. Soil Science Society of America Journal 51: 416-420.

County of San Luis Obispo. 2007. Local Coastal Program Policy Document, a Portion of the San Luis Obispo County Land Use Element of the General Plan. Coastal Plan Policies. Revised April. 208pp.

County of San Luis Obispo. 2013. Arroyo Grande Lagoon: Interim Sandbar Management Plan. Department of Public Works. October 9. ESA / D211720.00. 101pp.

County of San Luis Obispo. 2010a. Arroyo Grande Creek Channel Waterway Management Program (WMP). Final Report prepared for San Luis Obispo County Flood Control and Water Conservation District Zones 1 and 1A Flood Control District. Prepared by Waterways Consulting, Inc. October. 55pp.

County of San Luis Obispo. 2010b. Final Arroyo Grande Creek Channel Waterway Management Program, Environmental Impact Report. Prepared by SWCA Environmental Consultants, 1422 Monterey Street, Suite C200, San Luis Obispo, CA 93401. October. 358pp.

County of Santa Barbara. 2017. Sea Level Rise & Coastal Hazards Vulnerability Assessment. July. Accessible at: http://longrange.sbcountyplanning.org/programs/Coastal%20 Resiliency%20Project/coastalresiliency.php. 272pp.

Cunjak, R. A. 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. Canadian Journal of Fisheries and Aquatic Sciences 53: 267–282.

Cushman, R. M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management 5: 330-339.

Davies-Colley, R. J., M. A. Meleason, R. M. J. Hall and J. C. Rutherford. 2009. Modelling the time course of shade, temperature, and wood recovery in streams with riparian forest restoration. New Zealand Journal of Marine and Freshwater Research 43:673-688.

Department of Fish and Game, State of California. 2005. Arroyo Grande Creek Watershed Management Plan. March. Prepared by Central Coast Salmon Enhancement. 107pp.

Department of Interior (DOI). 1998. A user guide to assessing proper functioning condition and supporting science for lotic areas. TR 1737-15. 126pp.

Department of Water Resources (DWR). 2006. Progress on incorporating climate change into planning and management of California's water resources. Technical Memorandum Report. Sacramento, California. (available at http://baydeltaoffice.water.ca.gov/ climatechange/reports.cfm)

Dewine, J. M. and D. J. Cooper. 2008. Canopy shade and the successional replacement of tamarisk by native box elder. Journal of Applied Ecology 45: 505-514.

Dickard, M., M. Gonzalez, W. Elmore, S. Leonard, D. Smith, S. Smith, J. Staats, P. Summers, D. Weixelman, S. Wyman. 2015. Riparian area management: Proper functioning condition assessment for lotic areas. Technical Reference 1737-15. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO.

Doeg, T. J., and J. D. Koehn. 1994. Effects of draining and desilting a small weir on downstream fish and macroinvertebrates. Regulated Rivers Research and Management 9: 263-278.

Drexhage, K. 2015. Electronic communication to U.S. Army Corps of Engineers re 20-year level of protection in the action area. December 8. Follow-up email to provide further clarification sent to National Marine Fisheries Service on December 9.

Dvorsky, J. and J. Hagar. 2008. Arroyo Grande Creek steelhead distribution & abundance study - 2006. Prepared for Central Coast Salmon Enhancement in association with Hagar Environmental Science. March 20.

Dvorsky, J. and K. Wingfield. 2004. Arroyo Grande Creek watershed management plan: geomorphic and hydrologic conditions assessment – Final Technical Report. Prepared for: Central Coast Salmon Enhancement. December.

Dvorsky, J. 2015. Electronic communication to National Marine Fisheries Service re likelihood of implementing Phase II of the Arroyo Grande Creek Channel Waterway Management

Program. Friday, December 4.

Ebersole, J. L., W. J. Liss, and C. A. Frissell. 2001. Relationship between stream temperature, thermal refugia and rainbow trout *Oncorhynchus mykiss* abundance in arid-land streams in the northwestern United States. Ecology of Freshwater Fish 10: 1-10.

Environmental Protection Agency (EPA). 2001. Salmonid behavior and water temperature. Prepared as Part of EPA Region 10 Temperature Water Quality Criteria Guidance Development Project. Issue Paper 1. EPA-910-D-01-001. May. 38 pp. S. Sauter, J. McMillan, and J. Dunham.

Essex Environmental. 2000. Habitat assessment for the Arroyo Grande Creek Flood Control Project. Prepared for San Luis Obispo County. July 26.

Farhar, J. 2015. Electronic communication with email attachment word document "Final responses to NOAA.docx." re initial NMFS' questions on logistics and schedules in final Biological Assessment and final Waterway Management Program. June 3.

Federal Register (FR 81 FR 7414). 2016. Rules and Regulations: Interagency Cooperation—Endangered Species Act of 1973, as Amended; Definition of Destruction or Adverse Modification of Critical Habitat. Final Rule, 81 FR 7214. February 11, 2016. Vol. 81, No. 28. Effective March 14, 2016.

Friedman, J. M. and G. T. Auble. 2000. Floods, Flood Control, and Bottomland Vegetation. Chapter 8. Inland Flood Hazards: Human, Riparian, and Aquatic Communities. Edited by Ellen E. Wohl. Colorado State University. 20pp.

Ganju, N. K. and D. H. Schoellhamer. 2010. Decadal-timescale estuarine geomorphic change under future scenarios of climate and sediment supply. Estuaries and Coasts 33: 15-29.

Garner, K. L., Chang, M. Y., Fulda, M. T., Berlin, J. A., Freed, R. E., Soo-Hoo, M. M., Revell, D. L., Ikegami, M., Flint, L.E., Flint, A. L., Kendall, B. E. 2015. Impacts of sea level rise and climate change on coastal plant species in the central California coast. PeerJ 3:e958 (available at https://doi.org/10.7717/peerj.958).

Geist, D. R., C. S. Abernethy, S. L. Blanton, and V. I. Cullinan. 2000. The use of electromyogram telemetry to estimate energy expenditure of adult fall Chinook salmon. Transactions of the American Fisheries Society 129: 126-135.

Gergel, S. E., M. D. Dixon, and M. G. Turner. 2002. Consequences of human-altered floods: levees, floods, and floodplain forests along the Wisconsin River. Ecological Applications 12: 1755-1770.

Gibson, R. J. and G. Power. 1975. Selection by brook trout (*Salvelinus fontinalis*) and juvenile Atlantic salmon (*Salmo salar*) of shade related to water depth. Journal of the Fisheries Research Board of Canada 32: 1652-1656.

Gilbert, G. K. 1914. The transportation of debris by running water. United States Geological Survey Professional Paper 86. U.S. Government Printing Office, Washington, DC, USA.

Gomi, T., R. D. Moore, M. A. Hassan. 2005. Suspended sediment dynamics in small forest streams of the Pacific Northwest. Journal of the American Water Resources Association 41: 693-717.

Good, T. P., R. S. Waples, and P. Adams. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle. Administrative Report SC-66.

Grantham, T. E., A. M. Merenlender, and V. H. Resh. 2010. Climatic influences and anthropogenic stressors: an integrated framework for streamflow management in Mediterranean-climate California, U.S.A. Freshwater Biology 55: 188-204.

Grantham, T. E., J. H. Viers, and P. B. Moyle. 2014. Systematic screening of dams for environmental flow assessment and implementation. BioScience 64: 1006-1018.

Gray, L. J. and J. V. Ward. 1982. Effects of sediment releases from a reservoir on stream macroinvertebrates. Hydrobiologia 96: 177-184.

Griggs, F. T. 2009. California Riparian Habitat Restoration Handbook. Second Edition. July. River Partners. 83pp.

Gustafson, R. G., R. S. Waples, J. M. Myers, L. A. Weitkamp, G. J. Bryant, O. W. Johnson, and J. J. Hard. 2007. Pacific salmon extinctions: quantifying lost and remaining diversity. Conservation Biology 21: 1009–1020.

Harrison, L. R. and E. A. Keller. 2007. Modeling forced pool-riffle hydraulics in a boulder-bed stream, southern California. Geomorphology 83: 232-248.

Hawkins, D. K. and T. P. Quinn. 1996. Critical swimming velocity and associated morphology of juvenile coastal cutthroat trout (*Oncorhynchus clarki clarki*), steelhead trout (*Oncorhynchus mykiss*), and their hybrids. Canadian Journal of Fisheries and Aquatic Sciences 53: 1487-1496.

Hayes, S. A., M. H. Bond, C. V. Hanson, A. W. Jones, A. J. Ammann, J. A. Harding, A. L. Collins, J. Perez, and R. B. MacFarlane. 2011. Down, up, down and “smolting” twice? Seasonal movement patterns by juvenile steelhead (*Oncorhynchus mykiss*) in a coastal watershed with a bar closing estuary. Canadian Journal of Fisheries and Aquatic Sciences 68: 1341-1350.

Hayes, S. A., M. H. Bond, C. V. Hanson, E. V. Freund, J. J. Smith, E. C. Anderson, A. J. Ammann, and R. B. MacFarlane. 2008. Steelhead growth in a small central California watershed: upstream and estuarine rearing patterns. Transactions of the American

Fisheries Society 137: 114–128.

Hayhoe, K., D. Cayan, C. B. Field, P. C. Frumhoff, E. P. Maurer, N. L. Miller, S. C. Moser, S.H. Schneider, K. N. Cahill, E. E. Cleland, L. Dale, R. Drapek, R. M. Hanemann, L. S.Kalkstein, J. Lenihan, C. K. Lunch, R. P. Neilson, S. C. Sheridan, and J. H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences 101: 12422–12427.

Hedgecock, D., P. Siri, and D. R. Strong. 1994. Conservation biology of endangered Pacific salmonids: introductory remarks. Conservation Biology 8: 863-894.

Helfman, G. S. 1981. The advantage to fish of hovering in shade. Copeia 2: 392-400.

Helmbrecht, S. and D. A. Boughton. 2005. Recent Efforts to Monitor Anadromous *Oncorhynchus* Species in the California Coastal Region: A Compilation of Metadata. Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz. Administrative Report SC-381.

Hestir, E. L., D. H. Schoellhamer, T. Morgan-King, and S. L. Ustin. 2013. A step decrease in sediment concentration in a highly modified tidal river delta following the 1983 El Niño floods. Marine Geology 345:304-313.

Hewlett, J. D., and J. C. Fortson. 1982. Stream temperatures under an inadequate buffer strip in the southeast piedmont. Water Resources Bulletin 18: 983–988.

Hinch, S. G. and P. S. Rand. 2000. Optional swimming speeds and forward-assisted propulsion: energy-conserving behaviours of upriver-migrating adult salmon. Canadian Journal of Fisheries and Aquatic Sciences 57: 2470–2478.

Hinch, S. G., and P. S. Rand. 1998. Swim speeds and energy use of upriver-migrating sockeye salmon (*Oncorhynchus nerka*): role of local environment and fish characteristics. Canadian Journal of Fisheries and Aquatic Sciences 55: 1821-1831.

Hubert, W. A. 1996. Passive capture techniques. B.R. Murphy and D.W. Willis, editors. Pages 157-192 in Fisheries Techniques, 2nd edition. American Fisheries Society. Bethesda, Maryland.

Hunt & Associates Biological Consulting Services. 2008. South-Central California Coast Steelhead Recovery Planning Area, Conservation Action Planning (CAP) Workbooks Threats Assessment. Santa Barbara, California.

Hunt, K., N. E. Sikes, and A. L. Martinez. 2009. Cultural Resources Survey for the Arroyo Grande Creek Channel Waterway Management Program Project, San Luis Obispo County, California. Prepared for County of San Luis Obispo. SWCA Project No. 14414. SWCA Cultural Resources Report Database No. 2009-244. July 31, 2009.

Hupp, C. R. 1992. Riparian vegetation recovery patterns following stream channelization: A geomorphic perspective. Ecology 73: 1209–1226.

Inman, D. L. and S. A. Jenkins. 1999. Climate change and the episodicity of sediment flux of small California rivers. Journal of Geology 107: 251-270.

Jacobs, D. K., E. D. Stein, and T. Longcore. 2011. Classification of California estuaries based on natural closure patterns: templates for restoration and management. Southern California Coastal Water Research Project. Technical Report 619.a. August (Revised).

Jobling, M. 1994. Fish Bioenergetics. (Fish and Fisheries Series:13), ISBN 10: 041258090X/ ISBN 13: 9780412580901. Chapman and Hall. 309pp.

JRP Historical Consulting, LLC. 2009. Draft historical resources inventory and evaluation report, Arroyo Grande Creek waterway management program. August. 101pp.

Karr, J. R. and I. J. Schlosser. 1978. Water resources and the land-water interface. Science 201: 229-234.

Keim, R. E., S. H. Schoenholtz. 1999. Functions and effectiveness of silvicultural streamside management zones in loessial bluff forests. Forest Ecology and Management 118: 197-209.

Kondolf, G. M. 1997. Hungry water: effects of dams and gravel mining on river channels. Environmental Management 21: 533-551.

Kondolf, G. M., A. J. Boulton, S. O'Daniel, G. C. Poole, F. J. Rahel, E. H. Stanley, E. Wohl, A. Bång, J. Carlstrom, C. Cristoni and H. Huber. 2006. Process-based ecological river restoration: visualizing three-dimensional connectivity and dynamic vectors to recover lost linkages. Ecology and Society 11:5 (available at: http://www.ecologyandsociety.org/vol11/iss2/art5/).

Koopman, M. E., R. S. Nauman, and J. L. Leonard. 2010. Projected future climatic and ecological conditions in San Luis Obispo County. The National Center for Conservation Science and Policy. April. 35pp.

Kraus, N., K. Patsch, and S. Munger. 2008. Barrier beach breaching from the lagoon side, with reference to Northern California. Shore and Beach 76: 33-43.

Leopold, L. B. and T. Maddock Jr. 1953. The hydraulic geometry of stream channels and some physiographic implications U.S. Department of the Interior, United States Geological Survey (Geological Survey Professional Paper 252), Washington, D.C. 57pp.

Largier, J. L., B. S. Cheng, and K. D. Higgason, editors. 2010. Climate change impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils. 121pp

Liao, K. 2014. From flood control to flood adaptation: a case study on the Lower Green River Valley and the City of Kent in King County, Washington. Natural Hazards 71: 723-750.

Ligon, F. K., W. E. Dietrich, and W. J. Trush. 1995. Downstream ecological effects of dams. BioScience 45: 183-92.

Lisle, T. E. 1986. Effects of woody debris on anadromous salmonid habitat, Prince of Wales Island, Southeast Alaska. North American Journal of Fisheries Management 6: 538-550.

Lowrance, R. 1995. Water quality functions of riparian forest buffer systems in the Chesapeake Bay Watershed. U.S. Environmental Protection Agency, 903-R-95-004.

Lowrance, R., R. Leonard, and J. Sheridan. 1985. Managing riparian ecosystems to control nonpoint pollution. Journal of Soil and Water Conservation 40: 87-91.

Mannion, A. M. 1995. Agriculture and environmental change: Temporal and Spatial Dimensions. John Wiley& Sons, Chichester, Sussex. ISBN-13: 978-0471954781 ISBN-10: 0471954780. 418pp.

McCarthy, S. G., J. J. Duda, J. M. Emlen, G. R. Hodgson, D. A. Beauchamp. 2009. Linking Habitat Quality with Trophic Performance of Steelhead along Forest Gradients in the South Fork Trinity River Watershed, California. Transactions of the American Fisheries Society 138:506–521.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle. Administrative Report SC-42.

McLean, R. F., A. Tsyban, V. Burkett, J. O. Codignott, D. L. Forbes, N. Mimura, R. J. Beamish, V. Ittekkot. 2001. Coastal Zones and Marine Ecosystems. In Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Edited by James J. McCarthy Osvaldo F. Canziani, Neil A. Leary, David J. Dokken, and Kasey S. White, Cambridge University Press, Cambridge, UK, 343-379.

Montgomery, D. R. and J. M. Buffington. 1998. Chapter 2: Channel Processes, Classification, and Response. River Ecology and Management. Robert Naiman and Robert Bilby, Editors. Springer-Verlag New York, Inc. 30pp.

Montgomery, D. R., E. M. Beamer, G. R. Pess, and T. P. Quinn. 1999. Channel type and salmonid spawning distribution and abundance. Canadian Journal of Fisheries and Aquatic Sciences 56: 377–387.

Moore, R. D., D. L. Spittlehouse, and A. Story. 2005. Riparian microclimate and stream temperature response to forest harvesting: a review. Journal of the American Water Resources Association. 41: 813-834.

Mount, J. F. 1995. California rivers and streams: The Conflict between fluvial process and land use. University of California Press, Berkeley. 376pp.

Moyle, P. B. 1994. The decline of anadromous fishes in California. Conservation Biology 8: 869-870.

Murphy, M. L. and W. R. Meehan. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. Chapter: Stream ecosystems, pages 17-46. W. R. Meehan, editor. American Fisheries Society, Bethesda, Maryland. 622pp.

Myrick, C. A., and J. J. Cech Jr. 2004. Temperature effects on juvenile anadromous salmonids in California's central valley: what don't we know? Reviews in Fish Biology and Fisheries 14: 113-123.

Naiman, R. J. and H. Décamps. 1997. The ecology of interfaces—riparian zones. Annual Review of Ecology and Systematics 28: 621–658.

National Marine Fisheries Service. 2016a. 5-Year Review: Summary and Evaluation of South-Central California Coast Steelhead Distinct Population Segment. West Coast Region California Coastal Office, Santa Rosa, California. 75pp.

National Marine Fisheries Service. 2016b. Endangered Species Act (ESA) Section 7(a)(2) Jeopardy and Adverse Modification of Critical Habitat Biological Opinion, ESA Section 7(a)(2) "Not Likely to Adversely Affect" Determination, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Implementation of the National Flood Insurance Program in the State of Oregon. April 14. Refer to NMFS No: NWR-2011-3197. 410pp.

National Marine Fisheries Service. 2016c. Revised Guidance for Treatment of Climate Change in NMFS Endangered Species Act Decisions. Memo for NMFS Leadership Council from Eileen Sobeck. Dated June 17, 2016.

National Marine Fisheries Service. 2016d. Letter of National Marine Fisheries Service, Long Beach, to Army Corps of Engineers, Ventura Regulatory Office, December 21, 2016.

National Marine Fisheries Service and San Luis Obispo County and Waterways Consultants, Inc. 2015. In-person meeting seeking clarification on hydraulics analysis and proposed engineering design. Monday, June 15.

National Marine Fisheries Service. 2013. South-Central California Coast Steelhead Recovery Plan. West Coast Region, California Coastal Area Office, Long Beach, California.

National Marine Fisheries Service. 2008. Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Washington State Fish Passage and Habitat Enhancement Restoration Programmatic. NMFS Consultation No.: 2008/03598. Issued to Michelle Walker, Corps of Engineers, Seattle District Regulatory Branch CENWS-OD-RG Post Office Box 3755 Seattle, Washington 98124-3755. July 8. 172pp.

National Marine Fisheries Service. 2006. Endangered and threatened species: final listing determinations for 10 distinct population segments of west coast steelhead. Federal Register 71 (3): 834-862.

National Marine Fisheries Service. 2005. Endangered and threatened species: designated critical habitat for seven evolutionarily significant units of Pacific salmon and steelhead in California. Federal Register 70 (170): 52488-52586.

National Marine Fisheries Service. 2004. Sediment removal from freshwater salmonid habitat: Guidelines to NOAA Fisheries staff for the evaluation of sediment removal actions from California streams. NOAA Fisheries. Southwest Region. April 19.

National Marine Fisheries Service. 2003. Memorandum to Gary Stern from Joe Dillon. Review of herbicide application proposed for San Francisco Estuary Invasive Spartina Project: Spartina Control Program. July 31.

National Marine Fisheries Service. 2001. Biological Opinion on permitting of the Lopez Dam Seismic Remediation Project in San Luis Obispo County. Admin record number 151422SWR01PR111:APS. Issued on March 28 to the Army Corps of Engineers. Southwest Region. 501 West Ocean Blvd., Suite 4200, Long Beach, CA 90802.

Natural Resources Conservation Service. 1999. Arroyo Grande Creek: 40th Anniversary 1958-1998: PL 566 Project 1952-1961. 15 pages plus attachments.

Neelin, J. D., B. Langenbrunner, J. E. Meyerson, A. Hall, and N. Berg. 2013. California winter precipitation change under global warming in the coupled model intercomparison project phase 5 ensemble. Journal of Climate 26: 6238-6256.

Newton M., K. M. Howard, B. R. Kelpsas, R. Danhaus, C. M. Lottman, and S. Dubelman. 1984. Fate of glyphosate in an Oregon Forest Ecosystem. Journal of Agriculture and Food Chemistry 32: 1144–1151.

Nielsen, J. L., T. E. Lisle, and V. Ozaki. 1994. Thermally stratified pools and their use by steelhead in northern California streams. Transactions of the American Fisheries Society 123: 613-626.

Nilsson, C. 1984. Effect of stream regulation on riparian vegetation. In Regulated Rivers, eds. A. Lillehammer and S.J. Saltveit, pp. 93-106. Universitetsforlaget, Oslo.

Nordby, C. S. and J. B. Zedler. 1991. Response of Fish and Macrobenthic Assemblages to Hydrologic Disturbances in Tijuana Estuary and Los Peñasquitos Lagoon, California. Estuaries 14: 80-93.

Osborne, L. L. and D. A. Kovacic. 1993. Riparian vegetated buffer strips in water-quality restoration and stream management. Freshwater Biology 29: 243-258.

Pert, E. J. and D. C. Erman. 1994. Habitat use by adult rainbow trout under moderate artificial fluctuations in flow. Transactions of the American Fisheries Society 123: 913-923.

Pimm, S. L., H. L. Jones, and J. Diamond. 1988. On the risk of extinction. American Naturalist 132: 757-785.

Pinter, N. 2005. One step forward, two steps back on U.S. floodplains. Science 308: 207-208.

Platts, W. S. 1991. Livestock grazing (pages 389-423) in Influences of forest and rangeland management on salmonid fisheries and their habitats. W. R. Meehan, editor. American Fisheries Society, Special Publication 19, Bethesda, Maryland.

Pollock, M. M., and P. M. Kennard. 1998. A low-risk strategy for preserving riparian buffers needed to protect and restore salmonid habitat in forested watersheds of Washington State. 10,000 Years Institute, Bainbridge Island, Washington, 36pp.

Primack, R. 2004. A primer of conservation biology, 3rd edition. Sinauer Associates, Inc., Sunderland, Massachusetts, 363pp.

Quinn, T. P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. First Edition. University of Washington Press, Seattle, Washington, 378pp.

Rapp, C. F. and T. B. Abbe. 2003. A framework for delineating channel migration zones. Final Draft Publication #03-06-027. Washington State Department of Ecology and Washington State Department of Transportation, Olympia, Washington.

Reubens, B., J. Poesen, F. Danjon, G. Geudens, B. Muys. 2007. The role of fine and course roots in shallow slope stability and soil erosion control with a focus on root system architecture: a review. Trees 21: 385-402.

Rhoads, B. L., J. S. Schwartz, and S. Porter. 2003. Stream geomorphology, bank vegetation, and three-dimensional habitat hydraulics for fish in midwestern agricultural streams. Water Resources Research 39: 1218 (ESG 2-1 through 2-13).

Rischbieter, D. 2004 – 2013. Collection of Summary Monitoring Reports (2004, 2008, 2011, 2012, 2013). File Number: 19000. Permit Number: 18452, 4d Rule coverage. California Department of Parks & Recreation, dougr@water.ca.gov.

Rischbieter, D. 2004. Lower Arroyo Grande Creek and Lagoon Fishery and Aquatic Resources Summary Monitoring Report.

Rischbieter, D. 2009. Lower Arroyo Grande Creek and Lagoon Fishery and Aquatic Resources Summary 2009 Monitoring Report. December 2009. Oceano Dunes SVRA, Pismo Dunes State Reserve. California State Parks.

Rischbieter, D. 2012. Summary Monitoring Report. File Number: 19000. Permit Number: 18452, 4d Rule coverage. California Department of Parks & Recreation.

Rischbieter, D. 2012. Lower Arroyo Grande Creek and Lagoon Fishery and Aquatic Resources Summary 2011 Monitoring Report, Oceano Dunes State Vehicular Recreation Area, Pismo Dunes Natural Preserve. Environmental Scientist, California State Parks. January. File Number: 19000. APPS Permit 18452.

Roni, P., K. Hanson, and T. J. Beechie. 2008. Global overview of the physical and biological effectiveness of stream habitat rehabilitation techniques. American Fisheries Society, North American Journal of Fisheries Management 28: 856-890.

Roper, B. B., J. J. Dose, and J. E. Williams. 1997. Stream restoration: is fisheries biology enough? Fisheries 22: 6-11.

Ruiz-Campos, G. and E. P. Pister. 1995. Distribution, habitat, and current status of the San Pedro Mártir rainbow trout, *Oncorhynchus mykiss nelson* (Evermann). Bulletin of the Southern California Academy of Sciences 94: 131-148.

Sabater, F., A. Butturini, E. MartÍ, I. Muñoz, A. Romaní, J. Wray, and S. Sabater. 2000. Effects of riparian vegetation removal on nutrient retention in a Mediterranean stream. Journal of the North American Benthological Society 19: 609-620.

San Luis Obispo County, Dept. of Public Works. 2002. Post-construction monitoring report for the Arroyo Grande Creek sediment removal project, San Luis Obispo County (151422SWR00PR105:APS). December 4.

San Luis Obispo County. 2005. Hydrologic Report, Final Report, Water Years 2001-2002 and 2002-2003. Utilities Division, Public Works Department. May 16.

San Luis Obispo County, Dept. of Public Works. 2013. Hydrologic and Hydraulic Drainage Report for Oceano Drainage Improvement Project. Oceano, California. January. 39 pp.

San Luis Obispo County Flood Control and Water Conservation District (District). 2014. Teleconference between the District, Corps, and NMFS on the basis for the proposed 10-ft buffer. December 3.

San Luis Obispo County. 2015. Habitat Mitigation and Monitoring Plan Updated. Recent updates made by Katie Drexhage on behalf of San Luis Obispo County Flood Control and Water Conservation District. Received by NMFS through electronic correspondence on September 17, 2015.

San Luis Obispo County, Dept. of Public Works. 2015. Branch Mill Road Bridge Replacement Project – Project Completion Report submitted to National Marine Fisheries Service. December. 29pp.

San Luis Obispo County Flood Control and Water Conservation District (District). 2017a. Long-term Sediment Management Removal Guidelines 5.15. Provided to NMFS on May 15, 2017.

San Luis Obispo County Flood Control and Water Conservation District (District). 2017b. Meadow Creek Lagoon Watershed Plan: Goals and Objectives. Provided to NMFS on April 3, 2017.

San Luis Obispo County Flood Control and Water Conservation District (District). 2017c. Grant Programs Available for the Meadow Creek Lagoon Restoration. Provided to NMFS on May 15, 2017.

San Luis Obispo County Flood Control and Water Conservation District (District). 2017d. District correspondence to U.S. Army Corps of Engineers, Regulatory Division. July 24. 3pp.

San Luis Obispo County Flood Control and Water Conservation District (District). 2017e. Arroyo Grande Creek Waterway Management Program, Habitat Mitigation and Monitoring Plan. Provided to NMFS on July 10. 94pp.

Schultz, R. C., T. M. Isenhart, W. W. Simpkins, and J. P. Colletti. 2004. Riparian forest buffers in agroecosystems – lessons learned from the Bear Creek Watershed, central Iowa, U.S.A. Agroforestry Systems 61: 35-50.

Schumm, S. A., M. D. Harvey and C. C. Watson. 1984. Incised channels morphology, dynamics, and control. Littleton, Colorado, Water Resources Publications, 200pp.

Seaburn, G. E. 1969. Effects of urban development on direct runoff to East Meadow Brook, Nassau Countu, Long Island, New York; U.S. Geological Survey Professional Paper 627-B.

Shaler, N. S. 1891. The origin and nature of soils (pages 213-345) in United States Geological Survey Twelfth Annual Report. J. W. Powell, ed. U.S. Government Printing Office, Washington, D.C., U.S.A.

Shapovalov, L. 1944. Preliminary Report on the Fisheries of the Santa Maria River System, Santa Barbara, San Luis Obispo, and Ventura Counties, California. Bureau of Fish Conservation, California Department of Fish and Game. Administrative Report No. 44-

14.

Shapovalov, L. and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmogairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. State of California, Department of Fish and Game, Fish Bulletin 98.

Shaw, E. A. and J. S. Richardson. 2001. Direct and indirect effects of sediment pulse duration on stream invertebrate assemblages and rainbow trout (*Oncorhynchus mykiss*) growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58: 2213 – 2221.

Simon, A. and C. R. Hupp. 1987. Geomorphic and vegetative recovery processes along modified Tennessee streams: an interdisciplinary approach of disturbed fluvial systems. Forest Hydrology and Watershed Management, Proceedings of the Vancouver Symposium (August) 167: 251-262.

Simon, A. and C. R. Hupp. 1992. Geomorphic and vegetative recovery processes along modified stream channels of West Tennessee. No. USGS-OFR-91-502. United States Geological Survey, Washington, D.C.

Smith, J. J. and H. W. Li. 1983. Energetic factors influencing foraging tactics of juvenile steelhead trout, *Salmo gairdneri*. In Predators and prey in fishes, pp. 173-180. Springer, Netherlands.

Sommer, T. R., W. C. Harrell, and M. L. Nobriga. 2005. Habitat use and stranding risk of juvenile Chinook salmon on a seasonal floodplain. North American Journal of Fisheries Management 25: 1493-1504.

Spina, A. P. 2003. Habitat associations of steelhead trout near the southern extent of their range. California Fish and Game 89: 81–95.

Spina, A. P., M. A. Allen, and M. Clarke. 2005. Downstream migration, rearing abundance and pool habitat associations of juvenile steelhead in the lower main stem of a south-central California stream. North American Journal of Fisheries Management 25: 919-930.

Spina, A. P., M. McGoogan, and T. S. Gaffney. 2006. Influence of surface-water withdrawal on juvenile steelhead and their habitat in a south-central California nursery stream. California Fish and Game 92:81-90.

Standen, E. M., S. G. Hinch, and P. S. Rand. 2004. Influence of river speed on path selection by migrating adult sockeye salmon (*Oncorhynchus nerka*). Canadian Journal of Fisheries and Aquatic Sciences 61: 905–912.

Standen, E. M., S. G. Hinch, M. C. Healey, and A. P. Farrell. 2002. Energetic costs of migrating upriver through the Fraser River canyon, British Columbia, in adult pink (*Oncorhynchus gorbuscha*) and sockeye (*O. nerka*) salmon as assessed by EMG telemetry.

Canadian Journal of Fisheries and Aquatic Sciences 59: 1809–1818.

Stetson Engineers, Inc. 2004. Arroyo Grande Creek Habitat Conservation Plan and Environmental Assessment/Initial Study for the Protection of Steelhead and California Red-Legged Frogs. Prepared for County of San Luis Obispo. February.

Sutton, R. J., M. L. Deas, S. K. Tanaka, T. Soto, and R. A. Corum. 2007. Salmonid observations at a Klamath River thermal refuge under various hydrological and meteorological conditions. River Research and Applications 23: 775-785.

Swanson Hydrology and Geomorphology. 2004. Arroyo Grande Creek Watershed Management Plan: Geomorphic and hydrologic conditions assessment. Prepared for Central Coast Salmon Enhancement. December 8. 162pp.

Swanson Hydrology and Geomorphology. 2006a. Final Arroyo Grande Creek Erosion, Sedimentation and Flooding Alternatives Study for Coastal San Luis Resource Conservation District. January 4. 196pp.

Swanson Hydrology & Geomorphology. 2006b. Draft Report on Arroyo Grande Creek: Steelhead Distribution and Abundance Survey. Prepared for Central Coast Salmon Enhancement in association with Hagar Environmental Science. December 21.

Swanson Hydrology and Geomorphology. 2008. Arroyo Grande Creek: Steelhead Distribution and Abundance Survey – 2006. Prepared for Central Coast Salmon Enhancement in association with Hagar Environmental Science. March 20. Final Report.

SWCA Environmental Consultants. 2010. Final Arroyo Grande Creek Channel Waterway Management Program Environmental Impact Report. SHC#2009061030. Prepared for County of San Luis Obispo, Department of Public Works, County Government Center, Room 207, San Luis Obispo, CA 93408. October. 358 pp.

SWCA Environmental Consultants. 2013. Biological Assessment for Arroyo Grande Creek Channel Waterway Management Program. July. San Luis Obispo Office, 1422 Monterey Street, Suite C200, San Luis Obispo, California 93401. 148 pp.

SWCA Environmental Consultants. 2013. Arroyo Grande Creek Channel Waterway Management Program Revegetation, Enhancement, and Mitigation Plan (HMMP) for Jurisdictional Areas, San Luis Obispo County, California. Prepared for San Luis Obispo County Flood Control and Water Conservation District. July. SWCA Project Number: 14414. 74 pp.

SWCA Environmental Consultants. 2014. Arroyo Grande Creek Channel Waterway Management Program Revegetation, Enhancement, and Mitigation Plan (HMMP) for Jurisdictional Areas, San Luis Obispo County, California. Prepared for San Luis Obispo County Flood Control and Water Conservation District. April. SWCA Project Number: 14414. 80 pp.

Tabacchi, E., D. Correll, R. Hauer, G. Pinay, and A. Planty-Tabacchi. 1998. Development, maintenance and role of riparian vegetation in the river landscape. Freshwater Biology 40: 497-516.

Thorne, K. M., Buffington, K. J., Elliott-Fisk, D. L., Takekawa, J. Y. 2015. Tidal marsh susceptibility to sea-level rise: importance of local-scale models. Journal of Fish and Wildlife Management 6:290-304.

Trush, W. J., S. M. McBain, and L. B Leopold. 2000. Attributes of an alluvial river and their relation to water policy and management. Proceedings of the National Academy of Sciences 97: 11858-11863.

Tsuyuki, H. and S. N. Willscroft. 1977. Swimming stamina differences between genotypically distinct forms of rainbow (*Salmo gairdneri*) and steelhead trout. Journal of the Fisheries Research Board of Canada 34: 996-1003.

U.S. Army Corps of Engineers. 2016a. Formal correspondence to National Marine Fisheries Service re removing Phase II from the Arroyo Grande Creek Channel Waterway Management Program. January 13. Received on January 22, 2016.

U.S. Army Corps of Engineers. 2016b. Feedback on the draft biological opinion to National Marine Fisheries Service for the Arroyo Grande Creek Channel Waterway Management Program. August 16, meeting at the Corps' downtown Los Angeles office.

U.S. Forest Service. 2008. Stream Simulation: An ecological approach to providing passage for aquatic organisms at road-stream crossings. U.S. Department of Agriculture. National Technology and Development Program. August. San Dimas, California.

Ward, B. R., P. A. Slaney, A. R. Facchin, and R. W. Land. 1989. Size-biased survival in steelhead trout (*Oncorhynchus mykiss*): back-calculated lengths from adults' scales compared to migrating smolts at the Keogh River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 46: 1853–1858.

Waters, T. F. 1995. Sediment in Streams: Sources, Biological Effects, and Control. American Fisheries Society Monograph 7. Bethesda, Maryland. 251pp.

Waterways Consulting, Inc. 2015. Draft Biological Assessment for South Central California Coast Steelhead, Arroyo Grande Creek Channel for Arroyo Grande Creek Channel Waterway Management Program. Updated February 20. San Luis Obispo, California. Project No. 08-707. 59 pp.

Weaver, L. A., and G. C. Garman. 1994. Urbanization of a watershed and historical changes in a stream fish assemblage. Transactions of the American Fisheries Society 123: 162-172.

Welsch, D. J. 1991. Riparian forest buffers: function and design for protection and enhancement of water resources. U.S. Department of Agriculture, Forest Service, NA-PR-07-91, Radnor, Pennsylvania.

Wemple, B. C., J. A. Jones, and G. E. Grant. 1996. Channel network extension by logging roads in two basins, Western Cascades, Oregon. Water Resources Bulletin 32: 1195-1207.

Wenger, S. 1999. A review of the scientific literature on riparian buffer, width, extent, and vegetation. Office of Public Service and Outreach. Institute of Ecology, University of Georgia. Revised Version, March 5. See flood-control function, pg. 40.

Westerling, A. L., B. P. Bryant, H. K. Preisler, T. P. Holmes, H. G. Hidalgo, T. Das, and S. R. Shrestha. 2009. Climate Change, Growth, and California Wildfire. California Climate Change Center. CEC-500-2009-046-F.

Whiteway, S. L., P. M. Biron, A. Zimmermann, O. Venter, and J. W. Grant. 2010. Do in-stream restoration structures enhance salmonid abundance? A meta-analysis. Canadian Journal of Fisheries and Aquatic Sciences 67: 831–841.

Williams, T. H., S. T. Lindley, B. C. Spence, and D. A. Boughton. 2011. Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Southwest. Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz. 98pp.

Williams, T. H., B. C. Spence, D. A. Boughton, R. C. Johnson, L. G. Crozier, N. J. Mantua, M. R. O'Farrell, and S. T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. Southwest Fisheries Science Center, National Marine Fisheries Service, Santa Cruz. Administrative Report SC-564.

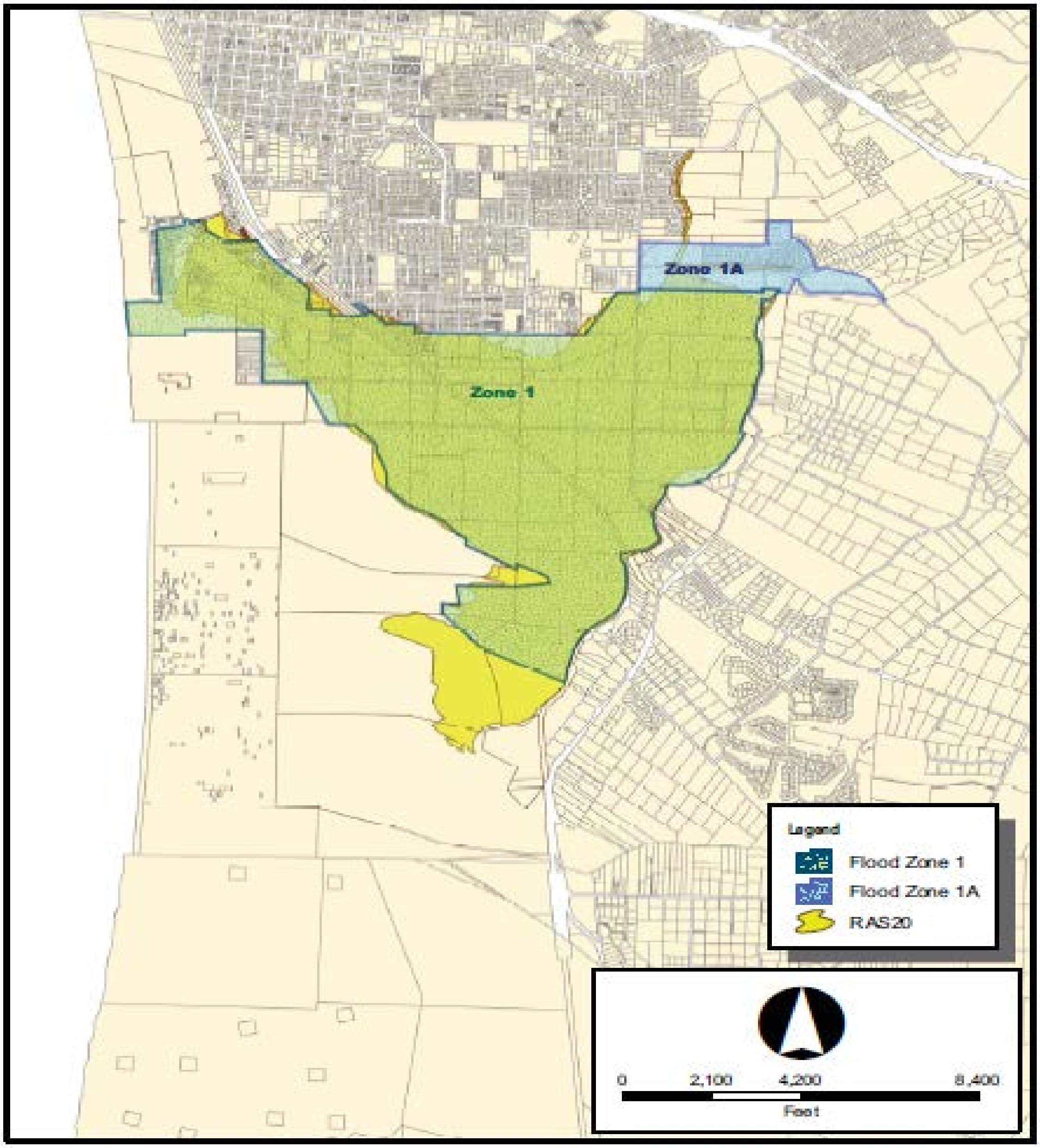
Willis, C. M. and G. B. Griggs. 2003. Reductions in Fluvial Sediment Discharge by Coastal Dams in California and Implications for Beach Sustainability. The Journal of Geology 111: 167-182.

Ziemer, R. R. and T. E. Lisle. 1998. Chapter 3: Hydrology in river ecology and management: lessons from the Pacific coastal ecoregion (pages 43- 68). R. J. Naiman and R. E. Bilby, editors. Springer-Verlag, New York, New York, U.S.A.

APPENDICES

APPENDIX A

Zone 1 and Zone 1A map boundaries.



Map source:
http://www.slocountywater.org/site/Flood%20Control%20and%20Water%20Conservation%20District%20Zones/ZONE%201-1A/pdf/Zone%201-1A%20Map.pdf

APPENDIX B

District-provided photograph depicting the proposed 10-ft buffer as described under the Proposed Action, the estimated width of the primary low-flow channel, and the side profile view of the riparian canopy created by the 10-ft buffer between the levees in the action area.

WATERWAYS CONSULTING, INC.
Santa Cruz, CA | watways.com | Portland, OR

FIGURE 9: Typical view of vegetation maintenance activities.

APPENDIX C

The table below was an organizing tool for NMFS, the Corps, and the District to track changes and modifications to the proposed action as well as new elements introduced into the RPA after discussions and collaboration with the Corps and the District.

	Changes/Refinements/Modifications/Clarification	**RPA**
	Collaboration resulted in a modified extent and layout for the riparian buffer; bridge vegetation removal will be reduced to 20ft u/s and d/s of each bridge crossing	30-ft rooted buffer, 15 feet on each side of channel for 69% of action area; 10ft/20ft buffer layout for 31% of action area; 150-ft riparian canopy
	Sediment management occurs over first two years rather than all in first year; sediment removal stays above the OHWM so existing bankfull depth is not affected; sediment removal areas are based on the **08/10/2015 100% design plans**	Initial removal in areas of accumulated sediment will be above the OHWM; average width was revised to 40 feet for each of the 22 sites.
	The District will remove accumulated sediment from areas where modeling results show that sedimentation has reduced capacity beyond 50% of the available freeboard (10-year flood protection).	Ongoing sediment removal will occur when modeling/surveys indicate less than 10-year protection is being achieved.
	The District will create alcoves near the low-flow channel; there will be no instream work where water is present; ongoing sediment removal will be discrete, short segments; newly formed habitat features will remain undisturbed if they become present in sediment management areas.	Alcoves will be created; ongoing sediment removal will have a maximum of 20% of channel length in the action area in 2-year period; the yearly maximum linear feet of disturbance during ongoing sediment removal is 2,740 feet; there will be a maximum of 500 feet for each project site with a no-disturbance buffer of 500 feet.
	Patchwork to repair portions of levees to reinstate up to the existing grade of other properly functioning portions of the levee system (repair is needed due to damage from vehicular and horse traffic, along with natural elements/weather, have eroded the earthen levees); repairs will include adding six inches to one foot of material in designated areas along the levees (approximately 18,000 cubic yards of fill material).	No new language needed; clarification only within the description of the proposed action per the biological opinion
	A wider buffer will be implemented based on the District-conducted comparison study of buffers upstream of the action area.	Composite roughness value will be 0.046 in the action area.
	The District will implement a response plan if log structures are not functioning as intended.	36 large-wood structures; annual photo monitoring will occur at all structures; response plan to restore intended function of logs
	The HMMP was updated as of July 10, 2017, to reflect changes under the RPA	Protection measures as in WMP per BA Feb. 2015; performance measures per HMMP July 2017
	The District provided clarification that the 25% represents the anticipated range of sediment accumulation based on natural variability; the 25% is not an absolute reduction of total lagoon volume; the District will use the six-year moving average of measured conditions to observe trends; the proposed action is anticipated to avoid a (+) trend toward lagoon filling beyond range of 25% variability	No new language needed; clarification only within the description of the proposed action per the biological opinion

(new element as of 4/3/17)	Meadow Creek Lagoon Watershed Plan	Levee removal, setback, or modification to gain minimum restored area of 8.28 acres; hydraulics study, alternatives analysis, stakeholder engagement; final certified EIR
(new element as of 5/15/17)	Intent to apply for grant funding (Grant Opportunities document)	Assume grant application will be submitted by District as early as possible given criteria of each particular grant program
(new element as of 5/15/17)	Sediment-source Reduction Strategies (see Removal Guidelines document)	Not included in RPA due to low likelihood of implementation based on expected outcomes of other RPA elements
(new element as of 5/15/17)	Lagoon dredging to reset lagoon to pre-project conditions	Not included in RPA due to low likelihood of implementation based on expected outcomes of other RPA elements