United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Suite W-2605
Sacramento, California 95825-1846

In Reply Refer to:
08ESMF00-
2013-CPA-0020

OCT - 5 2015

Alicia E. Kirchner
Chief, Planning Division
Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California 95814-2922

Dear Ms. Kirchner:

The U.S. Army Corps of Engineers' (Corps) has requested coordination under the Fish and Wildlife Coordination Act (FWCA) for the American River Common Features General Re-evaluation Report (GRR) project. The proposed flood risk management construction would occur along the lower American River and the Sacramento River in Sacramento County, California. The enclosed report constitutes the U.S. Fish and Wildlife Service's draft FWCA report for the proposed project. A draft FWCA report was provided to the Corps and other state and federal resource agencies on September 20, 2013. We did not receive any comments on the draft FWCA report.

If you have any questions regarding this report on the proposed project, please contact Jennifer Hobbs, Fish and Wildlife Biologist, at (916) 414-6541.

Sincerely,

for Jennifer M. Norris
Field Supervisor

Enclosure:

cc:
Anne Baker, COE, Sacramento, CA
Amy Kennedy, CDFW, Rancho Cordova, CA
Howard Brown, NOAA Fisheries, Sacramento, CA
Steve Schoenberg, Bay Delta Fish and Wildlife Office, Sacramento, CA

FISH AND WILDLIFE COORDINATION ACT REPORT
AMERICAN RIVER COMMON FEATURES
GENERAL RE-EVALUATION REPORT PROJECT

OCTOBER 2015

BACKGROUND

In February 1986, major storms in northern California caused record flows along the American River. Water releases from Folsom Reservoir into the American River, in combination with high flows on the Sacramento River, almost caused catastrophic flooding to the city of Sacramento and surrounding areas. The result of the February 1986 storms raised concerns over the adequacy of the existing flood control system, which led to a series of investigations to provide additional flood protection to the Sacramento area.

The U.S. Army Corps of Engineers (Corps) completed an initial feasibility study in December 1991 for the American River and Natomas Basin areas. The feasibility report recommended the construction of a concrete gravity flood detention dam just downstream of the confluence of the North and Middle Forks of the American River, and for levee improvements downstream of Folsom Dam. Due to environmental and cost concerns, Congress chose not to authorize the proposed detention dam and instead directed the Corps to supplement the analysis of flood control options considered in the 1991 study.

A supplemental study was completed and presented in the *Supplemental Information Report American River Watershed Project, California*, dated March 1996. The report presented three possible flood control plans: (1) the construction of the concrete gravity flood detention dam recommended in the 1991 report; (2) Folsom Dam improvements; and (3) a stepped release plan for Folsom Dam releases. The report also concluded that levee improvements downstream of Folsom Dam were needed and that these levee improvements were "common" to all three plans. Under the Water Resources Development Act of 1996 (WRDA 96), Congress authorized the American River Common Features Project (Common Features Project), which included levee modifications on both banks of the American River, levee modifications along the east bank of the Sacramento River downstream from the Natomas Cross Canal, installation of streamflow gauges upstream from Folsom Reservoir, modification of the flood warning system along the lower American River, and continued interim reoperation of Folsom Reservoir for flood control.

In 1999, Congress decided to authorize improvements to Folsom Dam to control a 200-year flood event with a peak release of 160,000 cubic feet per second (cfs) from the dam. By doing this, improvements to levees downstream of Folsom Dam could be fine-tuned to work closely with the Folsom Dam improvements being discussed by Congress. Subsequently, the Common Features Project was modified by the Water Resources Development Act of 1999 (WRDA 99) to include additional features so the American River could safely convey an emergency release of 160,000 cfs. Also authorized under WRDA 99 was the Folsom Dam Modification project, which would allow for larger releases from Folsom Dam earlier in a flood event. At the same time, Congress also directed the Corps to review additional modifications to the flood storage of Folsom Dam to maximize the use of the dam for flood damage reduction prior to consideration of any additional storage on the American River. The Folsom Dam Raise project was subsequently authorized by Congress in 2004.

Major construction components for the Common Features Project under the WRDA 96 authorization include construction of seepage remediation along about 22 miles of the American River levees. Under the WRDA 99 authorization, the major construction components include construction of seepage remediation and levee raises along four stretches of the American River. All Common Features Project features authorized under WRDA 96 and WRDA 99 have been constructed or are in design analysis for construction, and the U.S. Fish and Wildlife Service (Service) has previously coordinated with the Corps on the various aspects of the Common Features Project.

Deep under-seepage became a significant concern along the American River levees following a flood event in 1997. Since the levee improvements along the American River were still in the design phase, remediation of deep under-seepage needed to be included in the design plans. This additional effort led to considerable cost increases over what was originally authorized by Congress for the Common Features Project, including the WRDA 99 improvements that had already increased the cost of the original WRDA 96 authorization.

The Folsom Dam Post Authorization Change Report and the Economic Re-evaluation Report for Folsom Dam Improvements revealed that additional levee improvements were needed on the American and Sacramento Rivers in order to truly capture the benefits of the Folsom Dam projects. These levee deficiencies consisted primarily of erosion concerns on the American River, and seepage, stability, erosion, and height deficiencies on the Sacramento River downstream of its confluence with the American River. However, the full extent of these levee deficiencies was not known and additional re-evaluation studies were needed for the flood basins that comprise the city of Sacramento.

The purpose of the Common Features Project is to reduce the flood risk for the city of Sacramento. The following problems were identified within the Sacramento levee system:

- seepage and underseepage;
- levee erosion;
- levee stability;
- levee overtopping;
- access for maintenance and flood fighting;
- vegetation and encroachments;
- releases from Folsom Dam;
- floodplain management; and
- additional upstream storage from existing reservoirs.

DESCRIPTION OF PROJECT AREA

The project area is located along the Sacramento and American River watersheds. The Sacramento River watershed covers 26,000 square miles in central and northern California. Major tributaries of the Sacramento River include the Feather, Yuba, and American Rivers. The American River watershed covers about 2,100 square miles northeast of Sacramento and includes portions of Placer, El Dorado, Alpine, and Sacramento counties. The American River watershed includes Folsom Dam and Folsom Reservoir; inflowing rivers and streams, including the North, South and Middle forks of the American River; and the American River downstream to its confluence with the Sacramento

River in the city of Sacramento. The Sacramento and American rivers form a floodplain covering roughly 110,000 acres at their confluence. This floodplain includes most of the developed portions of the city of Sacramento.

The American River Common Features GRR study area includes: about 12 miles of the north and south banks of the American River immediately upstream of its confluence with the Sacramento River; the east bank of the Natomas East Main Drainage Canal (NEMDC), Dry Creek, Robla Creek, Arcade Creek, and the Magpie Creek Diversion Channel (collectively referred to as the East Side Tributaries); the east bank of the Sacramento River downstream from the American River to the town of Freeport, where the levee ties into the Beach Lake levee; and the Sacramento Weir and Bypass, which is located along the north edge of the city of West Sacramento.

Within the greater project area, there are four distinct flood basins: the American River North Basin, the American River South Basin, the Sacramento Bypass and the Natomas Basin. These basins are described in further detail below.

The American River North Basin is located north of the American River and east of the city of Natomas, and includes the North Sacramento and Arden Arcade communities. Project construction in this basin includes the levees on the north bank of the American River, levees on the east bank of NEMDC, and levees along Arcade Creek, Dry/Robla Creek, and the Magpie Creek Diversion Channel.

The American River South Basin is located south of the American River and east of the Sacramento River. Communities protected by these project levees include Downtown Sacramento, Land Park, Pocket-Meadowview, East Sacramento, South Sacramento and Rancho Cordova. Project construction in this basin would be limited to the south bank of the American River and the east bank of the Sacramento River.

The Sacramento Bypass is located in Yolo County, about 4 miles west of the city of Sacramento and along the northern edge of the city of West Sacramento. The Sacramento Weir runs along the west bank of the Sacramento River and connects the river to the Bypass. The Bypass is located in a rural area owned by the State of California and operated as the Sacramento Bypass Wildlife Area.

The Natomas Basin is located in the northern portion of the study area and is located east of the Sacramento River, west of NEMDC, and north of the American River. The Natomas Basin is considered to be a part of the study area, as described by the GRR; however, the proposed measures to raise the height of the Natomas Basin levees were previously analyzed in the Natomas Levee Improvement Program, Phase 4b Landside Improvements Project (NLIP Phase 4b Project) in 2010. Therefore, the Natomas Basin will not be analyzed in this document.

PROJECT DESCRIPTION

The purpose of the Common Features GRR is to determine if there is a Federal interest in modifying the authorized Common Features Project for flood risk management in the greater Sacramento area. National Environmental Policy Act (NEPA) evaluation is required when a major Federal action is under consideration and may have impacts on the quality of the natural and human environment. The Corps has determined that the proposed project may have significant effects on the environment and therefore, an EIS is required.

The Common Features GRR has identified a number of problems associated with the flood risk management system protecting the city of Sacramento and surrounding areas. There is a high probability that flows in the American and Sacramento Rivers would stress the network of levees protecting Sacramento to the point that levees could fail. The consequences of such a levee failure would be catastrophic since the area inundated by flood water is highly urbanized and the flooding could be up to 20 feet deep.

A wide variety of management measures were developed and then evaluated and screened to address the planning objectives to remedy the Sacramento area levee problems. Formulation strategies were then developed to address various combinations of the planning objectives and planning constraints. The formulation strategies used to address the objectives and constraints included measures to reduce flood stages, address seepage and underseepage, address stability, address erosion, address maintenance/emergency response access, and achieve the urban levee level of protection. Based upon these strategies, various combinations of the measures were assembled to form an array of preliminary plans. The preliminary plans were then evaluated, screened, and reformulated, resulting in a final array of alternatives. From this final array of alternatives, a tentatively selected plan was identified.

<u>No Action Alternative</u>

The Corps is required to consider a No Action Alternative as one of the alternatives for selection in order to comply with the requirements of NEPA. With the No Action Alternative, it is assumed that no additional features would be implemented by the Corps or by local interests to achieve the planning objectives over and above those elements of the previously authorized Common Features Project.

Under the No Action Alternative the Corps would not conduct any additional work to address seepage, slope stability, overtopping, or erosion concerns in the Sacramento metropolitan area. As a result, if a high flow event were to occur, the Sacramento area would remain at risk of a possible levee failure.

The urban development within the project area would continue to be at risk of flooding and lives would continue to be threatened. The levees within the study area could fail and result in a catastrophic disaster. If a levee failure were to occur, major government facilities would be impacted until the flood waters recede. Within the study area are many transportation corridors that could be flooded as well if the levees were to fail.

<u>Alternative 1: Fix Levees in Place</u>

Alternative 1 involves the construction of fix-in-place levee remediation measures to address seepage, stability, erosion, and overtopping concerns identified for the American and Sacramento river levees, and the East Side Tributaries. In addition, Alternative 1 would include levee raises for the Natomas Basin, which were analyzed under NEPA in the NLIP Phase 4b Project EIS/EIR in 2010. As a result, this FWCA report incorporates the analysis of the levee raise by reference, but is not discussed within this report.

Due to the urban nature and proximity of existing development within the American River North and South Basins, Alternative 1 proposes fix in place remediation. The purpose of this alternative would be to improve the flood damage reduction system to safely convey flows to a level that

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Alternative 1 involves the construction of fix-in-place levee remediation measures to address seepage, stability, erosion, and overtopping concerns identified for the American and Sacramento river levees, and the East Side Tributaries. In addition, Alternative 1 would include levee raises for the Natomas Basin, which were analyzed under NEPA in the NLIP Phase 4b Project EIS/EIR in 2010. As a result, this FWCA report incorporates the analysis of the levee raise by reference, but is not discussed within this report.

Due to the urban nature and proximity of existing development within the American River North and South Basins, Alternative 1 proposes fix in place remediation. The purpose of this alternative would be to improve the flood damage reduction system to safely convey flows to a level that maximizes net benefits. Table 1 summarizes the levee problems discussed above and the proposed remediation measure for each waterway.

Table 1. Alternative 1 Proposed Levee Improvement Measures by Waterway

Waterway	Seepage Measures	Stability Measures	Erosion Protection Measures	Overtopping Measures
American River[1]	–	–	Bank Protection, Launchable Rock Trench	–
Sacramento River	Cutoff Wall	Cutoff Wall	Bank Protection, Launchable Rock Trench	Levee Raise
NEMDC	Cutoff Wall	Cutoff Wall	–	Floodwall
Arcade Creek	Cutoff Wall	Cutoff Wall	–	Floodwall
Dry and Robla Creeks	–	–	–	Floodwall
Magpie Creek	–	–	–	Floodwall

In addition to the proposed levee improvement measures shown in Table 1, the following measures and policies would be addressed during construction.

- The Corps' standard levee footprint would be established during construction of structural improvements on all levees that are out of compliance. The standard levee footprint consists of a 20 foot crown width, a 3H:1V waterside slope, and a 2H:1V landside slope, when possible. If the 3H:1V waterside slope is not possible, than a minimum 2H:1V waterside slope would be established instead.

- A 10 foot landside maintenance access would be established, when possible.

- Compliance with Corps levee vegetation requirements would be established. The vegetation requirements include a 15 foot waterside, landside and vertical vegetation-free zone. When possible, a variance would be sought to allow vegetation to remain. If granted, the variance would allow for vegetation to remain on the lower waterside slope and within the waterside 15 foot vegetation-free zone. No vegetation would be permitted on the landside slope.
    - A vegetation variance would be requested to provide compliance for the Sacramento River portion of this project.
    - The erosion measures on the American River is not considered a structural fix, as these measures do not impact the structure of the levee, therefore the vegetation in this portion of the project would not be addressed under the Common Features GRR project. American River vegetation compliance would occur under a System-

1 Seepage, stability, and overtopping measures were addressed in the American River Common Features WRDA 96 and WRDA 99 construction projects.

Wide Improvement Framework by the local sponsors.

- The East Side Tributaries would be brought into vegetation compliance during construction in those levee reaches.

- Utility encroachments would be brought into compliance with Corps policy. Utilities that penetrate the levee would be removed and replaced with one of two fixes: a surface line over the levee prism or a through-levee line equipped with positive closure devices.

- Private encroachments would be removed by the non-Federal local sponsor or property owner prior to construction.

There would be no proposed measures under Alternative 1 for the Sacramento Bypass. The following sections contain more detailed information on the specific measures proposed by waterway under Alternative 1.

American River

Levees along the American River under Alternative 1 require improvements to address erosion. The proposed measures for these levees consist of waterside armoring to prevent erosion to the river bank and levee, which could potentially undermine the levee foundation. There are two measures proposed to address erosion on the American River levees: bank protection and a launchablc rock trench. Both of these measures are described in detail in the subsections below. These measures would be implemented for all of the proposed alternatives discussed in this document.

Bank Protection

This measure consists of placing rock protection on the river's bank, and in some locations, on the levee slope to prevent erosion. The location of rock placement would be based on site-specific analysis. When necessary, the eroded portion of the bank would be filled and compacted prior to the rock placement. The sites would be prepared by clearing and stripping the site prior to construction. Small vegetation and deleterious materials would be removed. In most cases large vegetation would be permitted to remain at these sites. Temporary access ramps would be constructed, if needed, using imported borrow material that would be trucked to the site.

Revetment would be imported from an offsite location via haul trucks and temporarily stored at a staging area located in the immediate vicinity of the construction site. A loader would be used to move revetment from the staging area to the excavator that would be placing material. The revetment would be placed at a slope varying from 2V:1H to 3V:1H, depending on the site specific conditions. A large rock berm would be placed in the water up to an elevation slightly above the mean summer water surface and a planting trench would be established on the rock berm surface for re-vegetation purposes. An excavator would either be working from the top of bank placing revetment on the bank and in the water, or from on top of the rock berm that is established.

Launchable Rock Trench

The launchable rock filled trench is designed to deploy once erosion has removed the bank material beneath it. All launchable rock trenches would be constructed outside of the natural river channel. The vegetation would be removed from the footprint of the trench and the levee slope prior to excavation. The trench configuration would include a 2H:1V landslide slope and a 1H:1V waterside slope, and would be excavated at the toe of the existing levee. All soil removed during trench excavation would be stockpiled for reuse or disposed of. The bottom of the trench would be constructed close to the summer mean water surface elevation in order to reduce the rock launching distance and the amount of rock required.

After excavation, the trench would be filled with revetment that would be imported from an off-site location via haul trucks. After rock placement, the trench would be covered with a minimum of 3 feet of stockpiled soil for a planting berm. Rock placed on the levee slope would be covered with 2 feet of stockpiled soil. All disturbed areas would be reseeded with native grasses and small shrubs where appropriate. Trees would be permitted on the berm if planted outside the specified vegetation free zone.

Sacramento River

Levees along the Sacramento River require improvements to address seepage, stability, and erosion. In addition, these levees require height improvements in order to convey additional flows that exceed the current design levels. To provide access for levee construction, inspection, maintenance, monitoring, and flood-fighting, some properties would need to be acquired.

Where the existing levee does not meet the levee design requirements, slope flattening, crown widening, and/or a levee raise is required. This improvement measure addresses problems with slope stability, geometry, overtopping, and levee access. To begin levee embankment grading, the area would be cleared, grubbed, stripped, and where necessary, portions of the existing embankment would be excavated to allow for bench cuts and keyways to tie in additional embankment fill. Excavated and borrow material from nearby borrow sites would be stockpiled at staging areas. Haul trucks and front end loaders would bring borrow materials to the site, which would then be spread evenly and compacted according to levee design plans.

The existing levee centerline would be shifted landward, where necessary, in order to meet the Corps' current levee footprint requirements; or, in order to construct the levee to the existing footprint, a retaining wall may be constructed at the landside levee toe. This measure would raise the levee landward of the existing levee without reducing the levee crown width or disturbing the waterside slope. Retaining walls would range from 4 to 6 feet high and would require landside slope benching to establish the additional fill into the levee section. The levee crown patrol road would be re-established and a new road at the levee toe would be added 10 feet landward of the retaining wall.

Cutoff Walls

To address seepage concerns, a cutoff wall would be constructed through the levee crown. The cutoff wall would be installed by one of two methods: conventional open trench cutoff walls or deep soil mixing (DSM) cutoff walls. The method of cutoff wall selected for each reach would depend on the depth of the cutoff wall needed to address seepage. The open trench method can be used to install a cutoff wall to a depth of about 85 feet. For cutoff walls of greater depth, the DSM method would be utilized.

Prior to construction of the cutoff wall, the construction site and staging areas would be cleared, grubbed, and stripped. The levee crown would be degraded to about half of the levee height to create a large enough working platform (about 30 feet) and to reduce the risk of hydraulically fracturing the levee embankment from the insertion of slurry fluids.

Open Trench Cutoff Walls

Under the open trench method, a trench 3 feet wide would be excavated at the top of levee centerline and into the subsurface materials up to 85 feet deep with a long boom excavator. As the trench is excavated, it is filled with low density temporary bentonite water slurry to prevent cave in. The soil from the excavated trench is mixed nearby with hydrated bentonite, and in some applications cement. The soil bentonite mixture is backfilled into the trench, displacing the temporary slurry. Once the slurry has hardened, it would be capped and the levee embankment would be reconstructed with impervious or semi-impervious soil.

DSM Cutoff Wall

The DSM method involves the use of a crane that supports a set of two to four mixing augers used to drill through the levee crown and subsurface to a maximum depth of about 140 feet. As the augers are inserted and withdrawn, a cement bentonite grout would be injected through the augers and mixed with native soils. An overlapping series of mixed columns would be drilled to create a continuous seepage cutoff barrier. Once the slurry has hardened, it would be capped and the levee embankment would be reconstructed with impervious or semi-impervious soil.

Bank Protection

Bank protection on the Sacramento River would be addressed by construction of the launchable rock trench method described for the American River above, or by standard bank protection, which consists of placing rock protection on the bank to prevent erosion. This measure entails filling the eroded portion of the bank, when necessary, and installing revetment along the waterside levee slope and streambank, from the streambed to a height determined by site-specific analysis. The sites would be prepared by removing vegetation along the levee slopes at either end of the site for construction of a temporary access ramp if needed. The ramp would then be constructed using imported borrow material that would be trucked onsite.

The placement of rock onto the levee slope would occur from atop the levee and/or from the waterside by means of barges. Rock required within the channel, both below and slightly above the water line at the time of placement, would be placed by an excavator located on a barge. Construction would require two barges: one barge would carry the excavator, while the other barge would hold the stockpile of rock to be placed on the channel slopes. Rock required on the upper portions of the slopes would be placed by an excavator located on top of the levee. Rock placement from atop the levee would require one excavator and one loader for each potential placement site. The loader brings the rock from a permitted source and stockpiles it near the levee in the construction area. The excavator then moves the rock from the stockpile to the waterside of the levee.

The revetment would be placed via the methods discussed above on existing banks at a slope varying from 2V:1H to 3V:1H, depending on site specific conditions. After revetment placement has been completed, a small planting berm would be constructed in the rock, when feasible, to allow for some re-vegetation of the site.

NEMDC

The east levee of the NEMDC requires improvements to address seepage and stability at locations where historic creeks had intersected the current levee alignment. A conventional open trench cutoff wall would be constructed at these locations to address these problems. The open trench cutoff walls would be constructed as described for the Sacramento River levee described above.

The NEMDC east levee also has height issues which would be addressed by construction of a floodwall. The floodwall would be placed at the waterside hinge point of the levee and would be designed to disturb a minimal amount of waterside slope and levee crown construction. The heights of the floodwalls vary from 1 to 4 feet, as required by water surface elevations. Constructing the floodwall raise would require doweling into the existing concrete floodwall and adding reinforced concrete to the floodwall section. The waterside slope would be re-established to its existing slope and the levee crown would grade away from the wall and be surfaced with aggregate base.

Arcade Creek

The Arcade Creek levees require improvements to address seepage, slope stability, and overtopping when the flood event exceeds the current design. A cutoff wall would also be constructed to address seepage for portions of the creek. There is a ditch adjacent to the north levee at the landside toe which provides a shortened seepage path and could affect the stability of the levee. The ditch would be replaced with a conduit or box culvert and then backfilled. This would lengthen the seepage path and improve the stability of the levee.

The majority of the levees on Arcade Creek have existing floodwalls; however, there remains a height issue in this reach. A 1 to 4 foot floodwall raise would allow the levees to pass flood events greater than the current design level. Construction of the floodwall would be consistent with the description for NEMDC above.

Dry and Robla Creeks

The Dry Creek and Robla Creek levees require improvements to address overtopping for when flood events exceed the design level. Height improvements would be made with a floodwall raise. The floodwall would be placed at the waterside hinge point of the levee and would be designed to disturb a minimal amount of waterside slope and levee crown construction. The height of the floodwalls would vary from 1 to 4 feet as required by water surface elevations. Construction of the floodwall would be consistent with the description for NEMDC above. The waterside slope would be re-established to its existing slope and the levee crown would be graded away from the wall and be surfaced with aggregate base.

Magpie Creek Diversion Channel

A number of features are proposed for the Magpie Creek Diversion Channel under Alternative 1. These features include the following:

- Strengthening the existing project levee;
- Construction of a 3 to 4 foot tall floodwall along the top of the existing levee for a distance of about 2,100 feet. Construction of the floodwall would be consistent with the description for NEMDC above;
- Construction of a new 1,000-foot-long levee along Raley Boulevard, south of the Magpie Creek bridge;
- Construction of a 79 acre flood detention basin on both sides of Raley Boulevard, primarily through the purchase of properties to preserve the existing floodplain; and
- Raley Boulevard improvements, including widening the Magpie Creek Bridge, raising the elevation of the roadway, and removing the Don Julio Creek culvert.

Alternative 2: Fix Levees in Place and Widen the Sacramento Weir and Bypass

Alternative 2 would include all of the levee improvements discussed in Alternative 1 above, except for the levee raises along the Sacramento River. Instead of the levee raises, the Sacramento Weir and Bypass would be widened to divert more flows into the Yolo Bypass. The levees along the American River, NEMDC, Arcade Creek, Dry Creek, Robla Creek, and the Magpie Creek Diversion Channel would be improved to address identified seepage, stability, erosion, and height concerns through methods described under Alternative 1 above. The levees along the Sacramento River would be improved to address identified seepage, stability, and erosion concerns through the measures described under Alternative 1 above. Due to the urban nature of the project area and proximity of development to the levees, the majority of the levee repairs would be fixed in place.

In addition, Alternative 2 would include levee raises for the Natomas Basin. The Natomas Basin levee raises are proposed under the Common Features Project GRR for authorization; however, these measures were analyzed under NEPA for the NLIP Phase 4b Project EIS/EIR in 2010.

The following sections contain more detailed information on the specific features and reaches included in this alternative. Table 2 summarizes the levee problems discussed above and the proposed measure for each waterway.

Table 2. Alternative 2 Proposed Remediation Measures by Waterway

Waterway	Seepage Measures	Stability Measures	Erosion Protection Measures	Overtopping Measures
American River[2]	–	–	Bank Protection, Launchable Rock Trench	–
Sacramento River	Cutoff Wall	Cutoff Wall	Bank Protection, Launchable Rock Trench	Sacramento Bypass and Weir Widening
NEMDC	Cutoff Wall	Cutoff Wall	–	Floodwall
Arcade Creek	Cutoff Wall	Cutoff Wall	–	Floodwall
Dry and Robla Creeks	–	–	–	Floodwall
Magpie Creek	–	–	–	Floodwall, Levee Raise

Sacramento Weir and Bypass

The existing Sacramento Weir and Bypass, which allow high flows in the Sacramento River to be diverted into the Yolo Bypass, would be expanded to roughly twice the current width to accommodate increased bypass flows. The existing north levee of the Sacramento Bypass would be degraded and a new levee would be constructed about 1,500 feet to the north. The existing Sacramento Weir would be expanded to match the wider bypass. The new north levee of the bypass would include a 300-foot-wide seepage berm on the landside, with a system of relief wells. An existing high tide relief well site near the existing north levee would be remediated by the non-Federal sponsor prior to construction.

American River

Measures for the American River levees under Alternative 2 would address erosion. These measures were identified and described under Alternative 1 and would also be included in Alternative 2. Implementation of these measures under Alternative 2 would be consistent with the description in Alternative 1.

East Side Tributaries

Measures for NEMDC, Arcade Creek, Dry Creek, Robla Creek, and the Magpie Creek Diversion Channel under Alternative 2 would address seepage, slope stability, and erosion control. These measures were identified and described in Alternative 1 and would also be included in Alternative 2. Implementation of these measures under Alternative 2 would be consistent with the description in Alternative 1.

2 Seepage, stability, and overtopping measures were addressed in the American River Common Features WRDA 96 and WRDA 99 construction projects.

Sacramento River

The measures for the Sacramento River levees under Alternative 2 would be consistent with Alternative 1, with one exception. Under Alternative 1, Sacramento River levee remediation measures were proposed to address seepage, stability, erosion control, and levee height problems. Under Alternative 2, there would be no need to address the levee height problems. Therefore, the measures from Alternative 1 that would be implemented under Alternative 2 for the Sacramento River levees would include: (1) installation of cutoff walls to address seepage concerns; (2) slope reshaping to address stability concerns; and (3) bank protection or launchable rock trench measures to address erosion. The description of these measures can be found above under Alternative 1 for the Sacramento River.

BIOLOGICAL RESOURCES

American River

The American River Parkway (Parkway) contains many vegetation types including riparian scrub, riparian forest, oak woodland, open water, grasslands, and some agriculture. Along the river channel, vegetation is primarily considered shaded riverine aquatic (SRA) cover. Trees adjacent to the channel are mainly oaks and cottonwoods with a thick understory of vines, shrubs, and herbaceous vegetation.

The levee slopes along the American River are primarily covered with grasses and a few scattered trees within the levee structure. Several areas within the Parkway have been used as mitigation sites for the Corps and other agency projects for valley elderberry longhorn beetle. There are also some areas within the Parkway that have been used to compensate for loss of riparian habitat or oak woodlands from projects. Vegetation on the landside of the levee is mostly non-native ornamentals and landscape plantings that were planted beyond the legal property and fence lines of residents.

Habitats in the project area around the American River support various wildlife species. Mammal species include mule deer, coyote, black-tailed jackrabbit, striped skunk, and a variety of rodents. Common bird species include American robin, spotted towhee, dark-eyed junco, black phoebe, California towhee, ash-throated flycatcher, northern flicker, mourning dove, California quail, house finch, American and lesser goldfinches, Bewick's and house wrens, northern mockingbird, yellow-billed magpie, red-winged and Brewer's blackbirds, oak titmouse, and Anna's hummingbird. Common raptors include red-tailed hawk, Cooper's hawk, red-shouldered hawk, American kestrel, and great horned owl. Reptile and amphibian species found within the project area include western fence lizard, gopher snake, western rattlesnake, common kingsnake, Pacific treefrog, and western toad.

The river and small backwater areas provide habitat for many water associated species such as raccoon, beaver, Canada goose, wood duck, common merganser, mallard, black phoebe, great blue heron, belted kingfisher, and common yellowthroat. The levee slopes, which are dominated by annual grassland, provide foraging habitat and cover for California ground squirrel, pocket gopher, and western meadowlark.

The lower American River supports a diverse and abundant fish community; altogether, at least 41 species of fish are known to inhabit the river (USFWS 1986). In recognition of its "outstanding and remarkable" fishery resources, the entire lower American River was included in the Wild and Scenic Rivers System in 1981, which provides some protection for these resources (USFWS 1991). Four anadromous species are important from a commercial and recreational perspective. The lower river supports a large run of fall-run Chinook salmon, a species with both commercial and recreational values. The salmon run is sustained by natural reproduction in the river, and by hatchery production at the Nimbus Salmon and Steelhead Hatchery, operated by the California Department of Fish and Wildlife (CDFW). The average annual production of fall-run Chinook salmon in the American River from 1992-2009 is 109,574 (USFWS 2013).

Steelhead, a popular sport fish, are largely sustained in the river by production from the Nimbus Hatchery, because summer water temperatures often exceed the tolerances of juvenile steelhead, which typically spend about 1 year in the river. American shad and striped bass enter the river to spawn; these two species, introduced into the Sacramento River system in the late 1800s, now support popular sport fisheries. In addition to species of economic interest, the lower American River supports many nongame species, including Sacramento pikeminnow, Sacramento sucker, tule perch, and hardhead (USFWS 1994).

NEMDC

This canal is a narrow channel with many trees in the lower portion. As the canal heads north the channel widens and has less woody vegetation. The levee slopes on the east side of the canal are clear of vegetation due to maintenance practices. The west side of this canal is not part of this project as it is part of the NLIP Phase 4b Project.

Arcade Creek

The levees along Arcade Creek are maintained vegetation free; however, the channel does have some trees and understory. Between Norwood Avenue and Rio Linda Boulevard the channel contains a thick riparian area but vegetation becomes sparse once it passes Rio Linda Boulevard. Due to the urban conditions in this area, wildlife is limited to those similar to the Parkway but in smaller numbers.

Dry and Robla Creeks

The Dry and Robla Creeks area is a wide open space floodplain, with both creeks being contained between the two levees. The creeks maintain sufficient water throughout the year for trees to survive along the channel. There are scattered wetlands located in the floodplain with a higher concentration at the confluence with the NEMDC. The actual levee slopes in this floodplain contain very little vegetation due to maintenance practices. Wildlife in the floodplain is similar to that in the Parkway.

Magpie Creek Diversion Channel

The project area of Magpie Creek Diversion Channel begins in an industrial area where the channel contains primary grasses. Upstream, the area becomes open space before it intersects with Raley Boulevard and additional industrial development. Seasonal wetlands in the area include natural vernal pools and other areas with standing water that provide a similar biological function as natural vernal pools. Wildlife in this area includes jack rabbits, skunks, beavers, and coyotes that also use the surrounding undeveloped area. Avian species that utilize this habitat include herons and waterfowl. Amphibian and reptile species include treefrog and common garter snake.

Sacramento River

Vegetation along the Sacramento River is mostly SRA cover consisting of oaks and cottonwoods with shrub understory. There are intermittent locations along the waterline with no trees due to revetment. The Sacramento River Bank Protection Project has repaired some erosion sites along this section of the river using rock revetment on the slope and creating small vegetated benches. These sites have been planted with riparian vegetation and woody material has been placed in the rock to provide in water habitat for fish species.

Due to the urban development adjacent to the levees in this area, wildlife is limited to small mammals and various avian species. Domestic animals from residents are also often seen along the levees in this basin of the project. Though a narrow riparian corridor, this area does function as a migratory corridor for wildlife as the area to the east is completely developed with housing. It is important to maintain a corridor to provide connectivity along the Sacramento River.

The Sacramento River contains a variety of habitat characteristics that are important to many fish species. Streamside vegetation provides SRA cover and aids in temperature control, streambank stability, and habitat complexity. Cover is used by all life stages of anadromous fish for shelter and provides habitat for salmonids, Sacramento splittail, delta smelt, black bass and sunfish.

Root structures of riparian vegetation can provide bank stability and shelter for juvenile fish. Woody debris can provide shelter from predation and refugia from stream flow. Riparian vegetation also influences the food chain of a stream, providing organic detritus and terrestrial insects. Terrestrial organisms falling from overhanging branches contribute to the food base of the aquatic community. Salmonids in particular are primarily insectivores and feed mainly on drifting food organisms.

In general, the Sacramento River channel provides a migratory pathway to many anadromous fish and provides seasonal rearing habitat to many other native fish species. Native anadromous fish species include Chinook salmon, green and white sturgeon, Pacific and river lamprey, and steelhead. Native resident fish species include delta smelt, hardhead, hitch, prickly sculpin, Sacramento blackfish, Sacramento pikeminnow, Sacramento splittail, Sacramento sucker, threespine stickleback and tule perch. Non-native anadromous species, such as American shad and striped bass, provide recreational sport fishing opportunities. Non-native resident fish species include several species of catfish, black bass, sunfish and minnows. Some non-native species may provide recreational fishing opportunities, such as largemouth, smallmouth, and striped bass, yet these species also prey upon native juvenile species that use nearshore habitats.

Sacramento Bypass and Weir

The Sacramento Bypass is a 360 acre area that is an important cover and feeding area for wildlife during the late fall, winter and early spring. Vegetation varies from scattered trees, such as mature cottonwoods, willows and valley oaks, to a sparsely covered sand soil area on the eastern end. There are also wetlands within the bypass. Game birds, raptors, songbirds, and native mammals are all present in this area.

The footprint of the expanded weir contains 8 acres of scattered trees along the road, railroad tracks, and levee slope. Primary wildlife use this area is avian species, beavers, skunks, and rabbits. The trees along the river provide shade for many native and non-native species. These trees are also used by various avian species for nesting.

Threatened and Endangered Species

Potentially affected federally-listed species within the project area include the valley elderberry longhorn beetle, giant garter snake, delta smelt, Central Valley steelhead, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and green sturgeon. The valley elderberry longhorn beetle, giant garter snake, delta smelt, yellow-billed cuckoo, and least Bell's vireo fall under the jurisdiction of the Service. The National Marine Fisheries Service (NMFS) is responsible for the listed salmonids and green sturgeon.

The riverbank and associated nearshore aquatic area that would be affected by the proposed action constitute portions of the designated critical habitat of the delta smelt. Indirect effects of the proposed action may also extend to other portions of this critical habitat. The Corps completed section 7 consultation with the Service. The consultation is included as Appendix 1.

In addition, the bank protection action area constitutes elements of essential fish habitat (EFH). EFH is the aquatic habitat (water and substrate) necessary to fish for spawning, breeding, feeding and or growth to maturity that will allow a level of production needed to support a long-term, sustainable commercial fishery and contribute to a health ecosystem. Consultation with NMFS regarding EFH is required for all commercially-harvested runs of salmon, including all runs of salmon in the project's action area.

Future Conditions Without the Project (No Action Alternative)

<u>American River</u>

Under the No Action Alternative, the Corps would not participate in construction of the proposed project. There would be no construction related effects to the vegetation and wildlife. However, looking over the past several decades the largest and most frequent flows come down the American River system, some of the floodplain in the Parkway has eroded away. During the 50 year life span of the project it is expected that larger flows would be released from Folsom Dam and sustained for longer periods, leading to potential loss of floodplain and the vegetation on it within the Parkway. While erosion and accretion within the riverine system is a normal and healthy process, Folsom Dam has cutoff sediment supply to the lower American River which creates a sediment starved section of the river. Sediment starvation means that accretion would not occur and the loss of floodplain and its ability to support habitat would be lost. This loss would also cause any wildlife in the area to relocate to other areas where the habitat they need is present. Because we cannot predict when and how large events would occur, it is not possible to determine when the floodplain would erode. The loss of the Parkway vegetation and wildlife habitat would be considered a significant impact.

East Side Tributaries

Under the No Action Alternative, the Corps would not participate in construction of the proposed project. There would be no construction related effects to the vegetation and wildlife. The riparian habitat on Arcade Creek between Norwood Avenue and Rio Linda Boulevard would remain. The other creeks do not contain much vegetation; however, the little vegetation that does exist would not be removed. Wildlife in these creek areas would not be disturbed due to construction activities.

Sacramento River

Under the No Action Alternative, the Corps would not participate in construction of the proposed project. There would be no construction related effects to the vegetation and wildlife. The banks along the Sacramento River are very erosive and without some kind of erosion control measures, the banks would continue to erode during high flows. As the banks of the river erode, vegetation would be lost and the levees could fail. It is likely that in order to save the levee structures, flood fighting activities would occur during a high flow emergency response. Flood fighting is usually performed by placing large rock along the levee slope to stop erosion and prevent levee failure and loss of lives. The placement of the rock could prevent and/or impede future growth of trees and vegetation on the levee slopes.

In the event that flood fighting activities are not successful and a levee failure occurs, all vegetation could be lost and wildlife could be swept away in the flood waters. The loss of vegetation that could occur in a large flood event and the placement of rock along the banks could have significant impacts to vegetation and wildlife, particularly to the functioning of a migratory corridor.

While this area of the project does not provide large patches of habitat, it does serve as a migratory corridor for wildlife from further south in the Sacramento-San Joaquin Delta to areas further north along the Sacramento River, such as the Parkway. Riparian corridors can be especially important for reptiles, amphibians, and small mammals.

Future Conditions With the Project

Impacts to vegetation and wildlife within the project area are evaluated based on data collected from tree surveys conducted in 2011, site visits, Google Earth, and the American River Parkway Plan (Parkway Plan). The goals and objectives of the Parkway Plan and how construction of the project would impact those goals and objectives were considered in the impact analysis. Table 3 summarizes the impacts to vegetation by basin and reach.

Alternative 1: Fix Levees in Place

American River

The construction of rock trenches along the American River would result in the removal of about 65 acres of riparian habitat within the Parkway. This acreage was determined by overlaying the largest possible footprint onto an aerial photograph and calculating the riparian habitat within the footprint. Much of this riparian habitat contains trees that have been in the Parkway for 50 to 100 years or more. The Parkway is the largest remaining riparian corridor in the city of Sacramento. In addition, construction would also impact 135 acres of grassland, which include the levees, patrol roads, and open lands. Project construction along the American River would be intermittent and would occur over a 7 year period. Trees would not be removed all at one time, they would be removed at each trench site as the trench is constructed.

Table 3. Potential Impacts by Flood Basin and Reach

Waterway	Impacts
American River	65 acres of riparian habitat
	135 acres of grassland habitat
East Side Tributaries	2 acres oak woodland
	4 acres of grassland
	10.5 acres riparian
Sacramento River	70 acres of riparian
Sacramento Bypass	300 acres of agricultural fields and drainage canals
	8 acres of riparian vegetation

Most of the 65 acres of riparian habitat is located on land designated by the Parkway Plan as Protected Areas or Nature Study Area. However, the Parkway Plan also allows for flood control activities to be conducted in order to pass 160,000 cfs through the system. Section 4.10 of the Parkway Plan states:

> *Flood control project, including levee protection projects and vegetation removal for flood control purposes, shall be designed to avoid or minimize adverse impacts on the Parkway, including impacts to wildlife and wildlife corridors. To the extent that adverse impacts are unavoidable, appropriate feasible compensatory mitigation shall be part of the project. Such mitigation should be close to the site of the adverse impact, unless such mitigation creates other undesirable impacts.*

Any trees planted would take many years to mature to the level where they provide the same value as those removed. Because there would be many years between when the trees are planted and when they mature to a value of those removed, this impact is considered significant. Construction would likely occur from May through October when birds are nesting. Once the project is authorized and funded, surveys of the project areas would occur to determine if migratory birds are nesting in areas which may be impacted during construction.

East Side Tributaries

Riparain and oak woodland along Arcade Creek and the NEMDC would need to be removed to construct the project. These trees are suitable nesting habitat for many avian species in the area. Surveys would be conducted to determine if any nesting birds are present prior to construction. If nesting birds are located adjacent to the project area, coordination with the resource agencies would occur. Any trees where nesting birds are located would not be removed while they are actively nesting. However, once the young have fledged, the trees may be removed to construct the project. The loss of trees in this area would be considered significant because new plantings would take many years to grow to the value of those removed.

This alternative would result in temporary impacts to about 4 acres of grasses along the creek channels and levee slopes. Once construction is complete, the areas would be planted with a native grass seed mix to prevent erosion and replace the grasses removed for construction. The grasslands are likely to grow back in a single season.

Sacramento River

Under this alternative the existing levee structure would be degraded by one half to create a working platform for slurry wall installation. As the levee is degraded, all vegetation on the top one half would be removed. Levee degradation will result in the loss of 70 acres of riparian habitat. These trees are located on the top half of the levee, so they provide a small amount of SRA cover and habitat for many avian species. They also contribute to the width of the riparian corridor. On average the current width of the riparian corridor along the Sacramento River is 100 feet. Riparian loss will remove about 60 feet of those 100 feet. The construction and planting of the berm as part of the erosion repair will create an additional 25 feet to the width of the riparian corridor. There will still be a net loss of 35 feet from the riparian corridor. The loss of this 35 feet from the width of the riparian habitat can cause increased predation because the narrower corridor will increase edge effects. Additionally, smaller widths of habitat make it more likely that stochastic events will affect the habitat and loss of the vegetation could result in complete removal of the riparian corridor diminishing connectivity. It will be important for the Corps and the non-federal and local sponsors to ensure that the remaining riparian habitat remains, regeneration occurs (it may need to be helped through active planting), and non-native vegetation does not become established within the corridor.

On the waterside of the levee, 930 large trees would be left in place on the lower one-third and rock would be placed around the base of the trees. The trees that would remain in place are scattered over 31,130 linear feet (50 acres). The rock protection around the trees would reduce the potential for erosion and anchor the trees in place to lower the risk of uprooting in high water events. The understory vegetation would be removed to provide a clean surface to place the rock. Excluding the large trees, vegetation in this area is primarily small shrubs, low growing plants of various species, and grasses. Once the rock protection is in place and a planting berm is constructed, the area would be planted with small shrubs. Appropriate plants would be selected to maximize wildlife habitat.

On the landside of the levee all trees would be removed on the levee slope and within 15 feet of the levee toe to comply with the Corps vegetation policy. Within this 15 feet compliance area, a 10-foot wide landside operations, maintenance, and emergency access corridor would be established. There are 670 trees of various species and size within this landside area that would be removed and not be replaced on-site. The removal of these trees is considered significant because it would take many years for the replacement trees to establish to the value of those removed.

The landside slopes are primarily covered with ornamental groundcovers installed by adjacent private property owners. In some places landscaping has been extended beyond the fence or property lines and up the levee slopes. Degrading of the levee would include removal of all vegetation on the upper half of the landside slope. All disturbed areas, including the levee slopes, would be planted with native grasses to prevent erosion. The 15 foot landside vegetation free zone would be maintained vegetation free, except for the native grasses.

The loss of woody vegetation would affect avian species. Surveys would be conducted to determine if any nesting birds are present prior to construction. If nesting birds are located adjacent to the project area, coordination with the resource agencies would occur. Trees where nesting birds are located would not be removed while they are actively nesting.

Alternative 2 – Fix Levees and Widen the Sacramento Weir and Bypass

The footprints of all features in this alternative are the same as Alternative 1 with the added feature of widening the Sacramento Weir and Bypass. Areas that no longer require a raise would still maintain the same footprint since the purpose of the raise would instead be accomplished via the installation of a retaining wall at the toe of the levee. Therefore, the effects to vegetation and wildlife are the same as those for Alternative 1, with the addition of those associated with the Sacramento Weir and Bypass.

Sacramento Weir and Bypass

Habitat within the existing Bypass would remain the same as the existing conditions. The Bypass would be expanded by about 300 acres, which would become open space and would likely become similar habitat for wildlife as the existing Bypass. Operations of the new weir and bypass would be determined after construction is complete. No grading or altering of the lands within the existing bypass would occur as part of this alternative. Since the southern side of the bypass is lowest in elevation, water would naturally flow to the existing area and continue to support existing vegetation and wildlife. Due to the natural flow of water in the Bypass, existing wetlands are not expected to be impacted by construction of the project. There is a potential for additional wetlands to actually develop in the added 300 acres of bypass since the land would no longer be farmed. Conversion of this land back to its natural state would have benefits to other wildlife and could become an expansion of the Sacramento Bypass Wildlife Area.

There are 8 acres of riparian vegetation that would be removed to construct the weir structure. The 8 acre area contains both the Old River Road and Union Pacific Railroad train tracks. Avian species are the primary wildlife in this area with some small animals like fox and coyotes, which pass through the area to access the river. Included within the 8 acres are 1,500 linear feet of vegetation along the Sacramento River which may be removed to allow the river to flow freely into the weir. Both native and non-native fish species use this area of the river. During construction there would be direct effects to wildlife as the human activities associated with the construction would likely cause any wildlife to relocate to other open space lands to avoid the disturbance; however, the expansion of the Sacramento Weir and Bypass would have a positive effect on vegetation and wildlife once construction is complete and lands are converted from farming activities to open space.

DISCUSSION

Service Mitigation Policy

The recommendations provided herein for the protection of fish and wildlife resources are in accordance with the Service's Mitigation Policy as published in the Federal Register 46:15; January 23, 1981).

The Mitigation Policy provides Service personnel with guidance in making recommendations to protect or conserve fish and wildlife resources. The policy helps ensure consistent and effective Service recommendations, while allowing agencies and developers to anticipate Service recommendations and plan early for mitigation needs. The intent of the policy is to ensure protection and conservation of the most important and valuable fish and wildlife resources, while allowing reasonable and balanced use of the Nation's natural resources.

Under the Mitigation Policy, resources are assigned to one of four distinct Resource Categories, each having a mitigation planning goal which is consistent with the fish and wildlife values involved. The Resource Categories cover a range of habitat values from those considered to be unique and irreplaceable to those believed to be much more common and of relatively lesser value to fish and wildlife. However, the Mitigation Policy does not apply to threatened and endangered species, Service recommendations for completed Federal projects or projects permitted or licensed prior to enactment of Service authorities, or Service recommendations related to the enhancement of fish and wildlife resources.

In applying the Mitigation Policy during an impact assessment, the Service first identifies each specific habitat or cover-type that may be impacted by the project. Evaluation species which utilize each habitat or cover-type are then selected for Resource Category analysis. Selection of evaluation species can be based on several criteria, as follows: (1) species known to be sensitive to specific land- and water-use actions; (2) species that play a key role in nutrient cycling or energy flow; (3) species that utilize a common environmental resource; or (4) species that are associated with Important Resource Problems, such as anadromous fish and migratory birds, as designated by the Director or Regional Directors of the Service. Based on the relative importance of each specific habitat to its selected evaluation species, and the habitat's relative abundance, the appropriate Resource Category and associated mitigation planning goal are determined.

Mitigation planning goals range from "no loss of existing habitat value" (i.e., Resource Category 1) to "minimize loss of habitat value" (i.e., Resource Category 4). The planning goal of Resource Category 2 is "no net loss of in-kind habitat value." To achieve this goal, any unavoidable losses would need to be replaced in-kind. "In-kind replacement" means providing or managing substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate those lost. The planning goal of Resource Category 3 is "no net loss of habitat while minimizing loss of in-kind value." To achieve this goal any unavoidable losses will be replaced in-kind or if it is not desirable or possible out-of-kind mitigation would be allowed. The planning goal of Resource Category 4 is "minimize loss of habitat value." To achieve this goal the Service will recommend ways to rectify, reduce, or minimize loss of habitat value.

In addition to mitigation planning goals based on habitat values, Region 8 of the Service, which includes California, has a mitigation planning goal of no net loss of acreage and value for wetland habitat. This goal is applied in all impact analyses.

In recommending mitigation for adverse impacts to fish and wildlife habitat, the Service uses the same sequential mitigation steps recommended in the Council on Environmental Quality's regulations. These mitigation steps (in order of preference) are: avoidance, minimization, rectifying, reducing or eliminating impacts over time, and compensation.

Ten fish and/or wildlife habitats were identified in the project area which had potential for impacts from the project: oak woodland, riparian forest, riparian scrub-shrub, SRA cover, shallow open water, emergent wetland, annual grassland, agriculture (non-rice cultivation), ornamental landscape, and other. The resource categories, evaluation species, and mitigation planning goal for the habitats impacted by the project are summarized in Table 4.

The evaluation species selected for the oak woodland that would be impacted are acorn woodpecker, turkey, and mule deer. Acorn woodpeckers utilize oak woodlands for nearly all their life requisites; 50-60 percent of the acorn woodpecker's annual diet consists of acorns. Acorn woodpeckers can also represent impacts to other canopy-dwelling species. Turkeys forage and breed in oak woodlands and are abundant in the project area. Mule deer also heavily depend on acorns as a dietary item in the fall and spring; the abundance of acorns and other browse influence the seasonal pattern of habitat use by deer. These latter species represent species which utilize the ground component of the habitat and both have important non-consumptive human uses (i.e., wildlife viewing and bird watching). Based on the high value of oak woodlands to the evaluation species, and their declining abundance, the Service has determined oak woodlands which would be affected by the project should be placed in Resource Category 2, with an associated mitigation planning goal of "no net loss of in-kind habitat value or acreage."

The evaluation species selected for the riparian forest that would be impacted by the project are Swainson's hawks, wood ducks, and Bullock's orioles. Riparian forest vegetation provides important cover, and roosting, foraging, and nesting habitat for these species. Large diameter trees also provide nesting sites for species such as wood ducks and Swainson's hawks. Riparian woodland cover-types are of generally high value to the evaluation species, and are overall, extremely scare (less than 2% remaining from pre-development conditions). Therefore, the Service finds that any riparian forest cover-type that would be impacted by the project should be placed in Resource Category 2, with an associated mitigation planning goal of "no net loss of in-kind habitat value or acreage." In addition, the Service's regional goal of no net loss of wetland acreage or habitat values, whichever is greater, would apply to this habitat type.

The evaluation species selected for the riparian scrub-shrub vegetation that would be impacted by the project is the yellow warbler. Riparian scrub-shrub vegetation provides important cover, and roosting, foraging, and nesting habitat for this species. Riparian cover-types are generally of high value to the evaluation species, and are overall extremely scarce (less than 2% remaining from pre-development conditions). Therefore, the Service finds that any riparian scrub-shrub cover-type that would be impacted by the project should be placed in Resource Category 2, with an associated mitigation planning goal of "no net loss of in-kind habitat value or acreage." In addition, the Service's regional goal of no net loss of wetland acreage or habitat values, whichever is greater, would apply to this habitat type.

The evaluation species selected for SRA cover that would be affected by the project are juvenile salmonids (salmon and steelhead) and the heron and egret family (family Ardeidae). Salmonids were selected because large declines in their numbers are among the most important resource issues in the region, and because of their very high commercial and sport fishing values. Herons and egrets were selected because of the Service's responsibilities for their management under the Migratory Bird Treaty Act, their relatively high value for non-consumptive human uses, such as bird watching, and their value as indicator species for the many birds which use SRA cover.

Table 4. Resource categories, evaluation species, and mitigation planning goal for the habitats possibly impacted by the proposed American River Common Features General Re-evaluation Report, Sacramento County, California.

COVER-TYPE	EVALUATION SPECIES	RESOURCE CATEGORY	MITIGATION GOAL
Oak Woodland	Acorn woodpecker Turkey Deer	2	No net loss of in-kind habitat value or acreage.
Riparian Forest	Swainson's hawk Wood duck Bullock's oriole	2	No net loss of in-kind habitat value or acreage.
Riparian Scrub-Shrub	Yellow warbler	2	No net loss of in-kind habitat value or acreage.
SRA Cover	Juvenile salmonids Herons and Egrets	1	No loss of existing habitat value.
Emergent Wetland	Marsh Wren	2	No net loss of in-kind habitat value or acreage.
Shallow Open Water	Egret Sunfish	2	No net loss of in-kind habitat value or acreage.
Annual Grassland	Red-tailed hawk	3	No net loss of habitat value while minimizing loss of in-kind habitat value.
Agriculture (non-rice cultivation)	White-tailed kite California vole	4	Minimize loss of habitat value.
Ornamental Landscape	None	4	Minimize loss of habitat value.
Other	None	4	Minimize loss of habitat value.

In 1992, the Service designated SRA cover that is impacted by bank protection activities within the Sacramento Bank Protection Project action area as Resource Category 1 (USFWS 1992). Under Resource Category 1, habitat to be impacted is high value, unique, and irreplaceable on a national basis or in the eco-region, and the Service's mitigation planning goal is for no loss of existing habitat value.

The evaluation species selected for the emergent wetland cover-type is the marsh wren. Drainage wetland habitat provides important cover, foraging, nesting, and roosting habitat for such water associated birds as well as some amphibians and aquatic mammals. Insects and spiders are taken from vegetation, the wetland floor, and while in flight (Gutzwiller and Anderson 1987). For protection from predators, the marsh wren usually constructs nests in reedy vegetation about 15 inches above water that is 2 to 3 feet deep (Gutzwiller and Anderson 1987). Because of the medium to high value of this habitat to the evaluation species, and its relative scarcity, the Service designates any emergent wetland habitat within the project area as Resource Category 2, with its associated mitigation planning goal of "no net loss of in-kind habitat value or acreage."

The evaluation species selected for the shallow open water cover-type is the egret and sunfish. Shallow, open water is important to a number of regionally important fish and wildlife. For example, wading birds (e.g., herons and egrets) use it for feeding, as do a number of gamefish, including sunfish, catfish and striped bass. It is also part of the critical habitat designated for federally listed delta smelt and Sacramento River winter-run Chinook salmon. Such shallow water is generally removed when typical bank protection is done, especially when the bank is reshaped. The result is likely to be higher velocities and deeper water along the new shoreline. Compounding the problem is the large amount of riprap that has already been placed in the vicinity of the proposed action, thus effectively removing many miles of shallow, open water. In concert with past Sacramento River Bank Protection Project planning, the Service is designating such habitat that would be impacted as Resource Category 2, with an associated planning goal of "no net loss of in-kind habitat value or acreage."

The evaluation species selected for the annual grassland cover-type is the red-tailed hawk, which utilizes these areas for foraging. This species was selected because of the Service's responsibility for their protection and management under the Migratory Bird Treaty Act, and their overall high non-consumptive values to humans. Annual grassland areas potentially impacted by the project vary in their relative values to the evaluation species, depending on the degree of human disturbance, plant species composition, and juxtaposition to other foraging and nesting areas. Therefore, the Service designates the annual grassland cover-type in the project area as Resource Category 3. Our associated mitigation planning goal for these areas is "no net loss of habitat value while minimizing loss of in-kind habitat value."

The evaluation species selected for the agriculture, non-rice cultivation, cover-type is the white-tailed kite (formerly black-shouldered kite) and the California vole. The white-tailed kite in California is a common species of open and cultivated bottomland and is an obligate predator on diurnal small mammals (Faanes and Howard 1987). Movements and nesting of the white-tailed kite is largely governed by concentrations of mice and voles (Faanes and Howard 1987). The California vole is a widespread and common herbivore in California (Brylski 1990), and its abundance and distribution, along with daytime activity, make it an important prey species. Because this habitat is not native, and is managed for crop production unless fallowed, the Service designates the agriculture cover-type in the project area as Resource Category 4. Our associated mitigation planning goal for these areas is "minimize loss of habitat value."

No evaluation species were identified for the ornamental landscape or "other" cover-types. The ornamental landscape is typically vegetation which occurs along the fence line of adjacent private properties and is maintained by individual landowners. The "other" cover-type encompasses those areas which do not fall within the other cover-types such as gravel and paved roads, parking areas, buildings, bare ground, riprap, etc. Generally these cover-types would not provide any significant habitat value for wildlife species. Therefore, the Service designates the ornamental landscape and "other" cover-types in the project area as Resource Category 4. Our associated mitigation planning goal for these areas is "minimize loss of habitat value."

The recommendations below are based on preliminary construction designs provided by the Corps for the Common Features GRR. Once the specific project designs are developed, the Service's recommendations will be refined.

RECOMMENDATIONS

The Service recommends:

1. Avoid the loss of SRA cover by planting native woody vegetation within the bank protection areas. Work with the Service, NMFS, and California Department of Fish and Wildlife (CDFW) to develop planting and monitoring plans, and with DWR and SAFCA to develop a variance to allow vegetation within the Corps' vegetation free zone to remain in place, especially in areas designed for rock slope protection.

2. Woody vegetation that needs to be removed within the construction footprint should be removed during the non-nesting season to avoid affecting active bird nests.

3. Avoid impacts to migratory birds nesting in trees along the access routes and adjacent to the proposed repair sites by conducting pre-construction surveys for active nests along proposed haul roads, staging areas, and construction sites. This would especially apply if construction begins in spring or early summer. Work activity around active nests should be avoided until the young have fledged. The following protocol from the CDFW for Swainson's hawk would suffice for the pre-construction survey for raptors.

   A focused survey for Swainson's hawk nests will be conducted by a qualified biologist during the nesting season (February 1 to August 31) to identify active nests within 0.25 mile of the project area. The survey will be conducted no less than 14 days and no more than 30 days prior to the beginning of construction. If nesting Swainson's hawks are found within 0.25 mile of the project area, no construction will occur during the active nesting season of February 1 to August 31, or until the young have fledged (as determined by a qualified biologist), unless otherwise negotiated with the California Department of Fish and Wildlife. If work is begun and completed between September 1 and February 28, a survey is not required.

4. Avoid future impacts to the site by ensuring all fill material is free of contaminants.

5. Minimize project impacts by reseeding all disturbed areas, including staging areas, at the completion of construction with native forbs and grasses. Reseeding should be conducted just prior to the rainy season to enhance germination and plant establishment. The reseeding mix should include species used by and beneficial for native pollinators. The Service can work with you in developing this seed mix.

6. Minimize the impact of removal and trimming of all trees and shrubs by having these activities supervised and/or completed by a certified arborist.

7. Compensate the loss of oak woodland, riparian forest, riparian scrub-scrub, and emergent wetland at a ratio of at least 2:1. The Corps should work with the Service and other resource agencies on the development of a riparian plan that will evaluate locations for riparian vegetation planting based on land use in the lower American River Parkway, effects from known future projects, such as the reoperation of Folsom Dam, where existing riparian and

valley elderberry longhorn beetle habitat exists, creating and maintaining connectivity between large riparian patches, and coordination with Sacramento County Parks. For the loss of other cover-types, the Corps should work with the Service and other resource agencies on the development of compensation success benchmarks to ensure that goals are achieved.

8. All bank protection areas should be planted with a diverse mix of woody and herbaceous riparian vegetation. Sites should be diverse (a mix of riparian forest and scrub-shrub) and fit into the surrounding landscape. The planting plan should take into account what is missing from the surrounding vegetation and attempt to create heterogeneous habitats. The Corps should develop a baseline map of existing vegetation communities. Given the amount of rock already placed and the amount proposed for placement, this can serve to create diverse and heterogeneous habitats.

9. Include within the planting contract a provision for the contractor to plant understory species after some of the woody canopy has established. Studies have shown that planting late successional understory species after woody species canopy cover has been established provides better success for establishing these understory plants. Incorporating these species within the planting mix provides more diverse habitat for wildlife species (Johnston 2009).

10. Contact the California Department of Fish and Wildlife regarding possible effects of the project on State listed species.

REFERENCES

Brylski, P. California vole *in* Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White, eds., California's Wildlife. Vol. I-III. California Department of Fish and Game, Sacramento, California. Available online at: http://www.dfg.ca.gov/biogeodata/cwhr/cawildlife.aspx, accessed July 23, 2013.

Faanes, C.A., and R.J. Howard. 1987. Habitat suitability index models: black-shouldered kite. U.S. Fish and Wildlife Service Biological Report Rep. 82(10.130). 130 pages.

Gutzwiller, K.J., and S.H. Anderson. 1987. Habitat suitability index models: marsh wren. U.S. Fish and Wildlife Service Biological Report 82(10.139). 13 pages.

Johnston, Prairie. 2009. Establishing understory plants into restored riparian forest on the middle Sacramento River. CSU Chico Masters Thesis.

USFWS (U.S. Fish and Wildlife Service). 1986. Potential impacts to fish and wildlife from alternative actions for increasing flood control along the lower American River, California. U.S. Fish and Wildlife Service, Sacramento, California.

______. 1991. American River Watershed Investigation, Auburn Area, Substantiating Report. U.S. Fish and Wildlife Service, Sacramento, California.

______. 1992. Shaded Riverine Aquatic Cover of the Sacramento River System: Classification as a Resource Category 1 Under the FWS Mitigation Policy. Sacramento Fish and Wildlife Office, Sacramento, California.

______. 1994. Planning Aid Report for the American River Watershed Investigation, Raising of Folsom Dam Alternative. U.S. Fish and Wildlife Service, Sacramento, California.

______. 2013. American River Watershed Information (Online), Available: http://www.fws.gov/stockton/afrp/ws_projects.cfm?code=AMERR, accessed April 5, 2013.

APPENDIX 1

U.S. FISH AND WILDLIFE
ENDANGERED SPECIES CONSULTATION

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Suite W-2605
Sacramento, California 95825-1846

In Reply Refer to:
08ESMF00-
2014-F-0518

SEP 1 1 2015

Ms. Alicia E Kirchner
Chief, Planning Division
U.S. Army Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California 95814

Subject: Formal Consultation on the American River Common Features (AFRC) Project, Sacramento County, California

Dear Ms. Kirchner:

This letter is in response to the U.S. Army Corps of Engineers (Corps) April 3, 2015, request for consultation with the U.S. Fish and Wildlife Service (Service) on the proposed American River Common Features General Reevaluation Report (ARCF GRR) project in Sacramento County, California. You request was received by the Service on April 7, 2015. The Corps originally initiated consultation on June 30, 2014; however, the Service responded on July 23, 2014, with a request for additional information regarding the project description and the effects analysis the Corps had completed. The April 3, 2015, letter and biological assessment began the formal consultation period. This response is provided under the authority of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

The Federal action on which we are consulting is the ARCF GRR, which includes levee improvements and bank protection along the Sacramento River, levee improvements along Arcade, Magpie, and Dry/Robla Creeks, widening the Sacramento Bypass and Weir, and bank protection along the lower American River. Pursuant to 50 CFR 402.12(j), you submitted a biological assessment for our review and requested concurrence with the findings presented therein. These findings conclude that the proposed project may affect and is not likely to adversely affect the vernal pool fairy shrimp (*Branchinecta lynchi*) and vernal pool tadpole shrimp (*Lepidurus packardi*); may affect likely to adversely affect the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), delta smelt (*Hypomesus transpacificus)* (smelt) and its critical habitat; the giant garter snake (*Thamnophis gigas*); and the yellow-billed cuckoo (*Coccyzus americanus occidentalis*). The project is outside of critical habitat designated for the valley elderberry longhorn beetle and critical habitat proposed for the yellow-billed cuckoo.

The Corps previously consulted with the Service on the Magpie Creek Flood Control Project and on September 15, 2004 a biological opinion regarding effects to the vernal pool fairy shrimp, vernal pool tadpole shrimp, and giant garter snake (File # 1-1-04-F-0132) was provided. The project described in the 2004 biological opinion is exactly the same as the Magpie Creek portion of the project description in the Common Features biological assessment. Because the environmental baseline for vernal pool fairy shrimp and vernal pool tadpole shrimp has not changed from the baseline that was analyzed in the 2004 biological opinion and the project description remains the same, effects to and take of vernal pool fairy shrimp and vernal pool tadpole shrimp are addressed i the September 15, 2004, biological opinion. More recent information regarding the status of the habitat along Magpie Creek for giant garter snake has changed from the 2004 biological opinion. This opinion addresses those changes and any potential effects to the giant garter snake.

Seasonal wetlands, which may provide suitable habitat for vernal pool fairy shrimp and vernal pool tadpole shrimp, occur in the vicinity of the Robla Creek woodland mitigation site A, however any vernal pools in this area would be avoided by these activities. The Corps will implement a 250-foot buffer between vernal pools and vegetation planting. Planting activities will be done in the fall when the wetlands are dry and will use best management practices to ensure that sediment does not enter the seasonal wetlands. The Service concurs that with your determination of may affect, not likely to adversely affect vernal pool fairy shrimp and vernal pool tadpole shrimp at the Robla Creek woodland mitigation site A.

This biological opinion is based on information provided in the Corps' letter requesting consultation and the biological assessment. A complete administrative record is on file at the Service's Sacramento Fish and Wildlife Office.

CONSULTATION HISTORY

September 4, 2013: The Service commented on the April 2013 draft biological assessment.

April 8, 2014: The Service commented on the October 2013 draft biological assessment.

June 30, 2014: The Corps initiated section 7 consultation with the Service.

July 23, 2014: The Service sent a letter in response to the Corps initiation requesting additional information.

April 3, 2015: The Corps provided an updated biological assessment with responses to the Service's July 23, 2014, request for additional information.

August 31, 2015: The Corps provided a revised biological assessment that addressed questions the Service had regarding the project description.

BIOLOGICAL OPINION

Description of the Action

Congress directed the Corps to investigate the feasibility of reducing flood risk of the city of Sacramento. The Corps completed feasibility studies in 1991 and 1996, recommending a concrete gravity flood detention dam on the north fork of the American River at the Auburn site along with levee improvements downstream of Folsom Dam. Other plans evaluated in the report were Folsom Dam improvements and a stepped release plan for Folsom Dam releases. These additional plans also included levee improvements downstream of Folsom Dam. Congress recognized that levee improvements were "common" to all candidate plans in the report and that there was a Federal interest in participating in these "common features." Thus, the ARCF Project was authorized in the Water Resources Development Act (WRDA) of 1996 and a decision on Auburn Dam was deferred to a later date. Major construction components of ARCF in the WRDA 1996 authorization included construction of seepage remediation along about 22 miles of American River levees and construction of levee strengthening and raising of 12 miles of Sacramento River levee in Natomas.

Following the 1986 flood, significant seepage was experienced on the Sacramento River from Verona (upstream end of Natomas) at River Mile (RM) 79 to Freeport at RM 45.5. In addition, both the north and south bank of the American River from RM 0 to about RM 11.4 experienced seepage. Seepage on the Sacramento River was so extensive that Congress, soon after the 1986 flood event, funded remediation in the Sacramento Urban Levee Improvement Project (Sac Urban). The Sac Urban Project constructed shallow seepage cutoff walls from Powerline Road in Natomas at approximately RM 64 down to Freeport.

Shortly thereafter, the Sacramento Valley experienced a flood event in 1997. Considerable seepage occurred on the Sacramento River as well as on the American River. Seepage on the American River was expected because remediation measures had yet to be constructed, but the occurrence of significant seepage on the Sacramento River in the reach remediated as part of the Sac Urban Project was alarming and confirmed that deep underseepage was also of significant concern. As a result, seepage remediation on the American River (then in the late 1990s in the design phase) would need to be designed to remediate both through- and deep underseepage.

In 1999, Congress decided not to authorize Auburn Dam, but instead authorized improvements for Folsom Dam. By doing this, improvements to levees downstream of Folsom Dam could be fine-tuned to work closely with the Folsom improvements being discussed by Congress. Therefore, the ARCF project was modified by WRDA 1999 to include additional necessary features for the American River so that it could safely convey the proposed emergency release of 160,000 cubic feet per second (cfs) from Folsom Dam. Major construction components for the ARCF project in the WRDA 1999 authorization include construction of seepage remediation and levee raise along four stretches of the American River, and construction of levee strengthening and raising of 5.5 miles of Natomas Cross Canal levee in Natomas. All American River features authorized in WRDA 1996 and 1999 have been constructed or are in design analysis for construction within a year or two.

The purpose of the ARCF project is to reduce the flood risk for the city of Sacramento. The following problems were identified within the Sacramento levee system:

- Seepage and underseepage;
- Levee erosion;
- Levee stability;
- Levee overtopping;
- Access for maintenance and flood fighting;
- Vegetation and encroachments;
- Releases from Folsom Dam;
- Floodplain management; and
- Additional upstream storage from existing reservoirs.

In order to evaluate the effects to listed species, the Corps looked at the largest foreseeable footprint. As the Corps moves into the design phase of the project, footprint changes will likely reduce the effects to listed species.

The project is designed to allow for the release of 160,000 cubic feet per second (cfs) from Folsom Dam. The levees along the American River are unable to withstand these maximum flows for extended periods of time without increased risk of erosion and potential failure. The exact location where erosion will occur and to what extent erosion will occur during any given event is unknown. Erosion within the American River Parkway will be addressed as part of the Folsom Dam Water Control Manual Update currently under evaluation and a biological assessment is being prepared to initiate section 7 consultation with both the Service and National Marine Fisheries Service (NMFS). Therefore, the effects of erosion along the lower American River and effects of increased Yolo Bypass flooding frequency due to changes in operations from Folsom Dam are not analyzed in this project description. This is because construction of the American River and Sacramento Bypass measures, which are dependent on releases from Folsom Dam, will not occur until after a biological opinion is received for the Water Control Manual Update. Sacramento River and East Side Tributaries measures are necessary to improve the flood risk management system in the Sacramento area regardless of the change in operation at Folsom Dam and are not dependent on Folsom Dam operations for their implementation. As a result, construction in these areas could occur regardless of the Folsom Dam Water Control Manual Update schedule.

The Corps' project involves the construction of fix-in-place levee remediation measures to address seepage, stability, erosion, and height concerns identified for the Sacramento River and American River levees, Natomas East Main Drainage Canal (NEMDC), Arcade, Dry/Robla, and Magpie Creeks (Figure 1). Most height concerns along the Sacramento River will be addressed by a widening of the Sacramento Weir and Bypass to divert more flows into the Yolo Bypass. Due to the urban nature and proximity of existing development within the American River North and South basins the Corps is planning fix in place remediation. This would improve the flood damage reduction system to safely convey flows to a level that maximizes net benefits. Table 1 summarizes the levee problems discussed above and the proposed measure for each waterway.

Sacramento Area Flood Control Agency (SAFCA), the project's local sponsor, will complete some portions of the Federal project. SAFCA is seeking permission from the Corps pursuant to 33 USC §408 (Section 408) for alteration of the Federal levees along the NEMDC and Arcade Creek.

In addition to the proposed levee improvements measures shown in Table 1, the following measures and policies would be addressed during construction:

- The non-Federal (Department of Water Resources (DWR)) will bring the levees into compliance with the Corps' standard levee footprint using a System Wide Implementation Framework (SWIF) process. A SWIF is a plan developed by the levee sponsor(s) and accepted by the Corps to implement system-wide improvements to a levee system (or multiple levee systems within a watershed) to address system-wide issues, including correction of unacceptable inspection items, in a prioritized way to optimize flood risk reduction. The standard levee footprint consists of a 20 foot crown width, 3:1 waterside

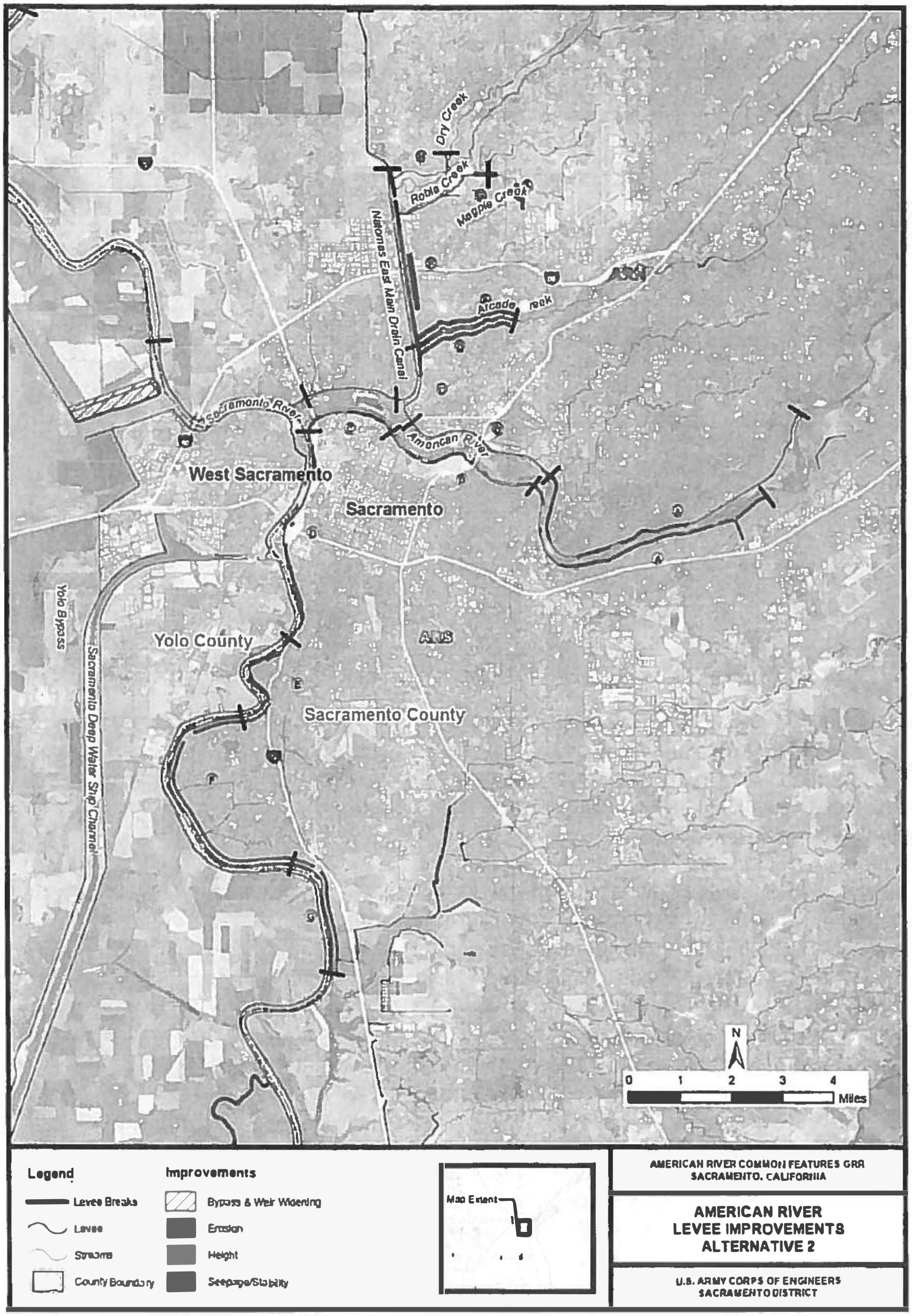

Figure 1. American River Common Features Project Area

Table 1. Remediation by Waterway.

Waterway	Seepage Measures	Stability Measures	Erosion Protection Measures	Overtopping Measures
American River[1]	---	---	Bank Protection, Launchable Rock Trench (31,000 linear feet)	---
Sacramento River	Cutoff Wall (50,300 linear feet)	Cutoff Wall (50,300 linear feet)	Bank Protection (50,300 linear feet)	Sacramento Bypass and Weir Widening, Levee Raise (1,500 feet)
NEMDC	Cutoff Wall (6,000 linear feet)	Cutoff Wall	---	Floodwall (15,600 linear feet)
Arcade Creek	Cutoff Wall (22,000 linear feet)	Cutoff Wall	---	Floodwall (22,000 linear feet)
Dry/Robla Creeks	---	---	---	Floodwall (2,500 linear feet)
Magpie Creek[2]	---	---	---	Floodwall, Levee Raise

[1]American River seepage, stability, and overtopping measures were addressed in a previous construction project.
[2]In addition to the floodwall, Magpie Creek will include construction of a new levee (3,100 linear feet) along Raley Boulevard south of the creek, and construction of a detention basin on both sides of Raley Boulevard (79 acres). In addition, some improvements would need to occur on Raley Boulevard, including widening of the Magpie Creek Bridge, raising the elevation of the roadway, and removing the Don Julio Creek culvert.

slope and 2:1 landside slope, when possible. If the 3:1 waterside slope is not possible, then a minimum 2:1 waterside slope would be established instead.

- Engineering Technical Letter 1110-2-583 (ETL) vegetation compliance would occur under a SWIF by the local maintaining agency (LMA). The intent of the SWIF is to collaboratively work with the resource agencies and levee sponsors to transition existing levees to Corps standards while maintaining Public Law (PL) 84-99 rehabilitation assistance and adhering to the Act and other environmental laws. The SWIF is a two-step process completed by the applicant that is composed of a letter of intent, which is followed by submission of a SWIF plan. The SWIF process allows eligible local sponsors to implement levee improvements in a prioritized "worst first" way to optimize the achievement of risk reduction. The Corps acknowledges that implementing system-wide improvements will need to be done within a collaborative intergovernmental framework and that it will take time to develop and implement improvements in complex situations. Challenges including ensuring that both environmental and levee safety considerations are adequately served.
- The vegetation requirements for the SWIF include a 15-foot waterside, landside, and vertical vegetation-free zone. Trees that pose an unacceptable risk to levee integrity will be removed and the root balls and roots will be remediated. Trees that do not pose a threat will not be removed. Vegetation on the landside slope would only be removed within the construction

footprint (up to ½ levee degrade) and the remaining vegetation would be dealt with under the SWIF process.

- Utility encroachments will be brought into compliance with Corps policy. Utilities that penetrate the levee would be removed and replaced with one of two fixes: (1) a surface line over the levee prism, or (2) a through-levee line equipped with positive closure devices.
- Private encroachments shall be removed by the non-Federal sponsor prior to construction.
- The Sacramento District of the Corps will pursue a vegetation variance which will allow vegetation on the lower ½ of the levee slope to 15 feet waterward of the waterside levee toe to remain in place. The Sacramento District has conducted an evaluation which examined the safety, structural integrity, and functionality of the levees that will be retained and not compromised if a tree were to fall and result in scouring of the root ball area. The results show that the tree fall and scour did not significantly affect levee performance, and the levee meets Corps seepage and slope stability criteria assuming the entire project is constructed.

American River

Levees along the American River require improvements to address erosion. The proposed measures for these levees consist of waterside armoring to prevent erosion to the river bank and levee, which could potentially undermine the levee foundation. There are two measures proposed for the American River levees: (1) a maximum of 31,000 linear feet (LF) of bank protection, and (2) a maximum of 65 acres/45,000 LF of launchable rock trench. Both of these measures are described in detail in the subsections below. These numbers are maximized because there is some overlap identified to account for the uncertainty of site-specific conditions. For example, for some reaches both bank protection and launchable rock trench impacts were estimated even though both measures will not be constructed in the same reach.

<u>Bank Protection</u>

This measure consists of placing rock revetment on the river's bank to prevent erosion. It entails installing revetment along the stream bank based on site-specific analysis (Figure 2). When necessary, the eroded portion of the bank will be filled and compacted prior to the rock placement. The sites will be prepared by clearing and stripping of loose material and understory growth prior to construction. In most cases, large vegetation will be permitted to remain at these sites. Temporary access ramps will be constructed, if needed, using imported borrow material that would be trucked on site.

The placement of rock onto the bank will occur from a land based staging area using long reach excavators and loader. The loader brings rock from a permitted source and stockpiles it near the levee in the construction area. The excavator then moves the rock from the stockpile to the waterside of the levee.

The revetment will be placed on the existing bank at a slope varying from 2V:1H to 3V:1H depending on site specific conditions. After revetment placement has been completed, a planting berm will be constructed in the rock to allow for revegetation of the site. The planting berm varies in width from 5 to 15 feet. In all cases the planting will occur outside the vegetation free zone as required by the ETL.

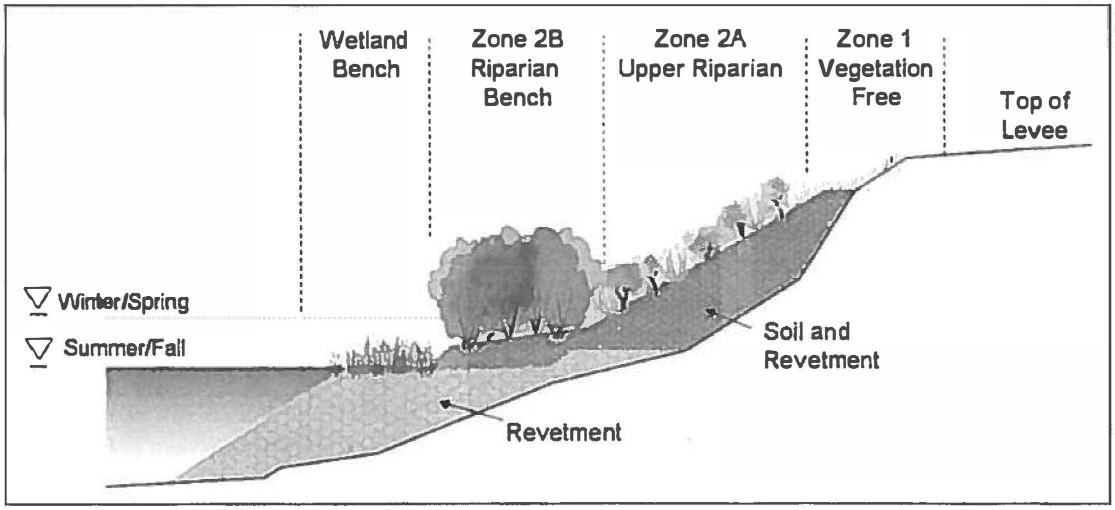

Figure 2. Bank Protection with Planting Bench.

<u>Launchable Rock Trench</u>

For the purposes of this project description, it is assumed that 65 acres of the lower American River will have a launchable rock trench fix. The remainder will be the bank protection described above. This measure includes construction of a launchable rock filled trench, designed to deploy once erosion has removed the bank material beneath it (Figure 3). All launchable rock trenches will be constructed outside of the natural river channel. The vegetation will be removed from the footprint of the trench and the levee slope prior to excavation of the trench. The trench configuration will include a 2:1 landside slope and 1:1 waterside slope and will be excavated at the toe of the existing levee. All soil removed during trench excavation will be stockpiled for potential reuse. The bottom of the trench will be constructed close to the summer mean water surface elevation in order to reduce the rock launching distance and amount of rock required.

After excavation, the trench will be filled with revetment that will be imported from an offsite commercial location. After rock placement the trench will be covered with a minimum of 3 feet of the stockpiled soil for a planting berm. Rock placed on the levee slope will be covered with 2 feet of stockpiled soil. All disturbed areas will be reseeded with native grasses and small shrubs where appropriate. Trees and shrubs could be permitted on the trench if planted outside the specified vegetation free zone as required by the ETL.

Sacramento River

Levees along the Sacramento River require improvements to address seepage, stability, and erosion. About 50,300 LF of bank protection and cutoff wall or slope stability work is proposed for the Sacramento River. In addition, these levees require a total of one mile of intermittent height improvements in order to convey additional flows that exceed current design levels.

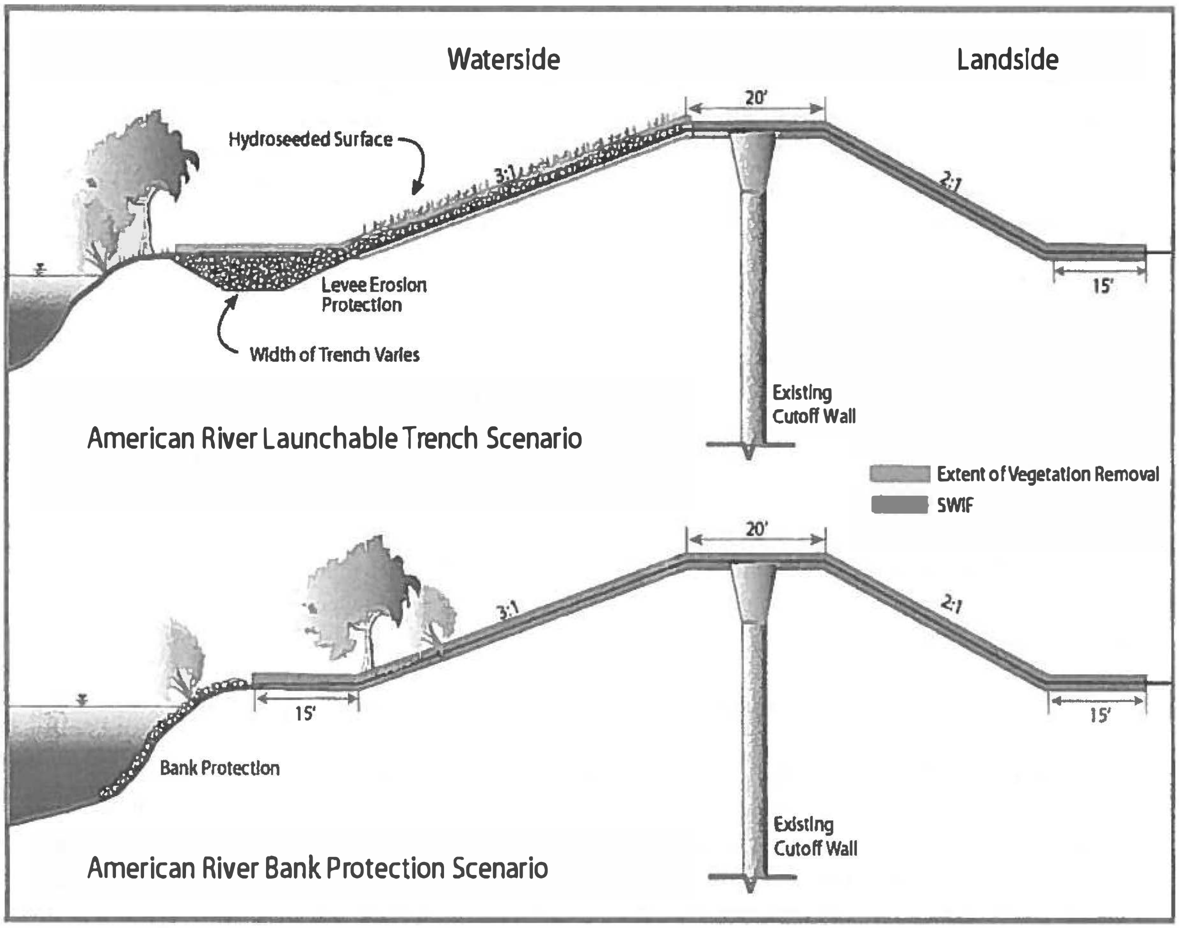

Figure 3. Launchable Rock Trench and Bank Protection.

Where the existing levee does not meet the levee design requirements, as discussed above, slope flattening, crown widening, and/or a minimal amount of levee raise is required. This improvement measure addresses problems with slope stability, geometry, height and levee crest access and maintenance. To begin levee embankment grading, loose material and vegetation understory will be cleared, grubbed, stripped, and where necessary, portions of the existing embankment will be excavated to allow for bench cuts and keyways to tie in additional embankment fill. Excavated and borrow material (from nearby borrow sites) will be stockpiled at staging areas. Haul trucks and front end loaders will bring borrow materials to the site, which will then be spread evenly and compacted according to levee design plans.

The levee will be raised about 1 to 2 feet resulting in the levee footprint extending out a maximum of 5 feet on the landside from the existing levee. The levee crown patrol road will be re-established at the completion of construction.

Cutoff Walls

To address seepage concerns, a cutoff wall will be constructed through the levee crown. The cutoff wall will be installed by one of two methods: (1) conventional open trench cutoff walls, or (2) deep soil mixing (DSM) cutoff walls. The method of cutoff wall selected for each reach will depend on the depth of the cutoff wall needed to address the seepage. The open trench method can be used to install a cutoff wall to a depth of about 85 feet. For cutoff walls of greater depth the DSM method will be utilized.

Prior to any cutoff wall construction method, the construction site and any staging areas will be cleared, grubbed, and stripped. The levee crown will be degraded up to half the levee height to create a large enough working platform (about 30 feet) and to reduce the risk of hydraulically fracturing the levee embankment from the insertion of slurry fluids. This method of slurry wall installation will also reduce the risk of slurry mixture following seepage paths and leaking into the river or into landside properties.

Open Trench Cutoff Wall

Under the open trench method, a trench about 3 feet wide will be excavated at the top of levee centerline and into the subsurface materials up to 85 feet deep with a long boom excavator. As the trench is excavated, it is filled with low density temporary bentonite water slurry to prevent cave in. The soil from the excavated trench is mixed nearby with hydrated bentonite, and in some applications cement. The soil bentonite mixture is backfilled into the trench, displacing the temporary slurry. Once the slurry was hardened, it will be capped and the levee embankment will be reconstructed with impervious or semi-impervious soil.

DSM Cutoff Wall

The DSM method involves a crane supported set of two to four mixing augers used to drill through the levee crown and subsurface to a maximum depth of about 140 feet. As the augers are inserted and withdrawn, a cement bentonite grout will be injected through the augers and mixed with the native soils. An overlapping series of mixed columns will be drilled to create a continuous seepage cutoff barrier. A degrade of up to one half the levee height will be required for construction of the DSM wall. For both methods, once the slurry has hardened it will be capped and the levee embankment will be reconstructed with impervious or semi-impervious soil.

Bank Protection

Proposed bank protection along the Sacramento River will address erosion concerns. Studies have shown that the Sacramento River levees have a medium to high risk of breach due to erosion. Bank protection will be addressed by standard bank protection with planting berm. The standard bank protection measure for the Sacramento River consists of placing rock protection on the bank to prevent erosion. This measure entails filling the eroded portion of the bank, where necessary, and installing revetment along the waterside levee slope and streambank from streambed to a height determined by site-specific analysis. Large trees on the lower half of the waterside slope will be protected in place to retain shaded riverine aquatic (SRA) habitat. The sites will be prepared by removing vegetation along the levee slopes at either end of the site for construction of a temporary access ramp, if needed. The ramp will then be constructed using imported commercial borrow material that will be trucked on site.

The placement of rock onto the levee slope will occur from atop the levee and/or from the waterside by means of barges. Rock required within the channel, both below and slightly above the water line at the time of placement, will be placed by an excavator located on a barge. Construction will require two barges: one barge would carry the excavator, while the other barge will hold the stockpile of rock to be placed on the channel slopes. Rock required on the upper portions of the slopes will be placed by an excavator located on top of the levee. Rock placement from atop the levee will require one excavator and one loader for each potential placement site. The loader brings the rock from a permitted source and stockpiles it near the levee in the construction area. The excavator then moves the rock from the stockpile to the waterside of the levee.

The revetment will be placed via the methods discussed above on existing bank at a slope varying from 2V:1H to 3V:1H depending on site specific conditions. After revetment placement has been completed, a small planting berm will be constructed in the rock to allow for some revegetation of the site.

Natomas East Main Drain Canal

The east levee of the NEMDC requires 6,000 LF of improvements to address seepage and stability at locations where historic creeks had intersected the current levee alignment. A cutoff wall will be constructed at this location to address the seepage and stability problems. The cutoff wall will be constructed by one of the methods described in the Sacramento River section above. SAFCA is proposing to construct 1,700 LF of cutoff wall beginning just south of the confluence of Arcade Creek and extending south along the NEMDC. The Corps will construct the remaining 4,300 LF of cutoff wall.

Arcade Creek

The Arcade Creek levees require improvements to address seepage, slope stability, and overtopping when the event exceeds the current design. A centerline cutoff wall will be constructed to address seepage along 22,000 LF of the Arcade Creek levees. Levees from Rio Linda Boulevard to Marysville Boulevard will have a cutoff wall constructed at the waterside toe of the levee. Construction of the waterside toe cutoff wall will require constructing a work bench along the toe of the levee. Excavation for the bench will extend deep enough below existing grade to remove organic material and soft, unsuitable foundation soils. Bench excavation will also extend into the existing waterside slope of the levee as needed. Riprap will be placed on the waterside benches after construction of the waterside toe cutoff wall. Some portions of the Arcade Creek north levee will require more substantial excavation and reconstruction of the waterside slope to provide a low permeable seepage levee slope barrier. Bench fill material will be integrated with the slope reconstruction fill to provide an integral seepage barrier with the cutoff wall over the full height of the levee slope. A small section of levee will have a sheet pile cutoff wall at the centerline of the levee, rather than the waterside toe cutoff wall.

There is a ditch adjacent to the north levee at the landside toe which provides a shortened seepage path, and could affect the stability of the levee. The ditch will be replaced with a conduit or box culvert and then backfilled. This will lengthen the seepage path and improve the stability of the levee. Additionally, pressure relief wells will be installed along the landside toe of the levee along the north levee west of Norwood Avenue.

The majority of the Arcade Creek levees have existing floodwalls, however there remains a height issue in this reach. A 1 to 4-foot floodwall will allow the levees to pass flood events greater than the current design level. The floodwall will be placed on the waterside hinge point of the levee and will be designed to disturb a minimal amount of waterside slope and levee crown for construction. The waterside slope will be re-established to its existing slope and the levee crown will grade away from the wall and be surfaced with aggregate base.

Dry and Robla Creeks

The Dry and Robla Creeks levees require improvements to address overtopping when flood events exceed the design level. Height improvements will be made with a new floodwall constructed to a height of 4 to 6 feet along 2,500 LF of the south levee. The floodwall will be placed at the waterside hinge point of the levee and will be designed to disturb a minimal amount of waterside slope and levee crown for construction. Construction of the floodwall will be consistent with the description for Arcade Creek above. The waterside slope will be re-established to its existing slope and the levee crown will grade away from the wall and be surfaced with aggregate base.

Magpie Creek Diversion Canal

The Magpie Creek Diversion Canal project description is the same as was described in the September 15, 2004 biological opinion.

Sacramento Weir and Bypass

The Sacramento Weir was completed in 1916. It is the only weir in the Sacramento River Flood Control Project that is manually operated; all others overflow by gravity on their own. It is located along the right bank of the Sacramento River about 4 miles upstream of the Tower Bridge, and about 2 miles upstream from the confluence with the American River. Its primary purpose is to protect the city of Sacramento from excessive flood stages in the Sacramento River channel downstream of the American River. The weir limits flood stages (water surface elevations) in the Sacramento River to project design levels through the Sacramento/West Sacramento area. Downstream of the Sacramento Weir, the design flood capacity of the American River is 5,000 cfs higher than that of the Sacramento River. Flows from the American River channel during a major flood event often exceed the capacity of the Sacramento River downstream of the confluence. When this occurs, floodwaters flow upstream from the mouth of the American River to the Sacramento Weir.

The project design capacity of the weir is 112,000 cfs. It is currently 1,920 feet long and consists of 48 gates to divert floodwaters to the west through the mile-long Sacramento Bypass to the Yolo Bypass. Each gate has 38 vertical wooden plank "needles" (4 inches thick by 1 foot wide by 6 feet long).

Though the weir crest elevation is 24.75 feet, the weir gates are not opened until the river reaches 27.5 feet at the I Street gage with a forecast to continue rising. This gage is about 1,000 feet upstream from the I Street Bridge and about 3,500 feet upstream from the mouth of the American River. The number of gates to be opened is determined by the National Weather Service/DWR river forecasting team to meet either of two criteria: (1) to prevent the stage at the I Street gage from exceeding 29 feet, or (2) to hold the stage at the downstream end of the weir to 27.5 feet (DWR 2010). The weir gates are then closed as rapidly as practicable once the stage at the weir drops below 25 feet. This provides "flushing" flows to re-suspend sediment deposited in the Sacramento River between the Sacramento Weir and the American River during the low flow periods when the weir is open during the peak of the flood event (DWR 2010).

The Sacramento Weir and Bypass will be expanded to roughly twice their current width to accommodate increased bypass flows. The existing north levee of the Sacramento Bypass will be degraded and a new levee would be constructed 1,500 feet to the north. The existing Sacramento Weir will be expanded to match the wider bypass. At this time, it is not known whether the new segment of weir will be constructed consistent with the 1916 design described above, or whether it will be designed to be a gravity-type weir. The new north levee of the bypass will be designed to be consistent with the existing Sacramento Bypass north levee; however, it will also include a 300-foot-wide seepage berm on the landside with a system of relief wells. A hazardous, toxic, and radiological waste site near the existing north levee will be remediated by the non-Federal sponsor prior to construction.

Operation of the new segment of the Sacramento Weir will occur during high water situations only, when the American River flows exceed 115,000 cfs. The existing Sacramento Weir will be operating at the pre-existing conditions described above. There are not expected to be any water quality impacts, though this has not been specifically modeled. The approximate change in water diversions, which are shown in Table 2, will vary based on the size of the flood event. The frequency of water diversion is expected to be the same, dependent on the stream gage at the I Street Bridge reaching 27.5 feet.

The widened portion of the Sacramento Weir will only be operated when the release from Folsom Dam is above 115,000 cfs. With the Folsom Dam improvements in place, releases from Folsom Dam will be above 115,000 cfs for flood events greater than the 100-year event. Therefore, for events up to and including the 100-year event, only the existing weir will be operated per the criteria previously established. For events greater than the 100-year event, when the release from Folsom Dam will go above 115,000 cfs, the new weir will be opened. Therefore, for events up to the 100-year event there will be no change in flow conditions in the Sacramento and Yolo Bypasses.

Table 2. Comparison of 10-, 100-, and 200-year Frequency Flows under Various Conditions

10-Year Event	Existing Condition	Future Without Project Condition	Future With Project Condition
American River	43,000 cfs	72,000 cfs	72,000 cfs
Sacramento Bypass	50,000 cfs	66,000 cfs	66,000 cfs
Yolo Bypass below Sacramento Bypass	270,000 cfs	296,000 cfs	296,000 cfs
100-Year Event	**Existing Condition**	**Future Without Project Condition**	**Future With Project Condition**
American River	145,000 cfs	115,000 cfs	115,000 cfs
Sacramento Bypass	131,000 cfs	115,000 cfs	115,000 cfs
Yolo Bypass below Sacramento Bypass	555,000 cfs	535,000 cfs	535,000 cfs
200-Year Event	**Existing Condition**	**Future Without Project Condition**	**Future With Project Condition**
American River	320,000 cfs	160,000 cfs	160,000 cfs
Sacramento Bypass	183,000 cfs	149,000 cfs	164,000 cfs
Yolo Bypass below Sacramento Bypass	656,000 cfs	631,000 cfs	643,000 cfs

For the 200-year event, there will be an increase in flows in the Sacramento Bypass of about 15,000 cfs. In the Yolo Bypass, this equates to an increase of about 0.10-foot of water surface elevation. During the 200-year event, the Yolo Bypass is already flooded from levee to levee. The addition of these flows will equate to about 0.5-foot of additional width on the Yolo Bypass levee slopes.

High Hazard Levee Encroachment and Vegetation Removal

The National Flood Insurance Program (NFIP) standards for levee accreditation and the State's ULDC both require removal or modification of encroachments that pose an unacceptably high risk to the performance and safety of a levee either by undermining its structural integrity or by interfering with necessary inspection, operation, and maintenance activities. To address this requirement, SAFCA has identified and evaluated all of the encroachments in the NEMDC, Robla Creek, and Arcade Creek area. Each of these encroachments has been evaluated and based on this evaluation the encroachments have been classified as either:

- High-risk – poses a threat to levee integrity, removable prior to the levee being accredited;
- High-risk – impedes operation, maintenance, and inspection, removable within 3 years after the levee is accredited; or
- Low-risk – not identified as high hazard.

High-risk encroachments to be removed are limited to residential landscaping located at 10 locations along the landside of the south and north levees of Arcade Creek and along the Robla Creek south levee.

Vegetation on levees must be modified or removed if it presents an unacceptable risk to the structural integrity or impedes operation and maintenance of the levee. Eight high-risk trees along Arcade Creek have been identified for removal. All of the trees are either nonnative (7) or snags (1). Five are located on the waterside of the levees. These trees are in addition to any trees that will be removed as a result of implementation of levee improvements in the Arcade Creek area.

Utility Relocation

Existing encroachments and penetrations within the NEMDC and Arcade Creek have been inventoried by SAFCA. Many utilities will be avoided, however some utilities may need to be temporarily removed or relocated prior to construction. Temporary bypass pumping may be required for sanitary sewers. SAFCA and the construction contractors will coordinate with utility owners to manage the utilities in advance of construction. Disturbed utilities will be restored after construction consistent with Central Valley Flood Protection Board requirements.

Stormwater Pollution Prevention

Temporary erosion/runoff best management control measures would be implemented during construction to minimize stormwater pollution resulting from erosion and sediment migration from the construction, borrow, and staging areas. These temporary control measures may include implementing construction staging in a manner that minimizes the amount of area disturbed at any one time; secondary containment for storage of fuel and oil; and the management of stockpiles and disturbed areas by means of earth berms, diversion ditches, straw wattles, straw bales, silt fences, gravel filters, mulching, revegetation, and temporary covers as appropriate. Erosion and stormwater pollution control measures will be consistent with National Pollutant Discharge Elimination System (NPDES) permit requirements and included in a Stormwater Pollution Prevention Plan (SWPPP).

After completion of construction activities, the temporary facilities (construction trailers and batch plants) will be removed and the site would be restored to pre-project conditions. Site restoration activities for areas disturbed by construction activities, including borrow areas and staging areas, will include a combination of regrading, reseeding, constructing permanent diversion ditches, using straw wattles and bales, and applying straw mulch and other measures deemed appropriate.

Borrow Sites, Haul Routes, and Staging Areas

Borrow Sites - It is estimated that a maximum of 1 million cubic yards (cy) of borrow material will be needed to construct the project. Detailed studies of the borrow needs have not been completed. Actual volumes exported from any single borrow site will be adjusted to match demands for fill. Borrow sites will be selected that avoid effects to endangered species or their habitat.

To identify potential locations for borrow material soil maps and land use maps were obtained for a 20-mile radius surrounding the project area. Except as discussed below for Arcade Creek and NEMDC, eventual borrow site selection will include the following criteria: avoid threatened and endangered species effects and habitat, current land use patterns, and soil types.

Excavation limits on the borrow sites will provide a minimum buffer of 50 feet from the edge of the borrow site boundary. From this setback, the slope from existing grade down to the bottom of the excavation will be no steeper than 3:1. Excavation depths from the borrow sites will be determined based on available suitable material. The borrow sites will be stripped of top material and excavated to appropriate depths. Once material is extracted, borrow sites will be returned to their existing use whenever possible, or these lands could be used to mitigate for project effects, if appropriate.

Because SAFCA has completed more detailed design and studies for work along NEMDC and Arcade Creek the borrow site has been selected. Borrow site 2 is located along the east side of the NEMDC north of where the levee repairs will occur. About 27,000 cubic yards of material will be excavated from the 5.5-acre borrow site in order to construct levee improvements along the NEMDC and Arcade Creek. Following borrow activities the site will be contoured to create about 0.5 acre of tule bench, set an elevation the will provide aquatic habitat all year, 1.0 acre of higher bench with seasonal wetlands, that will flood in the winter and spring, and 3.5 acres of native grassland.

Clean rock will be commercially acquired in order to construct the American and Sacramento River bank protection sites. For the Sacramento River, rock will be acquired from a commercial source in the Bay Area and barged up the Sacramento River to the construction sites. Rock for the American river sites will be acquired from a commercial source within a 50-mile radius and will be hauled in trucks to the construction sites.

Haul Routes – Haul routes will be determined during the design phase and will depend on what borrow sites and staging areas are selected. Haul routes will be selected based on existing commercial routes and levee roads. Haul routes will be selected that avoid effects to federally listed species.

For Arcade Creek and NEMDC, haul trucks will leave borrow site 2 and use East Levee Road from the borrow site down to a point just north of the existing Del Paso/Main Avenue Bridge over NEMDC. Temporary bridges crossing the NEMDC and Arcade Creek will be used to allow haul trucks to reach repair sites. Railroad car undercarriages on temporary abutment supports will be one option for temporary bridge crossings.

Staging Areas – Staging areas will be selected that do not require the removal of vegetation or habitat that is used by threatened or endangered species or effect threatened or endangered species. Four potential staging areas have been identified for improvements along Arcade Creek. All four areas will require little preparation other than surface striping and temporary connection roads and ramps to the levee crown. The primary use of staging areas will be for temporary trailers, parking, and material staging. Additionally, there will need to be space to process material and an area where excavated soils and imported soils will be spread out and processed material. Importing, processing, and exporting material for levee reconstruction will be continuous activities once the work flow is established during the start of the construction season. Staging areas will be returned to pre-project conditions following construction activities unless the owner agrees to some grade raising to help dispose of excess construction soils.

Operation and Maintenance

Operation and maintenance (O&M) of the levees in the Sacramento area are the responsibility of the local maintaining agencies, including the American River Flood Control District, the DWR, and the City of Sacramento. The applicable O&M Manual for the Sacramento area levees is the Standard Operation and Maintenance Manual for the Sacramento Flood Control Project. Typical levee O&M in the Sacramento in the Sacramento area currently includes the following actions:

- Vegetation maintenance up to four times a year by mowing or applying herbicide.
- Control of burrowing rodent activity monthly by baiting with pesticide.
- Slope repair, site-specific and as needed, by re-sloping and compacting.
- Patrol road reconditioning up to once a year by placing, spreading, grading, and compacting aggregate base or substrate.
- Visual inspection at least monthly, by driving on the patrol road on the crown and maintenance roads at the base of the levee.
- Post-construction, groundwater levels will be monitored using the piezometers.

The Corps will work with local maintaining agencies to develop the maintenance activities necessary for long-term operations and maintenance. This will occur during the preconstruction engineering and design phase of the project. The Corps will evaluate if these maintenance activities will affect any Federally-listed species and reinitiate section 7 consultation if there will be adverse effects to listed species. Currently, the Corps only has a project description for activities that will affect valley elderberry longhorn beetle habitat. This is included below.

Following construction, the O&M manual for these reaches will be adjusted to reflect the vegetation variance and the SWIF plan. Under the adjusted O&M manual, large trees that are protected in place under the variance will be allowed to remain on the waterside slopes and additional vegetation will be planted on the planting benches.

Vegetation maintenance includes keeping maintenance roads clear of overhanging branches. Some of the vegetation along the levees includes elderberry shrubs. As part of long-term O&M, elderberry shrubs will be trimmed by the three levee maintenance districts. Table 3 describes the maximum amount of elderberry acreage that will be trimmed each year as a result of O&M. Trimming consists of cutting overhanging branches along the levee slopes on both the landside and waterside. Some shrubs may be located adjacent to the levee with branches hanging over the levee maintenance road. Up to a third of a shrub will be trimmed in a single season. Trimming will occur between November 1 and March 15. Loss of habitat will be offset through the development of a conservation area as described in the conservation measures below. Each year the local maintaining agency will document the amount of valley elderberry longhorn beetle habitat that they have trimmed and report that number to the Corps to ensure compliance with this biological opinion. If the local maintaining agency has a need to exceed the amount of valley elderberry longhorn beetle habitat which needs to be trimmed or affected due to routine maintenance, then they will request the Corps reinitiate consultation on this biological opinion for those actions.

Table 3. O&M by Maintaining Agency

Local Maintaining Agency	Levee Systems Covered	Annual Acreage of Trimmed Elderberry Shrubs*	Total Acreage of Elderberry Shrubs Trimmed over the 50 Year Life of the Project
American River Flood Control District	Lower American River, Dry/Robla Creek, Arcade Creek, NEMDC	0.5	25
Maintenance Area 9	Sacramento River east levee between Sutterville Road and the Beach Lake Levee	0.2	10
City of Sacramento	Sacramento River East Levee between the confluence of the American River and Sutterville Road	0.1	5

*acreage based on an estimated average shrub of 0.027 acre and no more than 1/3 of a shrub trimmed any given year.

Valley Elderberry Longhorn Beetle Habitat

Valley elderberry longhorn beetles are closely associated with elderberry shrubs. In 2011, the Corps conducted surveys and mapped all of the elderberry shrubs on the levees and 15 feet on either side of the levee. Elderberry shrubs were located along the American River and Sacramento River. The Corps counted shrub clusters and used elderberry stem counts from previous projects in the area to estimate a standard number and size of elderberry stems per shrub cluster. Tables 4 and 5 list the stem counts for shrubs along the American River and Sacramento River respectively. While shrubs exist along Arcade Creek or Magpie Creek, the Corps and SAFCA will avoid effects to the beetle by following the conservation measures below.

Table 4. American River Elderberry Shrub Effects and Compensation

Location	Stems	Exit Holes	No. of Stems	Elderberry Ratios	Elderberry Plantings	Associated Native Planting	Associated Native Ratios
riparian	> or = 1" & < or = 3"	no	1,998	2	3,996	3,996	1
		yes	0	4	0	0	2
riparian	> 3" & < 5"	no	790	3	2,370	2,370	1
		yes	16	6	96	192	2
Riparian	> or = 5"	no	312	4	1,248	1,248	1
		yes	23	8	184	368	2
TOTAL			**3,139**		**7,894**	**8,174**	
				total basins or credits=	1,606.8		
				total acres for compensation	66.40		

Table 5. Sacramento River Elderberry Shrub Effects and Compensation

Location	Stems	Exit Holes	No. of Stems	Elderberry Ratios	Elderberry Plantings	Associated Native Plantings	Associated Native Ratios
riparian	> or = 1" & < or = 3"	no	104	2	208	208	1
		yes	0	4	0	0	2
riparian	> 3" & < 5"	no	40	3	120	120	1
		yes	1	6	6	12	2
riparian	> or = 5"	no	16	4	64	64	1
		yes	2	8	16	32	2
TOTAL			**163**		**414**	**436**	
				total basins or credits=	85		
				total acres need for compensation	3.51		

Delta Smelt Habitat

The American River lacks suitable turbidity making it unsuitable for delta smelt. Due to the higher temperatures within Arcade Creek, Magpie Creek, and NEMDC it is also unlikely that delta smelt will use these tributaries. Therefore, suitable delta smelt habitat occurs within the Sacramento River in the reach where erosion protection will occur. The Corps has calculated that there will be a complete loss of 14 acres of shallow water habitat due to the placement of riprap and a change of substrate from natural soil to riprap on 32 acres.

Giant Garter Snake Habitat

Giant garter snakes are not known to use large rivers such as the American and Sacramento Rivers. Given the close proximity to urban development, high level of human disturbance, presence of riparian vegetation along the banks of most channel reaches, and lack of extensive marsh or rice to the east, giant garter snakes are unlikely to occur in Arcade Creek, Dry Creek, Robla Creek, Magpie Creek, or the southern section of the NEMDC (south of where Dry Creek enters). North of Dry Creek, the NEMDC has less woody vegetation, less urban development, and large areas of open grassland along the landside of the levee with rice farming occurring to the west of the grasslands. Therefore, there is potential for the snake to occur either in the upland or within the NEMDC north of where Dry Creek enters. Work in this location will involve removal of borrow material at borrow site 2 (5.5 acres of upland habitat).

Habitat for the giant garter snake also exists north of the existing Sacramento Bypass north levee. The land north of the Sacramento Bypass is currently agricultural fields producing row crops and nut orchards. Existing giant garter snake aquatic habitat occurs in drainage ditches and farm canals and the surrounding upland habitat. About 15 acres of aquatic habitat will be filled making it and the associated 30 acres of upland habitat unavailable to the giant garter snake. The Sacramento Bypass also has a toe drain along the levee with 25 acres of aquatic and 50 acres of upland habitat that will be relocated to the toe of the new Sacramento Bypass levee.

Yellow-billed Cuckoo Habitat

Yellow-billed cuckoos use riparian habitat for foraging and nesting. Suitable habitat occurs within the lower American River. The project will affect 65 acres of riparian habitat that could be used by the yellow-billed cuckoo. While riparian habitat occurs along Arcade Creek, Magpie Creek, and NEMDC it is very narrow and cuckoos are not likely to use these areas. Riparian habitat occurs along the Sacramento River and in some areas may be of such a width that a cuckoo could stop and use it during migration, but it is not wide enough to support a nesting pair of cuckoos. The Corps will remove 110 acres of riparian habitat along the Sacramento River and disturb an additional 50 acres of riparian habitat by removing the understory and placing rock around the large trees. The Sacramento Bypass does not have suitable habitat for the yellow-billed cuckoo. But riparian habitat does exist north of the existing Sacramento Weir along the Sacramento River (8 acres). Cuckoos have been observed in the Yolo Bypass in recent years (Ebird 2015).

Conservation Measures

Valley Elderberry Longhorn Beetle

- The Corps assumes complete avoidance of the valley elderberry longhorn beetle when a 100-foot (or wider) buffer is established and maintained around elderberry shrubs.
- When work will occur within the 100-foot buffer, a setback of 20 feet from the dripline of each elderberry shrub will be maintained whenever possible.
- During construction activities, all areas to be avoided will be fenced and flagged.
- Contractors will be briefed on the need to avoid damaging elderberry shrubs and the possible penalties for not complying with these requirements.
- Signs will be erected every 50 feet along the edge of the avoidance area, identifying the area as an environmentally sensitive area.
- Any damage done to the buffer area will be restored.
- Buffer areas will continue to be protected after construction.
- No insecticides, herbicides, fertilizers, or other chemicals that might harm the beetle or its host plant will be used in the buffer areas.
- Elderberry shrubs that cannot be avoided would be transplanted to an appropriate riparian area at least 100 feet from construction activities.
- Elderberry shrubs will be surveyed prior to construction to ensure that the actual effects match the estimated effects of this biological opinion. If the Corps will effect more valley elderberry longhorn beetle habitat than estimated than they will reinitiate consultation with the Service.
- If possible, elderberry shrubs would be transplanted during their dormant season (November through the first two weeks in February). If transplantation occurs during the growing season, increased mitigation will apply.
- Elderberry compensation will be planted in the American River Parkway. The Corps has six existing sites which are offsetting previous Corps flood control projects along the lower American River and near Folsom Dam. The Corps will find areas within the lower American River parkway which will either expand existing compensation areas or provide for connectivity between conserved valley elderberry longhorn beetle habitat. Sites within the lower American River parkway will be coordinated with Sacramento County Parks and the Service during the design phase of the project. Sites will be designed and developed prior to any effects to valley elderberry

longhorn beetle habitat. The Corps will create 69.91 acres of riparian habitat which supports valley elderberry longhorn beetle within the lower American River parkway for the transplantation of elderberry shrubs. In addition, the local sponsors will create an additional 40 acres of land to benefit the valley elderberry longhorn beetle or purchase 40 acres of credits at a Service approved conservation bank to offset the loss of habitat due to trimming of elderberry shrubs along the lower American River, Sacramento River, Dry/Robla Creeks, Arcade Creek, Magpie Creek, and NEMDC.

- Management of these lands will include all measures specified in the Service's conservation guidelines (1999a) related to weed and litter control, fencing, and the placement of signs.
- Monitoring will occur for 10 consecutive years or for 7 non-consecutive years over a 15-year period. Annual monitoring reports will be submitted to the Service.
- Compensation areas will be protected in perpetuity and have a funding source for maintenance (endowment).

<u>Giant Garter Snake</u>

- Unless approved otherwise by the Service, construction will be initiated only during the giant garter snakes' active period (May 1–October 1, when they are able to move away from disturbance).
- Construction personnel will be given a Service-approved worker environmental awareness program.
- A survey for giant garter snakes will be conducted within 24 hours prior to construction beginning in potential giant garter snake habitat. Should there be any interruption in work for greater than 2 weeks, a biologist will resurvey the area within 24 hours prior to the restart of construction.
- Giant garter snakes encountered during construction will be allowed to move away from construction activities on their own.
- Movement of heavy equipment to and from the construction site will be restricted to established roadways. Stockpiling of construction materials will be restricted to designated staging areas, which will be located more than 200 feet away from giant garter snake aquatic habitat.
- Giant garter snake habitat within 200 feet of construction activities will be designated as an environmentally sensitive area and delineated with signs or fencing. This area will be avoided by all construction personnel.
- Habitat temporarily affected for one season (the 5.5 acre borrow site along the NEMDC and the 75 acres along the toe drain of the Sacramento Bypass levee) will be restored after construction by applying appropriate erosion control techniques and replanting/seeding with appropriate native plants. If for any reason construction extends into another active season the Corps will replace the habitat on-site and purchase credits at a ratio of 1:1 at a Service approved conservation bank.
- Habitat temporarily affected for more than three or more seasons will be restored and twice as much habitat will be created.
- Habitat permanently affected in the Sacramento Bypass in the form of drainage ditches and irrigation canals will be compensated for through the purchase of 135 acres of credits at a Service approved conservation bank.
- One year of monitoring will be conducted for the 80.5 acres that are temporarily affected.

- The Corps will purchase credits at a conservation bank prior to any permanent disturbance of giant garter snake habitat.
- A biological monitor will be on-site during all ground disturbing activities at borrow site 2.
- Exclusionary fencing will be placed, at least 10 days prior to the beginning of ground disturbing activities after May 1, to exclude giant garter snakes from entering areas where upland disturbance (borrow site 2 and Sacramento Bypass) will occur during the active season (May 1 to October 1). Prior to fencing installation, the fence line will be mowed (with a minimum height of 6 inches) in order to conduct a surface survey of potential burrows. Fencing will be installed with a minimum of 6 inches buried in the ground and a minimum of 24 inches above ground. Fence staking will be installed on the inside of the exclusion area. One-way escape funnels will be installed every 50 to 100 feet and sealed along the fence line to provide an escape for any giant garter snake that may be within the exclusion area. The fencing will enclose the entirety of the site, or additional exclusionary fencing can be extended 200 to 400 feet beyond the proposed entrance area. The fencing will be inspected before the start of each work day and maintained by the contractor until completion of the project. The fencing will be removed only when project activities are completed.

Yellow-Billed Cuckoo

- Prior to construction, surveys will be conducted to determine the presence of yellow-billed cuckoos within the project area in accordance with any required Service survey protocols and permits at the time of construction.
- If surveys find cuckoos in the area, vegetation removal will be done outside of the cuckoo nesting season.
- Riparian habitat that is removed due to project construction along the American River will be replanted within the American River parkway. The Corps intends to expand existing conserved riparian lands within the parkway that could support the yellow-billed cuckoo. The design of replacement riparian areas will be coordinated with the Service to ensure that the habitat benefits both valley elderberry longhorn beetles and yellow-billed cuckoos.

Fisheries Conservation Measures

- In-water construction activities (e.g., placement of rock revetment) will be limited to the work window of August 1 through November 30. If the Corps wants to work outside of this window they will consult with National Marine Fisheries Service (NMFS) and/or the Service.
- The Corps will purchase 42 acres of delta smelt credits from a Service-approved conservation bank to off-set the loss of 14 acres of shallow water habitat.
- The Corps will purchase an additional 32 acres of delta smelt credits from a Service-approved conservation bank to off-set the loss of spawning habitat due to the placement of riprap on the river bed.
- Erosion control measures (BMPs), including Storm Water Pollution Prevention Program and Water Pollution Control Program, that minimize soil or sediment from entering the river shall be installed, monitored for effectiveness, and maintained

throughout construction operations to minimize effects to federally listed fish and their designated critical habitat.

- Screen any water pump intakes, as specified by NMFS and the Service screening specifications. Water pumps will maintain an approach velocity of 0.2 feet per second or less when working in areas that may support delta smelt.
- The Corps shall include as part of the project, a Riparian Corridor Improvement Plan with the overall goal of maximizing the ecological function and value of the existing levee system within the Sacramento Metropolitan area.

Additional Minimization and Conservation Measures

- Obtain an ETL approved vegetation variance exempting sites from vegetation removal prior to final design and construction phase for the Sacramento River.
- Construction will be scheduled when listed terrestrial and aquatic species will be least likely to occur in the project area. If construction needs to extend into the timeframe that species are present, then coordination/reinitiation with the Service will occur.
- Compensation for impacts to native riparian habitat will occur on a 2:1 basis on-site or in close proximity to the impact area. Riparian vegetation impacted under the SAFCA 408/404 actions will be replaced on a 3:1 canopy cover acreage basis.
- Stockpile all liquid chemicals and supplies at a designated impermeable membrane fuel and refueling station with a 110% containment system.
- Stockpile construction materials such as portable equipment, vehicles, and supplies, at designated construction staging areas and barges, exclusive of any riparian and wetland areas.
- Implement BMPs to prevent slurry from seeping out to the river and require piping systems on the landside of the levee.
- Project related vehicles will observe a 20-mile-per-hour speed limit within construction areas, except on County roads and on State and federal highways.
- Site access will be limited to the smallest area possible in order to minimize disturbance. Litter, debris, unused materials, equipment, and supplies will be removed from the project area daily. Such materials or waste will be deposited at an appropriate disposal or storage site.
- Immediately (within 24 hours) cleanup and report any spills of hazardous materials to the resource agencies. Any such spills, and the success of the efforts to clean them up, shall also be reported in post-construction compliance reports.
- Designating a Service approved biologist as a point-of-contact for any contractor who might incidentally take a living, or find a dead, injured, or entrapped threatened or endangered species. This representative shall be identified to the employees and contractors during an all employee education program conducted by the Corps.

Action Area

The action area is defined in 50 CFR § 402.02, as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." For the purposes of the effects assessment, the action area encompasses the Sacramento River from the Sacramento Bypass downstream to River Mile 45, the Yolo Bypass south the confluence of the Sacramento Bypass, the lower American River from Arden Way to the confluence of the Sacramento River, Arcade Creek from Marysville Boulevard to the confluence of the NEMDC, the NEMDC from the south Dry

Creek levee to just south of the NEMDC Arcade Creek confluence, the southern Dry Creek levee between Dry Creek Road and Rose Street, the borrow site along the NEMDC, and any borrow sites. Additionally, we are including a buffer of 300 feet from construction to account for effects to listed species due to dust and noise.

Analytical Framework for the Jeopardy Analysis

The following analysis relies on four components to support the jeopardy determination for the giant garter snake, valley elderberry longhorn beetle, yellow-billed cuckoo, and delta smelt: (1) the *Status of the Species*, which evaluates the species' range-wide condition, the factors responsible for that condition, and their survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the species in the action area, the factors responsible for that condition, and the role of the action area in the species' survival and recovery; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on these species; and (4) the *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on these species.

In accordance with the implementing regulations for section 7 and Service policy, the jeopardy determination is made in the following manner: the effects of the proposed Federal action are evaluated in the context of the aggregate effects of all factors that have contributed to the current status of the delta smelt, valley elderberry longhorn beetle, giant garter snake, and yellow-billed cuckoo. Additionally, for non-Federal activities in the action area, we will evaluate those actions likely to affect the species in the future, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both its survival and recovery in the wild.

The following analysis places an emphasis on using the rang-wide survival and recovery needs of the delta smelt, valley elderberry longhorn beetle, giant garter snake, and yellow-billed cuckoo, and the role of the action area in providing for those needs as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Analytical Framework Adverse Modification

This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.2. Instead, we have relied upon the statutory provisions of the Act to complete the following analysis with respect to critical habitat.

In accordance with policy and regulation, the adverse modification analysis in this biological opinion relies on four components: (1) the *Status of the Critical Habitat*, which evaluates the range-wide condition of critical habitat for the delta smelt in terms of primary constituent elements (PCE)s, the factors responsible for that condition, and the intended recovery function of the critical habitat at the provincial and range-wide scale; (2) the *Environmental Baseline*, which evaluates the condition of the critical habitat in the action area, the factors responsible for that condition, and the recovery role of the critical habitat in the action area; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the PCEs and how that will influence the recovery role of affected critical habitat units and; (4) *Cummulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the PCEs and how that will influence the recovery role of affected critical habitat units.

For purposes of the adverse modification determination, the effects of the proposed Federal action on the delta smelt critical habitat are evaluated in the context of the range-wide condition of the critical habitat at the provincial and range-wide scales, taking into account any cumulative effects, to determine if the critical habitat range-wide would remain functional (or would retain the current ability for the PCEs to be functionally established in areas of currently unsuitable but capable habitat) to serve its intended recovery role for the delta smelt.

The analysis in this biological opinion places an emphasis on using the intended range-wide recovery function of delta smelt critical habitat and the role of the action area relative to that intended function as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the adverse modification determination.

Status of the Species and Environmental Baseline

Valley Elderberry Longhorn Beetle Status of the Species

Please refer to the *Withdrawl of the Proposed Rule to Remove the Valley Elderberry Longhorn Beetle from the Federal List of Endangered and Threatened Wildlife* (Service 2014) for the current status of the species. Ongoing threats to the valley elderberry longhorn beetle include habitat loss due to flood control projects, development projects, and invasive species. While these threats continue to affect the valley elderberry longhorn beetle throughout its range, to date no project has proposed a level of effect for which the Service has issued a biological opinion of jeopardy for the valley elderberry longhorn beetle.

Valley Elderberry Longhorn Beetle Environmental Baseline

The project footprint along both the Sacramento River and the American River contain riparian vegetation. The beetle is known in numerous locations along the American River parkway (CNDD 2015). Suitable habitat for the beetle in the form of elderberry shrubs occurs within the action area along the Sacramento River, the American River, and Arcade Creek.

Sacramento River - Riparian habitat along the Sacramento River, south of the city of Sacramento, occurs in narrow bands along the riverbank and levee. Generally an overstory layer is present composed of cottonwood, sycamore, and oak trees. Shrubs occur as a mid-story layer including buttonbush, blue elderberry, white alder, and Oregon ash. Elderberry shrubs occur randomly along the reach of river proposed for improvements. The Corps has documented at least 73 elderberry shrubs along the Sacramento River reach where construction is proposed. Natural river processes of erosion and accretion effect elderberry shrubs which is the host plant of the valley elderberry longhorn beetle by eroding away bank and potentially elderberry shrubs. Levee maintenance can adversely affect elderberries within this stretch of the Sacramento River either by pruning or drift of herbicides used along the levee slope.

American River – The valley elderberry longhorn beetles have been identfied along the lower American River Parkway in the CNDDB (2015). Additionally, the Corps has designed and built six sites along the lower American River as habitat for the valley elderberry longhorn beetle. These sites extend from RM 0.9 up to RM 21. Levee maintenance can adversely affect elderberry shrubs, though the largest threat to valley elderberry longhorn beetle is fires that have been started in the parkway and burned habitat that supports valley elderberry longhorn beetles.

Delta Smelt Status of Species

Listing Status: The Service proposed to list the delta smelt as threatened with proposed critical habitat on October 3, 1991 (56 FR 50075). The Service listed the delta smelt as threatened on March 5, 1993 (58 FR 12854), and designated critical habitat for this species on December 19, 1994 (59 FR 65256). The delta smelt was one of eight fish species addressed in the *Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes* (Service 1996). This recovery plan is currently under revision. A 5-year status review of the delta smelt was completed on March 31, 2004 (Service 2004). The 2004 review affirmed the need to retain the delta smelt as a threatened species. A 12-month finding on a petition to reclassify the delta smelt was completed on April 7, 2010 (75 FR 17667). After reviewing all available scientific and commercial information, the Service determined that re-classifying the delta smelt from a threatened to an endangered species was warranted, but precluded by other higher priority listing actions (Service 2010).

Distribution: The delta smelt is endemic to the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta) in California, and is restricted to the area from San Pablo Bay upstream through the Delta in Contra Costa, Sacramento, San Joaquin, Solano, and Yolo counties (Moyle 2002). Their range extends from San Pablo Bay upstream to Verona on the Sacramento River and Mossdale on the San Joaquin River. The delta smelt was formerly considered to be one of the most common pelagic fish in the upper Sacramento-San Joaquin Estuary.

Description: Live delta smelt are nearly translucent with a steely-blue sheen to their sides and have been characterized to have a pronounced odor reminiscent of cucumber (Moyle 2002). Although delta smelt have been recorded to reach lengths of up to 120 millimeters (mm) (4.7 in) (Moyle 2002), mean fork length of the delta smelt from 1974 to 1991 was measured to be 64.1 ± 0.1 mm. Since then, catch data from 1992 - 2004 showed mean fork length decreased to 54.1 ± .01 mm (Bennett 2005; Sweetnam 1999). Delta smelt are also identifiable by their relatively large eye to head size (Moyle 2002). Delta smelt have a small, translucent adipose fin located between the dorsal and caudal fins.

The delta smelt is one of six species currently recognized in the *Hypomesus* genus (Bennet 2005). Genetic analyses have confirmed that *H. transpacificus* presently exists as a single intermixing population (Stanley *et al.* 1995; Trenham *et al.* 1998; Fisch *et al.* 2011). Within the genus, delta smelt is most closely related to surf smelt (*H. pretiosis*), a species common along the western coast of North America. Despite morphological similarities, the delta smelt is less-closely related to the wakasagi (*H. nipponensis*), an andadromous western Pacific species introduced to Central Valley reservoirs in 1959, and may be seasonally sympatric with delta smelt in the estuary (Trenham *et al.* 1998). Allozyme studies have demonstrated that wakasagi and delta smelt are genetically distinct and presumably derived from different marine ancestors (Stanley *et al.* 1995).

Life History and Biology

Adult-Spawning: Adult delta smelt spawn during the late winter and spring months, with most spawning occurring during April through mid-May (Moyle 2002). Spawning occurs primarily in sloughs and shallow edge areas in the Delta. Delta smelt spawning has also been recorded in Suisun Marsh and the Napa River (Moyle 2002). Most spawning occurs at temperatures between 12-18°C. Although spawning may occur at temperatures up to 22°C, hatching success of the larvae is very low (Bennett 2005).

Fecundity of females ranges from about 1,200 to 2,600 eggs, and is correlated with female size (Moyle 2002). Moyle *et al.* (1992) considered delta smelt fecundity to be "relatively low." However, based on Winemiller and Rose (1992), delta smelt fecundity is fairly haigh for a fish its size. Captive delta smelt can spawn up to 4-5 times. While most adults do not survive to spawn a second season, a few (<5 percent) do (Moyle 2002; Bennett 2005). Those that do survive are typically larger (90-110 mm Standard Length[sdl]) females that may contribute disproportionately to the population's egg supply (Moyle 2002 and references therein). Two-year-old females may have 3-6 times as many ova as first year spawners.

Most of what is known about delta smelt spawning habitat in the wild is inferred from the location of spent females and young larvae captured in the California Department of Fish and Wildlife Spring Kodiak Trawl (SKT) and 20-mm Survey, respectively. In the laboratory, delta smelt spawned at night (Baskerville-Bridges *et al.* 2000; Mager *et al.* 2004). Other smelts, including marine beach spawning species and estuarine populations and the landlocked Lake Washington longfin smelt, are secretive spawners, entering spawning areas during the night and leaving before dawn. If this behavior is exhibited by delta smelt, then delta smelt distribution based on the SKT, which is conducted during daylight hours in offshore habitats, may reflect general regions of spawning activity, but not actual spawning sites.

Delta smelt spawning has only been directly observed in the laboratory and eggs have not been found in the wild. Consequently, what is known about the mechanics of delta smelt spawning is derived from laboratory observations and observations of related smelt species. Delta smelt eggs are 1 mm diameter and are adhesive and negatively buoyant (Moyle 1976, 2002; Mager *et al.* 2004; Wang 1986, 2007). Laboratory observations indicate that delta smelt are broadcast spawners, discharging eggs and milt close to the bottom over substrates of sand and/or pebble in current (DWR and Reclamation 1994; Brown and Kimmerer 2002; Lindberg *et al.* 2003; Wang 2007). Spawning over gravel or sand can also aid in the oxygenation of delta smelt eggs. Eggs that may have been laid in silt or muddy substrates might get buried or smothered, preventing their oxygenation from water flow (Lindberg pers. comm. 2011). The eggs of surf smelts and other beach spawning smelts adhere to sand particles, which keeps them negatively buoyant but not immobile, as the sand may move ("tumble") with water currents and turbulence (Hay 2007). It is not known whether delta smelt eggs "tumble incubate" in the wild, but tumbling of eggs may moderately disperse them, which might induce predation risk within a localized area.

The locations in the Delta where newly hatched larvae are present, most likely indicates spawning occurrence. The 20-mm trawl has captured small (~5 mm sdl) larvae in Cache Slough, the lower Sacramento River, San Joaquin River, and at the confluence of these two rivers (e.g., 20-mm trawl survey 1 in 2005). Larger larvae and juveniles (size > 23 mm sdl), which are more efficintly sampled by the 20-mm trawl gear, have been captured in Cache Slough and the Sacramento Deep Water Ship Channel in July (e.g. 20-mm trawl survey 9 in 2008). Because they are small fish inhabiting pelagic habitats with strong tidal and river currents, delta smelt larval distribution depends on both the spawning area from which they originate and the effect of transport processes caused by flows. Larval distribution is further affected by water salinity and temperature. Hydrodynamic simulations reveal that tidal action and other factors may cause substantial mixing of water with variable salinity and temperature among regions of the Delta (Monson *et al.* 2007). This could result in rapid dispersion of larvae away from spawning sites.

The timing of spawning may affect delta smelt population dynamics. Lindberg (2011) has suggested that smelt larvae that hatch early, around late February, have an advantage over larvae hatched during late spawning in May. Early season larvae have a longer growing season and may be able to grow larger faster during more favorable habitat conditions in the late winter and early spring. An early growing season may result in higher survivorship and a stronger spawning capability for that generation. Larvae hatched later in the season have a shorter growing season which effectively reduces survivorship and spawning success for the following spawning season.

Larval Development: Mager *et al.* (2004) reported that embryonic development to hatching takes 11-13 days at 14-16° C for delta smelt, and Baskerville-Bridges *et al.* (2000) reported hatching of delta smelt eggs after 8-10 days at temperatures between 15-17° C. Lindberg *et al.* (2003) reported high hatching rates of delta smelt eggs in the laboratory at 15° C, and Wang (2007) reported high hatching rates at temperatures between 14-17° C. Hatching success peaks near 15°C (Bennett 2005) and swim bladder inflation occurring at 60-70 days post hatch at 16-17°C (Mager *et al.* 2004). At hatching and during the succeeding three days, larvae are buoyant, swim actively near the water surface, and do not react to bright direct light (Mager *et al.* 2004). As development continues, newly hatched delta smelt become semi-buoyant and sink in stagnant water. However, larvae are unlikely to encounter stagnant water in the wild.

Growth rates of wild-caught delta smelt larvae are faster than laboratory-cultured individuals. Mager *et al.* (2004) reported growth rates of captive-raised delta smelt reared at near-optimum temperatrues (16-17°C). Their fish were about 12 mm long after 40 days and about 20 mm long after 70 days. In contrast, analyses of otoliths indicated that wild delta smelt larvae were 15-25 mm, or nearly twice as long at 40 days of age (Bennett 2005). By 70 days, most wild fish were 30-40 mm long and beyond the larval stage. This suggests there is a strong selective pressure for rapid larval growth in nature, a situation that is typical for fish in general (Houde 1987). Successful feeding seems to depend on a high density of food organisms and turbidity, and increases with stronger light conditions (Baskerville-Bridges *et al.* 2000; Mager *et al.* 2004; Baskerville-Bridges *et al.* 2004). The food available to larval fishes is constrained by mouth gape and status of fin development. Larval delta smelt cannot capture as many kinds of prey as larger individuals, but all life stages have small gapes that limit their range of potential prey. Prey availability is also constrained by habitat use, which affects what types of prey are encountered. Larval delta smelt are visual feeders. They find and select individual prey organisms and their ability to see prey in the water is enhanced by turbidity (Baskerville-Bridges *et al.* 2004). Thus, delta smelt diets are largely comprised of small crustacea that inhabit the estuary's turbid, low-salinity, open-water habitats (i.e., zooplankton). Larval delta smelt have particularly restricted diets (Nobriga 2002). They do not feed on the full array of zooplankton with which they co-occur; they mainly consume three copepods, *Eurytemora affinis*, *Pseudodiaptomus forbesi*, and freshwater species of the family Cyclopidae. Further, the diets of first-feeding delta smelt larvae are largely restricted to the larval stages of these copepods; older, larger life stages of the copepods are increasingly targeted as the delta smelt larvae grow, their gape increases, and they become stronger swimmers.

The triggers for and duration of delta smelt larval movement from spawning areas to rearing areas are not known. Hay (2007) noted that eulachon larvae are probably flushed into estuaries from upstream spawning areas within the first day after hatching, but downstream movement of delta smelt larvae occurs much later. Most larvae gradually move downstream toward the two parts per thousand (ppt) isohaline (X2). X2 is scaled as the distance in kilometers from the Golden Gate Bridge (Jassby *et al.* 1995).

At all life stages, delta smelt are found in greatest abundance in the water column and usually not in close association with the shoreline. They inhabit open, surface waters of the Delta and Suisun Bay, where they presumably aggregate in loose schools where conditions are favorable (Moyle 2002). In years of moderate to high Delta outflow (above normal to wet water years), delta smelt larvae are abundant in the Napa River, Suisun Bay and Montezuma Slough, but the degree to which these larvae are produced by locally spawning fish versus the degree to which they originate upstream and are transported by tidal currents to the bay and marsh is uncertain.

Juveniles: Young-of-the-year delta smelt rear in the low-salinity zone (LSZ) from late spring through fall and early winter. Once in the rearing area growth is rapid, and juvenile fish are 40-50 mm sdl long by early August (Erkkila *et al.* 1950; Ganssle 1966; Radtke 1966). They reach adult size (55-70 mm sdl) by early fall (Moyle 2002). Delta smelt growth during the fall months slows considerably (only 3-9 mm total), presumably because most of the energy ingested is being directed towards gonadal development (Erkkila *et al.* 1950; Radtke 1966).

Delta Smelt Population Dynamics and Abundance Trends

As a consequence of channelization, water operations, and agriculture in the Delta there has been a change to the physical appearance, water salinity, water clarity, and hydrology in the Delta such that most life stages of the delta smelt are now distributed across a smaller area than historically (Arthur *et al.* 1996; Feyrer *et al.* 2007). Wang (1991) noted in a 1989 and 1990 study of delta smelt larval distribution that, in general, the San Joaquin River was used more intensively for spawning than the Sacramento River. Nobriga *et al.* (2008) found that delta smelt capture probabilities in the Summer Townet Survey (TNS) are highest at specific conductance levels of 1,000 to 5,000 $\mu S\ cm^{-1}$ (approximately 0.6 to 3.0 practical salinity unit [psu]). Similarly, Feyrer *et al.* (2007) found a decreasing relationship between abundance of delta smelt in the Fall Midwater Trawl (FMWT) and specific conductance during September through December. The location of the low salinity zone (LSZ) and changes in delta smelt habitat quality in the San Francisco Estuary can be indexed by changes in X2. The LSZ historically had the highest primary productivity and is where zooplankton populations (on which delta smelt feed) were historically most dense (Knutson and Orsi 1983; Orsi and Mecum 1986). However, this has not always been true since the invasion of the overbite clam (Kimmerer and Orsi 1996). The abundance of many local aquatic species has tended to increase in years when winter-spring outflow has high and Z2 was pushed seaward (Jassby *et al.* 1995), implying that the quantity and quality (overall suitability) of estuarine habitat increases in years when outflows are high. However, delta smelt is not one of the species whose abundance has statistically covaried with winter-spring freshwater flows (Stevens and Miller 1983; Moyle *et al.* 1992; Kimmerer 2002a; Bennett 2005).

The distribution of juvenile delta smelt has also changed over the last several decades. During the years 1970 through 1978, delta smelt catches in the TNS survey declined rapidly to zero in the Central and South Delta and have remained near zero since. A similar shift in FMWT catches occurred after 1981 (Arthur *et al.* 1996). This portion of the Delta has also had a long-term trend increase in water clarity during July through December (Arthur *et al.* 1996; Feyrer *et al.* 2007; Nobriga *et al.* 2008).

The CDFW has conducted several long-term monitoring surveys that have been used to index the relative abundance of delta smelt. The 20-mm Survey has been conducted every year since 1995. This survey targets late-stage delta smelt larvae. Most sampling has occurred April-June. The TNS has been conducted nearly every year since 1959. This survey targets 38-mm striped bass, but collects similar-sized juvenile delta smelt. Most sampling has occurred June-August. The Fall Midwater Trawl Survey has been conducted nearly every year since 1967. This survey also targets age-0 striped bass, but collects delta smelt > 40 mm in length. The FMWT samples monthly, September-December. The relative abundance index data and maps of the sampling stations used in these surveys are available at http://www.CDFW.ca.gov/delta/. The methods that underlie the surveys have been described previously (Stevens and Miller 1983; Moyle *et al.* 1992; Dege and Brown 2004). The delta smelt catch data and relative abundance indices derived from these sampling programs have been used in numerous publications (e.g., Stevens and Miller 1983; Moyle *et al.* 1992; Jassby *et al.* 1995; Kimmerer 2002b; Dege and Brown 2004; Bennett 2005; Feyrer *et al.* 2007; Sommer *et al.* 2007; Kimmerer 2008; Newman 2008; Nobriga *et al.* 2008; Kimmerer *et al.* 2009; Mac

Nally *et al.* 2010; Thomson *et al.* 2010; Feyrer *et al.* 2011; Maunder and Deriso 2011). These abundance index time series document the long-term decline of the delta smelt.

Early statistical assessments of delta smelt population dynamics concluded that at best, the relative abundance of the adult delta smelt population had only a very weak influence on subsequent juvenile abundance (Sweetnam and Stevens 1993). Thus, early attempts to describe abundance variation in delta smelt ignored stock-recruit effects and researchers looked for environmental variables that were directly correlated with interannual abundance variation (e.g., Stevens and Miller 1983; Moyle *et al.* 1992; Sweetnam and Stevens 1993; Herbold 1994; Jassby *et al.* 1995). Because delta smelt live in a habitat that varies in size and quality with Delta outflow, the authors cited above searched for a linkage between Delta outflow (or X2) and the TNS and FMWT indices. Generally, these analyses did not find strong support for an outflow-abundance linkage. These analyses led to a prevailing conceptual model that multiple interacting factors had caused the delta smelt decline (Moyle *et al.* 1992; Bennett and Moyle 1996; Bennett 2005). It has also recently been noted that delta smelt's FMWT index is partly influenced by explanation for why few analyses could consistently link springtime environmental conditions to delta smelt's fall index.

One published exception to the multi-factor hypothesis was proposed by Gilbert (2010), who posited that nutrient pollution was the root cause of all the food web and fish assemblage changes that caused the decline of delta smelt and other pelagic fishes. However, the statistical approach she used to support her hypothesis was not appropriate and the untransformed data sets do not support this hypothesized chain of consequences stemming solely from wastewater inputs to the Delta (Jassby *et al.* in press). It is now recognized that delta smelt abundance plays an important role in subsequent abundance (Bennett 2005; Maunder and Deriso 2011). Bennett (2005) assessed (1) the influence of adult stock as indexed by the FMWT versus the next generation of juveniles indexed by the following calendar year's TNS; (2) the influence of the juvenile stock indexed by the TNS versus the subsequent adult stock indexed a few months later in the FMWT; (3) the influence of the FMWT on the following year's FMWT and on the FMWT two years later, and (4) he did the same for the TNS data. He concluded that (1) two-year-old delta smelt might play an important role in delta smelt population dynamics, (2) it was not clear wheter juvenile production was a density-independent or density-dependent function of adult abundance, and (3) adult production was a density-dependent function of juvenile abundance and the carrying capacity of the estuary to support this life-stage transition had declined over time. These conclusions are also supported by Maunder and Deriso (2011).

The concept of density-dependence and how it has affected the delta smelt is important because it may be used as a reason not to protect particular life stages from sources of mortality. Bennet (2005) concluded it was (statistically) unclear whether density-dependence occurs between generations. He also noted that the delta smelt indices strongly suggest that density-dependence has occurred, at least over the long-term, during the juvenile stage. The uncertainty about density-dependence between generations results because statistical assessments of the relationship between the adult stock and the next generation of recruits (juveniles_ result in similar fits for linear (density-independent) and nonlinear (density-dependent) relationships (Bennett 2005; Maunder and Deriso 2011).

One reason for this is that delta smelt population dynamics may have changed over time. Previous papers have reported a delta smelt step-decline during 1981-1982 (Kimmerer 2002a; Thomson *et al.* 2010). Prior to this decline, the stock-recruit data are consistent with "Ricker" type density-dependence where increasing adult abundance resulted in decreased juvenile abundance. Since the decline, recruitment has been positively and essentially linearly related to prior adult abundance, suggesting that reproduction has been basically density-independent for about the past 30 years.

This means that since the early 1980s, more adults translates into more juveniles and fewer adults translates into fewer juveniles without being 'compensated for' by density-dependence. In contrast to the transition among generations, the weight of scientific evidence strongly supports the hypothesis that, at least over the history of Interagency Ecological Program (IEP) fish monitoring, delta smelt has experienced density-dependence during the juvenile stage of its life cycle, i.e., between the summer and fall (Bennett 2005; Maunder and Deriso 2011). This has been inferred because, statistically, the FMWT index does not increase linearly with increases in the summer townet index. Rather, the best-fitting relationships between the summer townet index and the FMWT index show that the FMWT indices approach an asymptote as the summer townet increases or possibly even declines at the highest summer townet indices.

From a species conservation perspective, the most relevant aspect of this juvenile density dependence is that the carrying capacity of the estuary for delta smelt has declined (Bennett 2005). Thus, the delta smelt population decline has occurred for two basic reasons. First, the compensatory density-dependence that historically enabled juvenile abundance to rebound from low adult numbers stopped happening. This change had occurred by the early 1980s as described above. The reason is still not known, but the consequence of the change is that for the past several decades, adult abundance drives juvenile production in a largely density-independent manner. Thus, if numbers of adults or adult fecundity decline, juvenile production will also decline (Kimmerer 2011). Second, because juvenile carrying capacity has declined, juvenile production hits a 'ceiling' at a lower abundance than it once did. This limits adult abundance and possibly per capita fecundity, which cycles around and limits the abundance of the next generation of juveniles. The mechanism causing carrying capacity to decline is likely due to the long-term accumulation of deleterious habitat changes, both physical and biological, during the summer-fall (Bennett *et al.* 2008; Feyrer *et al.* 2007; 2011; Maunder and Deriso 2011).

Habitat

The existing physical appearance and hydrodynamics of the Delta have changed substantially from the environment in which native fish species like delta smelt evolved. The Delta once consisted of tidal marshes with networks of diffuse dendritic channels connected to floodplains of wetlands and upland areas (Moyle 2002). The in-Delta channels were further connected to drainages of larger and smaller rivers and creeks entering the Delta from the upland areas. In the absence of upstream reservoirs, freshwater inflow from smaller rivers and creeks and the Sacramento and San Joaquin Rivers were highly seasonal and more strongly and reliably affected by precipitation patterns than they are today. Consequently, variation in hydrology, salinity, turbidity, and other characteristics of the Delta aquatic ecosystem was greater in the past than it is today (Kimmerer 2002a). For instance, in the early 1900s, the location of maximum salinity intrusion into the Delta during dry periods varied from Chipps Island in the lower Delta to Stockton along the San Joaquin River and Merritt Island in the Sacramento River. Operations of upstream reservoirs have reduced spring flows while releases of water for Delta water export and increased flood control storage have increased late summer and fall inflows (Knowles 2002), though Delta outflows have been tightly constrained during late summer-fall for several decades. The following is a brief description of the changes that have occurred to delta smelt's habitat that are relevant to the environmental baseline for this consultation.

Changes to the LSZ: There have been documented changes to the delta smelt's LSZ habitat that have led to present-day, baseline habitat conditions. The close association of delta smelt with the San Francisco estuary LSZ has been known for many years (Stevens and Miller 1983; Moyle *et al.* 1992). Peterson (2003) developed a conceptual model that hypothesized how, "stationary and dynamic components of estuarine habitats" interacted to influence fisheries production in tidal river estuaries.

Peterson's model suggests that when the dynamic and static aspects of estuarine habitat sufficiently overlap, foraging, growth, density, and survival are all high, and that enables fish production to outpace losses to predators. The result is high levels of successful recruitment of new individuals. The model also hypothesizes that when the dynamic and static aspects of an estuarine habitat do not sufficiently overlap, foraging, growth, density, and survival are impaired such that losses to predators increase and recruitment of new individuals decreases. This model was developed specifically for species spawned in marine environments that were subsequently transported into estuaries. However, the concept of X2, which was developed in the San Francisco estuary to describe how freshwater flow affected estuarine habitat (Jassby *et al.* 1995), played a role in the intellectual development of Peterson's model. The Peterson model also provides a useful framework to conceptualize delta smelt's LSZ habitat.

Currently available information indicates that delta smelt habitat is most suitable for the fish when low-salinity water is near 20°C, highly turbid, oxygen saturated, low in contaminants, supports high densities of calanoid copepods and mysid shrimp (Moyle *et al.* 1992; Lott 1998; Nobriga 2002), and occurs over comparatively static 'landscapes' that support sandy beaches and bathymetric variation that enables the fish and their prey to aggregate (Kimmerer *et al.* 2002a; Bennett *et al.* 2002; Hobbs *et al.* 2006). Almost every component listed above has been degraded over time (see below). The Service has determined that this accumulation of habitat change is the fundamental reason or mechanism that has caused delta smelt to decline.

Alterations to estuarine bathymetry and salinity distribution (~ 1850-present): The position of the LSZ, where delta smelt rear, has changed over the years. The first major change in the LSZ was the conversion of the landscape over which tides oscillate and river flows vary (Moyle *et al.* 2010). The ancestral Delta was a large tidal marsh-floodplain habitat totaling approximately 700,000 acres. Most of the historic wetlands within the system were diked and reclaimed for agriculture or other human uses by 1920 (Atwater *et al.* 1979). Channels were dredged deep (~12 meters[m]) to accommodate shipping traffic from the Pacific Ocean and San Francisco Bay to ports in Sacramento and Stockton. These changes left Suisun Bay and the confluence of the Sacramento-San Joaquin Rivers as the largest and most bathymetrically variable places in the LSZ. This region remained a highly productive nursery for many decades (Stevens and Miller 1983; Moyle *et al.* 1992; Jassby *et al.* 1995). However, the deepened channels created to support shipping and flood control, requires more freshwater outflow to maintain the LSZ in the large Suisun Bay and River confluence than was once required (Gartrell 2010). The construction of the CVP and SWP not only provided water supply for urban, agricultural and industrial users, but also provided water needed to combat salinity intrusion into the Delta, which was observed by the early 20th century. California's demand for freshwater (keeps) continues to increase, thus seasonal salinity intrusion perpetually reduces the temporal overlap of the LSZ (indexed by X2) within the Suisun Bay (region), especially in the fall (Feyrer *et al.* 2007; 2011). Consequently, the second major habitat change in the Delta has been in the frequency with which the LSZ is maintained in Suisun Bay for any given amount of precipitation. There was a step-decline in the LSZ in 1977 from which it has never recovered for more than a few years at a time. Based on model forecasts of climate change and water demand, this trend is expected to continue (Feyrer *et al.* 2011).

Summer and fall environmental quality has decreased overall in the Delta because outflows are lower and water transparency is higher. These changes may be due to increased upstream water diversions for flooding rice fields (Kawakami *et al.* 2008). The confluence of the Sacramento and San Joaquin Rivers has, as a result, become increasingly important as a rearing location for delta smelt, with physical environmental conditions constricting the species range to a relatively narrow area (Feyrer *et al.* 2007; Nobriga *et al.* 2008). This has increased the likelihood that most of the juvenile population is exposed to chronic and cyclic environmental stressors, or catastrophic events. For instance, all seven delta smelt collected during the September 2007 FMWT survey were captured at statistically significantly higher salinities than what would be expected based upon historical distribution data generated by Feyrer *et al.* (2007). During the same year, the annual bloom of toxic cyanobacteria (Microcystis aeruginosa) spread far downstream to the west Delta and beyond during the summer (Peggy Lehman, pers comm). This has been suggested as an explanation for the anomaly in the distribution of delta smelt relative to water salinity levels (US Bureau of Reclamation 2008).

Bank Protection (Levees): The placement of riprap bank protection has led to the loss of riparian habitat, large woody debris, shallow water habitat, and natural channel migration. Bank stabilization and riprapping has been shown to change natural river processes such as erosion and accretion which reduces habitat complexity; creates a smooth, hydraulically enhanced surface that is not conducive to the habitat requirements of fish including delta smelt; stops woody vegetation from entering the river and reduces the long-term recruitment of large woody debris; inhibits plant growth through a change is substrate; lowers the amount of outside food sources because of the lack of riparian and wetland vegetation for aquatic invertebrates; and increases stream edge velocities which decreases available refuge areas for fish (Service 2000). More than half of the Sacramento River's lower 194 miles have been riprapped, mostly under the Corps Sacramento River bank Protection Project. Today most of the riparian forests and wetlands have been removed and the Sacramento River has been constrained to not allow natural erosion and accretion to occur.

Turbidity: From 1999 to present, the Delta experienced a change in estuarine turbidity that culminated in an estuary-wide step-decline in 1999 (Schoellhamer 2011). For decades, the turbidity of the modified estuary had been sustained by very large sediment deposits resulting mainly from gold mining in the latter 19th century. Sediments continued to accumulate into the mid-20th century, keeping the water relatively turbid even as sediment loads from the Sacramento River basin declined due to dam and levee construction (Wright and Schoellhamer 2005). The flushing of the sediment deposits may also have made the estuary deeper overall and thus a less suitable nursery from the 'static' bathymetric perspective (Schroeter 2008).

Delta smelt are associated with highly turbid waters; there is a negative correlation between the frequency of delta smelt occurrence in survey trawls during the summer, fall and early winter and water clarity. For example, the likelihood of delta smelt occurrence in trawls at a given sampling station decreases with increasing Secchi depth at the stations (Feyrer *et al.* 2007, Nobriga *et al.* 2008). This is very consistent with behavioral observations of captive delta smelt (Nobriga and Herbold 2008). Few daylight trawls catch delta smelt at Secchi depths over 0.5 m and capture probabilities for delta smelt are highest at 0.40 m depth or less. First-feeding delta smelt larvae require relatively turbid (muddy) waters to capture prey, but older fish do not require turbidity to capture prey and very high turbidity may even have some inhibitory effect on prey consumption (Hasenbein *et al.* 2013). Delta smelt may also use turbidity as cover from predators; this was hypothesized based on long-term monitoring of the distribution of fish in the wild (e.g., Feyrer *et al.* 2007) and recently supported by a laboratory experiment (Ferrari *et al.* 2014).

Temperature: Temperature also affects delta smelt distribution. Swanson and Cech (1995) and Swanson *et al.* (2000) indicate delta smelt tolerate temperatures (<8° C to >25° C), however warmer water temperatures >25° C restrict their distribution more than colder water temperatures (Nobriga and Herbold 2008). Delta smelt of all sizes are found in the main channels of the Delta and Suisun Marsh and the open waters of Suisun Bay where the water is well oxygenated and temperatures are usually less than 25° C in summer (Nobriga *et al.* 2008). Currently, delta smelt are subjected to thermally stressful temperatures every summer, and all available regional climate change projections predict central California will be warmer still in the coming decades (Dettinger 2005). We expect warmer estuary temperatures to be yet another significant conservation challenge based on climate change models. Warmer water temperatures would increase delta smelt mortality and constrict suitable habitat throughout the Delta during the summer months. Higher temperatures would shrink delta smelt distribution into the fall, limiting their presence to Suisun Bay and in waters with less than optimal salinities (Brown *et al.* 2013). Water temperatures are presently above 20°C for most of the summer in core habitat areas, sometimes even exceeding the nominal lethal limit of 25°C for short periods. Coldwater fishes begin to have behavioral impairments (Marine and Cech 2004) and lose competitive abilities (Taniguchi *et al.* 1998) prior to reaching their thermal tolerance limits. Thus, the estuary can already be considered thermally stressful to delta smelt and can only become more so if temperatures warm in the coming decades.

Foraging Ecology: Delta smelt feed primarily on small planktonic crustaceans, and occasionally on insect larvae (Moyle 2002). Juvenile-stage delta smelt prey upon copepods, cladocerans, amphipods, and insect larvae (Moyle 2002). Historically, the main prey of delta smelt was the euryhaline copepod *Eurytemora affinis* and the euryhaline mysid *Neomysis mercedis.* The slightly larger *Pseudodiaptomus forbesi* has replaced *E. affinis* as a major prey source of delta smelt since its introduction into the Bay-Delta, especially in summer, when it replaces *E. affinis* in the plankton community (Baxter *et al.* 2008; Moyle 2002). The most common copepod in the estuary now is a small nonnative species, *Limnoithona tetraspina.* It has been suggested that *L. tetraspina* may be an inferior food for pelagic fishes including delta smelt because of its small size and generally sedentary behavior (Bouley and Kimmerer 2006). Experimental studies addressing this issue have suggested that smelt larvae will attack *L. tetraspina* until they grow large enough to successfully capture larger copepods; also, growth rate of delta smelt fed *L. tetraspina* was lower than that of smelt fed the larger copepods (Sullivan *et al.*, unpublished). *L. tetraspina* is sometimes consumed in large numbers by juvenile delta smelt during late summer when this copepod is abundant in the LSZ (Slater and Baxter 2014). *Acartiella sinensis*, a calanoid copepod species that invaded the Delta at the same time as *L. tetraspina*, also occurs at high densities in Suisun Bay and in the western Delta over the last decade. Delta smelt eat these newer copepods, but *Pseudodiaptomus* remains their dominant prey (Baxter *et al.* 2008).

River flows influence estuarine salinity gradients and water residence times and thereby affect both habitat suitability for benthos and the transport of pelagic plankton upon which delta smelt feed. High tributary flow leads to lower residence time of water in the Delta, which generally results in lower plankton biomass (Kimmerer 2004). In contrast, higher residence times, which result from low tributary flows, can result in higher plankton biomass but water diversions, overbite clam grazing (Jassby *et al.* 2002) and possibly contaminants (Baxter *et al.* 2008) remove a lot of plankton biomass when residence times are high. These factors all affect food availability for planktivorous fishes that utilize the zooplankton in Delta channels. Delta smelt cannot occupy much of the Delta anymore during the summer (Nobriga *et al.* 2008). Thus, there is the potential for mismatches between regions of high zooplankton abundance in the Delta and delta smelt distribution now that the overbite clam has decimated LSZ zooplankton densities.

The delta smelt compete with and are prey for several native and introduced fish species in the Delta. The introduced Mississippi silverside may prey on delta smelt eggs and/or larvae and compete for copepod prey (Bennett and Moyle 1996; Bennett 2005). Young striped bass also use the LSZ for rearing and may compete for copepod prey and eat delta smelt. Centrarchid fishes and coded wire tagged Chinook salmon smolts released in the Delta for survival experiments since the early 1980s may potentially also prey on larval delta smelt (Brandes and McLain 2001; Nobriga and Chotkowski 2000). Studies during the early 1960s found delta smelt were only an occasional prey fish for striped bass, black crappie and white catfish (Turner and Kelley 1966). However, delta smelt were a comparatively rare fish even then, so it is not surprising they were a rare prey. Striped bass appear to have switched to piscivorous feeding habits at smaller sizes than they historically did, following severe declines in the abundance of mysid shrimp (Feyrer *et al.* 2003). Nobriga and Feyrer (2008) showed that Mississippi silverside, which is similar in size to delta smelt, was only eaten by subadult striped bass less than 400-mm fork length. While largemouth bass are not pelagic, they have been shown to consume some pelagic fishes (Nobriga and Feyrer 2007).

Other Stressors

Aquatic Macrophytes: For many decades, the Delta's waterways were turbid and growth of submerged plants was apparently unremarkable. That began to change in the mid-1980s, when the Delta was invaded by the non-native plant, *Egeria densa*, a fast-growing aquatic macrophyte that has now taken hold in many shallow habitats throughout the Delta (Brown and Michnuik 2007; Hestir 2010). *Egeria densa* and other non-native species of submerged aquatic vegetation (SAV) grow most rapidly in the summer and late fall when water temperatures are warm (> 20°C) and outflow is relatively low (Hestir 2010). The large canopies formed by these plants have physical and biological consequences for the ecosystem (Kimmerer *et al.* 2008). First, the dense nature of SAV promotes sedimentation of particulate matter from the water column, which increases water transparency that then limits the amount of habitat available for delta smelt (Feyrer *et al.* 2007; Nobriga *et al.* 2008). Second, dense SAV canopies provide habitat for a suite of non-native fishes that occupy the littoral and shallow habitats of the Delta, displacing native fishes (Nobriga *et al.* 2005; Brown and Michniuk 2007). Finally, the rise in SAV colonization over the last three decades has led to a shift in the dominant trophic pathways that fuel fish production in the Delta. Until the latter 1980s, the food web of most fishes was often dominated by mysid shrimp (Feyrer *et al.* 2003) that were subsidized by phytoplankton food sources (Rast and Sutton 1989). Now, most littoral and demeral fishes of the Delta have diets dominated by the epibenthic amphipods that eat SAV detritus or the epiphytic algae attached to SAV (Grimaldo *et al.* 2009).

E. densa and other non-native submerged aquatic vegetation (e.g., *Myriophyllum spicatum*) can affect delta smelt in direct and indirect ways. Directly, submerged aquatic vegetation can over whelm littoral habitats (inter-tidal shoals and beaches) where delta smelt may spawn making them unsuitable for spawning. Indirectly, submerged aquatic vegetation decreases turbidity (by trapping suspended sediment) which has contributed to a decrease in both juvenile and adult smelt habitat (Feyrer *et al.* 2007; Nobriga *et al.* 2008). Increased water transparency may delay feeding and may also make delta smelt more susceptible to predation pressure.

Predators: Delta smelt is a rare fish and has been a rare fish (compared to other species) for at least the past several decades (Nobriga and Herbold 2008). Therefore, it has also been rare in examinations of predator stomach contents. Delta smelt were occasional prey fish for striped bass, black crappie, and white catfish in the early 1960s (Turner and Kelly 1966) but went undetected in a recent study of predator stomach contents (Nobriga and Feyrer 2007). The predator with the highest historical documentation of predation on delta smelt is striped bass (*Morone saxatilis*, Stevens 1963; 1966; Thomas 1967). In these studies, striped bass were confirmed to prey on both juvenile and adult delta smelt. Striped bass are widely distributed in pelagic areas of the San Francisco Bay-Delta and parts of its watershed, and thus striped bass distribution fully encompasses the distribution of delta smelt juveniles and adults (Nobriga *et al.* 2013). Striped bass also tend to aggregate in the vicinity of water diversion structures, where delta smelt are frequently entrained (Nobriga and Feyrer 2007). No inverse correlations between the abundance of striped bass and the relative abundance of delta smelt have been found to date using a variety of statistical approaches (Mac Nally et al 2010; Thomson *et al.* 2010; Maunder and Deriso 2011; Miller *et al.* 2012; Nobriga et al 2013). Although the relative rarity of delta smelt in the estuary food web would presumably make them an incidental prey item for striped bass, it is possible that striped bass abundance and demand for prey are always high enough to limit delta smelt population growth rate (Nobriga *et al.* 2013).

Fish eggs and larvae can be opportunistically preyed upon by many invertebrate and vertebrate animals. There has always been a very long list of potential predators of delta smelt's eggs and larvae. One of these is the nonnative Mississippi silverside (*Menidia audens*), which like delta smelt is and annual fish with a maximum length near 100 mm (4 inches). Mississippi silversides may be both predators and competitors of delta smelt (Bennett 2005). Mississippi silversides were first introduced to the San Francisco Bay-Delta in the mid-1970s, and have increased dramatically in numbers since the mid-1980s. They forage in schools around the shoreline habitats and tidal marsh channels of the San Francisco Bay-Delta, where they are exceptionally common (Matern *et al.* 2002); Nobriga *et al.* 2005; Gewant and Bollens 2012). They readily consume delta smelt larvae in aquarium tests Bennett (20025_ concluded that "delta smelt are at high risk of eggs or larvae co-occur with schools of foraging silversides."

Another known predator is the largemouth bass are freshwater fish that prefer clear waters along shorelines (littoral habitat) with relatively dense water plants (Nobriga and Feyrer 2007; Brown and Michniuk 2007; Baxter *et al.* 2008). This is a suite of habitat characteristics that is distinctly different from those described above for delta smelt. Thus, unlike delta smelt and striped bass, delta smelt and largemouth bass have different habitat requirements (e.g., Nobriga *et al.* 2005) and their distributions do not strongly overlap. However, there has been a major increase in the Delta's largemouth bass population since the early 1990's that is believed to have been facilitated by the spread of the introduced plant *Egeria densa*, which provides rearing habitat for the bass (Baxter *et al.* 2008). Despite increases in largemouth bass populations and habitat, Nobriga and Feyrer (2007) did not find delta smelt as largemouth bass prey. Nor have more recent and extensive surveys of largemouth bass stomach contents. In captivity however, even young juvenile largemouth bass will attempt to consume delta smelt (Ferrari *et al.* 2014) so they presumably represent a predation threat when the species closely co-occur in the wild. In contrast to the situation for striped bass, several researchers have found inverse correlations between the relative abundance of largemouth bass or multi-species indices that included largemouth bass and the relative abundance of delta smelt (MacNally *et al.* 2010; Thomson *et al.* 2010; Maunder and Deriso 2011). At this time however, there is no way to determine whether these correlations are causative (predation by largemouth bass caused delta smelt to decline) or not (delta smelt simply use different habitats than largemouth bass and delta smelt habitat has decreased whil largemouth bass habitat has increased).

Other potential predators of eggs and larvae of smelt in littoral habitats are yelllowfin goby, entrarchids, and Chinook salmon. Potential native predators of juvenile and adult delta smelt would also have included numerous bird and fish species and this may be reflected in delta smelt's annual life-history. Annual fish species, also known as "opportunistic strategists", are adapted to high mortality rates in the adult stage (Winemiller and Rose 1992). This high mortality is usually due to predation or highly unpredictable environmental conditions, both of which could have characterized the ancestral niche of delta smelt.

Predation is a common source of density-dependent mortality in fish populations (Rose *et al.* 2001). Thus, it is possible that predation was a mechanism that historically generated the density-dependence observable in delta smelt population dynamics that has been noted by Bennett (2005) and Maunder and Deriso (2011). As is the case with other fishes, the vulnerability of delta smelt to predators may be influence primarily by habitat suitability. It is widely documented that pelagic fishes, including many smelt species, experience lower predation risks under turbid water conditions (Thetmeyer and Kils 1995; Utne-Palm 2002; Horpilla *et al.* 2004). Growth rates, a result of feeding success plus water temperature, are also well known to affect fishes' cumulative vulnerability to predation (Sogard 1997).

Competition: It has been hypothesized that delta smelt are adversely affected by competition from other introduced fish species that use overlapping habitats, including Mississippi silversides, (Bennett and Moyle 1995) striped bass, and wakasagi (Sweetnam 1999). Laboratory studies show that delta smelt growth is inhibited when reared with Mississippi silversides (Bennett 2005) but there is no empirical evidence to support the conclusion that competition between these species is a factor that influences the abundance of delta smelt in the wild. There is some speculation that the overbite clam competes with delta smelt for copepod nauplii (Nobriga and Herbold 2008). It is unknown how intensively overbite clam grazing and delta smelt directly compete for food, but overbite clam consumption of shared prey resources does have other ecosystem consequences that appear to have affected delta smelt indirectly.

Microcystis: Large blooms of toxic blue-green algae, *Microcystis aeruginosa*, were first detected in the Delta during the summer of 1999 (Lehman *et al.* 2005). Since then *M. aeruginosa* has bloomed each year, forming large colonies throughout most of the Delta and increasingly down into eastern Suisun Bay. Blooms typically occur between late spring and early fall (peak in the summer) when temperatures are above 20°C. *M. aeruginosa* can produce natural toxins that pose animal and human health risks if contacted or ingested directly. It is unclear whether microcystins and other toxins produced by local blooms are acutely toxic to fishes at current concentrations; however, the toxins accumulate in fish and their prey. During the summer of 2005, Age-0 striped bass and Mississippi silversides that were co-occurring with the *Microcystis* bloom showed various forms of liver damage (Lehman *et al.* 2010). When ingested with food, microcystins have been experimentally shown to cause substantial impairment of health in threadfin shad (Acuna *et al.* 2012). In addition, the copepods that delta smelt eat are particularly susceptible to these toxins (Ger 2008; Ger *et al.* 2010). An investigation of food web effects and fish toxicity concluded that even at low abundances, *M. aeruginosa* may impact estuarine fish productivity through both toxicity and food web impacts (Lehman *et al.* 2010). *M. aeruginosa* is most likely to affect juvenile delta smelt during summer blooms. Microcystis blooms may also decrease dissolved oxygen to lethal levels for fish (Saiki *et al.* 1998), although delta smelt do not strongly overlap the densest *Microcystis* concentrations, so dissolved oxygen is not likely a problem. *Microcystis* blooms are a symptom of eutrophication and high ammonia to nitrate ratios in the water.

Contaminants: Contaminants can change ecosystem functions and productivity through numerous pathways. However, contaminant loading and its ecosystem effects within the Delta are not well understood. Although a number of contaminant issues were first investigated during the Pelagic Organism Decline (POD) years, concern over contaminants in the Delta is not new. There are long-standing concerns related to mercury and selenium levels in the watershed, Delta, and San Francisco Bay (Linville *et al.* 2002; Davis *et al.* 2003). Phytoplankton growth rate may, at times, be inhibited by high concentrations of herbicides (Edmunds *et al.* 1999). New evidence indicates that phytoplankton growth rate is chronically inhibited by ammonium concentrations in and upstream of Suisun Bay (Wilkerson *et al.* 2006, Dugdale *et al.* 2007). Contaminant-related toxicity to invertebrates has been noted in water and sediments from the Delta and associated watersheds (e.g., Kuivila and Foe 1995, Giddings 2000, Werner *et al.* 2000, Weston *et al.* 2004). Undiluted drain water from agricultural drains in the San Joaquin River watershed can be acutely toxic (quickly lethal) to fish and have chronic effects on growth (Saiki *et al.* 1992).

Evidence for mortality of young striped bass due to discharge of agricultural drainage water containing rice herbicides into the Sacramento River (Bailey *et al.* 1994) led to new regulations for

water discharges. Bio assays using caged Sacramento sucker (Catostomus occidentalis) have revealed deoxyribonucleic acid strand breakage associated with runoff events in the watershed and Delta (Whitehead *et al.* 2004). Kuivila and Moon (2004) found that peak desities of larval and juvenile delta smelt sometimes coincided in time and space with elevated concentrations of dissolved pesticides in the spring. These periods of co-occurrence lasted for up to 2-3 weeks, but concentrations of individual pesticides were low and much less than would be expected to cause acute mortality. However, the effects of exposure to the complex mixtures of pesticides actually present are unknown.
Current science suggests the possible link between contaminants and the POD may be the effects of contaminant exposure on prey items, resulting in an indirect effect on the survival of POD species (Johnson *et al.* 2010). The POD investigators initiated several studies beginning in 2005 to address the possible role of contaminants and disease in the declines of Delta fish and other aquatic species. Their primary study consists of twice-monthly monitoring of ambient water toxicity at fifteen sites in the Delta and Suisun Bay. In 2005 and 2006, standard bioassays using the amphipod *Hyalella azteca* had low (<5 percent) frequency of occurrence of toxicity (Werner *et al.* 2008). The results indicated that 2007, a dry year, showed a higher incidence of toxic events than in the previous (wetter) year, 2006 (Werner *et al.* 2010). Parallel testing with the addition of piperonyl butoxide, an enzyme inhibitor, indicated that both organophosphate and pyrethroid pesticides may have contributed to the pulses of toxicity. Most of the tests that were positive for *H. azteca* toxicity have come from water samples from the lower Sacramento River.

Pyrethroids are of particular concern because of their widespread use, and their tendency to be genotoxic (DNA damaging) to fishes at low doses (in the range of micrograms per liter) (Campana *et al.* 1999). The pyrethroid esfenvalerate is associated with delayed spawning and reduced larval survival of bluegill sunfish (*Lepomis macrochirus*) (Tanner and Knuth 1996) and increased susceptibility of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) to disease (Clifford *et al.* 2005). In addition, synthetic pyrethroids may interfere with nerve cell function, which could eventually result in paralysis (Bradbury and Coats 1989; Shafer and Meyer 2004). Weston and Lydy (2010) found the largest source of pyrethroids flowing into the Delta to be coming from the Sacramento Regional Waste water Treatment Plant, where only secondary treatment occurs. Their data not only indicate the presence of these contaminants, but the concentrations found exceeded acute toxicity thresholds for the amphipod *Hyalella azteca*. This is of substantial concern because the use of insecticides flowing into the Delta. Furthermore, this was not the case for the Stockton Wastewater Treatment facility, where tertiary treatment occurs, suggesting that different treatment methods may remove or etain pyretroids differently (Baxter *et al.* 2010).

In conjunction with the POD investigation, larval delta smelt bioassays were conducted simultaneously with a subset of the invertebrate bioassays. The water samples for these tests were collected from six sites within the Delta during May-August of 2006 and 2007. Results from 2006 indicated that delta smelt are highly sensitive to high levels of ammonia, low turbidity, and low salinity. There is some preliminary indication that reduced survival may be due to disease organisms (Werner *et al.* 2008). No significant mortality of larval delta smelt was found in the 2006 bioassays, but there were two instances of significant mortality in June and July of 2007. In both cases, the water samples were collected from sites along the Sacramento River and had relatively low turbidity and salinity levels and moderate levels of ammonia. It is also important to note that no significant *H. azteca* mortality was detected in these water samples. While H. Azteca tests are very useful for detecting biologically relevant levels of water column toxicity for zooplankton, interpretation of the *H. azteca* test results with respect to fish should proceed with great caution. The relevance of the bioassay results to field conditions remains to be determined. Werner *et al.* (2010b) conducted ***in situ*** testing in the laboratory and compared contaminant sensitivity of delta smelt to common bioassay organisms, including *H. azteca*. The investigations included contaminants commonly observed in the

Delta, such as organophosphate and pyrethroid insecticides, copper, and total ammonia. In the laboratory, delta smelt were 1.8 to >11 times more sensitive thatn fathead minnow to ammonia, copper and all insecticides tested (except permethrin). The invertebrates tested were more sensitive to contaminants than delta smelt or fathead minnows. *Eurytemora affinis* and *Ceriodaphnia dubia* were the most sensitive to total ammonia. *C. dubia* was the most sensitive to copper and organophosphates pesticides. *H. azteca* was the most sensitive test organism to pyrethroids. Toxicity was not detected for the Sacramento River at Hood or the San Joaquin River at Rough and Ready Island during the 2009 in situ testing period. Delta smelt survival was low in treatment and control waters. Werner *et al.* (2010b) concluded that larval smelt may be too sensitive to salinity, temperature and transport stress for *in situ* exposures and recommended using surrogate species in future tests.

Persistent confinement of the spawning population of delta smelt to the Sacramento River increases the likelihood that a substantial portion of the spawners will be affected by a catastrophic event or localized chronic threat. For instance, large volumes of highly concentrated ammonia released into the Sacramento River from the Sacramento Regional County Sanitation District may affect embryo survival or inhibit prey production. Further, agricultural field in the Yolo Bypass and surrounding areas are regularly sprayed by pesticides, and water samples taken from Cache Slough sometimes exhibited toxicity to *H. azteca* (Werner *et al.* 2008; 2010). The thresholds of toxicity for delta smelt for most of the known contaminants have not been determined, but the exposure to a combination of different compounds increases the likelihood of adverse effects. The extent to which delta smelt larvae are exposed to contaminants varies with flow entering the Delta. Flow pulses during spawning increase exposure to many pesticides (Kuivila and Moon 2004) but decrease ammonia concentrations from wastewater treatment plants.

The POD investigations into potential contaminant effects also include the use of biomarkers that have been used previously to evaluate toxic effects on POD fishes (Bennett and Moyle 1996, Bennett 2005). The results to date have been mixed. A pathogen survey of 105 adult delta smelt, sampled from January through May, at several sites in the Delta, found that disease did not appear to overtly influence the health of the surveyed population for that year (Foott and Bigelow 2010). Histopathological and viral evaluation of young longfin smelt collected in 2006 indicated no histological abnormalities associated with exposure to toxics or disease (Foott *et al.* 2006). There was also no evidence of viral infection or high parasite loads. Similarly, young threadfin shad showed no histological evidence of contaminant effects or of viral infections (Foott *et al.* 2006). Parasites were noted in threadfin shad gills at a high frequency but the infections were not considered severe. Both longfin smelt and threadfin shad were considered healthy in 2006. Adult delta smelt collected from the Delta during the winter of 2005 also were considered healthy, showing little histopathological evidence for starvation or disease (Teh 2007). However, there was some evidence of low frequency endocrine disruption. In 2005, nine of 144 (six percent) of adult delta smelt males sampled were intersex, having immature oocytes in their testes (Teh 2007). Bennett (2005) reported that about 10 percent of the delta smelt analyzed for histopathological anomalies in 1999-2000 showed evidence of deleterious contaminant exposure. In contrast, 30-60 percent of these fish had liver glycogen depletion consistent with food limitation.

In contrast, preliminary histopathological analyses have found evidence of significant disease in other species and for POD species collected from other areas of the estuary. Massive intestinal infections with an unidentified myxosporean were found in yellowfin goby (*Acanthogobius flavimanus*) collected from Suisun Marsh. Severe viral infection was also found in Mississippi silverside and juvenile delta smelt collected from Suisun Bay during summer 2005. Lastly, preliminary evidence suggests that contaminants and disease may impair survival of age-0 striped bass. Baxter *et al.* 2008 found high occurrence and severity of parasitic infections, inflammatory conditions, and muscle degeneration in young striped bass collected in 2005; levels were lower in 2006. Several biomarkers of contaminant exposure including P450 activity (i.e., detoxification enzymes in liver), acetylcholinesterase activity (i.e., enzyme activity in brain), and vitellogenin induction (i.e., presence of egg yolk protein in blood of males) were also reported from striped bass collected in 2006 (Ostrach 2008).

Delta smelt can also be exposed to other toxic substances. Recent toxicological research has provided dose-response curves for several contaminants (Connon *et al.* 2009; 2011). This research has also shown that gene expression changes and impairment of delta smelt swimming performance occur at contaminant concentrations lower than levels that cause mortality.

Climate Change: Climate change is likely already impacting the delta smelt. Climate change may affect the delta smelt directly by creating physiological stress, the primary impacts of climate change on the species are expected to be through changes in the availability and distribution of delta smelt habitat.

The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). The term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years of being a typical period for such measurements (IPCC 2013a). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, whether the change is due to natural variability or human activity (IPCC 2013a). Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has increased since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions.

Scientific measurements spanning several decades demonstrate that changes in climate are occurring, and that the rate of change has increased since the 1950s. Examples include warming of the global climate system, and substantial increases in precipitation in some regions of the world and decreases in other regions (for these and other examples, see Solomon *et al.* 2007;; IPCC 2013b;; IPCC 2014). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate and is "very likely" (defined by the IPCC as 90 percent or higher probability) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from use of fossil fuels (Solomon *et al.* 2007; IPCC 2013b). Further confirmation of the role of GHGs comes from analyses by Huber and Knutti (2011), whom concluded it is extremely likely that approximately 75 percent of global warming since 1950 has been caused by human activities.

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (Meehl *et al.* 2007, entire; Ganguly *et al.* 2009; Prinn *et al.* 2011). All combinations of models and emissions scenarios yield very similar projections of increases in the most common measure of climate change, average global surface temperature (commonly known as global warming), until about 2030. Although projections of the magnitude and rate of warming differ after about 2030, the overall trajectory of all the projections is one of increasing global warming through the end of this century, even for the projections based on scenarios that assume that GHG emissions will stabilize or decline. Thus, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by the extent of GHG emissions (Meehl *et al.* 2007; Ganguly *et al.* 2009; Prinn *et al.* 2011; IPCC 2013b). See IPCC 2013b (entire), for a summary of other global projections of climate-related changes, such as frequency of heat waves and changes in precipitation.

Current Drought Conditions and Relative Abundance: California is experiencing its fourth consecutive dry water-year due to low rainfall and low snowpack. On January 17, 2014, the Governor of California declared a State of Emergency due to the drought and directed state officials to take all necessary actions to make water immediately available (Office of the Governor 2014). As of June 2015, the Governor's drought declaration remains in place and the current drought conditions are comparable to the driest years on record in California. The severity of California's drought has been exacerbated by record warm temperatures and below-normal precipitation in 2015, resulting in a severely reduced snowpack. During the last two years, Federal and state governments (Bureau of Reclamation and California Department of Water Resources) have taken actions to ensure the reduced water quality and supply does not reach a level of concern for human health and safety, while complying with biological opinions. The actions taken include the 2015 placement of a salinity rock barrier on West False River and numerous Temporary Urgency Change Orders to modify requirements under Decision 1641 to meet certain water quality objectives, reduction of river flows caused by low reservoir storage, and river temperature requirements.

Drought conditions and some drought management actions have decreased suitable and available aquatic habitat in the Delta for delta smelt breeding and survival, thereby reducing the overall population in the Delta. Fish surveys indicate that the relative abundance of delta smelt is very low. In the last five years, the FMWT, TNS, and 20mm survey results have produced some of the lowest adult and larval delta smelt abundance indexes on record (CDFW 2013, 2014, 2015). The 2014 FMWT abundance index which determines the relative population status for the delta smelt was set at 9, which is the lowest index on record. The low index numbers and relatively few occurrences represent the additive impact of drought to the delta smelt and its habitat.

Status of the Delta Smelt Critical Habitat

The Service designated critical habitat for the delta smelt on December 19, 1994 (Service 1994). The geographic area encompassed by the designation includes all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma sloughs; and the existing contiguous waters contained within the legal Delta (as defined in section 12220 of the California Water Code) (Service 1994).

Conservation Role of Delta Smelt Critical Habitat

The Service's primary objective in designating critical habitat was to identify the key components of delta smelt habitat that support successful spawning, larval and juvenile transport, rearing, and adult migration. Delta smelt are endemic to the Bay-Delta and the vast majority only live one year. Thus, regardless of annual hydrology, the Delta must provide suitable habitat all year, every year. Different regions of the Delta provide different habitat conditions for different life stages, but those habitat conditions must be present when needed, and have sufficient connectivity to provide migratory pathways and the flow of energy, materials and organisms among the habitat components. The entire Delta and Suisun Bay are designated as critical habitat; over the course of a year, the entire habitat is occupied.

Description of the Primary Constituent Elements

In designating critical habitat for the delta smelt, the Service identified the following primary constituent elements (PCEs) essential to the conservation of the species:

Primary Constituent Element 1: "Physical habitat" is defined as the structural components of habitat. Because delta smelt is a pelagic fish, spawning substrate is the only known important structural component of habitat. It is possible that depth variation is an important structural characteristic of pelagic habitat that helps fish maintain position within the estuary's low-salinity zone (LSZ) (Bennett *et al.* 2002, Hobbs *et al.* 2006).

Primary Constituent Element 2: "Water" is defined as water of suitable quality to support various delta smelt life stages with the abiotic elements that allow for survival and reproduction. Delta smelt inhabit open waters of the Delta and Suisun Bay. Certain conditions of temperature, turbidity, and food availability characterize suitable pelagic habitat for delta smelt. Factors such as high entrainment risk and contaminant exposure can degrade this PCE even when the basic water quality is consistent with suitable habitat.

Primary Constituent Element 3: "River flow" is defined as transport flow to facilitate spawning migrations and transport of offspring to LSZ rearing habitats. River flow includes both inflow to and outflow from the Delta, both of which influence the movement of migrating adult, larval, and juvenile delta smelt. Inflow, outflow, and Old and Middle Rivers flow influence the vulnerability of delta smelt larvae, juveniles, and adults to entrainment at Banks and Jones. River flow interacts with the fourth primary constituent element, salinity, by influencing the extent and location of the highly productive LSZ where delta smelt rear.

Primary Constituent Element 4: "Salinity" is defined as the LSZ nursery habitat. The LSZ is where freshwater transitions into brackish water; the LSZ is defined as 0.5-6.0 psu (parts per thousand salinity) (Kimmerer 2004). The 2 psu isohaline is a specific point within the LSZ where the average daily salinity at the bottom of the water is 2 psu (Jassby *et al.* 1995). By local convention the location of the LSZ is described in terms of the distance from the 2 psu isohaline to the Golden Gate Bridge (X2); X2 is an indicator of habitat suitability for many San Francisco Estuary organisms and is associated with variance in abundance of diverse components of the ecosystem (Jassby *et al.* 1995, Kimmerer 2002a). The LSZ expands and moves downstream when river flows into the estuary are high. Similarly, it contracts and moves upstream when river flows are low. During the past 40 years, monthly average X2 has varied from San Pablo Bay (45 kilometers) to as far upstream as Rio Vista on the Sacramento River (95 kilometers). At all times of year, the location of X2 influences both the area and quality of habitat available for delta smelt to successfully complete their life cycle. In general, delta smelt habitat quality and surface area are greater when X2 is located in Suisun Bay. Both habitat quality and quantity diminish the more frequently and further the LSZ moves upstream, toward the confluence.

Overview of Delta Smelt Habitat Requirements and the Primary Constituent Elements

Delta smelt live their entire lives in the tidally-influenced fresh- and brackish waters of the San Francisco Estuary (Moyle 2002). Delta smelt are an open-water, or pelagic, species. They do not associate strongly with structure. They may use nearshore habitats for spawning (PCE #1), but free-swimming life stages mainly occupy offshore waters (PCE #2). Thus, the distribution of the population is strongly influenced by river flows through the estuary (PCE #3) because the quantity of fresh water flowing through the estuary changes the amount and location of suitable low-salinity, open-water habitat (PCE #4). This is true for all life stages. During periods of high river flow into the estuary, delta smelt distribution can transiently extend as far west as the Napa River and San Pablo Bay. Delta smelt distribution is highly constricted near the Sacramento-San Joaquin river confluence during periods of low river flow into the estuary (Feyrer *et al.* 2007). In the 1994 designation of critical habitat, the best available science held that the delta smelt population was responding to variation in spring X2.

Alterations to Estuarine Bathymetry (PCE # 1) (~ 1850-present)

The first major change in the LSZ was the conversion of the landscape over which tides oscillate and river flows vary (Nichols *et al.* 1986). The ancestral Delta was a large tidal marsh-floodplain habitat totaling approximately 300,000 acres. Most of the wetlands were diked and reclaimed for agriculture or other human use by the 1920s. The physical habitat modifications of the Delta and Suisun Bay were mostly due to land reclamation and urbanization. Water conveyance projects and river channelization have had some influence on the regional physical habitat by armoring levees with riprap, building conveyance channels like the Delta Cross Channel, storage reservoirs like Clifton Court Forebay, and by building and operating temporary barriers in the south Delta and permanent gates and water distribution systems in Suisun Marsh.

In the 1930s to 1960s, the shipping channels were dredged deeper (~12 m) to accommodate shipping traffic from the Pacific Ocean and San Francisco Bay to ports in Sacramento and Stockton. These changes left Suisun Bay and the Sacramento-San Joaquin river confluence region as the largest and most bathymetrically variable places in the LSZ. This region remained a highly productive nursery for many decades (Stevens and Miller 1983; Moyle *et al.* 1992; Jassby *et al.* 1995). However, the deeper landscape created to support shipping and flood control requires more freshwater outflow to maintain the LSZ in the large Suisun Bay/river confluence region than was once required (Gartrell 2010).

Seasonal salinity intrusion reduces the temporal overlap of the LSZ (indexed by X2) with the Suisun Bay region, especially in the fall (Feyrer *et al.* 2007, 2010). Thus, the second major change has been in the frequency with which the LSZ is maintained in Suisun Bay for any given amount of precipitation. This metric showed a step-decline in 1977 from which it has never recovered for more than a few years at a time. Based on model forecasts of climate change and water demand, this trend is expected to continue (Feyrer *et al.* 2011). As such this alteration of PCE # 1 also affects the other PCEs, particularly PCE # 4. The major landscape factor affecting this interaction was the dredging of shipping channels.

Spawning delta smelt require all four PCEs, but spawners and embryos are the life stage that is believed to most require a specific structural component of habitat. Spawning delta smelt require sandy or small gravel substrates for egg deposition (Bennett 2005). The major invasive species effect on physical habitat is the dense growth of submerged aquatic vegetation in the Delta. These plants carpet large areas in parts of the Delta such as Frank's Tract. The vegetation beds act as mechanical filters removing turbidity and possibly other water quality components as the tides and river flows move water over them (Hestir 2010). Thus, the proliferation of submerged aquatic plants has likely also reduced the area of nearshore habitat suitable for delta smelt spawning.

Alterations to Water (PCE # 2)

PCE # 2 is primarily referring to a few key water quality components (other than salinity) that influence spawning and rearing habitat suitability for delta smelt. Research to date indicates that water quality conditions are more important than physical habitat conditions for predicting where delta smelt occur (Feyrer *et al.* 2007; Nobriga *et al.* 2008) probably because delta smelt is a pelagic fish except during its egg/embryo stage. However, the interaction of water quality and bathymetry is thought to generally affect estuarine habitat suitability (Peterson 2003) and there is evidence that delta smelt habitat is optimized when appropriate water quality conditions overlap the Suisun Bay region (Moyle *et al.* 1992; Hobbs *et al.* 2006; Feyrer *et al.* 2011). This is discussed further in the section about PCE # 4 (salinity).

Changing predation pressure (1879 to present): Noting is known about the historical predators of delta smelt or their possible influence on delta smelt. Fish eggs and larvae can be opportunistically preyed upon by many invertebrate and vertebrate animals so there has always been a very long list of potential predators of delta smelt's eggs and larvae. Potential native predators of juvenile and adult delta smelt would also have included numerous bird and fish species and this may be reflected in delta smelt's annual life-history. Annual fish species, also known as "opportunistic strategists", are adapted to high mortality rates in the adult stage (Winemiller and Rose 1992). This high mortality is usually due to predation or highly unpredictable environmental conditions, both of which could have characterized the ancestral niche of delta smelt.

The introduction of striped bass into the San Francisco Estuary in 1879 added a permanently resident, large piscivorous fish to the low-salinity zone: a habitat that is not known to have had an equivalent predator prior to the establishment of striped bass (Moyle 2002). This likely changed predation rates on delta smelt, but there are no data available to confirm this hypothesis. For many decades the estuary supported higher striped bass and delta smelt numbers than it does currently. This is evidence that delta smelt is able to successfully coexist with striped bass.

The current influence of striped bass and other predators on delta smelt population dynamics is also not known mainly because quantitative descriptions of predator impacts on rare prey are extremely difficult to generate. Delta smelt were observed in the stomach contents of striped bass and other fishes in the 1960s (Stevens 1963; Turner and Kelley 1966), but have not been observed in more recent studies (Feyrer *et al.* 2003; Nobriga and Feyrer 2007). Predation is a common source of density-dependent mortality in fish populations (Rose *et al.* 2001). Thus, it is possible that predation was a mechanism that historically generated the density-dependence observed in delta smelt population dynamics (Bennett 2005; Maunder and Deriso 2011). Because it is generally true for fishes, the vulnerability of delta smelt to predators is influenced primarily by habitat conditions. Turbidity may be a key mediatory of delta smelt's vulnerability to predators (Nobriga *et al.* 2005; 2008). Growth rates, an interactive outcome of feeding success and water temperature, are also well known to affect fishes' cumulative vulnerability to predation (Sogard 1997). Thus, predation rate is best characterized as an aspect food web function linked to PCE # 2.

Food web alterations attributable to the overbite clam (1987-present): The next major change to PCE #2 occurred following the invasion of the estuary by overbite clam (*Corbula amurensis*). The overbite clam was first detected in 1986 and from 1987-1990 its influence on the ecosystem became evident. Since 1987, there has been a step-decline in phytoplankton biomass (Alpine and Cloern 1992; Jassby *et al.* 2002). Phytoplankton in the LSZ is an important component of the pelagic food web that delta smelt are a part of because a key part of the diet of delta smelt's prey is phytoplankton. Not only does the overbite clam reduce food for delta smelt's prey, it can also graze directly on the larval stages of the copepods eaten by delta smelt (e.g., Kimmerer *et al.* 1994). The grazing pressure applied by the overbite clam rippled through the historical zooplankton community that fueled fishery production in the LSZ (Kimmerer and Orsi 1996; Orsi and Mecum 1996; Kimmerer 2002b; Feyrer *et al.* 2003). This major change in the way energy moved through the ecosystem has likely facilitated the numerous invasions of the estuary by suppressing the production of historically dominant zooplankton, which increases the opportunity for invasion by other species that are less dependent on high densities of LSZ phytoplankton.

The distribution and abundance of several LSZ fishes have changed since 1987 (Kimmerer 2002b; Kimmereer 2006; Rosenfield and Baxter 2007; Mac Nally *et al.* 2010). Surprisingly, the changes in phytoplankton and zooplankton production have not been as evident for delta smelt as for other organisms (Kimmer 2002b; Kimmerer 2006; Sommer *et al.* 2007; Mac Nally *et al.* 2010). Nonetheless, delta smelt collected in the FMWT have been persistently smaller since the overbite clam invasion (Sweetnam 1999; Bennett 2005). This is evidence for reduced growth rates that could have been caused by food web changes stemming from overbite clam grazing. The Service considers the prey density aspect of the estuarine food web to be a component of PCE #3 ("Water"). The Central Valley Project and State Water Project entrain some food web production (about 4.5 percent on a daily average basis was attributed to all water diversions in the Delta; Jassby *et al.* 2002). However, prey densities have been most strongly affected by clam grazing (Kimmerer *et al.* 1994; Jassby *et al.* 2002). Urban wastewater input, *Microcystis* blooms, and pesticide loads may also impair the production of zooplankton eaten by delta smelt or eaten by delta smelt's prey (Wilkerson *et al.* 2006; Dugdale *et al.* 2007; Jassby 2008; Ger *et al.* 2009; Werner *et al.* 2010).

Proliferation of submerged aquatic vegetation (1980s to present): For many decades, the Delta's waterways were turbid and the growth of submerged plants was apparently unremarkable. That began to change in the mid-1980s, when the Delta was invaded by non-native plant *Egeria densa*, a fast-growing aquarium plant that has taken hold in many shallow habitats (Brown and Michnuik 2007; Hestir 2010). *Egeria densa* and other non-native species of submerged aquatic vegetation (SAV) grow most rapidly in the summer and late fall when water temperatures are warm (>20°C) and outflow is relatively low (Hestir 2010). The large canopies formed by these plants have physical and biological consequences for the ecosystem (Kimmerer *et al.* 2008). First, dense SAV promotes water transparency. Increased water transparency leads to a loss of habitat for delta smelt (Feyrer *et al.* 2007; Nobriga *et al.* 2008). Second, dense SAV canopies provide habitat for a suite of non-native fishes, including largemouth bass, which now dominate many shallow habitats of the Delta and displace native fishes (Nobriga *et al.* 2005; Brown and Michniuk 2007). Finally, SAV colonization over the last three decades has led to a shift in the dominant freshwater food web pathways and that fuel fish production (Grimaldo *et al.* 2009b). It is noteworthy that SAV-dominated habitats are comparatively productive (Nobriga *et al.* 2005; Grimaldo *et al.* 2009b), but most of the productivity they generate remains in the nearshore environment and therefore does not contribute much to pelagic fish production (Grimaldo *et al.* 2009b).

Reduced turbidity (1999-present): The next major change was a change in estuarine turbidity that culminated in an estuary-wide step-decline in 1999 (Schoellhamer 2011). For decades, the turbidity of the modified estuary had been sustained by very large sediment deposits resulting mainly from gold mining in the latter 19th century. The sediments continued to accumulate into the mid-20th century, keeping the water relatively turbid even as sediment loads from the Sacramento River basin declined due to dam and levee construction (Wright and Schoellhamer 2004). The flushing of the sediment deposits may also have made the estuary deeper overall and thus a less suitable nursery from the 'static' bathymetric perspective (Schroeter 2008). Delta smelt larvae require turbidity to initiate feeding (Baskerville-Bridges *et al.* 2004), and as explained above, older fish are thought to use turbidity as cover from predators. Thus, turbidity is an aspect of PCE # 2 which is a necessary water quality aspect of delta smelt's critical habitat.

Dams and armored levees have contributed to the long-term decline in sediment load to the estuary (Wright and Schoellhamer 2004) and to the clearing of estuary water. This is a long-term effect that stemmed from building and maintaining infrastructure. Opportunities to substantively address this change are limited due to the extreme Central Valley flood and water supply risks that will result from decommissioning dams or removing levees.

Changing water temperature (present through long-term climate forecasts): Delta smelt is already subjected to thermally stressful temperatures every summer in the Delta. Water temperatures are presently above 20°C for most of the summer in core habitat areas, sometimes even exceeding the nominal lethal limit of 25°C for short periods. Coldwater fishes begin to have behavioral impairments (Marine and Cech 2004) and lose competitive abilities (Taniguchi *et al.* 1998) prior to reaching their thermal tolerance limits. Thus, the estuary can already be considered thermally stressful to delta smelt and can only become more so if temperatures warm in the coming decades.

All available regional climate change projections predict central California will be warmer still in the coming decades (Dettinger 2005). It is expected that warmer estuary temperatures will be yet another significant conservation challenge (Brown *et al.* 2013; Cloern *et al.* 2011). This is true because they will limit abiotic habitat suitability further than indicated by flow-based projection (e.g., Feyrer *et al.* 2011). In addition, warmer water temperatures mean that higher prey densities will be required just to maintain present-day growth rates, which are already lower than they once were (Sweetnam 1999; Bennett 2005). Water temperature is mainly affected by climate variation, both as air temperature and as flood and drought scale flow variation (Kimmer 2004; Wagner *et al.* 2011).

Sensitivities to contaminants (ongoing): Delta smelt's spawning migration coincides with early winter rains (Sommer *et al.* 2011). This 'first-flush' of inflow to the Delta brings sediment-bound pesticides with it (Bergamaschi *et al.* 2001), and peak densities of larvae and juveniles can co-occur with numerous pesticides (Kuivila and Moon 2004). Bennett (2005) reported that about 10 percent of the delta smelt analyzed for histopathological anomalies in 1999-2000 showed evidence of deleterious contaminant exposure, but this was low compared to the 30-60 percent of these fish that appeared to be food-limited.

Delta smelt can also be exposed to other toxic substances. Recent toxicological research has provided dose-response curves for several contaminants (Connon *et al.* 2009; 2011). This research has also shown the gene expression changes and impairment of delta smelt swimming performance occur at contaminant concentrations lower than levels that cause mortality. Climate scale flow variation (e.g., flood versus drought scale variation) affects the amount of methyl mercury (Darryl Slotton presentation) entering the ecosystem and may have some influence on the meaningful dilution of ammonium from urban wastewater inputs (Dick Dugdale presentation).

Invasive species may also affect PCE #2 by changing contaminant dynamics. For instance, *Microcystis* blooms generate toxic compounds that can kill delta smelt prey (Ger *et al.* 2009) and accumulate in the estuarine food web (Lehman *et al.* 2010). A second example is the biomagnification of selenium in the food web by *Corbula* (Stewart *et al.* 2004). This has been considered a potential issue for the clam's predators – namely sturgeon, splittail, and diving ducks (Richman and Lovvorn 2004; Stewart *et al.* 2004). However, it is not known whether this change in selenium dynamics negatively affects delta smelt and other fishes that do not directly prey on the clams.

Alterations of River Flows (PCE # 3)

This PCE refers to the transport flows that help guide young delta smelt from spawning habitats to rearing habitats, and to flows that guide adult delta smelt from rearing habitats to spawning habitats. Delta outflow also has some influence on delta smelt's supporting food web (Jassby *et al.* 2002; Kimmerer 2002a) and it affects abiotic habitat suitability as well (Feyrer *et al.* 2007; 2011). The latter is expanded upon in the discussion of PCE # 4. The environmental driver with the strongest influence on PCE # 3 is highly dependent on the time-scale being considered. The tide has the largest influence on flow velocities and directions in delta smelt's critical habitat at very short timescales (minutes to days), whereas interannual variation in precipitation and runoff has the largest influence on flows into and through the Delta at very long timescales (years to decades), and sometimes at shorter time scales (days to weeks) during major storm events. Changes to flow regimes can have the largest influence on PCE #3 at timescales of weeks to seasons. This is particularly true during periods of low natural inflow, for instance during the fall and during droughts, and in the south Delta where Old and Middle River flows are often managed using changes in export flow rates.

Entrainment into water export diversions (1951 to present): The amount of water diverted from the estuary has generally increased over time, and most of the increase during the 1950s and 1960s was due to CVP exports and since the latter 1960s, SWP exports. There are two basic potential fishery impacts that result from water diversion from the Delta: ecosystemic impacts and direct entrainment. From the ecosystemic perspective, water diversions are unnatural 'predators' because they 'consume' organisms at every trophic level in the ecosystem from phytoplankton (Jassby *et al.* 2002) to fish (Kimmerer 2008). Unlike natural predators which typically shift their prey use over time in association with changes in prey fish density (Nobriga and Feyrer 2008), fractional entrainment losses of fishes to diversions are functions of water and demand (e.g., Grimaldo *et al.* 2009). Thus, water diversions not only elevate 'predation' mortality in an aquatic system, but they can do so in an atypical, density-independent manner. Diversions and fish collection facilities in the south Delta are very large structures which attract large aggregations of actual predatory fish and prey on smaller species like delta smelt before they reach the fish salvage facilities and within these facilities (Gingras 1997).

Estimated entrainment losses of delta smelt to SWP and CVP diversions can be substantial in some years (Kimmerer 2008). Given the delta smelt's current density-independent population dynamics, even a statistically indiscernible entrainment effect on the population is likely to cause the species to continue to decline (Kimmerer 2011). The entrainment losses of delta smelt are not generally observed until they reach the early juvenile stage (~20-30 mm in length), but combinations of 20-mm Survey distribution data and hydrodynamic modeling provide evidence that their risk of entrainment into the CVP and SWP diversions can be described by any of several indices that integrate Delta inflow and export flow (Kimmerer and Nobriga 2008; Kimmerer 2008; Service 2008; Grimaldo *et al.* 2009).

Delta smelt entrainment losses estimated from survey data and hydrodynamics can also be substantial in some years (Kimmerer 2008), though it is possible that Kimmerer may have overestimated them (Miller 2011). Nonetheless, increasing higher outflow (or lower X2) moves the bulk of the larval population increasingly west, which results in fewer larvae distributed in the south Delta where they are at highest risk of entrainment. At the same time, indices like the export to inflow ratio or Old and Middle river flow are useful metrics for gauging the effect of exports on the south Delta.

The risk of delta smelt entrainment into smaller agricultural irrigation diversions used mainly to irrigate crops within the Delta is also related to flow conditions. These in-Delta irrigation diversions generally have mean flow rates less than 1 cubic meter per second (Nobriga *et al.* 2004). The lower the Delta outflow, the higher the proportion of the young delta smelt population that overlaps the array of irrigation diversions in the Delta (Kimmerer and Nobriga 2008). However, the irrigation diversions are not currently considered to represent a substantial source of mortality because they individually draw small quantities of water relative to channel volumes (Nobriga *et al.* 2004).

In Suisun Marsh, water diversions are largely made to support waterfowl production. Some Suisun Marsh diversions are larger for the size of channels they are in than most of the agricultural irrigation diversions in the Delta. Based on hydrodynamic simulations, proximity to water diversions in the marsh is expected to correlate strongly with entrainment (Culberson *et al.* 2004), and substantial delta smelt losses have been reported when these diversions are not screened (Pickard *et al.* 1982). Entrainment risk for delta smelt in western Suisun Marsh is considered low because the habitat surrounding the diversions is often too saline (Enos *et al.* 2007).
Salinity PCE # 4

The core delta smelt habitat, is the LSZ (Moyle *et al.* 1992; Bennett 2005). The LSZ is where freshwater transitions into brackish water; the LSZ is defined as the area of the estuary where salinity ranges from 0.5-6.0 psu (Kimmerer 2004). This area is always moving due to tidal and river flow variation. The 2 psu isohaline is a specific location within the LSZ where the average daily salinity at the bottom of the water is 2 psu (Jassby *et al.* 1995). By local convention, changes in the location of the LSZ are described in terms of the distance from the Golden Gate Bridge to the 2 psu isohaline (X2); X2 is an indicator of habitat suitability for many of the estuary's organisms and it is associated with variance in abundance of diverse components of the ecosystem (Jassby *et al.* 1995; Kimmerer 2002b; Kimmerer *et al.* 2009). The LSZ expands and moves downstream when river flows into the estuary are high (Kimmerer *et al.* 2009). Similarly, it contracts and moves upstream when river flows are low. During the past 40 years, monthly average X2 has varied from as far downstream of San Pablo Bay (45 km) to as far upstream as Rio Vista on the Sacramento River (95 km).

Larval delta smelt tend to reside somewhat landward (upstream) of X2 (Dege and Brown 2004), but the center of juvenile distribution tends to be very near X2 until the fish start making spawning migrations in the winter (Feyrer *et al.* 2011; Sommer *et al.* 2011). Because of this association between the distribution of salinity in the estuary and the distribution of the delta smelt population, the tidal and river flows that comprise PCE # 3 affect PCE # 4.

The expansion and contraction of the LSZ affects the areal extent of abiotic habitat for delta smelt, both during spring (Kimmerer *et al.* 2009) and fall (Feyrer *et al.* 2007; 2011). In the spring, most delta smelt are larvae or young juveniles and the LSZ is typically maintained over the expansive Suisun Bay region. Thus, abiotic habitat "limitation" is unlikely and no consistent influence of spring X2 variation on later stage abundance estimates has been reported to date (Jassby *et al.* 1995; Bennett 2005; Kimmerer *et al.* 2009). In fact, historical maxima in juvenile abundance according to CDFW's TNS occurred in low outflow years when abiotic habitat area was comparatively low (Kimmerer 2002a; Kimmerer *et al.* 2009).

In contrast, during fall delta smelt are late stage juveniles and for the past decade or more, the LSZ has been persistently constricted by low Delta outflow. Fall habitat conditions affect delta smelt distribution and the concurrent FMWT abundance index (Feyrer *et al.* 2007; 2011). However, the quantitative life cycle models developed to date have not found evidence for a year over year effect of fall LSZ location on delta smelt population dynamics (Mac Nally *et al.* 2010; Thompson *et al.* 2010; Maunder and Deriso 2011).

It is now recognized that some delta smelt occur year-round in the Cache Slough region including the Sacramento Deep Water Shipping Channel and Liberty Island (Kimmerer 2011; Miller 2011; Sommer *et al.* 2011). The latter has been a consistently available habitat only since 1997. This region is often lower in salinity than 0.6 psu, the lower formal limit of the LSZ as defined by Kimmerer (2004). Delta smelt likely use it because it is one of the most turbid habitats remaining in the Delta (Nobriga *et al.* 2005). A recent population genetic study found no evidence that delta smelt inhabiting this region are unique compared to delta smelt using the LSZ-proper (Fisch *et al.*

2011), therefore it is likely that individual delta smelt migrate between the LSZ and the Cache Slough region. This is consistent with the high summer water temperatures observed there, which might compel individual delta smelt to seek out cooler habitats within and outside the Cache Slough region.

Delta Smelt Environmental Baseline

The portions of the Action Area that fall within the range of delta smelt include the Sacramento River east levee, south of Sacramento and the Sacramento Weir. Delta smelt typically migrate up into this area as early as December and move out in the spring and summer. The proposed project contains habitat components that can be used for feeding, spawning, rearing, and movement. Some amount of erosion protection has already occurred within the action area. Additionally, the Corps has a project which will place rock along 31,000 linear feet of the right bank of the Sacramento River immediately across the river and extending upstream from the proposed project footprint. Compensation for the placement of this rock will be through the development of a setback levee that will provide 118 acres of newly created shallow water habitat.

Giant Garter Snake Status of the Species

For the most recent assessment of the species' range-wide status please refer to the *Giant Garter Snake (Thamnophis gigas) 5-year Review: Summary and Evaluation* (Service 2012) for the current status of the species. Ongoing threats to giant garter snake include habitat loss from water transfers, rice fallowing due to drought conditions, habitat disturbance and loss from irrigation and drainage ditch maintenance, climate change, and invasive species. While these threats continue to effect the giant garter snake throughout its range, to date no project has proposed a level of effect for which the Service has issued a biological opinion of jeopardy for the giant garter snake.

Giant Garter Snake Environmental Baseline

The *Draft Recovery Plan for the Giant Garter Snake* (Service 1999b) subdivides the range of the species into four recovery units. Each recovery unit includes populations. The action area for the proposed project is located within the Yolo Basin-Willow Slough unit and the American Basin unit. According to the 2012, 5-year review (Service 2012) the abundance and distribution of giant garter snakes has not changed significantly. Within the Action Area habitat loss and fragmentation is the most significant threat to the giant garter snake. Urbanizing areas within the Action Area include Sacramento and West Sacramento. Habitat loss through water transfers and rice fallowing also negatively affects giant garter snakes. In the Sacramento Valley, rice has served as a substitute for the large amounts of historical wetlands that used to exist in the Central Valley. Loss of this habitat has been shown to reduce or exclude giant garter snakes compared to areas which are actively irrigated in rice (Wylie *et al.* 2002a, b, 2004).

Flood control maintenance and agricultural activities can reduce and prevent the establishment of vegetation and burrows needed by the giant garter snake for cover and shelter on canals, levees, and agricultural ditches. This can also reduce the prey base for giant garter snake, affecting their feeding. Additionally, clearing, scraping and/or re-contouring canals, ditches, and levees, destroys burrows and crevices that are used as over-wintering habitat and during the summer for thermoregulation, shedding, and giving birth. These activities are being conducted by local maintaining agencies throughout the Action Area.

Other factors which effect the giant garter snake population in the Action Area include vehicular mortality particularly where canals or aquatic habitat are bordered by roads such as the crown of the levees. Non-native predators such as game fish, bull frogs (*Rana catesbiana*), and domestic cats can affect giant garter snake populations (Service 1999b). This can be particularly detrimental to young and juvenile giant garter snakes. All of the Action Area has non-native predators occurring in it.

Snakes have been located within the Yolo Bypass within 2 miles of the Sacramento Bypass. Numerous irrigation and drainage canals exist which provide connectivity from the Sacramento Bypass and areas that are known to support snakes in the Yolo Bypass. A snake observed 0.5 mile to the west of the NEMDC along Elkhorn Boulevard in 1996 (CNDDB 2015). Borrow site 2's northern boundary is Elkhorn Boulevard on the east side of the NEMDC. Giant garter snakes could be using the NEMDC for aquatic habitat and the surrounding grasslands for uplands.

Western Yellow-Billed Cuckoo Status of the Species

For the most recent assessment of the species range-wide status please refer to the October 3, 2014, *Determination of Threatened Status for the Western Distinct Population Segment of the Yellow-billed Cuckoo (Coccyzus americanus occidentalis)* (79 FR 59991). Ongoing threats to the yellow-billed cuckoo include habitat loss from flood control projects and maintenance, alterations to hydrology, climate change, and invasive species. While these threats continue to affect the yellow-billed cuckoo throughout its range, no project, to date, has proposed a level of effect for which the Service has issued a biological opinion of jeopardy for the yellow-billed cuckoo.

Western Yellow-Billed Cuckoo Baseline

Yellow-billed cuckoo detections have occurred most frequently in the upper Sacramento River where levees are setback from the river or do not exist. Additionally, the last 20 years has seen a large amount of riparian restoration occur in the upper Sacramento River. Habitat in the action area tends to be more narrow and linear than in the upper Sacramento River. Levees were constructed close to the bank of the Sacramento River leaving narrow bands of small patch sizes. Construction of the setback levee along the right bank of the Sacramento River as part of the West Sacramento Flood Control Project will provide some wider patches of riparian habitat that will benefit the yellow-billed cuckoo. The American River has a wider floodplain due to levees being setback from the channel. There are some patches large enough to support nesting yellow-billed cuckoos, though cuckoos have not been observed nesting along the American River.

Effects of the Proposed Action

Valley Elderberry Longhorn Beetle

Vegetation removal, including elderberries could cause mortality of any beetle larvae within the elderberry shrub. Transplanting the shrubs between November 1 and February 15, when the shrubs are dormant, will minimize the likelihood of killing larvae within the shrub. Transplanting the shrub could still result in mortality to larvae within the shrub, particularly if the shrub does not survive transplantation. Proper care of the transplants through watering in the initial years can minimize this loss and increase the likelihood that the shrub will survive and provide continued habitat for the valley elderberry longhorn beetle.

Construction that occurs near elderberry shrubs that will be protected in place can kill adult beetles if construction equipment is operating between the months of March and June when valley elderberry longhorn beetles have emerged from the elderberry shrubs and are locating mates for reproduction. Fencing the area which contains riparian habitat, specifically elderberry shrubs, and keeping a minimum of a 20 foot buffer from the dripline of the elderberry shrub will keep construction equipment from driving too close to the shrubs and minimize the number of beetles that might be struck or run over by equipment.

Transplanting elderberry shrubs out of the construction footprint has the potential to affect valley elderberry longhorn beetle dispersal if there is potential to remove large areas of elderberry shrubs. The Corps has provided maps of where existing valley elderberry longhorn beetle habitat exists and where shrubs will be removed due to the project. Along the Sacramento River, 13 elderberry shrubs distributed within 70 acres of riparian habitat will be transplanted as part of the project, however during surveys the Corps has documented an additional 60 elderberry shrubs that will be protected in place along the Sacramento River. The Corps has also proposed to include elderberry shrub plantings along the bank repair footprint where the elevation is suitable so the shrubs are not inundated too frequently. Along the American River, 250 elderberry shrubs distributed within 65 acres of riparian habitat will be transplanted as part of the project. The American River has many conservation sites and the Corps has proposed to offset the removal of elderberry shrubs through development of additional sites and enlargement of existing sites in the lower American River Parkway. The Corps is proposing to create an additional 69.91 acres of habitat for the valley elderberry longhorn beetle in the lower American River Parkway.

Trimming of elderberry shrubs can result in the loss of some habitat for the valley elderberry longhorn beetle. Unlike transplantation however, the shrub remains within the riparian corridor and can provide habitat for the beetle during dispersal. There is potential for one of the pruned stems to contain the larvae of the valley elderberry longhorn beetle. While elderberry shrubs do resprout readily, there is a temporal loss of habitat for the beetle and as part of the maintenance any resprouted stems will be removed in order to provide maintenance equipment access. To offset these effects the local maintaining agencies have proposed to create a 40-acre conservation area for the valley elderberry longhorn beetle. This area will be selected as described in the preceding paragraph. This will ensure habitat connectivity and help with long-term maintenance and monitoring of these lands.

Delta Smelt

Construction along the Sacramento River will place bank protection along a 50,300 linear foot section of the left bank of the Sacramento River. Delta smelt are a pelagic species that is typically found in the center of the channel. However, as described in the status of the species they do spawn on sandy beaches in shallow water habitat (0 to 3 meters) and in this portion of the Sacramento River are found close to the banks. The rock footprint will change the substrate along the 50,300 linear feet of 33 acres of shallow water habitat. Additionally 13 acres are being converted from riverine bank edge to a rock wedge. Construction related effects to individual delta smelt will be avoided because construction is occurring between August 1 and November 30, a time when delta smelt are located further downstream in the Delta and Suisun Bay. Effects due to increasing sediment downstream of the work area will be minimized through the conservation measures involving monitoring water quality during construction to ensure that effects do not extend into the portion of the Delta that delta smelt occupies during the late summer/fall period. Construction to widen the Sacramento Weir will occur on the landside of the existing Sacramento River right bank levee. Upon completion of the weir extension the levee removed between August 1 and November 30 avoiding effects to delta smelt habitat.

The primary negative effect of the project on potential spawning habitat is the change of substrate from sand to riprap. Rock used for bank protection is large enough to retard erosional forces of the river and therefore has interstitial spaces. Should delta smelt spawn over this riprap substrate, it is very likely that any eggs will fall into these interstitial spaces resulting in the loss of eggs and potentially causing fertilization to not occur if the eggs fall into the interstitial spaces. The Corps has proposed to offset this loss of spawning potential in these areas through the purchase of 33 acres of credits at a Service-approved delta smelt conservation bank. The placement of rock will permanently narrow the channel by 13 acres through the change of riverine edge to rock wedge. Rock slope protection limits the lateral mobility of a river channel, increases flow velocities (Sedell *et al.* 1990), limit sediment transport, and eliminates bankside refugia areas (Gregory *et al.* 1991). Rock placement can also affect primary productivity through the loss of vegetation. The Corps will protect large trees in place and plant riparian benches at the conclusion of the rock placement to replace the loss of vegetation. Planting benches and vegetation planting will also help to offset the increased velocities that the bank protection sites will experience due to the smoother rock surface. To offset the complete loss of riverine edge habitat the Corps has proposed to purchase 39 acres of credits at a Service-approved delta smelt conservation bank for a total of 72 acres of credits.

The Corps has proposed to evaluate effects to listed species including delta smelt when long-term maintenance activities for the Sacramento River can be described. If maintenance activities will affect delta smelt the Corps will reinitiate consultation with the Service. Therefore, this biological opinion does not address effects to the delta smelt from any long-term levee maintenance activities.

Delta Smelt Critical Habitat

This opinion on the critical habitat for the delta smelt does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR § 402.02. Instead, we have relied upon the statute and the August 6, 2004, Ninth Circuit Court of Appeals decision in *Gifford Pinchot Task Force v. U. S. Fish and Wildlife Service* (No. 03-35279) to complete the following analysis with respect to the proposed critical habitat.

Implementation of the proposed project will affect PCE #1 Physical Habitat as described under the environmental baseline section above. The placement of rock will change the substrate of shallow water habitat for 46 acres. Any loss of shallow water habitat will be compensated through the purchase of credits at a delta smelt conservation bank. It is expected that planting the sites post-construction will replace any loss of primary productivity within the Sacramento River water column.

Giant Garter Snake

Borrow Site 2 – Upland habitat will be disturbed at borrow site 2 (5.5 acres) when heavy equipment is brought in to remove soil for the Arcade Creek levee repair. Removal of soil from the site will result in the crushing of burrows that snakes use for aestivating and thermoregulation. Fencing the borrow site prior to borrow excavation will minimize the likelihood that snakes will be in the borrow site when construction equipment begins to mobilize. Fencing the site will temporarily (one active season) exclude the use of the area for giant garter snake. This could result in snakes having to move further distances to find upland refugia in the summer months and expose them to predation or other sources of mortality such as being run over by a vehicle on the levee road on the opposite side of the NEMDC. Because the aquatic habitat will not be disturbed by the project, there will not be any effects on the snake's ability to forage.

Upon completion of the project, the site will restored and re-graded to create three habitat types. The creation of additional tule marsh along the edge of the canal will benefit giant garter snakes that may be using the NEMDC as it will provide cover, an area for prey production, and refugia from predators. Additionally, the seasonal wetland bench will only provide aquatic habitat in the winter months when the snake is typically in burrows. The wetland bench will provide some upland habitat for the giant garter snake during the summer when the snake is active in the form of basking habitat and if dried wetland vegetation remains some refugia from predators; however, because the site will be flooded in the winter it will not serve as overwintering habitat for the snake. The remaining 3.5 acres of the borrow site will be restored to native grassland and will function as summer upland refugia and basking and in the winter serve as overwintering habitat for the snake.

Sacramento Bypass – Enlarging the Sacramento Bypass and Weir will result in both permanent and temporary effects to giant garter snake habitat. Construction of the widened bypass will have similar effects to giant garter snake as the work along borrow site 2. Snakes could be crushed by heavy equipment, entombed in refugia when burrows collapse, and exposed to increased predation because they may have to travel further to find habitat that is unavailable to them due to the project. The 25 acres of aquatic habitat and 50 acres of upland habitat that will be temporarily affected because of the relocation of a levee toe drain will be replaced within one year of construction. The Corps has committed to creating a toe drain that closely mimics the existing aquatic and upland habitat along the northern levee of the Sacramento Bypass. The effects of crushing snakes and exposing them to increased predation will be minimized through the use of the conservation measures described in the project description above.

Permanently, 15 acres of aquatic and 30 acres of upland habitat will be lost through the removal of drainage ditches and farm canals in the area that is currently outside of the bypass footprint. The Corps has committed to offsetting the loss of this habitat through the purchase of 135 acres of giant garter snake credits at a Service-approved conservation bank. Conservation banks provide protection, conservation easement, and funding, endowment, in perpetuity for the giant garter snake. These long-term protections and location of the conservation banks all contribute to the long-term recovery of the giant garter snake.

Operation of the expanded Sacramento Weir and Bypass will result in an increase of water surface elevation of approximately 0.5-foot on the levee slopes on either side of the Yolo Bypass. However, when this increase occurs, during a 200-year flood event, the Yolo Bypass levees already contain water up to 21 feet deep. As a result, giant garter snake burrows would likely already be saturated before the additional water associated with the widened Sacramento Bypass is a factor. The additional 0.5-foot resulting from this action would not significantly change the timing or duration of this flooding and would not result in further impacts to giant garter snake habitat.

The Corps has proposed to evaluate effects to listed species including giant garter snake when long-term maintenance activities for the Sacramento Bypass can be described. If maintenance activities will affect giant garter snakes the Corps will reinitiate consultation with the Service. Therefore, this biological opinion does not address effects to the giant garter snake from any long-term levee maintenance activities.

Yellow-Billed Cuckoo

Sacramento River – The Corps is planning on removing 70 acres of riparian habitat along the Sacramento River. The riparian corridor in this section of the Sacramento River is narrow (about 100 feet wide) because the levees were constructed so close to the edge of the channel bank. This is too narrow for the yellow-billed cuckoo to nest, however it is possible for the yellow-billed cuckoo to use this as a stopover when migrating to the Central Valley to breed. Vegetation removal will reduce the width of the riparian corridor from 100 feet to 40 feet on average. The Corps proposal to plant the bank protection sites will create a 25-foot wide planting berm leaving a loss of about 35 feet of riparian corridor. The Corps proposes to offset the loss of the 70 acres of riparian through the creation of 140 acres of riparian habitat along the lower American River.

American River – The construction of launchable rock trench will remove 65 acres of riparian habitat along the lower American River. The lower American River does have habitat patches large enough to support nesting yellow-billed cuckoos. Large patches of habitat will not be removed; rather a strip will be removed adjacent to the levee which could reduce the size of some of the potential nesting areas. To compensate for this the Corps is proposing to plant 130 acres along the lower American River. As described in the conservation measures, the Corps will develop a Riparian Conservation Plan that will determine the best locations to develop additional riparian habitat. The conservation areas will provide both habitat for yellow-billed cuckoo and valley elderberry longhorn. The areas will also ensure that there is a net increase of potential yellow-billed cuckoo nesting habitat along the lower American River Parkway. There will be a temporal loss of habitat because riparian habitat can take up to 20 years to develop.

In addition to the habitat loss for both the Sacramento and American Rivers, construction itself has the potential to adversely affect yellow-billed cuckoos. Construction that occurs when the cuckoo is in the Sacramento Valley has the potential to harass the bird due to noise. To minimize effects to the cuckoo due to construction noise the Corps conservation measure to do protocol level surveys prior to beginning construction will enable the Corps to determine if yellow-billed cuckoos are nesting near the construction footprint. The Corps has committed to avoid construction near an active yellow-billed cuckoo nest. However, cuckoos that could be foraging in the area could be harassed due to construction activities and noise and move to other locations in the lower American River parkway which could expose individual cuckoos to increased predation.

The Corps has proposed to evaluate effects to listed species including yellow-billed cuckoo when long-term maintenance activities for the Sacramento River and American River can be described. If maintenance activities will affect yellow-billed cuckoos the Corps will reinitiate consultation with the Service. Therefore, this biological opinion does not address effects to the yellow-billed cuckoo from any long-term levee maintenance activities.

Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. 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 Act.

Valley Elderberry Longhorn Beetle

Non-Federal adverse effects to the valley elderberry longhorn beetle include effects from nearby pesticide spraying drifting into valley elderberry longhorn beetle habitat and levee and channel maintenance. In the areas of the urbanized areas of the American and Sacramento Rivers human started fires is by far the largest effect to valley elderberry longhorn beetles. Over the last several years numerous fires have burned portions of the American River Parkway.

Delta Smelt

Adverse effects to delta smelt may result from point and non-point source chemical contaminant discharges within the action area. These contaminants include but are not limited to ammonia and free ammonium ion, numerous pesticides and herbicides from agricultural activities, and oil and gasoline product discharges. Oil and gasoline product discharges may be introduced into the Sacramento River from shipping and boating activities and from urban activities and runoff. Other future, non-Federal actions within the action area that are likely to occur and may adversely affect delta smelt include: the dumping of domestic and industrial garbage that decreases water quality; oil and gas development and production that may affect aquatic habitat and may introduce pollutants into the water; agricultural activities, including burning or removal of vegetation on levees that reduce riparian and wetland habitats that contribute to the quality of habitat used by delta smelt; and livestock grazing activities that may degrade or reduce riparian and wetland habitats that contribute to the quantity and quality of habitat used by delta smelt.

San Francisco Bay-Delta Climate Change

The effects of climate change do not act in isolation; they are anticipated to exacerbate existing threats to delta smelt. We considered the potential effects of climate change on the delta smelt based on projections derived from various modeling scenarios. A series of publications (Feyrer *et al.* 2011; Cloern *et al.* 2011; Brown *et al.* 2013) have modeled future impacts of climate change in the Delta and projected how this will affect delta smelt. These models used the B1 and A2 scenarios from the 2007 IPCC report. Each scenario included both a warmer-wetter and warmer-dryer sub scenario. Modeled predictions presented in these publications are based on current baseline conditions (no increased outflow, no breeching of levees) which may or may not change in the future. Temperature increases are likely to lead to a continued rise in sea level, further increasing salinity which will increasingly restrict delta smelt's already limited geographic range (Feyrer *et al.* 2011; Cloern *et al.* 2011; Brown *et al.* 2013). Higher air temperatures will reduce snowpacks, melt snow earlier in the winter or spring, and increase water temperatures. These changes will likely alter freshwater flows, possibly shifting and condensing the timing and location of delta smelt reproduction (Brown *et al.* 2013).

Projections indicate that temperature and precipitation changes will diminish snowpack, changing the availability of natural water supplies (Reclamation 2011). Warming may result in more precipitation falling as rain and less storage as snow. This would result in increased rain on snow events and increase winter runoff with an associated decrease in runoff for the remainder of the year (Reclamation 2011). Sacramento Valley Ecoregion projections include a 27 percent decrease in annual freshwater flows and earlier snowmelts, with increased freshwater flows in January and February but reduced throughout the rest of the year (PRBO Conservation Science 2011). Earlier seasonal warming increases the likelihood of rain-on-snow events, which are associated with mid-winter floods. Smaller snowpacks that melt earlier in the year may result in increased drought frequency and severity (Rieman and Isaak 2010). Thus overall, these changes may lead to increased frequency of flood and drought cycles during the 21st century (Reclamation 2011).

Sea level rise is likely to increase the frequency and range of saltwater intrusion. Salinity within the northern San Francisco Bay is projected to rise by 4.5 by the end of the century (Cloern *et al.* 2011). Elevated salinity levels could push the position of X2 farther up the estuary if outflows were not increased to compensate for it. Fall X2 mean values are projected to increase by a mean of about 7 km to the area of Antioch for a distance of about 90 km from the Golden Gate Bridge by 2100 (Brown *et al.* 2013). This increase in the position of X2 in the fall is expected to result in a decrease in suitable physical habitat (Brown *et al.* 2013) if current levees and channel structures are maintained. A decrease in spring habitat due to the movement of X2 upstream due to sea level rise is also expected to result from climate change.

We expect warmer estuary temperatures to be yet another significant conservation challenge based on climate change models. Mean annual water temperatures within the upper Sacramento River portion of the Bay-Delta estuary are expected to approach or exceed 14 °C during the second half of this century (Cloern *et al.* 2011). Warmer water temperatures could reduce delta smelt growth, increase delta smelt mortality and constrict suitable habitat within the estuary during the summer months. Due to warming temperatures, delta smelt are projected to spawn an average of 10 to 25 days earlier in the season depending on the location (Brown *et al.* 2013). Also due to expected temperature increases, total number of high mortality days is expected to increase for all IPCC climate change scenarios (Brown *et al.* 2013). The number of stress days is expected to be stable or decrease partly because many stress days will become high mortality days. This could lead to delta smelt being forced to grow under highly stressful conditions during summer and fall with less time to mature because of advanced spawning (Brown *et al.* 2013). Growth rates have been shown to slow as water temperatures increase therefore requiring delta smelt to consume more food to reach growth rates that are normal at lower water temperatures (Rose *et al.* 2013a). Delta smelt are already often smaller than they used to be (Sweetnam 1999; Bennett 2005) and expected temperature increases due to climate change will likely further slow growth rates.

At the same time, warmer water will tend to move the spawning season earlier in the year (Brown *et al.* 2013). That means the fish will have to grow faster still to compensate for that shorter growing season to produce even as many eggs as they do now – and that may already be a serious limitation on their population fecundity (Rose *et al.* 2013b). Higher temperatures may restrict delta smelt distribution into the fall, limiting their presence in Suisun Bay for more than just salinity reasons and force greater inhabitation of cooler high salinity waters (Brown *et al.* 2013). Water temperatures are already presently above 20°C for most of the summer in core habitat areas, sometimes even exceeding 25 °C for short periods.

The delta smelt is currently at the southern limit of the inland distribution of the family Osmeridae along the eastern Pacific coast. That indicates that this region was already about as warm as that fish family can handle. Increased temperatures associated with climate change may result in a habitat in the Bay-Delta that is outside of the species ecological tolerance limits.

<u>Giant Garter Snake</u>

The Service is aware of other projects currently under review by the State, county, and local authorities where biological surveys have documented the occurrence of federally-listed species. These projects include such actions as urban expansion, water transfer projects that may not have a Federal nexus, and continued agricultural development. The cumulative effects of these known actions pose a significant threat to the eventual recovery of the species. Additionally, an undetermined number of future land use conversions and routine agricultural practices are not subject to Federal permitting processes and may alter the habitat or increase incidental take of snakes, and are, therefore, cumulative to the proposed project. For example other cumulative effects include: (1) unpredictable fluctuations in aquatic habitat due to water management and diversions; (2) dredging and clearing of vegetation from irrigation canals; (3) discing or mowing upland habitat; (4) increased vehicular traffic on access roads adjacent to aquatic habitat; (5) use of burrow fumigants on levees and other potential upland refugia; (6) human intrusion into habitat; (7) use of inappropriate plastic erosion control netting (Stuart *et al.* 2001); (8) riprapping or lining of canals and stream banks; (9) fluctuations in acreages of rice production due to market conditions or water availability; (10) ornamental cultivation; (11) routine grounds maintenance of upland habitat; (12) contaminated runoff from agriculture and urbanization; (13) maintenance of non-Federal flood control structures; and (14) predation by feral animals and pets. Specific cumulative effects related to the proposed project include maintenance activities and/or an increased potential for vandalism, which may degrade or destroy habitat or cause unpredictable fluctuations in habitat.

Yellow-Billed Cuckoo

Habitat that is currently occupied by the yellow-billed cuckoo occurs on public and privately owned lands. Activities on non-Federal lands that may affect the yellow-billed cuckoo include the construction and maintenance of recreational hiking and bicycle trails; restoration of native riparian habitat; transportation related projects like construction and maintenance of State, county, and private roads and bridges; flood channel maintenance by the State water resources agencies, and conversion of riparian habitat to agriculture on private lands.

Conclusion

After reviewing the current status of the valley elderberry longhorn beetle, delta smelt, giant garter snake and yellow-billed cuckoo, the environmental baseline for the action area, the effects of the proposed ARFC project, and the cumulative effects on these species, it is the Service's biological opinion that the proposed AFRC project, is not likely to jeopardize the continued existence of these species. The Service reached this conclusion because the project-related effects to the species, when added to the environmental baseline and analyzed in consideration of all potential cumulative effects, will not rise to the level of precluding recovery or reducing the likelihood of survival of the species based on the conservation measures proposed by the Corps including: creating additional riparian habitat for the valley elderberry longhorn beetle and the yellow-billed cuckoo; purchasing credits at conservation banks for giant garter snake and delta smelt; and restoring any temporarily affected habitat to pre-project conditions.

After reviewing the current status of designated critical habitat for delta smelt, the environmental baseline of critical habitat in the action area, the effects of the proposed ARFC project, and the cumulative effects, it is the Service's biological opinion that the proposed ARFC project, as proposed, is not likely to destroy or adversely modify designated critical habitat. The Service reached this conclusion because the project-related effects to the designated critical habitat, when added to the environmental baseline and analyzed in consideration of all potential cumulative effects, will not rise to the level of precluding the function of the delta smelt critical habitat, to serve its intended conservation role for the species based on the Corps proposal to purchase credits at a conservation bank for permanent effects to the substrate of the Sacramento River. The effects to delta smelt critical habitat are small and discrete, relative to the entire area designated, and are not expected to appreciably diminish the value of the critical habitat or prevent it from sustaining its role in the conservation of the delta smelt.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by Service regulations at 50 CFR 17.3 as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Harm is defined by the same regulations as an act which actually kills or injures wildlife. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are nondiscretionary, and must be undertaken by the Corps and SAFCA so that become binding conditions of any contract issued for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity that is covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions, or (2) fails to require their contractor or SAFCA or to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the contract, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR §402.14(i)(3)].

Amount or Extent of Take

Valley Elderberry Longhorn Beetle

The Service anticipates that incidental take of valley elderberry longhorn beetle will be difficult to detect due to its life history and ecology. Specifically, valley elderberry longhorn beetles can be difficult to locate due to the fact that a majority of their life cycle is spent in the elderberry shrub and finding a dead or injured individual is unlikely due to their relatively small size. There is a risk of harm, harassment, injury and mortality as a result of the proposed construction activities; therefore, the Service is authorizing take incidental to the proposed action as harm, harassment, injury, and mortality of all valley elderberry longhorn beetles within 263 shrubs that will be transplanted as a result of construction and 40 acres of elderberry shrubs that will be trimmed for maintenance purposes over the project's 50 year life.

Delta Smelt

The Service expects that incidental take of delta smelt will be difficult to detect or quantify for the following reasons: the small size of adults, their occurrence in turbid aquatic habitat makes them difficult to detect, and the low likelihood of finding dead or impaired specimens. The Service anticipates that the extent of incidental take will be minimized due to the proposed conservation measures and low relative abundance. Due to the difficulty in quantifying the number of delta smelt that will be taken as a result of the proposed action, the number of acres of affected habitat becomes a surrogate for the species that will be taken. The Service anticipates that all individual adult delta smelt in the 46 acres of the action area may be subject to incidental take in the form of harm as described in this biological opinion. Incidental take of delta smelt for maintenance activities is not covered in this biological opinion.

Giant Garter Snake

The Service anticipates that incidental take of the snake will be difficult to detect or quantify for the following reasons: snakes are cryptically colored, secretive, and known to be sensitive to human activities. Snakes may avoid detection by retreating to burrows, soil crevices, vegetation, and other cover. Individual snakes are difficult to detect unless they are observed, undisturbed, at a distance. Most close-range observations represent chance encounters that are difficult to predict. It is not possible to make an accurate estimate of the number of snakes that will be harassed during construction activities, including in staging areas and roads carrying vehicular traffic. In instances when take is difficult to detect, the Service may estimate take in numbers of species per acre of habitat lost or degraded as a result of the action as a surrogate measure for quantifying individuals.

Therefore, the Service anticipates the number of giant garter snakes that may be found in 125.5 acres of aquatic and upland habitat will be harmed or killed as a result of habitat modification due to the proposed project. Incidental take of giant garter snake for maintenance activities is not covered in this biological opinion.

Yellow-Billed Cuckoo

The Service anticipates that incidental take of yellow-billed cuckoo will be difficult to detect due to its life history and ecology. Specifically, yellow-billed cuckoos can be difficult to locate due to their cryptic appearance and behavior and finding a dead or injured individual is unlikely. There is a risk of harm and harassment as a result of proposed construction activities and operations and maintenance of the restoration plantings; therefore, the Service is authorizing take incidental to the proposed action as harm of all yellow-billed cuckoos within 135 acres. Incidental take of yellow-billed cuckoo for maintenance activities is not covered in this biological opinion.

Effect of the Take

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

Reasonable and Prudent Measures

All necessary and appropriate measure to avoid or minimize effects on the species resulting from implementation of this project have been incorporated into the project's proposed conservation measures. Therefore, the Service believes the following reasonable and prudent measure is necessary and appropriate to minimize incidental take of the species.

1. All conservation measures, as described in the biological assessment and restated here in the Project Description section of this biological opinion, shall be fully implemented and adhered to. Further, this reasonable and prudent measure shall be supplemented by the terms and conditions below.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must ensure compliance with the following terms and conditions, which implement the reasonable and prudent measure described above. These terms and conditions are nondiscretionary.

1. The Corps shall include full implementation and adherence to the conservation measures as a condition of any permit or contract issued for the project.

2. The Corps will develop a Riparian Planting Plan. The plan will evaluate locations for riparian vegetation planting based on land use in the lower American River Parkway, effects from future projects, such as the reoperation of Folsom Dam, where existing riparian and valley elderberry longhorn beetle habitat exists, creating and maintaining connectivity between large riparian patches, and coordination with Sacramento County Parks. The plan will maximize habitat quality for both the valley elderberry longhorn beetle and the yellow-billed cuckoo.

3. In order to monitor whether the amount or extent of incidental take anticipated from implementation of the project is approached or exceeded, the Corps shall adhere to the following reporting requirements. Should this anticipated amount or extent of incidental take be exceeded, the Corps must immediately reinitiate formal consultation as per 50 CFR 402.16.

    (a) For those components of the action that will result in habitat degradation or modification whereby incidental take in the form of harm is anticipated, the Corps will provide monthly updates to the Service with a precise accounting of the total acreage of habitat impacted. Updates shall also include any information about changes in project implementation that result in habitat disturbance not described in the Project Description and not analyzed in this biological opinion.
    (b) For those components of the action that may result in direct encounters between listed species and project workers and their equipment whereby incidental take in the form of harassment, harm, injury, or death is anticipated, the Corps shall immediately contact the Service's Sacramento Fish and Wildlife Office (SFWO) at (916) 414-6600 to report the encounter. If the encounter occurs after normal working hours, the Corps shall contact the SFWO at the earliest possible opportunity the next working day. When injured or killed individuals of the listed species are found, the Corps shall follow the steps outlined in the Salvage and Disposition of Individuals section below.
    (c) Injured listed species must be cared for by a licensed veterinarian or other qualified person(s), such as a Service-approved biologist. Dead individuals must be sealed in a resealable plastic bag containing a paper with the date and time when the animal was found, the location where it was found, and the name of the person who found it. The bag containing the specimen must be frozen in a freezer located in a secure site, until instructions are received from the Service regarding the disposition of the dead specimen. The Service contact persons are the Habitat Conservation Division Chief at the Sacramento Fish and Wildlife Office at (916) 414-6600; the Assistant Field Supervisor of ESA/Regulatory Division at the Bay Delta Fish and Wildlife Office at (916) 930-5603; and the Resident Agent-in-Charge of the Service's Office of Law Enforcement at (916) 569-8444.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The Service recommends the following actions:

1. The Service recommends the Corps develop and implement restoration measures in areas designated in the Delta Fishes Recovery Plan (Service 1996) the Giant Garter Snake Recovery Plan (1999) and the Valley Elderberry Longhorn Beetle Recovery Plan (1984).

2. The Corps and SAFCA should develop and implement projects that support DWR's Central Valley Flood System Conservation Strategy. This document provides goals and measurable objectives and potential projects which could be implemented in a manner that while improving the riverine ecosystem also will improve the flood system.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION - CLOSING STATEMENT

This concludes formal consultation with the Corps on the American River Common Features GRR Project. As provided in 50 CFR §402.16, 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:

(a) If the amount or extent of taking specified in the incidental take statement is exceeded;

(b) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;

(c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or

(d) If a new species is listed or critical habitat designated that may be affected by the identified action.

If you have any questions regarding this biological opinion, please contact Jennifer Hobbs (jennifer_hobbs@fws.gov or (916) 414-6541) or Doug Weinrich, Assistant Field Supervisor at the letterhead address, (916) 414-6600.

Sincerely,

Jennifer M. Norris
Field Supervisor

cc:
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Literature Cited

Acuña, S., Baxa, D., and S. Teh. Sublethal dietary effects of microcystin producing Microcystis on threadfin shad, Dorosoma petenense. Toxicon 2012, 60, 1191–1202.

Alpine, A. E. and J.E. Cloern. 1992. Tropic interactions and direct physical effects control on phytoplankton biomass and production in an estuary. Limnology and Oceanography, 37(5): 946-955.

Arthur, J. F., M. D. Ball and S. Y. Baughman. 1996. Summary of Federal and State water project impacts in the San Francisco Bay-Delta estuary, California. Pages 445-495 in J. T. Hollibaugh (editor) San Francisco Bay: the ecosystem. AAAS, San Francisco, CA.

Atwater B.F, S.G. Conard, J.N. Dowden, C.W. Hedel, R.L. MacDonald, and W. Savage. 1979. History, landforms, and vegetation of the estuary's tidal marshes. Pages 347-386 in San Francisco Bay: The Urbanized Estuary – Investigations into the Natural History of San Francisco Bay and Delta With Reference to the Influence of Man. Pacific Division of the American Association for the Advancement of Science. San Francisco, CA.

Bailey, H. C., C. Alexander, C. DiGiorgio, M. Miller, S. I. Doroshov and D. E. Hinton. 1994. The effect of agricultural discharge on striped bass *(Morone saxatilis)* in California's Sacramento-San Joaquin drainage. Ecotoxicology 3: 123-142.

Baskerville-Bridges, B., J.C. Lindberg, J.V. Eenennaam and S. Doroshov. 2000. Contributed Paper to the IEP: Progress and development of delta smelt culture: Year-end report 2000. IEP Newsletter, Winter 2001, 14(1): 24-30. Available at < http://www.water.ca.gov/iep/newsletters/2001/IEPNewsletterWinter2001.pdf#page=24> .

Baskerville-Bridges, B., J. C. Lindberg, and S.I. Doroshov. 2004. The effect of light intensity, alga concentration, and prey density on the feeding behavior of delta smelt larvae. Pages 219-228 *in* F. Feyrer, L.R. Brown, R.L. Brown and J.J. Orsi, eds. Early fife history of fishes in the San Francisco Estuary and watershed. Am. Fish. Soc. Symp. 39, Bethesda, MD, USA.

Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold, A. Mueller-Solger, M. Nobriga, T. Sommer, and K. Souza. 2008. Pelagic organism decline progress report: 2007 synthesis of results. Available at: <http://www/science.calwater.ca.gov/pdf/workshops/POD/IEP_POD_2007_synthesis_report_031408.pdf>.

Baxter, R.R. and IEP Team. 2010. Interagency Ecological Program: Pelagic Organism Decline Work Plan 2 and 3.Synthesis of Results

Bennett, W.A. and P.B. Moyle. 1996. Where have all the fishes gone? Interactive factors producing fish declines. Pages 519-541 in Hollibaugh, JT, editor. San Francisco Bay: the ecosystem. Pacific Division of the American Association for the Advancement of Science. San Francisco, CA.

Bennett, W.A., W.J. Kimmerer, and J.R. Burau. 2002. Plasticity in vertical migration by native and exotic fishes in a dynamic low-salinity zone. Limnology and Oceanography 47:1496-1507.

Bennett, W.A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science. Available at <http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art1>.

Bennett, W.A., J.A. Hobbs, and S. Teh. 2008. Interplay of environmental forcing and growth-selective mortality in the poor year-class success of delta smelt in 2005. Final Report to the Interagency Ecological Program.

Bergamaschi, B.A., Kuivila, K.M., Fram, M.S. 2001. Pesticides associated with suspended sediments entering San Francisco Bay following the first major storm of water year 1996. Estuaries 24: 368-380.

Bouley, P. and W.J. Kimmerer. 2006. Ecology of a highly abundant, introduced cyclopoid copepod in a temperate estuary. Marine Ecology Progress Series, 324, 219-228.

Brandes, Patricia L. and J.S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. Contributions to the biology of Central Valley salmonids. Fish Bulletin 179(2). 100 pp.

Bradbury, S. P. and J. R., Coats. 1989. Toxicokinetics and toxicodynamics of pyrethroid insecticides in fish. Environmental Toxicology and Chemistry, 8: 373–380.

Brown, R.L. and W.J. Kimmerer. 2002. Delta smelt and CALFED's Environmental Water Account: A summary of the 2002 delta smelt workshop. Prepared for the CALFED Science Program, October 2002.

Brown, L.R. and D. Michniuk. 2007. Littoral fish assemblages of the alien-dominated Sacramento-San Joaquin Delta, California, 1980-1983 and 2001-2003. Estuaries and Coasts 30:186-200.

Brown, L. R., W. A. Bennett, R. W. Wagner, T. Morgan-King, N. Knowles, F. Feyrer, D. H. Schoellhamer, M.T. Stacey, and M. Dettinger. 2011. Implications for future survival of delta smelt from four climate change scenarios for the Sacramento-San Joaquin Delta, California, unpublished data.

Brown, L.R., W. A. Bennett, R. W. Wagner, T. Morgan-King, N. Knowles, F. Feyrer, D. H. Schoellhamer, M.T. Stacey, and M. Dettinger. 2013. Implications for future survival of delta smelt from four climate change scenarios for the Sacramento-San Joaquin Delta, California. Estuaries and Coasts. DOI 10.1007/s12237-013-9585-4. Available on the internet at http://link.springer.com/article/10.1007%2Fs12237-013-9585-4#.

California Department of Fish and Wildlife (CDFW). 2010. Fall Midwater Trawl [database on the internet]. Available from http://www.delta.ca.gov/data/mwt99/index.html. Accessed on September 18, 2002.

_____. 2013. Striped Bass Study. Available on the internet at: <http://www.dfg.ca.gov/delta/projects.asp?ProjectID=STRIPEDBASS>.

____ . 2014 Spring Kodiak Trawl [database on the internet]. Available on the internet at: <http://www.dfg.ca.gov/delta/projects.asp?ProjectID=SKT> Accessed on May 5, 2014.

____ . 2015 Fall Midwater Trawl [database on the internet]. Available on the internet at: <http://www.delta.ca.gov/data/mwt99/index.html>. Accessed on May 30, 2015.

____ . 2015 Spring Kodiak Trawl [database on the internet]. Available on the internet at: <http://www.dfg.ca.gov/delta/projects.asp?ProjectID=SKT> Accessed on February 26, 2015.

____ . 2015 20mm Survey [database on the internet]. Available on the internet at: <http://www.delta.ca.gov/data/20mm/2000/>. Accessed on May 30, 2015.

California Natural Diversity Database (CNDDB). 2015. Biogeographic Data Branch, Department of Fish and Wildlife. Sacramento, California. Accessed 31 August 2015.

Campana, M. A., Panzeri, A. M., Moreno, V. J., and F. N. Dulout .1999. Genotoxic evaluation of the pyrethroid lambda-cyhalothrin using the micronucleus test in erythrocytes of the fish *Cheirodon interruptus interruptus*. Mutation Research/Genetic Toxicology and Environmental Mutagenesis, 438(2), 155-161.

Cloern, J.E, N. Knowles L.R. Brown, D. Cayan, and M.D. Dettinger. 2011. Projected evolution of California's San Francisco Bay-Delta-River System in a century of climate change. PLoS ONE 6(9): e24465.

Connon, R. E., L.A. Deanovic, E.B. Fritsch, L.S. D'Abronzo, and I.Werner. 2011. Sublethal responses to ammonia exposure in the endangered delta smelt; *Hypomesus transpacificus* (Fam. Osmeridae). Aquatic Toxicology 105: 369-377.

Connon, R. E., J. Geist, J. Pfeiff, A.V. Loguinov, L.S. D'Abronzo, H. Wintz, C.D. Vulpe, nd I. Werner. 2009. Linking mechanistic and behavioral responses to sublethal esfenvalerate exposure in the endangered delta smelt; *Hypomesus transpacificus* (Fam. Osmeridae). BMC Genomics 10: 608. 18 pp.

Culberson, S.D., C.B. Harrison. C. Enright and M.L. Nobriga. 2004. Sensitivity of larval fish transport to location, timing, and behavior using a particle tracking model in Suisun Marsh, California. Pages 257-267 in F. Feyrer, L.R. Brown, R.L. Brown and J.J. Orsi (editors) Early life history of fishes in the San Francisco Estuary and watershed. American Fisheries Society Symposium 39, Bethesda, MD, USA.

Davis, J.A.; D. Yee, J.N. Collins, S.E. Schwartzbach, and S.N. Luoma. 2003. Potential for increased mercury accumulation in the estuary food web. San Francisco Estuary and Watershed Science 1: Article 4. Available on the internet at: <http://escholarship.org/uc/item/9fm1z1zb>.

Dege, M. and L.R. Brown. 2004. Effect of outflow on spring and summertime distribution and abundance of larval and juvenile fishes in the upper San Francisco Estuary. Am. Fish. Soc. Symposium 39: 49-65.

Dettinger, M.D. 2005. From climate-change spaghetti to climate-change distributions for 21st Century California. San Francisco Estuary and Watershed Science 3: http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art4.

DWR and Reclamation (California Department of Water Resources and U.S. Bureau of Reclamation). 1994. Biological Assessment - Effects of the Central Valley Project and State Water Project on Delta Smelt and Sacramento Splittail. Prepared for U.S. Fish and Wildlife Service, Sacramento, CA. 230 pp.

DWR. 2010. Fact Sheet Sacramento River Flood Control Project Weirs and Flood Relief Structures. Flood Operations Branch.

Dugdale, R.C., F.P. Wilkerson, V.E. Hogue and A. Marchi. 2007. The role of ammonium and nitrate in spring bloom development in San Francisco Bay. Estuarine, Coastal, and Shelf Science 73:17-29.

eBird. 2012. eBird: An online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. Available: http://www.ebird.org. (Accessed: Date 31 August 2015).

Edmunds, J.L., K.M. Kuivila, B.E. Cole and J.E. Cloern. 1999. Do herbicides impair phytoplankton primary production in the Sacramento-San Joaquin River Delta? In: USGS Toxic Substances Hydrology Program Technical Meeting Proceedings, Charleston, SC, March 8-12, 1999.

Enos, C, Sutherland, J, Nobriga, M. 2007. Results of a two-year fish entrainment study at Morrow Island Distribution System in Suisun Marsh. Interagency Ecological Program Newsletter 20(1): 10-19.

Erkkila, L.F., J.F. Moffett, O.B. Cope, B.R. Smith, and R.S. Nelson. 1950. Sacramento-San Joaquin Delta fishery resources: effects of Tracy pumping plant and delta cross channel. U.S. Fish and Wildlife Services Special Report. Fisheries 56. 109 pp.

Ferrari, M. C., Ranåker, L., Weinersmith, K. L., Young, M. J., Sih, A., and J. L. Conrad. 2014. Effects of turbidity and an invasive waterweed on predation by introduced largemouth bass. Environmental biology of fishes, 97(1), 79-90.

Feyrer, F, B. Herbold, S.A. Matern, and P.B. Moyle. 2003. Dietary shifts in a stressed fish assemblage: consequences of a bivalve invasion in the San Francisco Estuary. Environmental Biology of Fishes 67:277-288.

Feyrer, F., M.L. Nobriga, and T.R. Sommer. 2007. Multi-decadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal of Fisheries and Aquatic Sciences 64:723-734.

Feyrer, F., K. Newman, M.L. Nobriga and T.R. Sommer. 2011. Modeling the effects of future outflow on the abiotic habitat of an imperiled estuarine fish. Estuaries and Coasts: 34(1):120-128.

Fisch, K. M., J.M. Henderson, R.S. Burton and B. May. 2011. Population genetics and conservation implications for the endangered delta smelt in the San Francisco Bay-Delta. Conservation Genetics. Published online 1 July 2011.

Foott, J. S., True, K. and R. Stone. 2006. Histological evaluation and viral survey of juvenile longfin smelt, (*Spirinchus thaleichthys*) and threadfin shad (*Dorosoma petenense*) collected in the Sacramento-San Joaquin River Delta, April-October 2006. California Nevada Fish Health Center.

Foott, J. S. and J. Bigelow. 2010. Pathogen survey, gill Na-K-ATPase activity, and leukocyte profile of adult delta smelt. California Department of Fish and Wildlife 96(4): 223-231.

Ganssle, D. 1966. Fishes and decapods of San Pablo and Suisun bays. Pages 64-94 in D.W. Kelley (editors) Ecological studies of the Sacramento-San Joaquin Estuary, Part 1.

Gartrell, G. 2010. Delta Flow Criteria informational proceeding. State Water Resources Control Board, Contra Costa Water District. 14 pp.

Ger, K.A. 2008. Trophic impacts of *Microcystis* on the crustacean zooplankton community of the Delta. 2008 CALFED Science Conference, Sacramento, California.

Ger, K.A., Teh, S. J., Baxa, D. V., Lesmeister, S. and C. R. Goldman. 2010. The effects of dietary Microcystis aeruginosa and microcystin on the copepods of the upper San Francisco Estuary. Freshwater Biology, 55: 1548–1559.

Gewant, D., and Bollens, S. M. 2012. Fish assemblages of interior tidal marsh channels in relation to environmental variables in the upper San Francisco Estuary. Environmental biology of fishes, 94(2), 483-499.

Giddings, J.M., L.W. Hall, Jr. and K.R. Solomon. 2000. Ecological risks of diazinon from agricultural use in the Sacramento - San Joaquin River Basins, California. Risk Analysis 20:545–572.

Gilbert, P.M. 2010. Long-term changes in nutrient loading and stoichiometry and their relationships with changes in the food web and dominant pelagic fish species in the San Francisco estuary, California. Reviews in Fisheries Science 18(2):211–232.

Glick, P., B.A. Stein, and N.A. Edelson, editors. 2011. Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation, Washington, D.C.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. Bioscience 41:540-551.

Grimaldo, L.F., T. Sommer, N. Van Ark, G. Jones, E. Holland, P.B. Moyle, P. Smith and B. Herbold. 2009. Factors affecting fish entrainment into massive water diversions in a freshwater tidal estuary: can fish losses be managed? North American Journal of Fisheries Management 29(5) 1253-1270. First published online on: 09 January 2011 (iFirst).

Grimaldo, L.F., A. R. Stewart and W. Kimmerer. 2009b. Dietary segregation of pelagic and littoral fish assemblages in a highly modified tidal freshwater estuary. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 1(1): 200-217.

Hasenbein, M., Komoroske, L. M., Connon, R. E., Geist, J., and N. A. Fangue .2013. Turbidity and salinity affect feeding performance and physiological stress in the endangered delta smelt. Integrative and comparative biology, 53(4), 620-634.

Hay, D. 2007. Spawning biology of eulachons, longfins and some other smelt species Sacramento, November 15, 2007, Powerpoint presentation. Available on the internet at <http://www.science.calwater.ca.gov/pdf/workshops/workshop_smelt_presentation_Hay_111508.pdf>.

Herbold, B. 1994. Habitat requirements of delta smelt. Interagency Ecological Studies Program Newsletter, Winter 1994. California Department of Water Resources, Sacramento, California.

Hestir, E. 2010. Trends in estuarine water quality and submerged aquatic vegetation invasion. PhD dissertation, University of California, Davis.

Hobbs, J.A., W.A. Bennett, and J. Burton. 2006. Assessing nursery habitat quality for native smelts (Osmeridae) in the low-salinity zone of the San Francisco Estuary. Journal of Fish Biology 69: 907-922.

Houde, E.D. 1987. Subtleties and episodes in the early life of fishes. Journal of Fish Biology 35 (Suppl A): 29-38.

Horpilla, J., A. Liljendahl-Nurminen, and T. Malinen. 2004. Effects of clay turbidity and light on the predator–prey interaction between smelts and chaoborids. Canadian Journal of Fisheries and Aquatic Sciences. 61: 1862-1870.

International Panel on Climate Change (IPCC). 2013. Climate Change 2013: The physical science basis. Contribution of the Working Group I to the 5th Assessment Report of the Intergovernmental Panel on Climate Change. Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (editors). Cambridge University Press, Cambridge, United Kindgom and New York, New York. 1535 pp. Available at <http;//www.ipcc.ch/>.

Jassby, A.D., W.J. Kimmerer, S.G. Monismith, C. Armor, J.E. Cloern, T.M. Powell, J.R.Schubel, and T.J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecol. Appl. 5(1): 272-289.

Jassby, A.D., J.E. Cloern, and B.E. Cole. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47:698-712.

Jassby, A.D. 2008. Phytoplankton in the upper San Francisco estuary: recent biomass trends, their causes and their trophic significance. San Francisco Estuary and Watershed Science, Vol. 6, Issue 1 (February 2008), Article 2.

Johnson, M. L., I. Werner, S. Teh, and F. Loge. 2010. Evaluation of chemical, toxicological, and histopathologic data to determine their role in the pelagic organism decline. University of California, Davis. Davis, California.

Kawakami, B.T., Denton, R.A., and G. Gartrell. 2008. Investigation of the Basis for Increases in Delta Fall Salinity. CALFED Science Conference Poster Presentation.

Kimmerer, W.J. and J.J. Orsi. 1996. Causes of long-term declines in zooplankton in the San Francisco Bay estuary since 1987. Pages 403-424 in J. T. Hollibaugh (editor) San Francisco Bay: the ecosystem. AAAS, San Francisco, CA.

Kimmerer, W.J. 2002a. Physical, biological and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25: 1275-1290.

____ . 2002b. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages. Marine Ecology Progress Series 243:39-55.

____ . 2004. Open water processes of the San Francisco Estuary: from physical forcing to biological processes. San Francisco Estuary and Watershed Science. Available on the internet at <http://repositories.cdlib.org/jmie/sfews/vol2/iss1/art1>.

____ . 2006. Response of anchovies dampens effects of the invasive bivalve *Corbula amurensis* on the San Francisco Estuary foodweb. Marine Ecology Progress Series 324: 207-218.

____ . 2008. Losses of Sacramento River Chinook salmon and delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 6:2 (2). Available on the internet at <http://repositories.cdlib.org/jmie/sfews/vol6/iss2/art2>.

____ . 2011. Modeling Delta Smelt Losses at the South Delta Export Facilities. San Francisco Estuary and Watershed Science, 9(1). San Francisco Estuary and Watershed Science, John Muir Institute of the Environment, UC Davis. Available on the internet at: <http://escholarship.org/uc/item/0rd2n5vb>.

Kimmerer W, Brown L, Culberson S, Moyle P, Nobriga M, Thompson J. 2008. The State of Bay Delta Science 2008 Chapter 4: Aquatic Ecosystems. The CALFED Science Program.

Kimmerer, W.J., E. Gartside, and J. J. Orsi. 1994. Predation by an introduced clam as the probable cause of substantial declines in zooplankton in San Francisco Bay. Mar. Ecol. Prog. Ser. 113: 81-93

Kimmerer, W.J., and M.L. Nobriga. 2008. Investigating particle transport and fate in the Sacramento-San Joaquin Delta using a particle tracking model. San Francisco Estuary and Watershed Science, 6:2 (4). Available on the internet at <http://repositories.cdlib.org/jmie/sfews/vol6/iss1/art4>.

Kimmerer, W.J., E.S. Gross, and M.L. MacWilliams. 2009. Is the response of estuarine nekton to freshwater flow in the San Francisco Estuary explained by variation in habitat volume? Estuaries and Coasts (32): 375-389. 15 pp. DOI 10.1007/s12237-008-9124-x.

Kimmerer, W.J. 2011. Modeling delta smelt losses at the South Delta export facilities. San Francisco Estuary and Watershed Science 9: Issue 1 [April 2011], article 6.

Knowles, N. 2002. Natural and human influences on freshwater inflows and salinity in the San Francisco Estuary at monthly to interannual scales. Water Resources Research 38(12): 1289. doi:10.1029/2001WR000360. Available on the internet at: <http://sfbay.wr.usgs.gov/publications/pdf/knowles_2002_sf_estuary.pdf>.

Knutson Jr., A.C. and J.J. Orsi. 1983. Factors regulating abundance and distribution of the shrimp *Neomysis mercedis* in the Sacramento-San Joaquin Estuary. T. Am. Fish. Soc. 112: 476-485.

Kuivila, K. M. and C. G. Foe. 1995. Concentrations, transport, and biological effects of dormant spray pesticides in the San Francisco Estuary, California. Environmental Toxicology and Chemistry 14: 1141-1150.

Kuivila, K.M. and G.E. Moon. 2004. Potential exposure of larval and juvenile delta smelt to dissolved pesticides in the Sacramento-San Joaquin Delta, California. American Fisheries Society Symposium 39:229-242.

Lehman, P.W., G. Boyer, C. Hall, S. Waller and K. Gehrts. 2005. Distribution and toxicity of a new colonial *Microcystis aeruginosa* bloom in the San Francisco Bay Estuary, California. Hydrobiologia 541:87-99.

Lehman, P. W., S. J. Teh, G. L. Boyer, M. L. Nobriga, E. Bass and C. Hogle. 2010. Initial impacts of *Microcystis aeruginosa* blooms on the aquatic food web in the San Francisco Estuary. Hydrobiologia 637:229–248.

Lindberg, J. C., B. Baskerville-Bridges, and S.I. Doroshov. 2003. "Two Reproductive Concerns Tested in Captive Delta Smelt, *Hypomesus transpacificus*, 2002: I. Effect of substrate and water velocity on spawning behavior.

Linville, R. G., S.N. Luoma, L. Cutter, and G.A. Cutter. 2002. Increased selenium threat as a result of invasion of the exotic bivalve *Potamocorbula amurensis* into the San Francisco Bay-Delta. Aquatic Toxicology 57: 51-64.

Lott, J. 1998. Feeding habits of juvenile and adult delta smelt from the Sacramento-San Joaquin River Estuary. Interagency Ecological Program Newsletter 11(1):14-19. Available at <http://iep.water.ca.gov/report/newsletter/>.

Mac Nally, R., Thomson, J.R., Kimmerer, W. J., Feyrer, F., Newman, K.B., Sih, A., Bennett, W.A., Brown, L., Fleishman, E., Culberson, S.D., and G. Castillo. 2010. Analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). Ecological Applications 20(5): 1417–1430.

Mager, R.C., S.I. Doroshov, J.P. Van Eenennaam, and R.L. Brown. 2004. Early life stages of delta smelt. Pages 169-180 *in* F. Feyrer, L.R. Brown, R.L. Brown and J.J. Orsi, eds. Early fife history of fishes in the San Francisco Estuary and watershed. Am. Fish. Soc. Symp. 39, Bethesda, MD, USA.

Marine, K.R. and J.J. Cech Jr. 2004. Effects of high water temperature on growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook salmon. North American Journal of Fisheries Management: 24(1):198–210.

Matern, S. A., Moyle, P. B., and L. C. Pierce. 2002. Native and alien fishes in a California estuarine marsh: twenty-one years of changing assemblages. Transactions of the American Fisheries Society, 131(5), 797-816.

Maunder, M.N and R. B. Deriso. 2011. A state–space multistage life cycle model to evaluate population impacts in the presence of density dependence: illustrated with application to delta smelt (*Hypomesus transpacificus*). Can. J. Fish. Aquat. Sci. 68: 1285–1306.

Miller, W. J. 2011. Revisiting assumptions that underlie estimates of proportional entrainment of delta smelt by state and federal water diversions from the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science, 9(1). Available at <http://escholarship.org/uc/item/5941x1h8>.

Miller, W.J., Manly B., Murphy D.D., Fullerton, D. and R.R. Ramey .2012. An Investigation of Factors Affecting the Decline of Delta Smelt (*Hypomesus transpacificus*) in the Sacramento-San Joaquin Estuary, Reviews in Fisheries Science, 20:1, 1-19

Monson, N.E., J.E. Cloern and J.R. Burau. 2007. Effects of flow diversion on water and habitat quality: examples from California's highly manipulated Sacramento-San Joaquin.

Moyle, P. B. 1976. Inland fishes of California. University of California Press. Berkeley, CA.

_____. 2002. Inland fishes of California. University of California Press, Berkeley and Los Angeles, CA.

Moyle, P.B., B. Herbold, D.E. Stevens, and L.W. Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 121:67-77.

Moyle, Peter B; Lund, Jay R.; Bennett, William A; & Fleenor, William E.(2010). Habitat Variability and Complexity in the Upper San Francisco Estuary. *San Francisco Estuary and Watershed Science*, 8(3). jmie_sfews_11019. Retrieved from: http://escholarship.org/uc/item/0kf0d32x

Newman K.B. 2008. Sample design-based methodology for estimating delta smelt abundance. San Francisco Estuary and Watershed Science 6(3): article 3.Available at: <http://repositories.cdlib.org/jmic/sfews/vol6/iss3/art3>.

Nichols, F.H., J.E. Cloern, S.N. Luoma, and D.H. Peterson. 1986. The modification of an Estuary. Science 231:567-573.

Nobriga, M. and M. Chotkowski. 2000. Recent historical evidence of centrarchid increases and tule perch decrease in the Delta. Interagency Ecological Program Newsletter 13(1):23-27. Available at <http://www.iep.ca.gov/report/newsletter>.

Nobriga, M.L. 2002. Larval delta smelt diet composition and feeding incidence: environmental and ontogenetic influences. California Fish and Game 88:149-164.

Nobriga, M. L., Z. Matica, and Z.P. Hymanson. 2004. Evaluating Entrainment Vulnerability to Agricultural Irrigation Diversions: A Comparison among Open-Water Fishes. Pages 281-295 in F. Feyrer, L.R. Brown, R.L. Brown, and J.J. Orsi, editors. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Nobriga, M.L., F. Feyrer, R.D. Baxter, and M. Chotkowski. 2005. Fish community ecology in an altered river delta: spatial patterns in species composition, life history strategies and biomass. Estuaries 28:776-785.

Nobriga, M.L. and F. Feyrer. 2007. Shallow-water piscivore-prey dynamics in California's Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 5: Available at <http://repositories.cdlib.org/jmie/sfews/vol5/iss2/art4>.

Nobriga, M. L. and F. Feyrer. 2008. Diet composition of San Francisco Estuary striped bass: does trophic adaptability have its limits? Environmental Biology of Fishes. 83: 495-503.

Nobriga, M. and B. Herbold. 2008. Conceptual model for delta smelt (*Hypomesus transpacificus*) for the Delta Regional Ecosystem Restoration and Implementation Plan (DRERIP).

Nobriga, M.L., T.R. Sommer, F. Feyrer, and K. Fleming. 2008. Long-term trends in summertime habitat suitability for delta smelt, *Hypomesus transpacificus*. San Francisco Estuary and Watershed Science 6: Available at <http//repositories.cdlib.org/jmie/sfews/vol6/iss1/art1>.

Nobriga, M.L., Erik Loboschefsky and Frederick Feyrer .2013. Common Predator, Rare Prey: Exploring Striped Bass Predation on Delta Smelt in California's San Francisco Estuary, Transactions of the American Fisheries Society, 142:6, 1563-1575

Orsi, J.J. and W.L. Mecum. 1986. Zooplankton distribution and abundance in the Sacramento-San Joaquin Delta in relation to certain environmental factors. Estuaries 9(4B):326-339.

Ostrach, D. 2008. Multiple stressors and their effects on the striped bass population in the San Francisco estuary. Presented at Interagency Ecological Program 2008 Annual Workshop, Pacific Grove, CA. February 26-29, 2008.

Peterson, M. S. 2003. A conceptual view of environment-habitat-production linkages in Tidal Riverine Estuaries. Review in Fisheries Science 11(4): 291-313.

Pickard, A, Baracco, A, Kano, R. 1982. Occurrence, abundance, and size of fish at the Roaring River Slough intake, Suisun Marsh, California, during the 1980-81 and the 1981-82 diversion seasons. Interagency Ecological Program Technical Report 3. California Department of Water Resources, Sacramento, CA.

PRBO Conservation Science. 2011. Projected Effects of Climate Change in California: Ecoregional Summaries Emphasizing Consequences for Wildlife. Version 1.0. http://data.prbo.org/apps/bssc/climatechange

Radtke, L.D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta with observations on food of sturgeon, in Ecological studies of the Sacramento-San Joaquin Delta, Part II. In: S.L. Turner and D.W. Kelley (Eds.), Ecological Studies of the Sacramento–San Joaquin Estuary, pp. 115-129. California Department of Fish and Game Fish Bulletin 136.

Rast, W. and J. Sutton. 1989. Stable isotope analysis of striped bass food chain in Sacramento-San Joaquin Estuary, California, April-September, 1986. Water Resources Investigations Rept. 88-4164, U.S. Geological Survey, Sacramento, California. 62 pp.

Reclamation. 2008. OCAP Biological Assessment on the Continued Long-term Operations of the Central Valley Project and the State Water Project.

Richman, S. E., and J. R. Lovvorn. 2004. Relative foraging value to Lesser Scaup ducks of native and exotic clams from San Francisco Bay. Ecological Applications 14:1217-1231.

Rieman, Bruce E.; Isaak, Daniel J. 2010. Climate change, aquatic ecosystems, and fishes in the Rocky Mountain West: implications and alternatives for management. Gen. Tech. Rep. RMRS-GTR-250. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 46 p.

Rose, K.A., J.H. Cowan, K.O. Winemiller, R.A. Myers, and R. Hilborn. 2001. Compensatory density-dependence in fish populations: importance, controversy, understanding, and prognosis. Fish and Fisheries 2: 293-327.

Rose, K.A., Kimmerer W.J., Edwards K.P., and W. A. Bennett. 2013A. Individual-Based Modeling of Delta Smelt Population Dynamics in the Upper San Francisco Estuary: I. Model Description and Baseline Results, Transactions of the American Fisheries Society, 142:5, 1238-1259.

Rose K.A., Kimmerer W.J., Edwards K.P., and W. Bennett. 2013B. Individual-Based Modeling of Delta Smelt Population Dynamics in the Upper San Francisco Estuary: II. Alternative Baselines and Good versus Bad Years, Transactions of the American Fisheries Society, 142:5, 1260-1272

Rosenfield, J.A. and R.D. Baxter. 2007. Population dynamics and distribution patterns of longfin smelt in the San Francisco Estuary. Transactions of the American Fisheries Society 136:1577–1592.

Saiki, M.K., M.R. Jennings and R. H. Wiedmeyer. 1992. Toxicity of agricultural subsurface drainwater from the San Joaquin River, California, to juvenile Chinook salmon and striped bass. Transactions of the American Fisheries Society 121:78-93.

Saiki, M. K. 1998. An ecological assessment of the Grassland Bypass Project on fishes inhabiting the Grassland Water District, California. Unpublished report by the U.S. Fish and Wildlife Service, Sacramento, California.

Schoellhamer, D. H. 2011. Sudden clearing of estuarine waters upon crossing the threshold from transport as an erodible sediment pool is depleted: San Francisco Bay, 1999. Estuaries and Coasts 34: 885-899.

Schroeter, RE. 2008. Biology and long-term trends of alien hydromedusae and striped bass in a brackish tidal marsh in the San Francisco Estuary. PhD dissertation, UC Davis.

Sedell, J.R., G.H. Reeves, F.R. Hauer, J.A. Stanford, and C.R. Hawkins. 1990. Role of refugia in recovery from disturbances: modern fragmented and disconnected river systems. Environmental Management 14:711-724.

Shafer, T. J., and Meyer, D. A. 2004. Effects of pyrethroids on voltage-sensitive calcium channels: a critical evaluation of strengths, weaknesses, data needs, and relationship to assessment of cumulative neurotoxicity. Toxicology and applied pharmacology, 196(2), 303-318.

Slater, S.B. and R.D. Baxter. .2014. Diet, Prey Selection, and Body Condition of Age-0 Delta Smelt,*Hypomesus transpacificus*, in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science, 12(3).

Sogard, S. M. 1997. Size-selective mortality in the juvenile stage of teleost fishes: a review. Bulletin of Marine Science 60: 1129-1157.

Sommer, T.R., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32(6):270-277.

Sommer, T., F.H. Mejia, M.L. Nobriga, F. Feyrer, and L. Grimaldo. 2011. The Spawning Migration of Delta Smelt in the Upper San Francisco Estuary. San Francisco Estuary and Watershed Science 9(2), 17 pages.

Stanley S.E., P.B. Moyle, and H.B. Shaffer. 1995. Allozyme analysis of delta smelt, *Hypomesus transpacificus*, and longfin smelt, *Spirinchus thaleichthys*, in the Sacramento-San Joaquin estuary. Copeia 1995:390–396.

Stevens, D.E. 1963. Food habits of striped bass, *Roccus saxatilis* (Walbaum), in the Sacramento-Rio Vista area of the Sacramento River. Master's Thesis. University of California, Davis.

Stevens, D.E. and L.W. Miller. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin river system. North American Journal of Fisheries Management 3:425-437.

Stewart, A.R., S.N. Luoma, C.E. Schlekat, M.A. Doblin, and K.A. Hieb. 2004. Foodweb pathway determines how selenium affects aquatic ecosystems: a San Francisco Bay case study. Environmental Science and Technology 38:4519-4526.

Swanson, C. and J.J. Cech Jr. 1995. Environmental tolerances and requirements of the delta smelt, *Hypomesus transpacificus*. Final Report. California Department of Water Resources Contracts B-59499 and B-58959. Davis, California. July 20, 1995.

Swanson, C., T. Reid, P.S. Young, and J.J. Cech Jr. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced wakasagi (*H. nipponensis*) in an altered California estuary. Oecologia 123: 384-390.

Sweetnam, D.A. and D.E. Stevens. 1993. Report to the Fish and Game Commission: A status review of the delta smelt (*Hypomesus transpacificus*) in California. Candidate Species Status Report 93-DS. Sacramento, California. 98 pp. plus appendices.

Sweetnam, D.A. 1999. Status of delta smelt in the Sacramento-San Joaquin Estuary. California Fish and Game 85:22-27.

Taniguchi, Y., F.J. Rahel, D.C. Novinger, and K.G. Gerow. 1998. Temperature mediation of competitive interactions among three fish species that replace each other along longitudinal stream gradients. Canadian Journal of Fisheries and Aquatic Sciences 55:1894-1901.

Tanner, D. K. and M. L. Knuth. 1996. Effects of *Esfenvalerate* on the Reproductive Success of the Bluegill Sunfish, *Lepomis macrochirus* in Littoral Enclosures. Arch. Environ. Contain. Toxicol. 31,244-251

Teh, S.J. 2007. Final report of histopathological evaluation of starvation and/or toxic effects on pelagic fishes title: pilot study of the health status of 2005 adult delta smelt in the upper San Francisco Estuary. Available on the internet at: <http://www.science.calwater.ca.gov/pdf/workshops/POD/2007_final/Swee_Teh_POD_health_status_2007.pdf>.

Thetmeyer. H. and U. Kils. 1995. To see and not be seen: the visibility of predator and prey with respect to feeding behaviour. Mar. Ecol. Prog. Ser. 126: 1-8.

Thomas, J. L. 1967. The diet of juvenile and adult striped bass, Roccus saxatilis, in the Sacramento-San Joaquin river system. California Fish and Game, 53(1), 49-62.

Thomson, J.R., W.J. Kimmerer, L.R. Brown, K.M. Newman, Mac Nally, R., Bennett, W.A., Feyrer, F. and E. Fleishman. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications 20(5): 1431–1448.

Trenham, P.C., H.B. Shaffer, and P.B. Moyle. 1998. Biochemical identification and assessment of population subdivision in morphometrically similar native and invading smelt species (*Hypomesus*) in the Sacramento-San Joaquin Estuary, California. T. Am. Fish. Soc. 127: 417-424.

Turner, J.L., Kelley, DW (editors). 1966. Ecological studies of the Sacramento-San Joaquin Delta, part II, fishes of the Delta. California Department of Fish and Game Fish Bulletin 136.

[Reclamation] U.S. Bureau of Reclamation. 2008.Central Valley Project and State Water Project Operations and Criteria Plan Biological Assessment. Mid-Pacific Region, Sacramento, California.

Reclamation. 2011 SECURE Water Act Section 9503(c) – Reclamation Climate Change and Water, Report to Congress

U.S. Fish and Wildlife Service (Service). 1984. Valley Elderberry Longhorn Beetle Recovery Plan, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California. 70 pages.

____ . 1991. Endangered and threatened wildlife and plants: Proposed threatened status for the delta smelt, October 3, 1991. Federal Register 56(192): 50075-50084.

____ . 1993. Endangered and threatened wildlife and plants: Determination of threatened status for the delta smelt. March 5, 1993. Federal Register 58(42):12854-12864.

____ . 1994. Endangered and threatened wildlife and plants: Critical habitat determination for the delta smelt. December 19, 1994. Federal Register 59(242): 65256-65279.

______. 1996. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. Portland, Oregon.

______. 1999a. Conservation Guidelines for the Valley Elderberry Longhorn Beetle. Sacramento, California.

____ . 1999b. Draft Recovery Plan for the Giant Garter Snake (*Thamnophis gigas*). U.S. Fish and Wildlife Service, Portland, Oregon. x + 192 pp.

____ . 2004. Five Year Status Review for the Delta Smelt. Sacramento, California. 50 pp.

____ . 2008. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP), Service File No. 81420-2008-F-1481-5. Available on the internet at <http://www.fws.gov/sfbaydelta/ocap/>.

____ . 2010. Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition to Reclassify the Delta Smelt From Threatened to Endangered Throughout its Range. Federal Register 75(66):17667-17680.

____ . 2012. Giant Garter Snake *(Thamnophis gigas)* 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California.

____ . 2014. Withdrawl of the Proposed Rule to Delist the Valley Elderberry Longhorn Beetle from the Federal List of Endangered and Threatened Wildlife. Federal Register 79:55874-55917. September 17, 2014.

____ . 2014. Determination of Threatened Status for the Western Distinct Population Segment of the Yellow-billed Cuckoo. Federal Register 79:59991-60038. October 3, 2014.

Utne-Palm AC. 2002. Visual feeding of fish in a turbid environment: physical and behavioural aspects. Marine and Freshwater Behaviour Physiology 35:111–128

Wagner, W., M. Stacey, L. Brown and M. Dettinger. 2011. Statistical models of temperature in the Sacramento-San Joaquin Delta under climate-change scenarios and ecological implications. Estuaries and Coasts34(3): 544-556.

Wang, J.C.S. 1986. Fishes of the Sacramento-San Joaquin Estuary and adjacent waters, California: a guide to the early life stages. Interagency Ecological Studies Program Technical Report 9. Sacramento.

Wang, J.C.S. 1991. Early life stages and early life history of the delta smelt, *Hypomesus transpacificus*, in the Sacramento-San Joaquin Estuary, with comparison of early life stages of the longfin smelt, *Spirinchus thaleichthys*. Interagency Ecological Studies Program Technical Report 28, August 1991.

Wang, J.C.S. 2007. Spawning, early life stages, and early life histories of the Osmerids found in the Sacramento-San Joaquin Delta of California. Tracy Fish Facilities Studies California Volume 38. U.S. Bureau of Reclamation, Mid-Pacific Region.

Werner, I., L.A. Deanovic, V. Conner, V. de Vlaming, H.C. Bailey, and D.E. Hinton. 2000. Insecticide-caused toxicity to *Ceriodaphnia dubia* (Cladocera) in the Sacramento-San Joaquin River Delta, California, USA. Environ. Tox. Chem. 19(1): 215-227.

Werner, I, L. Deanovic, D. Markiewicz, M. Stillway, N. Offer, R. Connon, and S. Brander. 2008. Pelagic organism decline (POD): Acute and chronic invertebrate and fish toxicity testing in the Sacramento-San Joaquin Delta, 2006-2007. Final report to the Interagency Ecological Program, April 30, 2008.

Werner, I., D. Markiewicz, L. Deanovic, R. Connon, S. Beggel, S. Teh, M. Stillway, C. Reece. 2010. Pelagic organism decline (POD): Acute and chronic invertebrate and fish toxicity testing in the Sacramento-San Joaquin Delta, 2008-2010. Final Report. U.C. Davis-Aquatic Toxicology Laboratory, Davis, California.

Weston, D.P., J. You and M.J. Lydy. 2004. Distribution and toxicity of sediment-associated pesticides in agriculture-dominated water bodies of California's Central Valley. Environmental Science and Technology 38: 2752-2759.

Weston, B.P. and M.J. Lydy. 2010. Urban and agricultural sources of pyrethroid insecticides to the Sacramento-San Joaquin Delta of California. Environmental Science and Technology 44:1833-1840.

Whitehead, A., K.M. Kuivila, J.L. Orlando, S. Kotelevtsev and S.L. Anderson. 2004. Genotoxicity in native fish associated with agricultural runoff events. Environmental Toxicology and Chemistry: 23:2868–2877.

Wicks, B.J., Joensen, R., Tang, Q, and D.J. Randall. 2002. Swimming and ammonia toxicity in salmonids: the effect of sub lethal ammonia exposure on the swimming performance of coho salmon and the acute toxicity of ammonia in swimming and resting rainbow trout. Aquatic Toxicology 59: 55-69.

Wilkerson, F.P., R.C. Dugdale, V.E. Hogue and A. Marchi. 2006. Phytoplankton blooms and nitrogen productivity in San Francisco Bay. Estuaries and Coasts 29:401-416.

Winemiller, K.O. and Rose, K.A. 1992. Patterns of life-history diversification in North American fishes: implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences 49:2196-2218.

Wright, S. A., and D.H. Schoellhamer. 2004. Trends in the sediment yield of the Sacramento River, California, 1957-2001. San Francisco Estuary and Watershed Science. Vol.2, Issue 2 (May 2004) Available on the internet at <http://repositories.cdlib.org/jmie/sfews/vol2/iss2/art2>.

Wylie, G. D., M. L. Casazza, and N. M. Carpenter. 2002a. Monitoring giant garter snakes at Colusa National Wildlife Refuge: 2001. progress report. Unpublished report. U.S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California. April 2002. 10 pp.

Wylie, G.D., M.L. Casazza, and L.L. Martin. 2002b. The distribution of giant garter snakes and their habitat in the Natomas Basin: A report for the U.S. Fish and Wildlife Service. Unpublished report. U.S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California. December 20, 2002. 25pp.

Wylie, G.D., M.L. Casazza and L.L Martin. 2004. Giant garter snake surveys in the Natomas Basin: 2003 Results. Unpublished report. U.S. Geological Survey, Biological Resources Division, Dixon Field Station, Dixon, California. January 2004. 75pp.

Personal Communications

Lindberg, Joan. 2011. Personal communication during a meeting conducted by Brian Hansen, USFWS. 2011.